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Are Technology-Intensive Industries More Dynamically Competitive? No and Yes

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A substantial body of research in management and related public policy fields concludes that recent decades saw greater dynamic competition throughout technology-intensive (TI) industries, with widespread steady increase in TI industry and business performance instability as key implications. We set this conclusion within a broader framework of purportedly increasing dynamic competition among TI industry businesses, and then test for evidence of its performance implications in a large sample of U.S. businesses operating from 1978 to 1997 in 31 industries, with high average research and development expenditure-to-sales ratios. In the full sample, we find no evidence of sustained increase in TI industry and business performance instability, nor any evidence of significant cross-sectional differences in performance instability between TI and non-TI industry businesses over these 20 years. For a small segment of very high-performing businesses from TI industries, however, we do uncover evidence of declining performance stability and cross-sectional differences in performance stability. We conclude that assumptions of widespread long-term increase in dynamic competition lack robust evidentiary support. It is premature to embrace and apply broadly new theoretical perspectives, management practices, and public policies to TI industry competitive dynamics that may be slightly changed since the late 1970s. Yet, there may be increasing dynamic competition among very high-performing TI industry businesses. In that small realm, careful application of new perspectives, practices, and policies may lead to deeper insight on business behavior and performance in TI industries.

Key words: dynamic competition; technology-intensive industries
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The last 15 years have seen robust debate among academics in management and related fields regarding what many perceived as quickening innovation pace, shortening technology, and product life cycles, increasing volatility in sales and profits, and shifting patterns of business rivalry, particularly in industries described as "high technology" or "new economy" or as we describe them below, technology-intensive (TI) industries. Several scholars argue that these changes began in the United States during the mid-1970s and worked through the 1980s and 1990s to transform competition in TI industries from predominately static to dynamic with traditional sources of competitive advantage rendered increasingly less durable (D'Aveni 1994, Bettis and Hitt 1995, Nault and Vandenbosch 1996, Thomas 1996, Schmalensee 2000, Evans and Schmalensee 2002, Hitt et al. 2001).

Prescriptive implications of increasing dynamic competition are far reaching for management research. Theoretical perspectives reaching back to Schumpeter (1934, 1939, 1950) have acknowledged the potential for greater swings in year-to-year profitability, sales, even survival in TI industries where dynamic competition; that is, innovation-based competition for markets, is more pronounced. Increasing dynamic competition in TI industries implies a new vogue for Schumpeterian perspectives emphasizing environmental volatility, potential for performance instability, and the importance of ephemeral factors in any explanation of business performance differences. For management researchers advocating a "fundamental shift" in the nature of competition (Thomas 1996, Wiggins and Ruefli 2005), sustained competitive advantage has become increasingly rare. When observed, it is better explained as a concatenation of several ephemeral advantages, rather than as a few "big bets" with long-term implications. Increasing dynamic competition in TI industries demands greater attention to perspectives emphasizing "strategic entrepreneurship" (Hitt et al. 2001) and "dynamic capabilities" (Henderson 1993, Teece et al. 1997, Brown and Eisenhardt 1989, Eisenhardt and Martin 2000) rather than difficult to reverse commitments (Ghemewat 1991) to business resources, industry structures, and corporate relationships that might be quickly rendered obsolete in fast-changing technological landscapes (Bettis and Hitt 1995).

Makadok (1998) was probably first to point out that this popular view rests on uneven empirical support, mostly in the form of descriptive analyses (Schmalensee 2000, Evans and Schmalensee 2002), case studies (Rindova and Kotha 2001), and single industry statistical studies (Nault and Vandenbosch 1996). To date, only four broad sample, multi-industry studies have investigated these assumed trends across several years. They yield a mixed bag of evidence consistent (Thomas 1996, Wiggins and Ruefli 2005) and inconsistent (Castrogiovanni 2002, McNamara et al. 2003) with the assumption of increasing dynamic competition in a range of industries. These four studies all sample from a range of TI *and* non-TI industries even though the phenomenon of increasing dynamic competition may be most pronounced in TI industries. Other analytical methods vary considerably across the four studies and make it difficult to accord their findings appropriate weight.

In this context of popular assertion, uneven empirical support and inconsistent methods, we see an opportunity to make at least three contributions to research, practice, and public policy related to debate over purported increase in TI industry dynamic competition. First, we contribute with a comparative review and assessment of all four previous broad sample, multi-industry studies (Thomas 1996, Wiggins and Ruefli 2005, Castrogiovanni 2002, McNamara et al. 2003), their methods, their key results, and their appropriate weight in the scales of this debate. Second, we contribute with a summary of causal factors, behavioral consequences, and performance implications commonly cited by researchers assuming increased dynamic competition. Third and most importantly, we contribute with a new multi-industry empirical study probing for evidence of performance implications consistent with assumptions of increasing dynamic competition in TI industries: (1) increasing TI industry dynamism (volatility) in sales and profitability; (2) decreasing ability to maintain abnormally higher or lower profitability in TI industry businesses; (3) decreasing ability to maintain sales leadership in TI industry businesses; and (4) increasing mortality rates in TI industry businesses. We examine evidence related to these performance implications in analyses of operating behavior and returns of 2,309 businesses operating in 31 TI industries from 1978 to 1997. We apply these tests to probe for longitudinal trends within the sample of businesses in TI industries from 1978 to 1997, and for cross-sectional trends between this sample and a broader sample of businesses operating in non-TI industries from 1978 to 1997. Our results follow from more precise definition of TI industries, broader TI industry coverage, and more robust analytical methods than previous studies, including the four multi-industry studies noted above (Thomas 1996, Wiggins and Ruefli 2005, Castrogiovanni 2002, McNamara et al. 2003).

Results yield a mix of general and segment-specific trends important to scholars debating dynamic competition trends as well as executives and public policymakers responding to that debate with business and business regulation initiatives. On the one hand, results from longitudinal study of all businesses in TI industries yield no general trend of increasing dynamic competition from 1978 to 1997. At the industry level, we find no evidence of increasing dynamism. At the business level, we find no patterns suggesting a general decrease in the ability to maintain year-to-year operating performance differences, market leadership, and or survival. Similarly, cross-sectional tests comparing all businesses in TI to all businesses in non-TI industries across the same 20-year period uncover few, if any, significant performance differences. On the other hand, we do uncover evidence that a small segment of very high-performing businesses in TI industries exhibit statistically significant and practically substantial declines in their ability to sustain lofty performance advantages over our 20-year period of observation. These very high-performing businesses in TI industries also exhibit inferior ability to maintain superior performance compared to similar businesses from non-TI industries. These contrasting results tell us that claims of increasing dynamic competition in TI industries lack broad general support. Yet, such claims should not be entirely dismissed. Theoretical perspectives, practical business strategies, and prudential public policies based on the assumption of increasing dynamic competition in TI industries may yet apply to a select group of businesses in very high-performing TI industry segments. If the question posed by this research is whether dynamic competition has steadily increased in TI industries, then our answer is generally "no," but on the margins, perhaps "yes."

Background

Defining Dynamic Competition and Its Constituent Elements

Central to this study is concept of dynamic competition, which harkens back to Schumpeter (1934, 1939, 1950) and his vision of technology-based competition and economic development as a process of "creative destruction" rather than as a stable equilibrium condition. We adopt Schumpeter's (1950, pp. 81–86) definition of dynamic competition summarized as innovation-based rivalry *for markets* rather than price- and output-based competition *within markets*. Constituent elements of dynamic competition include: (1) episodic rivalry between incumbent and insurgent businesses seeking to establish favorable technology standards serving a market; (2) businesses investing substantially in research and development (R&D) to perfect and diffuse to customers favorable technology standards; (3) with the resolution of technology standards, outcomes permitting one or only a few "winners" to dominate the market, only to see their dominance later imperiled with the next radical change redefining technology standards and related business modes; and (4) wide swings in sales and profitability as individual businesses and whole industries alternate between dominant and fringe players (Schmalensee 2000, Evans and Schmalensee 2002).[1]

With such attributes, it is not surprising that dynamic competition is described by contemporary management researchers in terms of fast-changing technologies, markets, and organizational environments as well as shifting patterns of investment and performance. For example, Thomas (1996, p. 221) holds that "*dynamic* (*or Schumpeterian*) *competition* changes technology at various points of the value chain, challenging firms to compete in completely new ways." As dynamic competition increases, "the strategic focus of firms shifts from careful exploitation of given, highly durable strategic assets to the steady creation of many new, rapidly depreciable assets."

With faster rates of technological change and the strategic shift to ephemeral sources of advantage, it is not surprising that increasing dynamic competition is associated with greater environmental volatility and performance instability. Schmalensee (2000) describes the U.S. software industry of the 1980s and 1990s in such terms. Software businesses are vulnerable to wide swings in profitability, sales, and market share. It is increasingly difficult to maintain market leadership, fend off rival innovators, or just keep up with the "generally brisk" pace of innovation and survive (Schmalensee 2000, p. 193).

Purported Causes and Consequences of Increasing Dynamic Competition

Other contemporaries echo these points, and identify causes and consequences of increasing dynamic competition in TI industries. Bettis and Hitt (1995), Brown and Eisenhardt (1998), and others look to the 1980s and early 1990s for causal factors that transformed the competitive landscape of U.S. TI industries, and included: (1) U.S. TI industry deregulation and globalization, particularly in information, computer, and telecommunications industries, thus permitting competitive entry by new domestic and foreign firms (Bettis and Hitt 1995); (2) intellectual property regime change broadening the scope of patentable innovations, thus broadening the realm of product markets where rivals might be excluded with a greater likelihood of inventor-take-all results (Hall and Ziedonis 2001); (3) growth in venture capital markets and entrepreneurial ranks, thus permitting faster challenges to incumbents by rival firms and technologies (Brown and Eisenhardt 1998); and (4) new transactional (e.g., cross-licensing) and organizational modes (e.g., alliances, networks), thus promoting faster technology diffusion, imitation, and competitive response (Gans et al. 2002).

The behavioral consequences of increasing dynamic competition in TI industries might be summarized as greater reliance on "strategic entrepreneurship" (Hitt et al. 2001). TI industry businesses rely more on R&D and network relationships rather than physical assets and proprietary relationships. They "morph" organizational structure to adapt to fast-changing markets (Rindova and Kotha 2001). They "cannibalize" current technology assets in advance of rivals to create the next innovation to win to the next episodic standards battle for the market (D'Aveni 1994, Nault and Vandenbosch 1996). They know how to communicate with firm stakeholders regarding increased performance instability that comes from pairing the Romeo of strategy with the Juliet of entrepreneurship (Hitt et al. 2001). By the mid-1990s, such perceived environmental trends and business responses led Garud and Karaswarmy (1995, p. 93) to proclaim that the "Schumpeterian era during which gales of creative destruction brought about revolutionary changes over long periods of time ... is past. In recent times, we have entered a neo-Schumpeterian era where technological change appears to be ceaseless. To survive in this new era, firms have to innovate continually ... ."[2]

Increased instability is the chief performance implication following from these causes and behavioral consequences of purportedly increasing dynamic competition. We defer momentarily development of specific testable hypotheses related to this purported change, but note how predictions of greater industrywide and intraindustry performance instability follow intuitively from trends promoting shorter technology cycles, and more frequent innovating, patenting, competitive entry, episodic standards battles, and market repositioning.

Previous Broad Sample Evidence

To date, only four published studies have examined the claims of increasing dynamic competition in a broad set of industries and firms, though none focus on performance trends across TI industries specifically. The study by Thomas (1996) examined growth rates in the market value of corporations operating primarily in one of 200 U.S. manufacturing industries from 1958 to 1991. Thomas (1996) linked firm market value to corporate expenditures on salary and general administrative expenses, which he took as a proxy for industry rivalry levels. He observed an inverted-U-shaped relationship between levels of industry rivalry and growth of firm market value in later years of his sample (1970s–1991). He took this relationship as evidence of a generalized "hypercompetitive shift" in recent U.S. corporate performance.

Castrogiovanni (2002) examined changes in organization task environments of manufacturing establishments operating in one of 88 U.S. industries in the 1980s and 1990s. In contrast to Thomas (1996), he observed a generally decreasing trend in industry dynamism over time across this sample, and questioned the proposition of any fundamental shift indicating greater performance volatility. Findings published by McNamara et al. (2003) confirmed and extended Castrogiovanni's (2002) findings. They examined time trends in industry dynamism as well as intraindustry business performance instability in a sample of more than 110,000 annual business unit returns reported for nearly 20,000 businesses operating in more than 900 nonbanking industries from 1978 to 1997. They found no trends indicating greater industry dynamism, decreasing industry munificence, less sustainable operating business performance differences, or business mortality rates. McNamara et al. (2003) concluded that claims by many strategy scholars of generally increasing dynamism and performance instability were unfounded generally. Yet, they held out the possibility that such claims might find support in a subset of industries and businesses more precisely defined by their vulnerability to trends inducing greater dynamism.

Wiggins and Ruefli (2005, p. 894) accepted previous findings by McNamara et al. (2003) regarding the lack of time trends in broader industry dynamism and munificence, and regarding intraindustry business mortality rates, but uncovered other time trends in performance indicative to them of increasing instability. They examined performance stability trends in 6,772 U.S. corporations and their affiliated businesses operating in 40 industries from the 1970s to 1997. Using an iterative Kolmogorov-Smirnov technique, they partitioned samples into superior, modal, and inferior performing strata, and found in multivariate analyses that corporations in the superior stratum for a minimum of 10 consecutive years (7.78% of their observations based on return on operating assets (ROA) performance measure and 3.77% of the sample using a Tobin's Q performance measure) were significantly less likely to remain there later in their time period of study. Interestingly, for our study, they also found this trend in certain corporations/business judged to be operating in seven "high-tech" industries they sampled. With the superior stratum, they also conducted univariate analyses, indicating that businesses leaving this stratum were significantly less likely to return in later years. They took these results as broad evidence of significantly increasing corporate/business performance instability consistent with Thomas (1996) and his conclusion of a hypercompetitive shift in the U.S. economy.

These four studies yield evidence indicating support for (Thomas 1996, Wiggins and Ruefli 2005) and skepticism about (Castrogiovanni 2002, McNamara et al. 2003) claims of increasing performance instability since the late 1970s. Closer scrutiny to sampling and other analytical methods used might indicate appropriate weight to give each study. For example, results from Thomas (1996) and Castrogiovanni (2002) might be given less weight because their samples were limited to manufacturing industries, which currently comprise a small and decreasing percentage of overall economic activity in the United States. These two studies and McNamara et al. (2003) might also be given less weight because they fail to segregate TI industries and businesses to probe for performance stability time trends specifically related to debate over increasing dynamic competition. Here, Wiggins and Ruefli (2005) stand out as they did examine time trends in seven TI industries and found results largely consistent with their broader set of results, indicating greater performance instability over time. Yet, these seven industries represent only a fraction of the U.S. TI industry sector. Their subsample results merit reexamination with a full range of TI industries before giving Wiggins and Ruefli (2005) greatest weight.

Other analytical methods used in Wiggins and Ruefli (2005) merit closer scrutiny and caution by researchers trying to weigh findings appropriately. Wiggins and Ruefli (2005, p. 907) emphasize that any evaluation of time trends in Schumpeterian competition should include clearly superior performing firms with sustainable advantages (i.e., at least 10 years of superior performance) rather than evaluate performance time trends for all competitors who might deviate from average performance positively or negatively over time. In this context, they argue for greater weight accorded to their findings compared to findings in McNamara et al. (2003) who found no time-trends in the ability of businesses to sustain abnormally higher (superior) or lower (inferior) performance levels. The Wiggins and Ruefli (2005) position on limited (to superior performer) sampling seems to contradict Schumpeter's own view that innovation-based competition has performance implications not just for high performers, but also for other firms responding to challenges of innovation-based competition. Schumpeter (1939, Vol. 1, p. 134) describes four prospective performance paths of these "old" incumbents facing competitive challenge.

> For some of the "old" firms new opportunities for expansion open up: the new methods or commodities create New Economic Space. But for others the emergence of the new methods means economic death; for still others, contraction and drifting into the background. Finally, there are firms and industries which are forced to undergo a difficult and painful process of modernization, rationalization, and reconstruction . . . . Aggregative analysis, here, as elsewhere, not only does not tell the whole tale but necessarily obliterates the main (and the only interesting) point of the tale.

The "point of the tale" is that innovation-based competition for markets generates performance implications for established firms and businesses at all performance levels, from the persistently profitable to the mediocre, the underperforming but restructuring, and even to the possibly moribund. Attention to the failure or renewal of incumbent firms facing competitive challenge also occupies Schumpeter's attention in his *Theory of Economic Development* ("[D]istress is a form of the process by which means of production are withdrawn from old businesses…" 1934, p. 232) and in *Capitalism, Socialism, and Democracy* ("Our argument extends beyond the cases of new concerns, methods, and industries. Old concerns and established industries, whether or not directly attacked, still live in the perennial gale." 1950, p. 90). Any examination of time trends in such Schumpeterian competition should be similarly broad in analytical scope.

In this context, we find it difficult to accord to any one of these four studies greater evidentiary weight in the debate about increasing dynamic competition. We still know relatively little about long-term time trends in the performance stability of businesses in TI industries. If increasing performance instability follows from increasing dynamic competition since the late 1970s, then we should observe it in the performance patterns of a well-defined set of TI industry businesses over the same period.

Hypotheses

Consistent with our last point, we start with a statement of the two broad research propositions concerning TI industries in the 1980s and 1990s: (1) TI industries generally as well as individual businesses within TI industries have experienced increasing dynamic competition and (2) TI industries generally as well as individual businesses within TI industries have experienced greater dynamic competition than non-TI industries and businesses. We examine support for these longitudinal and cross-sectional propositions through a battery of tests, each of which probes for evidence of performance implications associated with greater dynamic competition in a broad sample of TI industries from 1978 to 1997. These performance implications follow from our discussion above and include tests for time trends in: (1) the durability of abnormal returns; (2) the loss of market leadership; (3) mortality; and (4) broader industrywide volatility. So that our tests have broader and deeper implications, we apply them to a sample of 2,309 businesses operating in 31 TI industries in the United States from 1978 to 1997. We apply them to these TI industries and businesses alone (longitudinally), and in comparison with an even larger sample of businesses operating in non-TI industries for assessment over the same time period (cross-sectionally).

Durability of Abnormal Business Returns and Greater Dynamic Competition in TI Industries

For businesses in TI industries, our general research propositions imply at least three sets of predictions regarding performance implications of increasing dynamic competition. The first set links increasing dynamic competition to decreasing durability of abnormal business unit returns within TI industries. Makadok (1998) and Roberts (2001) point out a rich research stream describing the self-adjusting market mechanism leading to the decay of abnormally high (or low) business returns back to average levels (Mueller 1977, 1986; Jacobsen 1988). D'Aveni (1994, pp. 46–47), for example, cites several factors in the 1980s and 1990s contributing to increased competitive pressures on more profitable market leaders: lower barriers to entry; more radical redefinition of market boundaries; more frequent technological change; shorter product life cycles; and more aggressive interactions among rivals. These trends mean that only "temporary advantage and short periods of profit are achievable until competitors catch up with or outmaneuver the aggressor's last competitive move" (D'Aveni 1994, p. 46).

Regarding TI industries during the 1980s and 1990s, strategy researchers have also noted shorter cycles of innovation and competitive imitation, more frequent patenting and cross-licensing, greater use of alliances and networked organizational forms to commercialize innovations, and deregulatory trends permitting potential rivals to cross traditional industry boundaries more easily (Bettis and Hitt 1995, Chakravarthy 1997). These developments would promote lower entry and intra-industry mobility barriers, greater rivalry, and faster dissipation of abnormally higher returns. Gans et al. (2002) describe an increasingly popular alternative basis for starting episodes of innovation-based competition for pharmaceutical markets. Innovating firms first legally appropriate and then selectively license their technologies to several surrogate insurgent businesses, which, in turn, start a faster developing threat to incumbents and their competitive position (Gans et al. 2002). As insurgents and previously disadvantaged businesses use new forms of competitive assault to challenge incumbents, the decay rate of abnormal performance in TI industries is likely to have increased over time. Also, because these dynamics are more likely in TI industries, we expect to find that the impact of these dynamics will be stronger in TI versus non-TI industries. Thus we hypothesize that:

Hypothesis 1A. *Abnormal returns of businesses in TI industries have decayed more quickly over time.*

Hypothesis 1B. *Abnormal returns of businesses in TI industries have decayed more quickly than for businesses in non-TI industries.*

Business Market Leadership and Greater Dynamic Competition in TI Industries

As researchers in both strategy and economics have noted (Ferrier et al. 1999, Schmalensee 2000), a key metric of business success in TI industries is the ability to attain and maintain a leading market share position. Positive network effects, feedback mechanisms, and increasing returns to scale from market leadership are especially important in TI industries. Yet, factors increasing dynamic competition are likely to affect the likelihood that businesses successfully battling others for the market in one episode will prevail again in the next episode of technology-based competition. Ferrier et al. (1999) find that market leaders are less likely to maintain their dominance against rivals making radical and unanswered strategic thrusts. Increasingly dynamic TI industries imply that market leaders face more frequent and deeper thrusts, that they may be less able to respond effectively, and that they may find it more difficult to maintain market leadership over time and in comparison to their counterparts in non-TI industries. Thus we predict:

Hypothesis 2A. *Market leading businesses in TI industries have been more likely to be supplanted from one year to the next over time.*

Hypothesis 2B. *Market leading businesses in TI industries have been more likely to be supplanted from one year to the next than market leading businesses in non-TI industries.*

Business Mortality and Greater Dynamic Competition in TI Industries

Numerous researchers have argued that organizations exhibit inertial tendencies, find organizational change very difficult, and, consequently, find their survivability called into question during periods of dramatic environmental change (Hannan and Freeman 1977, 1984). Thus, organizational pressures for inertia are likely to have profound effects in faster evolving TI industries of the 1980s and 1990s. Increased dynamic competition means greater potential for discontinuities in technological development and the sudden obsolescence of an organization's existing technologies (Tushman and Anderson 1986).

Alternatively, the very technological prowess of TI industry incumbents may create a technological "oversupply" for consumers. New entrants can exploit this oversupply condition with the introduction of cheaper but functionally equivalent technologies that "disrupt" incumbent positions (Christensen 1997). In terms of product life-cycle research (Abernathy and Utterback 1978, Utterback 1994), this trend implies shorter periods of dominant design and faster more frequent challenge by rivals with alternative designs in the late 1990s compared to the late 1970s. Incumbent businesses not well adapted to the resulting turbulence could see the value of their resources depleted and become more likely to be selected out (Tushman and Anderson 1986, Henderson and Clark 1990). Schmalensee (2000), Evans and Schmalensee (2002), and others (Posner 2001) propose that the increasing frequency and strength of such technological discontinuities and or disruptions in the 1980s and 1990s could help explain potential for higher business mortality (exit) rates in TI industries. Winner-take-all battles for the market are natural results of dynamic competition in TI industries. This also means that exit by unsuccessful businesses is also a natural result that should increase in frequency if dynamic competition is itself increasing. Similarly, we should find that business mortality in the form of industry exit during the 1980s and 1990s should be greater overall in TI versus non-TI industries, thus:

Hypothesis 3A. *Mortality* (*exit*) *rates within TI industries have increased over time.*

Hypothesis 3B. *Mortality* (*exit*) *rates within TI industries have been greater than within non-TI industries.*

Industry Dynamism and Greater Dynamic Competition in TI Industries

With our final set of hypotheses, we raise the level of analysis to the industry level. Our general research propositions directly imply that TI industry dynamism should have increased during the 1980s and 1990s. As new technologies appear, gain acceptance, and mature more quickly and with greater frequency, Schumpeterian creative destruction could become more widespread and pronounced across TI industries, a trend explicitly predicted by Garud and Karaswarmy (1995, p. 93) and contemplated by other scholars examining broader trends in the TI industry sector (Bettis and Hitt 1995, Chakravarthy 1997, McKnight et al. 2001). In line with these views, we expect to find that industry-wide dynamism has increased from 1978 to 1997 and was greater than in non-TI industry dynamism over the same period, thus:

Hypothesis 4A. *TI industries have exhibited greater dynamism over time.*

Hypothesis 4B. *TI industries have exhibited greater dynamism than non-TI industries.*

Methods

Data Collection and Sampling

To find data to test these hypotheses derived from our theoretical framework, we turn to the Compustat Industry Segment ("Compustat") database. Our choice follows previous researchers interested in understanding broader economywide trends in the performance stability of industries and businesses (McNamara et al.

2003, Wiggins and Ruefli 2005) as well as the relative importance of factor types driving such performance (Roquebert et al. 1996; McGahan and Porter 1997, 1999, 2002, 2003). We start with the entire Compustat database from 1978 to 1997, a total of 234,164 annual observations of operating results reported by U.S. corporations for their major four-digit Standard Industrial Classification (SIC) industry segments (at least 10% of sales, income, or assets), which we refer to as "business segments" or simply as "businesses."[3]

We follow McGahan and Porter's (1997) suggestions for screening these data and for arriving at our base sample for subsequent analyses.[4] Once screened on their criteria, our base sample comprises a total of 114,191 observations from 1978 to 1997 posted by 19,214 different businesses operating in 982 different nonbanking four-digit industries and affiliated with 10,298 different corporations. On average, we have approximately 5,700 annual business observations in each of the 20 years covered. The breadth of coverage in this base sample is very similar to the McNamara et al. (2003) study, and compares favorably to much more narrow samples in other prior studies in this line of research (Thomas 1996, Castrogiovanni 2002, Wiggins and Ruefli 2005). We also highlight our principal focus on the business within industry rather than corporate unit of analysis. This focus is more likely to result in comparison of performance results for organizations competing in homogenous market settings.

Consistent with criteria for identifying TI industries described in Bettis and Hitt (1995) and Evans and Schmalensee (2000), we then calculate the relative R&D intensity of corporations within all industries of the base sample to identify a subsample of businesses from TI industries.[5] TI industries are defined as those with average R&D expenditure-to-sales ratios in 1997 at least one standard deviation above the mean R&D expenditure-to-sales ratio for all industries in 1997.[6] We focus on the final year of the study period to make this important distinction, so that, in line with recent analyses of TI industries (Evans and Schmalensee 2002), we can identify industries with TI attributes at the end of (though not necessarily throughout) the study period. Thus, industries that may not have met TI attributes in 1978 will have an opportunity to be included in the TI sample if they transformed into a TI industry during the 1980s and 1990s.[7] The mean and standard deviation for this measure of average business R&D intensity for 1997 is 1.6% and 3.5%, respectively. Based on this screen, we create a subsample comprising 11,626 observations from 1978 to 1997 for 2,309 different businesses operating in 31 different four-digit industries affiliated with 1,898 different corporations.[8]

We use multiple dependent variables related to industry and business performance conditions. At the business level, we include measures of business ROA, the likelihood of falling from higher to lower business ROA levels, the likelihood of market share leadership loss by businesses, and the likelihood of industry exit (mortality) by businesses. At the industry level, we include measures of overall industry dynamism derived from aggregation of intraindustry business sales. These performance-based measures become the basis for our examination of time trends in performance stability.

Abnormal Business Returns Models

To test Hypothesis 1A, we first employ regression analysis to model ROA for businesses in TI industries across all 20 years of our data based on a year-to-year autoregressive process similar to that used by Mueller (1977, 1986), Jacobsen (1988), and McNamara et al. (2003). With this model, we assess the degree to which abnormally higher or lower business returns decay over time to the population mean. Our dependent variable is the ROA of business j operating in year t (ROA_{jt}). It is regressed on a constant, a one-year lagged value of the dependent variable (ROA_{jt-1}), a year counter ranging from 1 (in 1979) to 19 (in 1997) ($YEAR_t$), a term interacting lagged ROA and the year counter ($ROA_{jt-1} * YEAR_t$), and a set of control variables.

With this model, the coefficient estimate of the one-year lagged ROA (ROA_{jt-1}) generally falls between 0 and 1.00 with a value near 1.00, indicating that there is little if any decay in returns from the previous to the current year. The coefficient estimate on the year counter ($YEAR_t$) indicates linear time trends in returns. The key term in this model is the interaction term ($ROA_{jt-1} * YEAR_t$) the coefficient estimate for which indicates whether the rate of decay in lagged returns exhibits any linear time trends over the study period. We predict that this interaction term will exhibit a significant and negative coefficient estimate, indicating an increasing rate of decay in abnormal business returns over 1979–1997. To control for macroeconomic and industry conditions that may also affect the degree to which abnormal returns persist, we include three control variables. Economic growth ($GDPG_t$) is the annual rate of growth in the U.S. gross domestic product. We control for inflation (INF_t) using the annual percentage change in the U.S. consumer price index. We also include a third control for industry concentration, using a Herfindahl-Hirschman score (HHI_{it}) because concentration may influence the ability of a single business to curb rivalry and cooperate to maintain performance stability (Viscusi et al. 1995).

To test Hypothesis 1B, we specify a slightly different autoregressive model designed to assess cross-sectional differences between businesses in TI versus non-TI industries from 1978 to 1997. With this model, we use businesses from all industries in our sample and implement a regression, including the same base variables as in our first autoregressive model. Then, we add a dummy variable for businesses operating in TI industries ($TECH_i$). On its own, this term provides insight on the possibility of systematic differences in the operating returns of businesses in TI industries over the entire period studied. We then add an interaction term ($ROA_{jt-1} * TECH_i$), capturing any differences in the rate of decay in abnormal returns between businesses from TI versus non-TI industries from 1978 to 1997. If significant and negative, this term would indicate a higher decay rate for firms in TI industries in line with Hypothesis 1B.

The autoregressive model makes no distinction between changes in the persistence of abnormally higher or lower returns. Again, this follows from Schumpeter's own insights about the performance impact of dynamic competition no matter the favorable or unfavorable market position of a TI business. On its face, this model seems most appropriate to examination of claims that the 1980s and 1990s saw greater performance instability for formerly more persistent high-, low-, and midrange performing businesses. Complementing this broader examination, we add a more targeted analysis focusing only on performance durability of high-performing businesses. A second logistic regression ("logit") model assesses changes over time in the durability of returns for progressively higher performing businesses from TI industries.

We begin this complementary analysis by defining high-performing businesses broadly; that is, as businesses with ROA above their industry average in a given year. We use only these observations in our first analysis. We construct a 0–1 dependent variable to identify whether that business is still performing above the industry average ROA in the following year. We then estimate a logit model with this dependent variable. For independent variables, we again include controls for economic growth ($GDPG_t$), inflation (INF_t), and industry concentration (HHI_{it}). A year counter ($YEAR_t$) captures any time trend in the likelihood that a business performing above the industry average ROA continues to do so in the next year. When our subsample is limited to above-average performers from TI industries alone, Hypothesis 1A will be supported if the coefficient estimate for the *YEAR* variable is negative and significant, indicating that the likelihood of sustaining above-average performance has decreased over time. If we replace the year counter with a dummy for TI industries ($TECH_i$), we can use the entire subsample of businesses from TI and non-TI industries in a logit model permitting a test of Hypothesis 1B. Support will be indicated if the coefficient on TI industry dummy is negative and significant.

We repeat this first analysis, but with progressively more exclusive definitions of high-performing businesses: those with ROA more than one standard deviation above their industry average; then those with ROA more than two standard deviations above their industry average; and finally those with ROA more than three standard deviations above their industry average. With each new and more exclusive definition of high-performing businesses, we reestimate logit models to test for support of Hypotheses 1A and 1B.

We see benefits in assessing performance durability combining the autoregressive and the likelihood of maintaining superior performance. It permits durability assessments using multiple progressively more exclusive definitions to assess the robustness of initial results and compare performance durability trends generally and in increasingly select segments of high performers.

Loss of Market Leadership Models

We also use logit models to test Hypotheses 2A and 2B. We begin here by identifying the business in each industry with the largest share of industry sales in a given year, and use only these observations in our model implementations. We then construct a 0–1 dependent variable to identify whether that business is no longer the industry sales leader in the following year. To test Hypothesis 2A, we limit our analysis to the TI industry market share leaders. We estimate an initial logit model, including a control for industry concentration, the Herfindahl-Hirschman index score (HHI_{it}). Industry concentration may also influence the ability of a single business to exercise market power and for multiple businesses to collude and maintain market stability (Viscusi et al. 1995). We then add a year counter ($YEAR_t$) to indicate whether there is a time trend in the likelihood that a market share leader will be dethroned. In line with Hypothesis 2A, we expect to find the coefficient estimate for the year counter ($YEAR_t$) variable to be positive and significant, indicating that the likelihood of losing market share leadership by businesses in TI industries increased in the 1980s and 1990s.

To test Hypothesis 2B, we include businesses with leading shares of annual industry sales from all industries in our sample. Again using a logit model, we test whether the likelihood of lost industry sales leadership by these TI industry businesses is different from the likelihood for business leaders in non-TI industries during the 1980s and 1990s. Current year industry concentration (HHI_{it}) and a dummy variable for TI industries ($TECH_i$) comprise our independent variables. Hypothesis 2B will be supported if the coefficient estimate for the TI industry dummy ($TECH_i$) is positive and significant, indicating that leading businesses in TI industries are more likely to be dethroned in the following year than leaders in non-TI industries.

Business Mortality (Exit) Models

To test Hypothesis 3A, we resort to a proportional hazard rate model (Lin and Wei 1989) explaining the likelihood that a business will disappear (exit) from one year to the next. The model operationalizes business mortality as a 0–1 dependent variables identifying whether a business does not survive in the following year. Our independent variables include a year counter ($YEAR_t$), and various controls to account for macroeconomic and industry-specific conditions that might also affect business mortality. We include economic growth ($GDPG_t$) to control for economic conditions possibly affecting the likelihood of business failure. We also include the annual dollar volume of U.S. mergers and acquisitions (VMA_t) because activity in this field may also change the likelihood of industry exit. Finally, we control for industry density ($INDDENS_{it}$) using a count value of businesses in the appropriate four-digit SIC. We also include the quadratic form of this term ($INDDENS_{it}^2$) to capture possible nonlinear, inverted U-shaped density effects on mortality. These control variables are standardized with a mean value of 0 and a standard deviation of 1 to allow for estimates that are of a magnitude easily represented in the results table. Consistent with Hypothesis 3A, we predict that the coefficient estimate for the year counter ($YEAR_t$) term will be significant and positive, indicating an increasing likelihood of mortality (exit) over the study period.

To test Hypothesis 3B, we include businesses from all industries in our sample and use the proportional hazards model to test for systemic differences in the mortality rate of businesses in TI versus non-TI industries. We first regress the dependent variable for business mortality on the control variables ($GDPG_t$, VMA_t, $INDDENS_{it}$, $INDDENS_{it}^2$) used in the first mortality analysis. We then add a dummy variable for TI industries ($TECH_i$) to test whether there were differences in the likelihood of business mortality for TI versus non-TI industries. Consistent with Hypothesis 3B, we predict that the estimate for $TECH_i$ will be significant and positive, indicating a higher mortality rate in TI industries.

Industry Dynamism Models

To test Hypothesis 4A, we take a within-subjects regression model approach. This amounts to a regression of industry dynamism on individual industry dummies and three of four possible time periods in our sample for comparison of overall dynamism scores. As a preliminary step, we follow previous research (Dess and Beard 1984) in calculating dynamism for each four-digit industry operating in four different five-year panels of our data (1978–1982, 1983–1987, 1988–1992, and 1993–1997). To compute these scores, we first regress industry sales on 0–1 dummy variables representing years in a five-year panel. We then divide the standard error of each regression by the mean value of sales for that industry and use the resulting value as a dynamism score for each industry in each year of four 5-year periods examined. In effect, the dynamism score is capturing volatility in the demand for industry products and services, an important outcome of various TI industry trends noted by researchers contending that dynamic competition increased since the 1980s (Bettis and Hitt 1995, McKnight et al. 2001, Evans and Schmalensee 2002).

We then regress the industry dynamism scores on 0–1 dummies for each of the 31 industries less one in our analysis. Industry dummies control for systematic, industry-specific differences in dynamism. We then add time period dummies for three of the four time panels (1978–1982, 1983–1987, and 1988–1992). By regressing the annual measure of dynamism on these time period dummies, we obtain coefficient estimates for comparison with each other and against the omitted time period, 1993–1997. Hypothesis 4A will be supported if we find that the parameter estimates for all of the time period indicator variables in the dynamism regression are negative (relative to the omitted time period, 1993–1997) and significant. The greatest negative estimate should be in the earliest time period, thus indicating a positive trend for dynamism over the period studied. To test Hypothesis 4B, we estimate an industry dynamism regression model where we first control for time period effects. We then add a dummy variable ($TECH_i$) to denote a TI industry to compare the level dynamism in the 31 TI industries to non-TI industries. Hypothesis 4B will be supported if the TI industry dummy ($TECH_i$) is positive and significant, indicating that average dynamism levels in the TI industries were higher than in non-TI industries.

Results

Abnormal Returns Model Results

Hypothesis 1A predicts a decrease in the durability of abnormal business returns in TI industries over the study period. We test this prediction with results from the first two autoregressive analyses reported in Table 1. These results provide little indication of any significant increase in business performance instability over the period of study. Consistent with Jacobsen (1988), we find that the base autoregressive coefficient is significant, positive, and less than one ($ROA_{it-1} = 0.7068$). Business performance exhibits, significant time trends, and abnormal business returns tend to regress to the mean over time. Recall that Hypothesis 1A's support depends on there being a significant increase in the decay rate of abnormal business returns over the period studied. This implies a significant and negative coefficient estimate for the interaction term included in the expanded autoregressive model in Column 2 of Table 1 ($ROA_{it-1} * YEAR_t < 0$). Yet, the coefficient estimate on this interaction term is not significantly different from zero ($t = -0.22$; $p = 0.83$), thus indicating no support for Hypothesis 1A. We find no evidence of decreasing

Table 1 Autoregressive Model Analysis of Performance Persistence

Independent variables	Longitudinal examination of differences in decay rate over time for businesses operating in TI industries: Base model	Longitudinal examination of differences in decay rate over time for businesses operating in TI industries: Year counter interaction model	Cross-sectional examination of differences in decay rate for businesses operating in TI versus non-TI industries: Base model	Cross-sectional examination of differences in decay rate for businesses operating in TI versus non-TI industries: TI industry dummy interaction model
Control variables:				
Intercept	0.0153*	0.0150*	0.0171**	0.0178**
	(0.0067)	(0.0069)	(0.0018)	(0.0018)
Prior performance (ROA_{jt-1})	0.7068**	0.7109**	0.6724**	0.6647**
	(0.0071)	(0.0204)	(0.0023)	(0.0026)
Year counter ($YEAR_t$)	−0.0002	−0.0002	−0.0004**	−0.0004**
	(0.0003)	(0.0003)	(0.0001)	(0.0001)
GDP growth rate ($GDPG_t$)	−0.0006	−0.0006	0.0029**	0.0029**
	(0.0006)	(0.0006)	(0.0002)	(0.0002)
Inflation rate (INF_t)	0.0025**	0.0025**	0.0017**	0.0017**
	(0.0007)	(0.0007)	(0.0002)	(0.0002)
Industry concentration (HHI_t)	−0.0285**	−0.0284**	0.0070**	0.0073**
	(0.0103)	(0.0103)	(0.0015)	(0.0015)
TI industry ($TECH_i$)			−0.0091**	−0.0136**
			(0.0010)	(0.0012)
Hypothesized variables:				
Year interaction ($ROA_{jt-1} * YEAR$)		−0.0003		
		(0.0014)		
TI industry interaction ($ROA_{jt-1} * TECH_i$)				0.0448**
				(0.0061)
F	2,118.8**	1,765.5**	14,639.5**	12,563.2**
R^2	0.4895	0.4895	0.4941	0.4944
Incremental F		0.0100		53.81**
Incremental R^2		0.0000		0.0003
N	11,055	11,055	89,938	89,938

Notes. Standard error terms appear in parentheses.
$^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$.

durability in the abnormal returns of businesses in TI industries in the 1980s and 1990s.[9]

To test Hypothesis 1B, we look for differences in the decay rate of abnormal returns for businesses in TI versus non-TI industries over 1978–1997. As with our first analysis, we find a base decay rate in the expected range, 0.6724. We also observe a negative time trend in ROA, consistent with the findings of Barber and Lyon (1996). As for our hypothesized relationship, results in Column 4 of Table 1 indicate significant differences in the decay rate of abnormal business returns in TI versus non-TI industries, but the positive sign on the interaction term suggests that the decay rate for businesses in TI industries is *lower* than for businesses in non-TI industries. Admittedly, this effect has a small degree of explanatory value on the overall regression ($\Delta R^2 = 0.0003$), and thus should be interpreted with care. Still, this result is clearly inconsistent with the view that businesses in TI industries face more difficulty in sustaining performance differences than firms in non-TI industries.

Recall that we also sought to examine Hypotheses 1A and 1B focusing solely on higher performing firms. Results from these logit models are presented in Tables 2 and 3. We would find support for Hypothesis 1A with a negative coefficient on the year counter ($YEAR_t$) of the logit models in Table 2. As we move from 1978 to 1997, increasing dynamic competition in TI industries would make it is less likely that high-performing businesses in TI industries will be able to sustain their performance level. With these analyses, we find an interesting but inconsistent pattern of results. When we define high performers most broadly—any business performing above their respective TI industry average—we see in Column 1 of Table 2 that the year counter is significant ($p < 0.01$) and *positive* rather than negative as predicted. Above-average performing businesses in TI industries may be *more* likely to sustain their current performance level over time. When we tighten our definition of high performance in Column 2 to include only businesses with returns more than one standard deviation above the industry average, the year counter loses significance. When we tighten further to include only businesses

Table 2 Logit Model Longitudinal Analysis of Superior Performance Sustainability

Independent variables	Likelihood of sustaining performance above industry average	Likelihood of sustaining performance one standard deviations above industry average	Likelihood of sustaining performance two standard deviations above industry average	Likelihood of sustaining performance three standard deviations above industry average
Control variables:				
Intercept	0.7607**	0.6708*	0.0584	0.3833
	(0.1960)	(0.3360)	(0.8346)	(1.6201)
GDP growth rate ($GDPG_t$)	0.0188	0.0093	0.0653	−0.1623
	(0.0197)	(0.0340)	(0.0855)	(0.1708)
Inflation rate (INF_t)	0.0456*	−0.0012	0.0751	−0.0010
	(0.0196)	(0.0329)	(0.0788)	(0.1496)
Industry concentration (HHI_t)	−0.7881**	−0.8911*	0.2253	1.2089
	(0.2634)	(0.4100)	(0.6280)	(0.7443)
Hypothesized variable:				
Year counter ($YEAR_t$)	0.0452**	−0.0145	−0.0744*	−0.0191
	(0.0083)	(0.0147)	(0.0379)	(0.0774)
X^2	45.1100**	5.8700	16.4100**	3.7500
Incremental X^2 (adding $YEAR_t$)	29.0300**	0.9800	3.9000*	0.0600
Pseudo R^2	0.0070	0.0037	0.0700	0.0698
Incremental pseudo R^2 (adding $YEAR_t$)	0.0045	0.0007	0.0157	0.0011
N	6,415	1,331	218	50

Notes. Standard error terms appear in parentheses.
$^\dagger p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$.

performing more than two standard deviations above the industry average in Column 3, the sign on the year counter becomes significant and negative ($p < 0.05$) in line with the increasing dynamic competition argument. And when we tighten the definition of high performance yet again in Column 4 to include only businesses performing at more than three standard deviations above the industry average, only 50 observations left from our starting group of 6,415 above-average performing data points, the negative sign on the year counter remains but loses significance.

This pattern of results does not lend itself to easy interpretation. On the one hand, these logit results yield evidence that above-average performing TI businesses were more rather than less likely to sustain their success as the 1980s and 1990s unfolded, a result contrary to Hypothesis 1A. On the other hand, we do find some evidence that very high-performing TI businesses did not follow that trend. This very small segment of businesses performing more than two standard deviations above industry average performance, the top 2% of TI businesses in our sample, were less likely to sustain their very high level of performance as they moved through the 1980s and 1990s. This does not mean that very high-performing TI businesses became poor (below average) performers. They were just more likely to fall out of this lofty performance stratum, which is consistent with Hypothesis 1A and the argument that top performers find it more difficult to sustain very high profitability in their industry as dynamic competition increased over this period.

If we do a log transformation of the parameter estimates, this finding translates to a dramatic decline in the likelihood that their performance is sustainable. Using the results from this analysis, we expect that this small segment of very high-performing TI businesses (two standard deviations above the industry average) would, in the early period of observation (1978) have a 73.5% likelihood of sustaining such lofty performance in the following year (1979). Ten years later, that likelihood declines to 47.1%. By the end of the period of observation (1996–1997), that likelihood declines to 31.4%.

An interesting and parallel pattern of results also emerges when testing Hypothesis 1B's prediction of cross-sectional differences in TI versus non-TI industry business performance using only a subsample of high-performing businesses (see Table 3). Column 1 of Table 3 defines high-performing businesses most broadly as any business with operating returns above their industry mean. With this definition, we see that the indicator term for a TI industry business ($TECH_i$) is positive and significant ($p < 0.01$), contrary to Hypothesis 1B. In other words, from 1978 to 1997, businesses in TI industries were slightly more likely to sustain above-average performance in the subsequent year compared to businesses performing above the mean in non-TI industries. As we tighten up the definition of high-performing businesses from above average (Column 1) to one (Column 2), two (Column 3), and three (Column 4) standard deviations above the industry mean, the sign on the TI industry business indicator switches

Table 3 Logit Model Cross-Sectional of Superior Performance Sustainability

Independent variables	Businesses performing at least above industry average	Businesses performing at least one standard deviation above industry average	Businesses performing at least two standard deviations above industry average	Businesses performing at least three standard deviations above industry average
Control variables:				
Intercept	1.3372**	0.2660**	−0.3877	0.2831†
	(0.0336)	(0.0536)	(0.1070)	(0.1670)
GDP growth rate ($GDPG_t$)	0.0052	0.0152	0.0154	0.0303
	(0.0064)	(0.0101)	(0.0192)	(0.0249)
Inflation rate (INF_t)	−0.0152**	0.0009	0.0302**	0.0106
	(0.0038)	(0.0061)	(0.0116)	(0.0156)
Industry concentration (HHI_t)	0.2100**	0.6710**	1.4142**	1.3897**
	(0.0481)	(0.0574)	(0.0803)	(0.1310)
Hypothesized variable:				
TI industry ($TECH_i$)	0.1082**	−0.0514	−0.2684†	−0.8635**
	(0.0341)	(0.0596)	(0.1450)	(0.3123)
X^2	48.7900**	152.88**	364.84**	138.72**
Incremental X^2 (adding $TECH_i$)	10.2000**	0.7500	3.4500†	7.8700**
Pseudo R^2	0.0010	0.0110	0.0820	0.0506
Incremental pseudo R^2 (adding $TECH_i$)	0.0002	0.0000	0.0007	0.0028
N	49,421	13,738	4,085	2,604

Notes. Standard error terms appear in parentheses.
†$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

from positive to negative and becomes increasingly significant ($p < 0.10$ and $p < 0.01$ for businesses two and three standard deviations above industry average performance, respectively). These results suggest that very high-performing TI businesses were somewhat less able to sustain their lofty level of performance compared to similarly performing businesses in non-TI industries over the 20 years we observed.[10]

Consider the practical implications of these findings, first, by starting with a hypothetical business operating in an industry with average concentration and operating in a year with average economywide growth and inflation. If that business is currently performing at least two standard deviations above industry average, it has a 60.3% likelihood of sustaining that performance level in a TI industry. In a non-TI industry, that same very high-performing business has a 66.5% likelihood of sustaining such performance. These differences are more pronounced for businesses performing more than three standard deviations above the industry average. A TI business now has a 55.1% likelihood of sustaining its extraordinary performance level, but a non-TI business has a 74.4% likelihood. Broadly speaking, cross-sectional differences in performance stability among high-performing TI and non-TI businesses do not support the proposition of increasing dynamic competition. Again, however, a small segment of very high-performing businesses, those with performance at least two standard deviations about industry average, exhibit differences consistent with the proposition.

Loss of Market Share Leadership Model Results

Results from analysis of the likelihood of losing of market share leadership are reported in Table 4. With Hypothesis 2A, we predict that the likelihood of business losing the leading share of overall industry sales in a TI industry will increase over the period studied. Results in Column 2 do not support this prediction. The parameter estimate for the year counter ($YEAR_t$) variable is not significant ($\chi^2 = 0.17$; $p = 0.68$), indicating no significant change in the likelihood of losing market share leadership from one year to the next from 1978 to 1997. TI industry leaders in the late 1990s seem as secure (or as insecure) in their position as they were in the late 1970s.

Results in Column 4 of Table 2 also provide little support for assumptions of greater overall dynamic competition among businesses in TI than non-TI industries. Hypothesis 2B predicts that businesses with the greatest share of sales in TI industries in a given year will be more likely to lose that position in the next year than their counterparts in non-TI industries. But the parameter estimate for TI industries ($TECH_i$) exhibits a *negative* rather than the predicted positive sign, though in any case, the coefficient is not significant ($\chi^2 = 0.99$; $p = 0.32$). Again, results indicate no difference in the likelihood of market share leadership loss for businesses in TI versus non-TI industries over 20 years of observation.[11]

Table 4 Logit Model Analysis of Market Leadership Sustainability

Independent variables	Longitudinal examination of differences in likelihood of losing market share leadership for businesses operating in TI industries: Base model	Year counter model	Cross-sectional examination of differences in likelihood of losing market share leadership for businesses operating in TI vs. non-TI industries: Base model	TI industry dummy model
Control variables:				
Intercept	1.0894** (0.1609)	0.9957** (0.2795)	0.9506** (0.0381)	0.9437** (0.0393)
Industry concentration (HHI_{it})	−0.3995 (0.5148)	−0.4154 (0.5159)	−0.6789** (0.0686)	−0.6870** (0.0695)
Hypothesized variables:				
Year counter ($YEAR_t$)		−0.0083 (0.0204)		
TI industry ($TECH_i$)				−0.0782 (0.1079)
χ^2	0.6000	0.7700	97.8000**	98.2800**
Incremental χ^2	0.1700	0.1700		0.4800
N	513	513	13,717	13,717

Notes. Standard errors in parentheses.
$^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$.

Mortality (Exit) Model Results

Table 3 reports results from the mortality (exit) analyses. As with our earlier tests, these analyses provide little evidence supporting Hypothesis 3A's prediction of increasing business mortality (exit) in TI industries from 1978–1997. We expect to find the parameter estimate for the year variable in our hazard rate model to be positive and significant, thus indicating an increase in the intra-TI industry business mortality (exit) rate over time. Instead, the key parameter estimate in Column 2 of Table 5 ($YEAR_t$) exhibits a *negative* rather than the predicted positive sign, though in any case, the coefficient is not significant ($\chi^2 = 2.21$; $p = 0.14$). Again, our results suggest no sustained positive linear trend in the likelihood of business mortality in (exit from) TI industries.

As with our earlier tests comparing business performance measures in TI and non-TI industries, we test Hypothesis 3B's prediction that businesses in TI industries will exhibit greater mortality (exit) rates compared to businesses in non-TI industries from 1978 to 1997. Results in Column 4 of Table 3 suggest no supporting evidence for this prediction. Mortality (exit) rates for businesses in TI industries are not significantly different from rates for the broader sample of businesses from non-TI industries. The parameter estimate for the TI industry indicator variable in Column 4 of Table 3 ($TECH_i$) is not significant ($\chi^2 = 0.62$, $p = 0.43$). Thus we find no support for Hypothesis 3B.

Industry Dynamism Model Results

We now turn our attention to the results associated with the industry-level hypotheses. Recall that we developed hypotheses predicting an increase in dynamism over time across TI industries (Hypothesis 4A) as well as greater dynamism in TI compared to non-TI industries over the period of observation (Hypothesis 4B). Results from our within subjects analysis of industry dynamism listed in Table 6 support neither of these predictions. As a preliminary analysis, we first estimate an equation for each dependent variable using industry dummy variables only. We then add dummies for three of our four five-year data windows, omitting the final time period, 1993–1997. Hypothesis 4A predicts that the time period dummies should all be negative with the largest magnitude in the earliest time period. As Column 2 of Table 6 indicates, the signs on the time-period dummies are neither consistent with the predicted pattern nor significantly different from zero. Indeed, addition of the time period dummies does not significantly improve the explanatory power of the regression ($F = 0.14$; $p > 0.10$). Thus we observe neither significant increase nor decrease in the dynamism of TI industries from 1978 to 1997.

To test Hypothesis 4B, we compare the level of dynamism in TI and non-TI industries over the entire 20-year period. Again, we find no evidence of significant difference in the overall dynamism of TI versus non-TI industries. The TI industry dummy ($TECH_i$) exhibits a *negative* rather than the predicted positive sign, but in any case, is not significantly different from zero at commonly acceptable levels. Indeed, all of the terms in this cross-sectional model yield little if any collective explanation of variation in industry dynamism ($R^2 = 0.0052$). Thus we find no support for Hypothesis 4B. In sum, our industry-level analyses provide no evidence consistent with either an increase in dynamic competition in TI industries during the 1980s and 1990s, or significantly

Table 5 Hazard Rate Model Analysis of Business Mortality (Exit)

	Longitudinal examination of differences in mortality likelihood for businesses operating in TI industries		Cross-sectional examination of differences in mortality likelihood for businesses operating in TI versus non-TI industries	
Independent variables	Base model	Year counter model	Base model	TI industry dummy model
Control variables:				
GDP growth rate ($GDPG_t$)	−0.0004	−0.0030	−0.0012	−0.0012
	(0.0115)	(0.0118)	(0.0037)	(0.0037)
M&A value (VMA_t)	0.0255†	0.0395*	0.0205**	0.0207**
	(0.0141)	(0.0169)	(0.0044)	(0.0044)
Industry density ($INDDENS_{it}$)	−0.0297	−0.0189	−0.0299**	−0.0292**
	(0.0188)	(0.0204)	(0.0055)	(0.0056)
Industry density^2 ($INDDENS_{it}^2$)	0.0075	0.0054	0.0074**	0.0072**
	(0.0053)	(0.0055)	(0.0021)	(0.0021)
Hypothesized variables:				
Year counter ($YEAR_t$)		−0.0035		
		(0.0023)		
TI industry ($TECH_i$)				−0.0075
				(0.0095)
χ^2	6.3900	8.6700	53.5600**	54.1500**
Incremental χ^2		2.2800		0.5900
N	13,151	13,151	107,979	107,979

Notes. Standard errors in parentheses.
$^\dagger p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$.

greater dynamism in TI versus non-TI industries over the same period.

Discussion and Conclusion

Summary of Central Findings

Our results tell more than one story. On the one hand, our broad sample results tell a story inconsistent with claims of increasing dynamic competition in recent academic, managerial, and policy debates. There is little if any broad evidence of changed performance linked to increased dynamic competition in TI industries. There is no general decrease in abnormal business returns durability, no general increase in dethronement of market leaders, no general increase in mortality, and no general increase in industry dynamism. We found this when

Table 6 Within Subjects Model Analysis of Industry Dynamism

	Longitudinal examination of differences in dynamism over time TI industries		Cross-sectional examination of differences in dynamism in TI and non-TI industries	
Independent variables	Base model	Time period dummy model	Base model	Time period and TI industry dummy model
Intercept	0.1469	0.1332	0.0958**	0.0964**
	(0.1059)	(0.1106)	(0.0035)	(0.0036)
Time period 1 (1978–1982)		−0.0281	0.0134**	0.0132*
		(0.0604)	(0.0044)	(0.0052)
Time period 2 (1983–1987)		0.0028	−0.0013	−0.0014
		(0.0485)	(0.0051)	(0.0051)
Time period 3 (1988–1992)		0.0383	−0.0018	−0.0018
		(0.0485)	(0.0043)	(0.0051)
TI industry ($TECH_i$)				−0.0152
				(0.0095)
F	0.8200	0.7700	3.8700**	3.5500**
R^2	0.2430	0.2573	0.0042	0.0052
Incremental F		0.4900		2.5900*
Incremental R^2		0.0143		0.0010
N	104	104	2,736	2,736

Notes. Industry dummy variables excluded from the table. Standard errors in parentheses.
$^\dagger p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$.

we examined TI industries and businesses alone over time as well as in our comparisons of TI industries and businesses to their non-TI counterparts. We see little basis for claims of generally increasing dynamic competition in TI industries in the 1980s and 1990s.[12] We look with caution and some constructive skepticism on any calls to discard well-tested theories, managerial practices, and public policies to respond to "new realities" in TI industries. Broadly speaking, competitive dynamics in TI industries of the late 1990s (and likely today) do not appear to be substantially different from competitive dynamics in TI industries of the late 1970s.

On the other hand, our broad sample results miss important subsample differences, which tell another story about changes in the technological landscape of very high-performing businesses. We do see evidence of shifting patterns for very high-performing TI businesses since the late 1970s. The evidence points to a long-term trend of increasing performance instability for these select TI businesses. The evidence also points to consistently greater performance instability for these select TI businesses compared to counterparts in non-TI industries. Thus we see evidence suggesting increasing dynamic competition in TI industries since the late 1970s, but only for a select group of very high performers. We observed reduced sustainability of very high performance in a subsample of only 218 TI industry businesses; that is, only 2% of the firms in the TI sample and 0.2% of our base sample. From an asset perspective, these 218 firms combined account for less than 1% (0.92%) of the total assets in the 31 TI industries and 0.09% of the total assets in our overall sample. Within this extremely narrow sample of firms, there may be value in deepening investigation of change in the competitive landscape of very high-performing TI businesses using new theoretical perspectives, business strategies, and regulatory guides. Ironically, those new perspectives, strategies, and guides for the 1990s and 2000s derive substantially from Schumpeterian notions of dynamic competition developed in the first half of the twentieth century (Schumpeter 1934, 1939, 1950).

Understanding these two stories about dynamic competition in TI industries should help debate between advocates and skeptics move forward more productively. In line with arguments made by several scholars in management, economics, and law (Bettis and Hitt 1995, Schmalensee 2000, Posner 2001), TI industries appear to offer especially challenging economic conditions for "winning firms." We documented the decreasing durability of very high operating returns by businesses in TI industries, and the significant gap in performance durability for these select businesses in TI versus non-TI industries.

At the same time, our results are in line with skeptics (Castrogiovanni 2002, McNamara et al. 2003), who find evidence of broad-based time trends in performance stability wanting. Our battery of tests probed for broad-based evidence of performance implications linked to increasing dynamic competition both within TI industries over time and between TI and non-TI industries. We included analyses at both the business and industry levels, looking for higher rates of decay in abnormal returns, increased likelihood of lost of industry sales leadership, increased likelihood of organizational mortality, and increased market dynamism. We documented no broad-based supporting evidence, and indeed, some broad-based evidence indicating increased rather than decreased performance stability in TI industries since the 1970s.

Thus, there is something both for advocates who may focus on time trends in performance stability for relatively few high-performing TI businesses, and for skeptics who may take a less focused panoramic view of time trends in performance stability across all TI businesses. Future debate will benefit from being more explicit about these differing perspectives and conclusions about the proposition of increasing dynamic competition. It is now more than a decade since special issues in the *Strategic Management Journal* (1995) and *Organization Science* (1996) helped generate a wave of new empirical research on technology strategy issues for a competitive landscape that many thought had changed considerably since the late 1970s. Our results help to put that previous wave of research in broader context, refine implications for scholars and others, and set boundary conditions for future research and constructive debate.

Reconciling Our Findings with Previous Broad Sample Studies

Can we reconcile these results with previous broad sample results reported by Thomas (1996), Castrogiovanni (2002), McNamara et al. (2003), and Wiggins and Ruefli (2005)? Our samples, models, and results indicating no general long-term decrease in performance durability among businesses in TI industries are consistent with results reported by follow McNamara et al. (2003), indicating no long-term decrease in performance durability across TI and non-TI industries. Similarly, our results also follow Castrogiovanni (2002), who found no sustained increase industry dynamism in a sample of firms from manufacturing industries.[13]

We can also reconcile our results with those reported by Thomas (1996), who observed firm performance in 200 manufacturing industries from 1958 to 1991 and concluded in favor of a "hypercompetitive shift" occurring during the second half of this time period. To do so, we first subsample from 1978 to 1991, the period of our study that overlaps with Thomas (1996) and falls within the time of his hypercompetitive shift. Next, we re-estimate an autoregressive model with all of our business unit returns, both from TI and non-TI industries.

We then regress current year t business j ROA on a one-year lagged dependent variable, on a year counter, on the interaction of these two terms ($ROA_{jt-1} * YEAR_t$), and then on the same set of additional controls we used the above. The interaction term is negative and significant (parameter estimate $= -0.02$, $p < 0.01$), thus indicating an *increasing* rate of decay to the economywide performance mean from 1978 to 1991. Based on these results, we might conclude, like Thomas (1996) did, that the U.S. economy had become increasingly hypercompetitive, and presumably, that businesses in TI industries had become more dynamically competitive. But our period observation extends years beyond 1991 when rates of decay reversed. Abnormally higher and lower business returns became easier (again) to maintain. Perhaps, Thomas ended his study too soon to see that his hypercompetitive shift was only temporary.

It is more difficult but not impossible, we think, to reconcile our results with Wiggins and Ruefli (2005), who also conclude that "best of times" recently became shorter and more difficult for U.S. firms. Our results are partly consistent with theirs in that we both see decreased ability for very high performers to retain their lofty performance. However, we see this effect in only a narrow set of TI industries, while they see it across a broader set of industries. So do our findings for very high performers hold for a wider sample of industries? Interestingly, we find no economywide evidence that very high-performing businesses are any less likely to sustain their year-to-year performance as we move from the late 1970s to the late 1990s (parameter estimate $= -0.004$, $p = 0.67$ for businesses performing at two standard deviations above the industry average; parameter estimate $= 0.0002$, $p = 0.98$ for businesses performing at three standard deviations above the industry average). These findings suggest that forces leading to greater instability among very high-performing TI businesses in the 1980s and 1990s did not extend to the broader business population. How then do we explain our differences with Wiggins and Ruefli (2005)? One possibility rests with their methodology. Other scholars have questioned the methodology Wiggins and Ruefli (2005) used to identify higher performing firms (McGahan and Porter 2005). Aside from such methodological concerns, we find their definition of higher performance over 10 years to be extreme and narrow compared to our broader set of alternative measures of high performance—above average, above one standard deviation, above two standard deviations—in a given year.

Limitations and Future Research

Going forward, we see many avenues for this research to follow. We briefly note two. First, we see value in understanding better how the causal chain works from dynamic competition drivers to performance outcomes. Our study examined evidence regarding the performance implications of increased dynamic competition in the 1980s and 1990s, but we did not examine the antecedents and behavioral actions associated with dynamic competition. We suggest that future research more fully develop a theoretical model about the drivers for, actions associated with, and performance consequences of dynamic competition. Additional research on the antecedents, behavioral consequences, and performance implications of dynamic competition also promises benefits to practicing managers interested in understanding whether the TI industry landscape has changed at all, and if so, what guides to use in navigating that changed landscape. Public policymakers and regulators concerned with antitrust issues (Schmalensee 2000, Posner 2001, Evans and Schmalensee 2002) would also benefit from a more nuanced view of TI industry trends informed by careful empirical study rather than broad-brush assertions of ubiquitous change.

A second avenue for extending our research concerns a key boundary condition we set to investigate time trends in dynamic competition. We defined the population of TI industries based on R&D expenditures as a percentage of sales. This approach has advantages of data availability and comparability across a wide range of businesses and industries. It yields a sample of TI industries and businesses corresponding very closely to industries and businesses identified similarly in other scholarly research (Evans and Schmalensee 2002). Future research might test the robustness of our findings with samples of businesses and industries based on quite different criteria for defining "technology intensive" or "R&D intensive" or "high technology." Perhaps other measures based on absolute R&D expenditures rather than R&D intensity, or more direct measures of technology and knowledge endowments (e.g., patent counts, scientist counts, average employee educational levels) may result in different businesses and industries included for analysis, possibly resulting in a better understanding of the industry conditions that lead to greater dynamic competition. These and other avenues provide direction for future research and constructive debate about the antecedents, behavioral consequences, and performance implications of increasing dynamic competition, and the boundary conditions of related theories, practices, and public policies.

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Endnotes

[1]Examples of dynamic competition fitting this description in recent times come from many TI industry contexts. The personal computer industry, for example, requires firms to make substantial investments in human capital and know-how and produces episodic battles for establishment of favorable technology standards leading to the serial dominance of one or a few "winners." In this industry, market leadership changed hands six times over a 30-year period (1977–2007): from Radio Shack to Atari, Commodore, Apple, IBM, Compaq, Dell, and then Hewlett-Packard.

[2]Outside the management field, scholars in economics, law, and public policy have advanced similar views about increasing dynamic competition in the 1980s and 1990s. Industrial organization economists like Baumol (1993, 2002) and Khalil (1997) describe emerging patterns of technology-based competition (after Lewis Carroll's *Through the Looking Glass*) as generating a "Red Queen" effect, in which it is necessary to "run" (innovate) as rapidly as possible just to "stand still" in terms of performance vis-à-vis imitative rivals. Barnett and Hansen (1996) and Barnett and Sorenson (2002) describe similar dynamics in organizational innovation and evolution. Public policy commentary by Ahlborn et al. (2001) criticizes existing antitrust regulations in Europe while policy commentary by Jorde and Teece (1989) and legal analyses offered by Posner (2001) criticize current U.S. antitrust regulations for perceived bias against successful businesses in TI industries—Microsoft with its Windows operating system and Explorer Web browser, for example. To these critics, such businesses enjoy increasing returns to scale, dominant market positions, and high profits as a "normal" result of episodic "winner-take-all" (or "winner-take-most") rivalries. Increasingly frequent and radical technological shifts will make it difficult for such businesses to hold onto leadership through simple extension of an initially dominant market position, thus obviating the need for close government antitrust oversight. Their arguments reflect growing faith in what Roberts (2001) describes as a Schumpeterian built-in error correction mechanism of markets created by TI businesses and consumers.

[3]This 20-year panel allows us to examine business segment financial data using a consistent set of financial reporting standards over an extended period of time, during which dynamic competition may be increasing. Statement of Financial Accounting Standards 14 outlines the manner by which industries for individual businesses are identified for U.S. Securities and Exchange Commission regulatory reporting purposes. These standards are fully in force from 1978 to 1997. We end our data collection in 1997, because a change in accounting standards taking effect in 1998 substantially altered the schema used to identify and report business activities in individual industries.

[4]Following their recommendations, we eliminate observations if: (1) they do not contain a primary SIC designation; (2) they are from residual industry categories or government-related classifications; (3) they operate in financial services industries because their returns are difficult to compare with those in other industries; (4) they are from small businesses with sales and or assets less than $10 million because small businesses are prone to extremely wide variance in operating returns; (5) they have ROA values exceeding 100% because this suggests that the corporate parent either understates the assets of the business or consciously lumps profits into it for reporting purposes alone; or (6) they are described as "corporate" or "other" businesses because these do not appear to be active businesses.

[5]We use data from the Compustat corporate level database for this test because R&D expenditures are not widely reported in segments.

[6]We also conduct an analysis using a two standard deviation cutoff and find results consistent with those reported here.

[7]To ensure that the industry sample we choose is not skewed by using only a single year of data, we also identify a sample of TI industries using a three-year window (1995–1997). Using the same selection criteria, the three-year screen identifies 32 industries as TI, 29 of which are the same as those identified using the 1997 R&D intensity measure. We conclude that the sample we identify is robust with respect to the length of the window used.

[8]The 31 TI industries include: 2800-Chemicals and Allied Products; 2820-Plastics Materials, and Synthetic Resins; 2833-Medicinal Chemical Botanical Products; 2834-Pharmaceutical Preparations; 2835-In Vitro and In Vivo Diagnostic Substances; 2836-Biological Products; 3555-Printing Trades Machinery and Equipment; 3570-Computers and Office Equipment; 3571-Electronic Computers; 3572-Computer Storage Devices; 3575-Computer Terminals; 3577-Computer Peripheral Equipment; 3578-Calculating and Adding Machines; 3661-Telephone and Telegraph Apparatus; 3663-Radio and Television Broadcasting and Communications Equipment; 3674-Semiconductors and Related Devices; 3695-Magnetic and Optical Recording Media; 3822-Automatic Controls for Regulating Commercial and Residential Climate; 3823-Industrial Instruments for Measurement, Display, and Control of Process Variables; 3825-Instruments for Measuring and Testing of Electricity and Electrical Signals; 3826-Laboratory Analytical Instruments; 3827-Optical Instruments and Lenses; 3841-Surgical and Medical Instruments and Apparatus; 3842-Orthopedic, Prosthetic, and Surgical Appliances; 3844-X-ray Apparatus and Related Irradiation Apparatus; 3845-Electromedical and Electrotherapeutic Apparatus; 3861-Photographic Equipment and Supplies; 4822-Radio Telegraph Services; 7372-Prepackaged Software; 7373-Computer Integrated Systems Design; and 8731-Commercial, Physical, and Biological Research.

[9]We also re-estimated autoregressive models with year dummies rather than a linear time counter. Results again suggest no long-term trends of increasing or decreasing rate of decay to mean performance levels. We also analyzed each of these 31 four-digit SICs separately to see if they exhibited any significantly different time trends in the durability of abnormal returns. We found few industry-specific differences in linear decay rate. Twenty-six TI industries exhibited no significant linear trends. Two TI industries exhibited higher decay rates over time consistent with increasing dynamic competition and significant at $p < 0.10$ or higher levels: 3823-Industrial Instruments for Measurement, Display, and Control of Process Variables; and 3825-Instruments for Measuring and Testing of Electricity and Electrical Signals. On the other hand, four

other industries exhibited lower decay rates over time inconsistent with increasing dynamic competition and significant at $p < 0.05$ or higher levels: 3571-Electronic Computers; 3,826-Laboratory Analytical Instruments; 3845-Electromedical and Electrotherapeutic Apparatus; and 4822-Radio and Telegraph Services.

[10]To assess the robustness of our results, we also re-estimate logit models based on the likelihood of remaining in the high-performing businesses stratum in the following year after membership in this stratum two, three, four, and five years earlier. Results from these re-estimations are consistent with those reported here.

[11]We also re-estimate our market dethronement models to assess changes in the likelihood of being dethroned from one of the top three market share positions in the next year. These results are consistent with those reported here.

[12]While we are cautious in interpreting null effects as indicating that there is definitively no relationship between variables, the power of our tests suggests that if there were practically significant effects, we would likely have found them. In this study, we report results from 16 tests based on multivariate model estimations. Thirteen of them offer no indication of the expected performance implications associated with purportedly increasing dynamic competition. For 11 of these 13 test results, we have strong power (≥ 0.90) to detect either small effect sizes (0.02) for our ordinary least squares regressions or modest odds ratios (1.2) for our logit analyses (Cohen and Cohen 1983). The two tests for which we have lower power include an analysis of the durability of extremely high-performing TI firms (those over three standard deviations above industry average) summarized in the last column of Table 2 and a TI industry dynamism analysis in the first two columns of Table 6.

[13]Indeed, when we re-estimate our models after subsampling from the 88 manufacturing industries Castrogiovanni (2002) used, we obtain results consistent with those reported here.

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