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Target Age and the Valuation of Innovation Acquisitions in High Technology Industries

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TARGET AGE AND THE VALUATION OF INNOVATION ACQUISITIONS IN HIGH TECHNOLOGY INDUSTRIES

Valuing IT Opportunities

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Abstract

External acquisition of new technology is a growing trend in the innovation process in information technology industries. Despite its importance, there has been little empirical research on the timing of strategic decisions when opportunities arise. Should firms acquire early to avoid higher prices when the technology and its usage are more mature, or should they wait until a proven track record is established so that a better valuation of the opportunity can be obtained? Through a combination of real options, complementary assets, and dynamic capabilities perspectives, we derive our hypotheses on the impact of target age on the value created for the buyer. Applying an event study methodology to new technology acquisitions in the telecommunications industry from 1995 to 2001, we find evidence that supports acquiring early in the face of uncertainty. Furthermore, we find that the intellectual property (such as patents held by the target) moderates the impact of target age. Our data set is created by combining data from multiple sources including acquisition announcements, patent data from the U.S. Patents Office, Internet searches on small, privately held targets, and data from standard databases such as Compustat and the Center for Research in Security Prices (CRSP). In summary, the equity markets reward the acquisition of younger companies. While patent ownership by the target does not impact the value creation from younger acquisitions, the equity markets penalize the acquisition of older companies that do not own patents. This research contributes to our understanding of the valuation of technology acquisitions in industries characterized by emerging standards and high levels of uncertainty.

Keywords: Acquisition, innovation, age, valuation, return on investment

Introduction

Historically, research on the valuation of information technology (IT) investments has focused primarily on the allocation of resources towards competing internal projects, evaluating hardware and software platforms, or assessing long-term strategic opportunities (Benaroch and Kauffman 1999; Schwartz and Zozaya-Gorostiza 2003). Now, firms frequently view startup companies as research and development (R&D) sites that provide an opportunity to defer investments until the technology is proven. The IT industry is particularly suited for external innovation since startups have relatively low capital requirements and the market environment changes rapidly. As such, external acquisitions constitute a critical means of innovation in the IT industry. Consequently, the valuation of such acquisitions is an important research topic.

Firms like Microsoft and Cisco augment internal R&D with prolific acquisition programs that are becoming increasingly important (Chesbrough 2003) as a way for "maturing strategic buyers to access new growth opportunities" and to place "bets on new ideas or technologies" (Anonymous 2006). External acquisition is of particular importance in the IT industry since time-to-market pressures often render internal development too slow (Lambe and Spekman 1997). Competitive pressures have fostered acquisitions as acquirers "snap up U.S. high tech firms— they realize it's faster and cheaper to buy technology" (Wysocki 1999, pp. 4). Acquisitions also add a key exploratory component to resource reconfiguration (Levinthal and March 1993; March 1991), preventing over-investment in exploitative growth. In the context of IT opportunities, they allow firms to access knowledge and technologies to fill gaps or correct blind spots (Chesbrough 2003). Even when exploratory buying of technologies does not directly contribute towards advantage, it may contribute indirectly through learning or spillover (Benner

and Tushman 2003; March 1991). Further, technology acquisitions have fostered a strong market for ideas, providing incentives for entrepreneurs to sweat, to risk and, maybe, to exit wealthy (Gans and Stern 2003).

However, despite considerable research, value creation through acquisitions is not well understood, particularly in high technology industries like IT. What makes one acquisition create value for a buyer while another loses value? A substantial body of research, especially in the finance and strategy areas, examines the value created by mergers and acquisitions. Early reviews (Datta et al. 1992; Jarrell et al. 1988; Jensen and Ruback 1983) and more recent ones (Andrade et al. 2001; King et al. 2004) report that any value created is primarily distributed to the target company rather than to the buyer. Yet, buyers continue to acquire.

In this paper we focus on the effect of a fundamental, observable characteristic of a target, specifically target age, on value creation for the buyer in high technology environments. We examine acquisitions made by equipment manufacturers within the telecommunications industry because of the industry's emerging standards, deregulation, strong externalities, numerous innovations, acquisition volume, and high levels of uncertainty (Warner 2003). In environments with considerable uncertainty, target age is objective and observable (even for small, private startups) and has received considerable media and industry attention, but limited research consideration. From the perspective of the buyer, the emergence of an early stage company begins an inherent valuation dilemma and a conflict between risk and safety. Exactly *when* to acquire a target is not clear. Should organizations wait until more information is available about the technology and its market so that a better valuation can be obtained? Or should acquisition investments be done early to avoid higher prices later when more information is available? Even conventional proverbs offer conflicting advice as managers may choose to "look before they leap" or alternatively they may believe that "he who hesitates is lost". This ambiguity is also reflected in the trade literature, where target age is a frequent focal point (Anonymous 2006; Wysocki 1999). Diametrically opposed opinions are espoused such as emphasizing that "the important thing is, the bets are being placed on younger companies" (Wysocki 1999), while others find lessons in the difficulties that acquirers like Cisco and Lucent have had with acquiring early stage companies (Schiesel 2000). Clearly the role of target age in value creation is unclear.

We develop our hypotheses through real options, complementary assets and dynamic capabilities perspectives that are especially relevant to the high velocity environment of the telecommunications industry. We use standard event study methods (Brown and Warner 1985) to measure value creation by examining the abnormal stock market reaction to acquisition announcements by equipment manufacturers. The use of event study methods has three advantages in our context. First, the event study method effectively isolates the impact of the acquisition on the acquiring firm better than aggregate measures based on annually reported accounting data (MacKinlay 1997), particularly when firms make several acquisitions within the same year (Fuller et al. 2002). Second, for acquisitions of early stage targets, immediate impact on accounting indicators may be insignificant or even negative and will depend more on the stage of development of the innovation rather than its future value. Further, intangible values inherent in technology acquisitions (such as intellectual property and knowledge assets) are difficult to value through traditional productivity metrics (Bharadwaj et al. 1999), while stock prices respond rapidly and include a capitalization of future benefits (Brown and Warner 1985). Third, event studies are well established in the finance, management and strategy literatures as a method for assessing value created through acquisitions. Utilizing a metric that has been frequently used in the literature enables us to exploit previous findings in developing our model.

The rest of this paper is organized as follows. Using the literatures on real options, complementary assets, and dynamic capabilities, we develop hypotheses about the effects of target age on acquirer market value. Then, we detail the data and methodology used to test the hypotheses. Next, we discuss the results of the analysis. Finally, we summarize the findings of the research and outline future research directions.

Theory and Hypotheses Development

Value Creation through Acquisitions

Understanding the effect of acquisitions on acquirer value is especially difficult in high technology industries and in highly uncertain markets. In these markets, "there is rapid and discontinuous change in demand, competitors, technology and/or regulation, such that information is often inaccurate, unavailable, or obsolete" (Bourgeois and Eisenhardt 1988, p. 816). There are also many unknowns. What will be the dominant design? Which technology will lead the market? In examining the construction of R&D portfolios, MacMillan and McGrath (2002) categorize

uncertainty into technical uncertainty (related to the efficacy of the product) and market uncertainty (related to the economic environment). Both types of uncertainty contribute to the difficulty that acquirers have in obtaining accurate and current information; both types obscure the answer of how acquisitions create value; and both types further exacerbate the challenge of valuing acquisition opportunities in the IT industry.

Even in non-technology industries, the impact of acquisitions on acquirer value is not fully understood. A recent meta-analysis of acquisition effects by King et al. (2004) reports a consensus of slightly negative overall effect on acquirer value and that any value that is created through an acquisition is primarily distributed to the target company rather than to the buyer. Furthermore, while the average effect is slightly negative, some acquisitions do enhance acquirer value, yet these are difficult to isolate from other acquisitions that destroy value (Andrade et al. 2001; Lubatkin 1983). Specifically emphasizing the range of impacts, Capron and Pistre (2002, p. 781) note that "if most of the studies show that, on average, acquirer shareholders about break even, very few emphasize that this mean hides a large variance in acquirer gains." Typical explanatory variables used in acquisition research (e.g. relatedness of acquisitions, equity or cash payment methods, and prior acquisition history) have inconclusive impact on value creation for the buyer (King et al. 2004). A summarizing suggestion is that acquisitions for good reasons enhance acquirer value, but that these effects are difficult to isolate from value destruction caused by other acquisitions (Andrade et al. 2001; Lubatkin 1983). We are left with the assessment that not all acquisitions are alike (Bower 2001), and despite considerable study, Andrade et al. (2001, p. 104) conclude that there is an open "fundamental question of how mergers actually create or destroy value".

A Dynamic Capabilities Perspective on Value Creation

Focusing on firm value in periods of rapid change (Teece et al. 1997), the dynamic capabilities framework has the potential to offer new insights into the mechanisms of value creation through acquisitions. In this framework, competitive advantage follows from the identification of opportunities and the resulting reconfiguration of resources. Because dynamic capabilities focus on the ways in which resources are changed, they have more explanatory power in the acquisitions context than a static resource based view. Further, the addition of the dynamic capabilities perspective helps to decompose an acquisition into two parts—an acquisition in the market for products and an acquisition in the market for ideas. In the former, the acquisition focuses on existing operations; in the latter, the key is on future growth opportunities. The dynamic capabilities perspective provides particular insight into technology acquisitions in the market for ideas that are more difficult to value than existing operations.

Dynamic capabilities are important in environments characterized by change, but the specific ways in which dynamic capabilities allow a firm to take advantage of a changing environment are ill-understood. Based on a review of the extant literature in real options, complementary assets, and the resource based view, we derive three necessary (but not individually sufficient) mechanisms through which dynamic capabilities create value in general, and in the acquisitions context in particular. We categorize these mechanisms as *awareness*, the ability to anticipate opportunities before others; *flexibility*, the ability to create flexible resource portfolios that can be reconfigured to take advantage of changing environments; and *agility*, the ability to leverage complementary resources quickly and efficiently to take advantage of flexible resource portfolios. These three mechanisms are described and defined in Table 1 and provide a theoretical lens to develop our hypotheses.

Target Age and the Value from Acquisition

In static environments, some research and recent news articles (e.g. Schiesel 2000) indicate that a cautious approach would be to wait for technologies to mature and to see what environmental changes occur. For example, imitation can cost just 65% of the innovation cost and take only 70% of the time (Mansfield et al. 1981). Accordingly, performance benefits have been associated with waiting and acquiring later stage companies rather than early stage companies (Chaudhuri et al. 2005). For example, more mature companies are typically larger with more resources which can lead to greater opportunities for complementary related products and processes (Lubatkin 1987; Seth 1990). Further, theoretical development has demonstrated conditions where waiting to invest can be optimal (McDonald and Siegel 1986). Additionally, Chaudhuri and Tabrizi (1999) caution against the detrimental effects of "acquisition fever", particularly when skilled people are important, but also note that when assets can confer substantial advantage, focusing on specific products can make sense. Overall, by acquiring early, buyers face substantial market and technological uncertainty (Lambe and Spekman 1997).

Table 1. Mechanisms for Value Creation through Dynamic Capabilities

Mechanisms	References and Quotes
Awareness The ability to anticipate opportunities before others **Components of Awareness** • *Anticipating* environmental changes before others. • Effectively using *information asymmetry* about the target and technology to gain advantage. • Relating environmental changes to the *acquisition opportunities* available to the firm.	Competitive advantage can come from "using dynamic capabilities sooner, more astutely, or more fortuitously than the competition to create resource configurations that have advantage." (Eisenhardt and Martin 2000, p. 1117) • *Anticipating coming changes:* The origins of competitive advantage may therefore lie in the ability to identify and respond to environmental clues well in advance of observing performance-oriented payoffs" (Cockburn et al. 2000, p. 1123) • *Using information asymmetry:* Higgins and Rodriguez (2006, p. 3) find that "pre-acquisition information-gathering activities are positively and significantly correlated with acquirer success." • *Relating environmental changes to opportunities:* "Managers recognize the value of different types of experience and initiate market entry when such experience provides advantage" (King and Tucci 2002, p. 183)
Flexibility The ability to create flexible resource portfolios that can be reconfigured to take advantage of changing environments **Components of Flexibility** • Creating *real options* for the firm through the acquisition of flexible resources. • Creating a *portfolio* of technology options for the firm. • Incorporating innovation *early* when it is easier to integrate.	"Organizational form is related to the dynamic capabilities and the strategic *flexibility* of a firm and can be used as a strategic tool to support the rapid changes in strategy required to compete in dynamic markets" (Rindova and Kotha 2001, p. 1264, emphasis added) • *Creating real options:* "Viewing the technological challenge as a series of sequentially exercised options ... permits project redirection, advances in learning, and permits investment to be discontinued at the earliest possible time" (McGrath 1997, pp. 1996-1997) • *Incorporating innovation at an early stage when it is easier to integrate:* "In examining the ability of organizations to change and integrate with another organization, structural inertia increases monotonically with age" (Hannan and Freeman 1984, p. 157) • *Collecting a portfolio of technology options and acting opportunistically:* Relying on continuous morphing ... may require significant changes in managerial thinking, a shift in focus from control … toward opportunistic evolution and experimentation" (Rindova and Kotha 2001, p. 1278)
Agility The ability to leverage complementary resources to take advantage of flexible resource portfolios and changing environmental conditions. **Components of Agility** • Effectively using *complementary assets* within the firm to better leverage target resources. • Superior decision processes to act *preemptively* and *quickly*.	"Winners ... can demonstrate timely responsiveness and rapid and flexible product innovation, coupled with the management capability to effectively coordinate and redeploy internal and external competences" (Teece et al. 1997, p. 515) • *Effectively using complementary assets:* the ownership of complementary assets, particularly when they are specialized and/or cospecialized, help establish who wins and who loses from innovation" (Teece 1986, p. 304) • *Acting preemptively:* `To create a sustainable advantage, you must either be blessed with competitors that have a restricted menu of options or be able to preempt them. (Ghemawat 1986, p. 58) • *Acting quickly:* Rapidly changing environments are unforgiving to those who delay"(MacMillan and McGrath 2002, p. 35). Fast decision making allows decision makers to keep pace with change and is linked to strong performance" (Eisenhardt 1989, p. 544)

But in environments experiencing rapid technology change, despite time and cost savings from delay, missed opportunities can be expensive and potentially fatal. Based on the three mechanisms in Table 1, we argue that in high technology environments, acquiring younger companies creates more value for the acquirer than acquiring older companies. The arguments are summarized in Table 2. Overall, while the capabilities of the acquirer do not change as the target ages, the opportunity to take advantage through the identified mechanisms decreases as the target age increases.

First, the awareness mechanism indicates that acquirer value creation will be greater when the target is young. Considering the various uncertainties present, many are fundamentally unknowable, yet some may just be unknown to some in the market. In particular, for a new technology at a new company, the overall industry may know little about the innovation. Certain close suppliers or partners may be more aware and know details about the technology that others do not. However, as the target ages, the marketplace has more opportunity to learn, thereby eroding benefits from information asymmetry. Further, early acquisition signals to the market that the acquirer may have private knowledge about the target and the future value of its technology. Once the acquisition has been announced, the market can analyze the deal and quickly reflect the new information.

Second, the flexibility mechanism also indicates that acquirer value creation will be greater when the target is young. Acquiring early creates flexibility since early stage companies have more growth options and less established operations. Real options research, particularly regarding R&D (McGrath 1997; McGrath and MacMillan 2000), argues that if the target technology is viewed as a real option, a riskier option can be preferred even by risk averse decision makers because of the flexibility it provides. Also, by acquiring early, these options can be obtained at a lower cost, allowing more technology acquisitions within a given budget. The acquirer is then able to build a portfolio of innovations, enabling flexibility and opportunistic behavior. Finally, older acquisitions are less flexible, thereby increasing the difficulties associated with integrating the target (Hannan and Freeman 1984).

Table 2. Effects of Target Age

Mechanism	Effects of Target Age
Awareness	• As the target ages, the overall marketplace can learn about technology and its viability. Consequently, advantages from information asymmetry are reduced. • Early acquisition signals that the acquirer has private knowledge about the target and technology
Flexibility	• Acquiring early creates flexibility with future growth options since early stage companies have more growth options and less established operations. • For the same budget, lower cost acquisitions allow more innovations to be acquired and the acquirer is able to build a portfolio of innovations that allow opportunistic action. • Structural inertia of the target increases with age making integration of later stage acquired resources more difficult.
Agility	• By acquiring early, the buyer can prevent competitors from acquiring the innovation. • Early acquisition allows benefits from complementary assets of the larger buyer to be leveraged, reducing the potential of duplicate development of resources.

Third, the agility mechanism also indicates that the value created for the acquirer will be greater when the target is young. In the presence of competition, even if a newly available technology is not immediately of value, an agile company may still find compelling reasons to act quickly. By preemptively acquiring, a firm can reduce competitors' available options and, to some degree, mitigate uncertainty. King et al. (2004, p. 197) note that "the use of acquisitions to manage environmental or technological uncertainties, or the pursuit of growth to decrease organizational vulnerabilities, offer alternate, non-financial motives for M&A activity." Because a target can be bought by only one acquirer, the opportunity cost of failing to act can be large (Dierickx and Cool 1989). Further, existing companies may be concerned that a new technology is a substitute for their current products. Acquisition would then be motivated by preventing competitors from developing such products and services. Finally, buyers are usually larger than the targets. Early acquisition allows benefits from the complementary assets of the larger buyer to be leveraged, reducing the potential of duplicate development of resources (Teece 1986; Tripsas 1997).

In summary, in environments experiencing rapid technology change, missed opportunities can be expensive and potentially fatal. The opportunity and benefit from using real options, complementary assets and dynamic capabilities is linked to the target age. We empirically test the preceding reasoning through the following hypothesis.

Hypothesis 1: *In high velocity environments, value creation for the buyer will be negatively associated with target age.*

The Moderating Role of Target Intellectual Property

However, a key difference in some target companies lies in the intellectual property (IP) they possess, protected through patents. In the telecommunication equipment industry, like in other high technology industries, intellectual property is increasingly valuable (Granstrand 2000). Patents are seen as leading a shift towards intellectual capitalism, since operations are often highly imitable or can be outsourced. Patents are also recognized as an important indicator of research and development activity and the ownership of protected IP (Griliches 1990).

From the dynamic capabilities perspective, the presence of intellectual property in the target can moderate the negative impact of age on acquirer value. Intellectual property signals the presence of research and development activity in the target, which in turn creates unexplored growth options that make an older target more akin to a young company. We argue this moderating effect of intellectual property (as measured through the existence of patents held by the target) through the three identified mechanisms of dynamic capabilities (see Table 3).

First, when the target has patents, the benefits of awareness about a young target are reduced. Patents disclose significant information about the target's technology. Rather than having to learn about the technology over time as the target ages, the entire industry can examine publicly available information. Knowledge about a target is less dependent on its age. Further, although valuation of the target is still difficult, on the margin, the valuation can be more objective with increased information. While some of the advantages from early acquisitions remain, those due to awareness will be reduced because patents increase information available about the target and its technology.

The presence of intellectual property also mutes the negative impact of target age on the flexibility of the acquirer. Acquisition can confer the unexplored option value of the ongoing research activities to the buyer and thus preserve the shelf life of a target. Further, as the target firm ages, it develops embedded knowledge-based assets. Patents codify key intangible assets, so that the acquiring firm is more likely to appropriate value (Bresman et al. 1999) and less subject to holdup by key individuals in the target organization (Anand and Galetovic 2000). These effects dampen the negative valuation of an older acquisition and moderate the negative impact of age on value creation.

Finally, the presence of intellectual property also mutes the negative impact of target age from the agility perspective. Again, the presence of target patents indicates R&D activity even in older targets. These activities may produce on-going innovation, reducing concerns about aging and a lack of innovation (Sorensen and Stuart 2000). Further, patents allow for other mechanisms, such as exclusive licensing, that reduce the preemptive benefits of acquiring young targets. Therefore, we further hypothesize that:

Hypothesis 2: *In high velocity environments, the presence of intellectual property in the target moderates the negative effect of the target age on value created for the buyer.*

Table 3. Moderating Effects of Target Intellectual Property

Mechanism	Moderating Effect of Target Intellectual Property
Awareness	• Because patents are publicly available, common knowledge about the technology reduces information asymmetry and the associated advantages of acquiring early.
Flexibility	• The presence of target patents indicates R&D activity that creates growth options even for older targets. These options provide flexibility and reduce the negative impact of target age. • As a target firm ages, it develops embedded knowledge-based assets. Patents codify key intangible assets and thus offset some effects of structural inertia in older targets, so that the acquiring firm is more likely to be able to appropriate value and less subject to holdup by key individuals in the target organization.
Agility	• Again, the presence of target patents indicates R&D activity even in older targets. These activities may produce on-going innovation and reduce the negative impact of target age. • Patents allow other mechanisms, such as exclusive licensing, that reduce the preemptive benefits of acquiring young targets.

Data and Methodology

To test our hypotheses, we examined the telecommunications industry between 1995 and 2001. During this period, there was a high volume of acquisitions in many industries (Andrade et al. 2001) and in the telecommunications industry particularly (Warner 2003). Also during the same period, there was rapid growth in telecommunications in general, and the Internet and wireless communications specifically, with significant uncertainty about which technologies would emerge as standards. In summary, the telecommunications industry during this period was in a state of turmoil, with emerging technologies threatening to command "a decisive cost or quality advantage and…[to strike] not at the margins of the profits and the outputs of the existing firms, but at their foundations and their very lives" (Schumpeter 1942, p. 84). Detailed examinations of the acquisition announcements exhibited considerable divergence in both the types of companies and technologies purchased as well as the reactions from the equity market.

Data Sources

To build our data set, we searched the *Wall Street Journal*, *Business Wire*, *PR Newswire* and *Dow Jones News Service* to identify 361 acquisition announcements by publicly traded buyers in the telecommunications industry from 1995 to 2001. Of these 361 announcements, 249 announcements were by equipment manufacturers (such as Cisco, Nortel and Lucent), while 112 were acquisition announcements by service providers (such as Verizon, Cingular and MCI). Equipment manufacturers made acquisitions to obtain new products, technology or infrastructure, while a majority of the acquisitions by service providers related to the acquisition of new customers, new geographic coverage areas, new licenses and consolidation for economies of scale. To focus on the acquisition of products and technology in a high velocity industry, we concentrated on the 249 acquisition announcements by equipment manufacturers. The dataset was further augmented with information from the SDC Mergers & Acquisitions database. First, we checked for any acquisitions by equipment manufacturers during this time period to ensure that no relevant acquisitions were missed from the search for announcements. Additionally, though announced, some acquisitions were later withdrawn. After removing withdrawn acquisitions and those for which insufficient market trading data was available, 238 acquisitions remained.

Because of the importance of the exact date that the market learns of the acquisition (McWilliams and Siegel 1997), we searched all publications included in the Factiva database for a one year period preceding the announcement date, to check for leakage of information regarding the acquisition. We adjusted the announcement date to the earliest date when the acquisition was announced or reported in the media. When the announcement was made after 4 p.m. or on a day the equity market was closed, we adjusted the announcement date to the next trading date.

Determining the Age of the Target

Unfortunately, the age of the target at the time of acquisition was not readily available through public data sources. To determine the company start date, several sources were consulted. First, in some cases the press release about the acquisition noted the start date of the target company. Also, news articles profiling the company or company founders sometimes noted the start date. By searching through news archives and company filings, start dates were obtained for 185 of the 238 companies in our sample. In 47 cases, both the month and year were available; in the remaining 138 cases, only the year was given and the beginning of the year was used to determine target age. The age of the target ranged from as little as 2 months to 61 years with a mean of 8.3 years.

Calculating Abnormal Returns

We use the event study methodology to estimate the change in stock price (the abnormal return) for the acquirer attributable to the acquisition announcement by adjusting the stock price changes for market-wide movements (Brown and Warner 1985). Abnormal returns are calculated using both the Market Model as well as the Market Adjusted Return. The Market Model posits a linear relationship between the return on a stock and the return on the market portfolio over a given time period. This relationship is expressed as:

$$r_{i,t} = \alpha_i + \beta_i r_{m,t} + \varepsilon_{i,t} \quad (1)$$

where

$r_{i,t}$ is the return of stock i on day t;

$r_{m,t}$ is the return of the market portfolio on day t;

α_i is the intercept of the relationship for stock i;

β_i is the slope of the relationship for stock i; and

$\varepsilon_{i,t}$ is the error term for stock i on day t.

The term $\beta_i\, r_{m,t}$ is the return to stock i on day t that can be attributed to market wide movements, while $\varepsilon_{i,t}$ is the unexplained part of the return that captures the effect of firm specific events on day t.

For each firm, we estimate $\hat{\alpha}_i$ and $\hat{\beta}_i$ using ordinary least squares (OLS) regression over an estimation period of 200 trading days, with the equally weighted CRSP index as a proxy for the market portfolio. Each firm's estimation period ended 10 trading days prior to the announcement date. A minimum of 40 return observations in the estimation period is required for the estimation procedure. The abnormal return ($A_{i,t}$) for stock i on day t is:

$$A_{i,t} = r_{i,t} - \hat{\alpha}_i - \hat{\beta}_i r_{m,t} \tag{2}$$

where $r_{i,t}$ is the actual return on stock i on day t. The rationale is that in the absence of any abnormal return, the return for the stock can be predicted by the Market Model parameters.

In addition, we use the Market Adjusted Return as recommended when frequent acquisitions would overlap the estimation period used in the Market Model, reducing the value of including the market parameters (Fuller et al. 2002). Instead, we use a short, one-day event period which reduces the importance of market parameters (Brown and Warner 1985). The abnormal return ($A_{i,t}$) for stock i on day t is:

$$A_{i,t} = r_{i,t} - r_{m,t} \tag{3}$$

The rationale is that in the absence of any abnormal return, the return for the stock can be predicted by the market return. For short-window event studies, any gain in estimation from including the Market Model parameters may be lost by overlap of other acquisitions during the model parameter estimation period (Fuller et al. 2002). We use both the Market Model and the Market Adjusted Return as robustness checks for the results.

To pool observations across time, for each firm in our sample, we translate calendar time to event time by considering the announcement date as day 0 in event time, the next trading date is day 1, and so on. To summarize the average valuation impact of industry exchange announcements on the market value of firms in our sample, we focus on the abnormal returns on the event day (day 0). The use of a one day window allows us to isolate the effects of the acquisition announcement (McWilliams and Siegel 1997). The abnormal returns ranged widely from -23% to 18% with a mean reaction of -1.2%.

Control Variables and Data Sources

To control for some known factors that affect acquisition valuation, three types of control variables are used in the following regressions— characteristics of the buyer, characteristics of the target, and characteristics of the specific acquisition. All monetary values are converted to the January 1995 equivalent using the U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index. For buyer characteristics, we incorporate the total market valuation of the buyer immediately prior to the announcement because firm size has been found to influence acquirer valuation (Moeller et al. 2004) and because abnormal returns are percentages of market value. The buyer market value ranges from 104 million US$ to 430 billion US$ with a mean of 93 billion US$. The buyer R&D intensity (defined as the expenditure for the prior year on R&D divided by revenue) is included to control for absorptive capacity (Cohen and Levinthal 1990) and ranges from 0.01 to 5.75 with a mean of 0.21. The buyer free cash index (defined as the prior year operating income before depreciation minus income taxes minus interest expense minus preferred dividends minus common dividends all divided by revenue) is included to control for possible unprofitable investments made because of excess cash (Jensen 1986) and ranges from -1.25 to 0.40 with a mean of 0.13. The buyer leverage (defined as the prior year debt divided by assets) is included to account for

possible improvement in managerial decision making due to the high leverage (Maloney et al. 1993) and ranges from 0.03 to 0.86 with a mean of 0.27.

Next, for target characteristics, we use the total number of employees at the target at the time of the acquisition to control for the target firm size. Because our independent variable is the target age, it is important to distinguish between specific age related effects and those due to firm size (Barron et al. 1994; Sorensen and Stuart 2000); combined with the acquisition value, the number of employees helps control for size related effects. Target employees range from 17 to 7800 with a mean of 523. To determine the number of employees, we combined information from SDC, press releases about the acquisition, news articles about the target, profiles of the target founders and required filings. Because of the difficulty in accurately determining the number of employees, 28 acquisitions are excluded; however, excluded acquisitions range across all ages and acquisition values. The target public/private status (defined as 1 if the target was private, 0 if public) is included to control for previously documented public versus private effects (e.g. Chang 1998; Fuller et al. 2002). To determine the patents held by the target company, we consulted National Bureau of Economic Research (NBER) patent database (Hall et al. 2001), as well as details directly available from the U.S. Patent and Trademark Office (for recent years not covered by the NBER database). The number of patents held by target companies ranged from zero (46.3% of the sample) to a maximum of 660. For the analysis that follows, we used a dummy variable to indicate if the target had any patents at the time of acquisition. While patent counts have been used in similar context, recent research indicates that absolute counts are a problematic due to large patent quality heterogeneity (Hall et al. 2005); instead, richer metrics (including discounting for patent age, including citations and self-citations) are shown to have significant explanatory value. Unfortunately, because many of the targets are young and the data set is recent, richer metrics such as forward citation indexes are likely to be censored (Hall et al. 2001). Further, because 46% of the targets did not have any patents, a dichotomous variable provides a good abstraction.

Finally, we include characteristics of the acquisition. The total value of the acquisition is included to control for the size of the acquisition. The values as reported by the SDC database range from 3.1 million US$ to 36 billion US$ with a mean of just over 1.2 billion US$. Further, the weight of the acquisition (defined as the ratio of acquisition value to acquisition value plus the buyer market value) is included to control for the impact of the acquisition on the buyer because of the relative sizes of the buyer and target (Asquith et al. 1993; Moeller et al. 2004). Acquisition weights range from 0.001% to 68% with a mean of 7%. Beyond the actual size of the target, a large relative size difference could impact bargaining which could allow the buyer to extract more of the total acquisition value from the target. The source of funds for the acquisition (cash versus stock) as reported in the SDC database is included to control for the method of payment (King et al. 2004). During the period of our analysis, it was especially important to control for the impact of payment method on valuation because the relatively high market valuations for technology based companies during this period could have led to deflated acquisition costs from using overvalued equity. Alternatively, Higgins and Rodriguez (2006) indicate that equity based transactions may be preferable in the context of R&D acquisitions since the aligning of target and acquirer incentives may signal increased commitment by the target firm personnel to the acquiring organization. We used a dummy variable to indicate the primary source of funds. A few acquisitions were not completely cash or stock. Where the payment form was mixed, we coded it based on the largest source of funds used to complete the transaction.

No industry controls were included since all of the acquisitions were within a narrow industry subset. Additionally, no controls for friendly versus hostile acquisitions were included since the SDC database did not indicate that any of the acquisitions were hostile. Based on data availability for the independent and control variables, a sample of 145 acquisitions remain for the regression models.

To evaluate the sensitivity of the models to outlying values, we also examine the standardized Cook's distance for the data points in the regression. Based on this analysis, no data points have a strong indication of being problematic outliers. For the data points identified as possible outliers, we rechecked the source announcement data, the possibility of announcement leakage and all the independent and control variables. We found no basis for excluding any data points.

In summary, our analysis is based on the following equation:

$$R = \beta_0 + \beta_1 *M + \beta_2 *I + \beta_3 *F + \beta_4 *L + \beta_5 *E + \beta_6 *V + \beta_7 *P + \beta_8 *W + \beta_9 *D + \beta_{10} *S + \beta_{11} *A + \beta_{12} *A*P + \varepsilon \quad (4)$$

where

R is the day 0 abnormal market reaction (%);

M is the buyer market value (US$);

I is the buyer R&D intensity;

F is the buyer free cash index;

L is the buyer leverage;

E is the natural log of the number of target employees;

V is an indicator variable that is set to 1 if the target is private;

P is and indicator variable that is set to 1 if the target company had patents;

W is the acquisition weight (acquisition value divided by the acquisition value and buyer market value);

D is the total value of the deal (US$);

S is an indicator variable that is set to 1 if the transaction was primarily paid through stock and 0 otherwise;

A is the natural log of the target age;

$A*P$ is the interaction of target age and target patents (to evaluate Hypothesis 2); and

ε is unexplained error.

Summarized descriptive statistics are in Table 4. We also mean centered the continuous variables in the model (total acquisition value D, and target age A) to reduce multicollinearity effects when interaction terms are present (Aiken and West 1991).

Table 4. Descriptive Statistics for Independent and Control Variables

Variable	Minimum	Maximum	Mean	Std. Dev
Buyer Market Value (billion US$)	0.104	426.1	92.7	116.6
Buyer R&D Intensity (R&D / Sales)	0.01	5.75	0.207	0.478
Buyer Free Cash Index (Free Cash / Sales)	-1.25	0.40	0.130	0.191
Buyer Assets (billion US$)	0.021	370.7	18.93	32.79
Buyer Leverage (Debt/Asset)	0.03	0.86	0.268	0.152
Target Employees	17	7800	527.8	1171.6
Target Private (1 if yes, 0 if no)	0	1	0.66	0.475
Target Age (years)	0.17	60.7	8.28	8.86
Target Patents (1 if yes, 0 if no)	0	1	0.54	0.500
Acquisition Weight (% = Acquisition Value / (Acquisition Value + Buyer Market Value))	0.001	67.80	7.032	13.29
Acquisition Value (billion US$)	0.003	35.8	1.23	3.61
Acquisition Payment Method (1 if stock, 0 if cash)	0	1	0.72	0.448

Results and Discussion

Abnormal Returns

Table 1 shows the both the Market Model and Market Adjusted abnormal returns in the whole sample of 145 firms and specific sub-samples. The results presented in Panel A for the whole sample are consistent with earlier results

in the literature and exhibit a strong negative abnormal return from acquisition announcements. The mean abnormal return is -1.16 % for day 0 and the t-statistics and Wilcoxon signed rank test statistic are significant. Interestingly, the other panels show that the day 0 negative abnormal return in the whole sample are muted for younger companies, providing preliminary support for Hypotheses 1, that we further investigate through the regression analysis reported below.

Cross Sectional Regression Analysis

To test the two hypotheses, four hierarchical regression models were analyzed based on equation 4. The results are shown in Table 6 for the Market Model and for the Market Adjusted Returns; both sets of regressions use the single day (day 0) abnormal return as the dependent variable. The results are similar in both models and we describe the results based on the Market Adjusted Returns (Table 6) below.

In the first model (Model 1), only the control variables were entered. In Model 1 only the acquisition value (β_9 = -0.26) significant at the 10% level (t = -1.72). In the second model, the age of the target (using a natural log transformation of age) was entered in the regression model. Consistent with a diminishing marginal effect of target age, model 2 is significant (F = 1.622) and the natural log of target age (β_{11} = -1.19) is significant at the 10% level (t = -1.73). Acquisition value remains significant with approximately the same coefficient as in model 1.

Table 5. Cumulative Buyer Abnormal Returns for the Whole Sample and Specific Sub-Samples

	Market Model				Market Adjusted Return			
	Days -1 to 1	**Days -1 to 0**	**Days 0 to 0**	**Days 0 to 1**	**Days -1 to 1**	**Days -1 to 0**	**Days 0 to 0**	**Days 0 to 1**
Panel A: Whole Sample of 145 acquisition announcements								
Mean abnormal return (%)	-1.16	-1.13	-1.16	-1.19	-0.57	-0.60	-0.99	-0.96
T-statistics	-2.164*	-2.586**	-3.751***	-2.717**	-1.021	-1.324	-3.090***	-2.111*
Wilcoxon signed-rank test Z-statistic	-1.613	-1.689	-2.589	-2.118	-1.514	-1.505	-2.695	-2.255
Panel B: Sample of 78 acquisitions where the target company owns patents								
Mean abnormal return (%)	-1.44	-1.82	-1.48	-1.11	-0.97	-1.53	-1.35	-0.78
T-statistics	-2.239*	-3.455***	-3.982***	-2.103*	-1.429	-2.766**	-3.455***	-1.421
Wilcoxon signed-rank test Z-statistic	-1.718	-2.728	-2.654	-1.253	-1.989	-2.971	-2.937	-1.542
Panel C: Sample of 67 acquisitions where the target company does not own patents								
Mean abnormal return (%)	-0.83	-0.33	-0.79	-1.29	-0.10	0.48	-0.58	-1.16
T-statistics	-0.977	-0.479	-1.604	-1.852*	-0.118	0.689	-1.169	-1.660*
Wilcoxon signed-rank test Z-statistic	-0.566	0.414	-1.019	-1.827	-0.089	1.021	-0.832	-1.719
Panel D: Sample of 73 acquisitions where target age is below median (younger targets)								
Mean abnormal return (%)	0.00	-0.28	-0.53	-0.25	0.45	0.05	-0.35	0.04
T-statistics	-0.005	-0.444	-1.180	-0.395	0.565	0.084	-0.764	0.068
Wilcoxon signed-rank test Z-statistic	-0.135	0.082	-0.445	-0.562	0.226	0.250	-0.175	-0.097
Panel E: Sample of 72 acquisitions where target age is above median (older targets)								
Mean abnormal return (%)	-2.34	-2.00	-1.81	-2.14	-1.59	-1.26	-1.64	-1.97
T-statistics	-3.092***	-3.239***	-4.142***	-3.477***	-2.013	-1.955*	-3.592***	-3.051**
Wilcoxon signed-rank test Z-statistic	-2.218	-2.549	-3.327	-2.520	-2.396	-2.407	-3.690	-3.138

One-tailed significance levels: * (p < 0:05); ** (p < 0:01); *** (p < 0:001).

Table 6. Hierarchical Regression Models

Variables	Market Model			Market Adjusted Return		
	Model 1	Model 2	Full Model	Model 1	Model 2	Full Model
Control β_0: Intercept	0.560	-2.061	-1.398	0.300	-2.383	-1.728
	(0.152)	(-0.521)	(-0.356)	(0.079)	(-0.583)	(-0.425)
Control β_1:Buyer Market Value	-0.108	-0.401	-0.679	-0.395	-0.694	-0.970
(billion US$)	(-0.024)	(-0.088)	(-0.151)	(-0.084)	(-0.148)	(-0.209)
Control β_2: Buyer R&D Intensity	-0.120	0.148	-0.028	-0.030	0.245	0.070
(R&D/Sales)	(-0.084)	(0.103)	(-0.020)	(-0.020)	(0.165)	(0.048)
Control β_3: Buyer Free Cash Index	-0.133	-0.019	-0.203	0.172	0.289	0.108
(Free Cash / Sales)	(-0.036)	(-0.005)	(-0.056)	(0.046)	(0.077)	(0.029)
Control β_4: Buyer Leverage	-5.435	-5.880*	-5.997*	-5.076	-5.532	-5.647
(Buyer Debt / Buyer Assets)	(-1.565)	(-1.702)	(-1.754)	(-1.451)	(-1.549)	(-1.597)
Control β_5: Log of Target Employees	-0.123	0.396	0.138	-0.111	0.419	0.165
	(-0.218)	(0.627)	(0.217)	(-0.191)	(0.643)	(0.250)
Control β_6: Target Private	0.897	0.735	0.847	1.252	1.086	1.197
(1 if yes, 0 if no)	(0.678)	(0.558)	(0.650)	(0.916)	(0.798)	(0.887)
Control β_7: Target Patents	0.537	1.081	1.382	0.558	1.115	1.413
(1 if yes, 0 if no)	(0.494)	(0.962)	(1.233)	(0.497)	(0.961)	(1.218)
Control β_8: Acquisition Weight	-0.042	-0.053	-0.051	-0.046	-0.056	-0.055
(Acq. Value / (Acq. Value + Buyer Value)	(-0.912)	(-1.129)	(-1.113)	(-0.953)	(-1.167)	(-1.151)
Control β_9: Acquisition Value	-0.264*	-0.279*	-0.283**	-0.259*	-0.275*	-0.279*
(billion US$)	(-1.808)	(-1.921)	(-1.974)	(-1.719)	(-1.831)	(-1.879)
Control β_{10}: Acquisition Payment Method	-0.222	-0.369	-0.366	-0.194	-0.344	-0.342
(1 if stock, 0 if cash)	(-0.203)	(-0.339)	(-0.340)	(-0.172)	(-0.306)	(-0.307)
β_{11}: Log of Target Age		-1.163*	-2.152***		-1.191*	-2.169**
(years)		(-1.746)	(-2.606)		(-1.730)	(-2.539)
β_{12}: Patent*log of Target Age			2.216**			2.191*
			(1.988)			(1.900)
R^2	9.6 %	11.7 %	14.2 %	9.8 %	11.8 %	14.2 %
ΔR^2		2.1 %	2.5 %		2.0 %	2.3 %
F	1.429	1.596	1.825**	1.463	1.622*	1.817*

OLS Estimates of coefficients. (t-values) are shown in parenthesis.

Two-tailed significance levels: * (p < 0:10); ** (p < 0:05); *** (p < 0:01)

Sample is 145 acquisitions with the dependent variable day 0 buyer abnormal returns.

In the third model, we investigate the moderating effect of patents on the relationship between buyer abnormal returns and target age. Model 3 is the complete model depicted in equation 4 and adds the interaction term of age and patents. The model is significant (F = 1.817) and the parameter estimate for the interaction (β_{12} = 2.19) is

significant at the 5% level (t = 1.90). Further, the significance of the direct effect of age increases to the 5% level (t = -2.54). As before, the acquisition value coefficient (β_9 = -0.28) remains significant (t = -1.88). In all models, the VIF factors remain well below 10, suggesting that multicollinearity is not a significant problem in the data. The Market Model (also in Table 6) exhibits quite similar results.

The results support hypothesis 1. In all models that include the natural log of the target age, we find support for early external acquisition of new technology. The results are consistent with high valuations of purchase of a real option with high variance of expected returns. In Figure 1, the solid line illustrates the positive reaction to the acquisition of young firms, with rapid loss of value for the buyer as the target ages.

Although the results support hypothesis 1, we had concern that the results could be due to a consistent market reaction for a few specific acquirers (with large numbers of acquisitions) who may prefer to acquire early or late. While the dataset lacks sufficient data points for a firm fixed-effects regression model, we performed three additional hierarchical regressions (like Table 6). In each regression, we removed the acquirer with the largest number of acquisitions. In each regression, the age effect, $\beta_{11,}$ remained consistent with Table 6 and significant ($p < 0.021$ after dropping the most frequent acquirer; $p < 0.014$ after dropping the second; and $p < 0.015$ after dropping the third.) These models indicate that our results are not dependent on a few, high acquisition volume firms.

The results also support hypothesis 2. The coefficient for the interaction term is significant in model 3 in using both the Market Model and the Market Adjusted Returns. Overall, we find that the presence of target patents mutes the negative impact of target age on value created for the buyer. Figure 1 also illustrates the differing returns for targets with and without patents. While the reaction is neutral for targets with patents, independent of age, the reaction for targets without patents exhibits significant loss of value for the buyer as the target age increases.

Interestingly, the results could be interpreted as being different than the results found by Chaudhuri (2004) and Chaudhuri et al. (2005) who propose competing hypotheses of the effect of target age on performance, but find better performance for the buyer with increased target age. However, a key distinction in the research makes our results complementary rather than contradictory. Specifically, their dependent variables (current revenue from investment and time to market reduction) favor concrete effects on a specific product. By using abnormal returns, we capture the intangible effects that an acquired technology might provide (such as competitive preemption or complementary effects on existing products) that would not be reflected in current revenue or time to market reduction. In summary, while Chaudhuri et al. (2005) analyze the short term impact of a later stage acquisition, abnormal returns capture the future impact of the acquisition and its intangible effects.

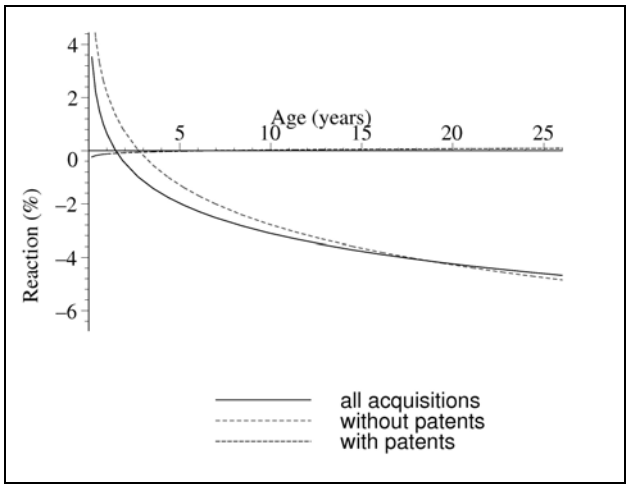

Figure 1. Impact of Target Age on Abnormal Reaction

Conclusions

In the high velocity telecommunications industry, the equity markets reward the acquisition of younger companies (Figure 1). While patent ownership by the target does not impact the value creation from younger acquisitions, the

equity markets penalize the acquisition of older companies that do not own patents. The results are robust under alternative definitions of abnormal returns and are consistent with a dynamic capabilities perspective on value creation through acquisitions in high velocity industries. By focusing on the intersection of dynamic capabilities and acquisitions in the context of innovation, our research contributes both to the understanding of dynamic capabilities and to the value creation effects of innovation acquisitions in high technology industries. First, by detailing the mechanisms of awareness, flexibility, and agility, we contribute additional detail to the general concepts of dynamic capabilities and address some of the challenges of incorporating time within the RBV framework (Priem and Butler 2001). Additionally, we provide insight into the source of value from dynamic capabilities as firms exploit real options, information asymmetry, competitive dynamics and complementary assets to create value in uncertain environments. We provide empirical support for the arguments of Brown and Eisenhardt (1997) regarding the benefits of fast strategic decision-making in high velocity environments.

Further, by explaining some of the distinction between value-creating and value-destroying acquisitions (Andrade et al. 2001), we contribute to the growing understanding of acquisitions in a particularly difficult but important context. Alchian (1950) cautioned against trial-and-error approaches to deal with uncertainty, warning that an individual company may not survive an error, yet the industry overall may discover success through a shotgun approach. Some of the serial acquirers of external R&D in our study seem to be using the shotgun approach individually. Yet we see evidence of value benefits from early stage acquisitions that could be classified as more exploratory than exploitative. Through the mechanisms in Table 1, our research provides insights on how environmental uncertainty can become a strategic advantage. While proactive investment in environmental and technological awareness can lead to absorptive capacity (Cohen and Levinthal 1990), the capacity must be translated to value through action. Further, faced with uncertainty, "even moves that offer ephemeral advantages may be worth making, even if only to avoid competitive *disadvantage*"(Ghemawat 1986, p. 58, emphasis in original). Our evidence supports the ideas that competitive advantage can, at a minimum, be created by acting to avoid potential disadvantage. So, somewhat counter-intuitively, in the face of uncertainty, a risk averse buyer may choose to act rather than risk failure by not acting. More importantly, from a real option perspective, there is greater value in acting quickly.

Going forward, while the valuation metrics show indication of market support for acquiring early, the future is not completely knowable, even in an efficient market. It remains to be seen if the uncertain advantages attached to actions translate to long term, sustainable competitive advantage and an evolutionary stabilization of the dynamic market as uncertainties are reduced over time and create value. By acting quickly on external technology acquisition, managers can gain time over competitors. Dierickx and Cool (1989) similarly argue that levels cannot be changed instantaneously. As a new emphasis on external acquisition of innovation emerges (Anonymous 2006; Chesbrough 2003), the implications are of both academic and managerial importance. Our results suggest an advantage to early acquisition and that time itself may be the fundamental resource— valuable, rare, inimitable and non-substitutable.

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