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Effects of Technological Change on Acquisition Behavior: An Empirical Analysis of Electronic Design Automation

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Abstract. This paper contains an empirical analysis of acquisition dynamics in the electronic design automation (EDA) industry. Using qualitative and quantitative data, we show that particular groups of EDA firms strongly contribute to acquisition activity in the industry at specific times. Based on this we provide empirical evidence that specialized firms pursue focused and 'defensive' acquisitions during times of uncertainty, indicating that concentration on existing competencies is preferred over diversification into promising new, but unfamiliar markets.

1 Introduction

High-technology (high-tech)[1] industries are characterized by rapid technological change during which firms have to maintain their competitive positions based on their (technological) competencies. Acquisitions (synonymous: takeovers, mergers) are a means to access such competencies and their analysis thus of high practical relevance to inform firms how to use them [1]. Although there is a large body of empirical management research literature on the acquisition phenomenon, most of this work focuses on outcomes of corporate takeovers. Researchers have acknowledged the complexity of acquisitions by looking at potential aspects that affect post-merger performance [2, 3], with factors like the targeted knowledge base, innovation type and market relatedness emerging [4, 5, 6]. It was found that inconsistency is often due to substantial lack of explanatory value of the independent variables [7].

Another reason could be simultaneous inclusion of several industries and insufficient consideration of strategies. Finally, only few studies addressed the question of why acquisitions are done at a single-industry level [8]. Yet, this is crucial given that motives behind acquisitions differ in relevance across industries and that the latter consist of different strategic groups [9]. Therefore, individual firm behavior

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[1] Our definition refers to the North American Industrial Classification System categories high-tech manufacturing, communication services, software services, and engineering and tech services [12].

is a function of a particular environment with specific technological changes [10], firm-specific strategic positions characterized by type and breadth of product portfolios, and institutional factors [11]. Related to the latter, work on merger waves empirically identifies drivers for temporal clustering of acquisitions, with technological shocks being a major one [13, 14, 15].

In order to assess corporate behavior appropriately it is crucial to understand the competitive environment within which the firm is primarily active. Each firm competes on the basis of its competencies, which are ultimately embodied in the specific products and services the firm offers and that its customers are willing to pay for [16]. Hence, we provide a focused analysis of firm behavior in general and of acquisition behavior in particular by concentrating on a single industry, EDA, involving detailed knowledge about that particular business and information about the types of products of each firm.

This allows to identify different strategic groups as well as relevant industry specific trends, answering the following research questions: Does technological change have a significant impact on the acquisition behavior and do firms with different product portfolios behave differently during that technological change? In answering this question whose relevance was pointed out in the beginning of the introduction and motivated further by an exposition of the literature on post-merger performance, acquisition waves and strategic groups, we contribute to the strategic management field and the above specific literatures in it.

2 Theoretical Background and Hypotheses Development

The velocity at which modern technological regimes change, makes the concept of dynamic capabilities in the field of strategic management increasingly relevant [17]. This is because not changing the resource base of a firm through them gives conservative, exploitation-oriented projects priority over longer-term, explorative endeavors [18]. In this case, firms also need to devote large amounts of managerial and financial resources to address current customers, a situation also known as *"the tyranny of the served market"* [19]. Not adapting to changing conditions becomes visible in product portfolios, since existing offerings are the outcome firm's past strategy [20].

Eventually, technological change can render existing competencies obsolete [21]. The literature on post-merger performance thus suggests technology-driven acquisitions as a means to address competency loss, which correlates with the intensity of technological change [22]. Furthermore, research on merger waves has shown that industry-specific conditions nuance wider institutional factors in their effect on acquisition behavior [23].

In order to dissect acquisition behavior for a single industry, it is necessary to go beyond a simple count of acquisitions. Instead, differences between the industry's strategic groups need to be considered. Although all firms are equally exposed to technological change some might be affected differently since firms within one industry differ [24]. Therefore, we take the structure of product portfolios into account to address individual differences across firms. This approach also address calls in prior work to address more directly the relevance and importance of within-industry diversification on performance [25]. Also, to reveal such qualitative relationships between product portfolios, technological change and acquisition patterns we need to limit the scope of our study to acquisitions in one specific industry.[2] This is further supported by benefits from diversification into industry-specific or 'related' fields being shown to be transferable to a single-industry level, and the role of acquisitions for innovation [26].

Following approaches from configuration theory, technological change is understood here as a cause of environmental turbulence beyond incremental and modular reconfigurations that implies major technological development [27, 28]. Based on this definition of technological change, we distinguish between two generic types of takeover strategies within the boundaries of a single industry. The first can be characterized as 'expansive', meaning that the acquirer extends its activities into new product-/service-categories within the boundaries of its industry. The second generic type of takeover strategy can be described as 'defensive' in that the acquiring firm purchases an organization that offers products/services in sub-categories or product segments in which the acquirer already has an established interest.

Our empirical analysis is about U.S. EDA firms. EDA is the general term for the software tools that are used to design and test semiconductors. As part of the extremely dynamic semiconductor sector, EDA firms work under a permanent pressure to innovate. The existence of the so-called 'design gap' is a good indicator of this pressure. This gap embodies the enormous challenge that chip design software firms face. Manufacturers of silicon-based chips constantly invent smaller-scale manufacturing processes, and they need corresponding design software to realize the advantages and address the challenges of miniaturization [29]. In other words, while a new smaller manufacturing process is being developed, chipmakers approach EDA software firms to incorporate corresponding features into their products. This leads to the 'design gap' in which design software has to constantly catch up with technological advancements. This permanently creates fertile niches for EDA software in which new ideas and technologies can evolve in the form of new ventures, while entry barriers in terms of required capital are low. As a consequence, we deal with an industry that is characterized by a high frequency of corporate acquisitions.

We define the type of takeover strategies that emerge from technological change by observing the targets and their particular products in relation to the introduction of the 90 nm chip scale, which is a technological change with strong implications for the EDA industry. At the beginning of 2004, Intel started to release its first 90 nm microprocessors to end customers [30]. In fact, a discussion about 90 nm can be observed starting in 2003 [31], which indicates a concern about competencies in light of this technological change. Given acquisitions can mitigate their erosion, the following hypothesis is proposed:

H1: The introduction of the 90 nm chip technology has a positive impact on the number of acquisitions by firms in the EDA industry.

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[2] See the methodology section for more information on the set of acquisitions analyzed.

Apart from expecting a general increase in acquisition behavior, our industry knowledge and our data also allows us to differentiate between product categories within EDA. To understand EDA tool categories, it is important to understand that chip designers depend on EDA tools providing a high level of abstraction which in the end can be automatically transformed into a blueprint for physical manufacturing (including defined placements and routings).

The chip design process flow can be broadly divided into three subcategories/ phases, the Electronic System Level (ESL), IC Front-End (IC-FE) and IC Back-End (IC-BE) design [29]. ESL encompasses the most abstract software at the beginning of a design process while IC-BE is closest to the concrete physical layout of the chip. Because of the ramifications of early design choices in the beginning of the development process tools at the highest abstraction levels become more and more valuable as complexity continues to increase. This could also be observed with the introduction of the 90 nm process in mass production.

Around 2003, experts became vocal on the importance of ESL tools for coping with challenges from the introduction of 90 nm manufacturing scales [32]. Detailed product information allows us to distinguish between firms with and without ESL software in their product portfolios. We consider the acquisition of a target that offers ESL products as more unrelated or expansive compared to an acquisition of a target with non-ESL products when the acquirer has no ESL products in its product portfolio.

Since the 90 nm transition induced demand for ESL competencies, we would expect non-ESL firms to diversify into the ESL segment in their attempt to maintain competencies and therefore, to pursue expansive acquisition strategies. In addition, diversification along the value-added design chain is very feasible considering the integrated nature of the chip design flow, where ESL is a new endpoint extending the chain by one module. Since for customers, complete design suites from only one EDA supplier ensure perfect compatibility and reduce implementation efforts from interfaces with third parties [33], the following hypothesis can be stated:

H2a: Firms without ESL products react to 90 nm chip technology with an expansive strategy by acquiring targets with ESL products.

Opposed to this expansive acquisition motive, ‘non-ESL firms’ could also prefer defensive acquisitions in the sense of related takeovers. This would enable firms without any ESL products to strengthen their existing product lines and to increase revenue from those by acquiring (innovative) targets. In dynamic environments such a focused strategy could be more rational since business extension implies more efforts and operative friction [34]. In addition, by acquiring similar targets, competition in the industry is decreased and margins can potentially be improved. Thus, a second (competing) hypothesis can also be posed as follows:

H2b: EDA firms without ESL products react to the 90 nm chip technology through a defensive strategy by acquiring targets within product segments they already occupy.

Hypotheses 2a and 2b both imply a positive moderating effect on the total number of acquisitions by firms without ESL products of the technological change to 90 nm. Testing which of them holds based on acquisition behavior is therefore only possible using the detailed industry-level data with qualitative information that is at our disposal.

3 Methodology

To test our above hypotheses we employ a unique panel dataset of U.S. EDA firms from 1996–2006. Despite an international industry structure, the large majority of global revenue comes from EDA firms based in the U.S. [35]. This allows us to control for any country effects without losing global information about specific trends and developments. Gartner Dataquest and Gary Smith EDA published annual reports on firms in the global EDA industry for the period 1996–2006 including information about the specific sub-segments in which firms are active, allowing us to track the type and breadth of firm-specific activities within the EDA industry over time. For the U.S. firms in these reports matching financial data for all public U.S. firms from the Compustat database was obtained and patent information was sourced from the database of the National Bureau of Economic Research (NBER). Information about the takeover activity of the firms comes from the Thomson One Banker database.

An acquisition is defined here as a purchase that leads to a corporate equity stake of more than 50 percent of another company [36]. This excludes deals resulting in minority stakes and the repurchasing of a company's own shares. Also excluded are corporate deals involving non-EDA companies, such as IT service companies. Through this strict data treatment, we are able to interpret every acquisition as an event following which the acquiring party has full control over the target and full formal access to the firm's technological competencies. Starting with a sample of 468 acquisitions conducted by public U.S. EDA firms between 1996 and 2006, every acquisition entry was manually evaluated using these rules, resulting in a final set of 247 before any empirical analysis was conducted. Furthermore, qualitative triangulation through secondary sources (e.g. [32]) ensured the filtering was appropriate.

From the NBER database 16,446 patents have been extracted, of which 2,748 were applied for prior to our chosen time period (1996–2006). These latter patents are used to calculate starting patent stocks in 1996. Before the matching process, 84.2 percent of all patents are in the IPC categories 'G' (Physics) and 'H' (Electricity). Almost 13.9 percent are in the 'B' (Performing Operations, Transporting) and 'C' (Chemistry, Metallurgy) categories. Due to our narrow industry focus and to avoid any patent selection bias, we estimated all our models with two versions of our patent data. One version included only patents belonging to the more industry-related categories 'G' and 'H' and one version included all patents. The reported models in this analysis include all patents since the results do not differ significantly.

A proper selection is necessary to account for the arguments about the distinct dynamics. Since we talk about industry-specific trends we need to make sure that all included firms experience upcoming technological changes in their direct environment in a similar way. Therefore, every firm within the dataset generated has been analyzed regarding its business affiliation to the EDA industry. Thus, for a condensed set of 36 companies we identified EDA as (at least) one of its core business and kept them in the final dataset. The years 1996 and 1997 have been excluded from our analyses owing to there being too few data points. For the purpose of this analysis, our dataset is sufficiently large, since data of similar size has been used [37]. VIF values of 1.17 to 3.75 indicate that multicollinearity is unlikely to be an issue in our analysis [38].

Our dependent variable is the number of acquisitions being conducted by a given firm in a given year. Since this is a count variable, we employ a negative binomial model for our regression analysis [39]. The panel structure of our dataset allows us to address within- and between-differences in our dataset. We used the Hausman test to decide between fixed- and random effects. Based on the insignificant test results and our special interest in the behavior of a whole industry, we estimate a random effects model to also account for time-constant variables and to avoid a bias towards the subset of *"treated"* individuals.

Our first explanatory variable represents the change in microchip complexity going from 130 nm to 90 nm in mass production. The first large-scale introduction of 90 nm microprocessors happened in 2004 [30]. Considering usual lead times within the semiconductor industry, we consider this trend to have already been fully established in 2003. Further confirmation comes from publications and articles about the coming of the 90 nm chip scale and its implications for chip design in 2003. As our time period runs from 1998–2006, our new *90 nm* variable equals zero up until including 2002, and becomes unity from 2003.[3]

Utilizing our detailed product information we are able to summarize and distinguish between the different product-related EDA main categories, namely ESL, IC-FE, and IC-BE plus 'others', which represents all non-categorized product segments. To distinguish between ESL and non-ESL offering firms we employ two dummy variables. The *(Firm with) ESL products* variable is equal to equity if a respective firm offers products in the ESL sub-segment in a given year. Contrary to this, the *(Firm with) only non-ESL products* variable indicates whether a company is *only* offering IC-FE and/or IC-BE but no ESL in a given year. The residual sub-category 'others' is not included in the model, i.e. the other two dummies are to be interpreted relative to this omitted category.[4] For the two explanatory variables included, we allow for a one-year time lag to reduce endogeneity and biases from different accounting methods [36].

Our employed model controls for different levels of innovative activity, firm size, and financial performance as these factors showed significant effects on the propensity to acquire in past acquisition research. Internal R&D can be an alternative to acquisition of external know-how [40]. Therefore, we consider different levels of R&D activity, calculating the variable *R&D intensity* as the ratio of R&D expenditures to net sales [41]. In addition to R&D input, the level of past output is a well-accepted indicator of the ability to identify and absorb new intellectual property [42]. Also known as absorptive capacity, this innovative output is measured by the patent stock of a firm [43]. The standard perpetual formula is used, which is then

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[3] Taking absolute years can be a rather rough timeframe for the described trend since high-tech industries often change quicker than years. That is why we altered the length of the time trend to check the robustness of our model, as is described in the results section.

[4] *(Firm with) ESL products* and *(Firm with) only non-ESL products* have a correlation of -0.55 at a significance level below 0.05 (see Table 2).

normalized by firm size as proxied by net sales [44, 45].[5] Normalization allows addressing the issue of size disparities between firms that could undervalue the patent stock of smaller EDA firms.

Thus, we calculate *R&D output* as the ratio of patent stock to net sales, with the depreciation rate set at 15 percent [43]. Although our data only covers the years 1996–2006 all available patent information before 1996 (2,748 patents) was used to avoid truncation bias for the calculation. To control for size related differences in firm behavior, we employ a *firm size* variable by using the natural logarithm of net sales of a firm.[6] Similarly, we use the change in annual net sales ('sales') for each firm i and year t to control for firm growth. Controlling for financial success we calculate *profitability* as EBITDA to net sales. In order to account for a company's ability to meet its short-term obligations from its current assets, *liquidity* is calculated as the ratio of current assets to current liabilities. To account for the economic and institutional environment of the industry, we include the annual *industry's annual acquisitions* as a variable gauging general, industry-wide behavioral patterns. Except for the latter, we employ a one-year time lag for all described control variables for the same reasons we lagged two of our independent variables (*[Firm with] ESL products* and *[Firm with] only non-ESL products*). Tables 1 and 2 provide the descriptive statistics and correlations as well as variance inflation factors.

Table 1. Descriptive statistics

	Variable	Mean	S.D.	Min.	Max.
1	Number of annual acquisitions	0.57	1.16	0.00	7.00
2	New 90 nm technology	0.43	0.50	0.00	1.00
3	(Firm with) ESL products	0.31	0.46	0.00	1.00
4	(Firm with) only non-ESL products	0.40	0.49	0.00	1.00
5	90 nm technology (techn.) * ESL products	0.17	0.38	0.00	1.00
6	90 nm techn. * only non-ESL products	0.11	0.32	0.00	1.00
7	R&D intensity	0.27	0.20	0.03	1.99
8	R&D output	0.34	0.46	0.00	3.32
9	Firm size	5.49	1.72	1.70	9.04
10	Growth	0.25	0.70	-0.65	6.46
11	Profitability	0.14	0.29	-1.49	0.78
12	Liquidity	2.91	1.94	0.31	14.81
13	Industry's annual acquisitions	12.65	5.65	4.00	22.00

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[5] To normalize patent stock, [44] use assets and [45] uses employees to account for firm size.

[6] Compared to the often-employed value of total assets, net total sales are better suited to represent the size of software firms. The number of employees can act as an alternative to net sales and produces qualitatively similar results when used in our estimations.

Table 2. Correlation matrix and variance inflation factors

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00												
2	-0.03	1.00											
3	0.45	0.16	1.00										
4	-0.27	-0.25	-0.55	1.00									
5	0.15	0.52	0.67	-0.37	1.00								
6	-0.07	0.41	-0.24	0.43	-0.16	1.00							
7	-0.04	-0.03	-0.01	0.20	0.00	0.06	1.00						
8	-0.12	0.20	-0.04	-0.13	0.05	0.05	0.25	1.00					
9	0.22	0.14	0.17	-0.44	0.14	-0.20	-0.52	-0.31	1.00				
10	0.07	-0.21	-0.09	0.10	-0.11	-0.08	0.37	0.12	-0.32	1.00			
11	0.24	0.03	0.13	-0.27	0.07	-0.09	-0.50	-0.38	0.62	-0.19	1.00		
12	-0.17	-0.07	-0.29	0.19	-0.24	0.08	0.17	0.26	-0.27	0.10	-0.12	1.00	
13	0.22	-0.35	-0.11	0.17	-0.22	-0.07	-0.03	-0.11	-0.06	-0.04	-0.02	0.02	1.00

Note: variable numbers refer to Table 1; all correlations > |0.17| significant at $p < 0.05$

4 Results

Table 3 shows the results of our negative binomial regression models. Most obviously, our first hypothesis does not hold true in any of the employed models meaning that the introduction of the 90 nm chip production scale by itself has no significant effect on the number of acquisitions within the EDA industry. As a robustness check, we adjusted the length of the 90 nm time dummy and employed different lengths from one to three years always yielding insignificant results. Models 2 and 3 include all of our three explanatory variables, where Model 3 features additionally contingency effects (interactions) through which we can simultaneously test our first and second hypotheses.

Looking at the interaction effects, we can confirm that EDA firms without any ESL products acquire significantly more from 2003: the time when chip design became increasingly more complex and ESL products experienced strong demand due to the smaller manufacturing scale at 90 nm. So far, this empirical result confirms our reasoning for expecting higher acquisition activity levels from firms without ESL products, but it does not clarify if firms acquire more in general or with a focus on ESL targets. Yet, further support for one of our latter hypotheses comes from the fact that EDA companies that already offered ESL software products did not seem to be affected by the introduction of smaller chip scales. More precisely, these types of companies show significantly higher acquisition activities during the entire time period analyzed (significant in model 2 and 3).

Table 3. Negative binomial panel regression analyses on the number of annual acquisitions

Variable	Model 1		Model 2		Model 3	
New 90 nm technology	0.12	(0.26)	0.13	(0.27)	-0.41	(0.64)
(Firm with) ESL products			1.41^{***}	(0.54)	1.42^{**}	(0.56)
(Firm with) only non-ESL products			0.33	(0.56)	-0.21	(0.62)
90 nm techn. * ESL products					0.35	(0.68)
90 nm techn. * only non-ESL products					1.91^{**}	(0.87)
R&D intensity	-0.34	(1.21)	0.07	(1.11)	0.30	(1.15)
R&D output	0.43	(0.59)	0.47	(0.50)	0.60	(0.50)
Firm size	0.22	(0.19)	0.25	(0.16)	0.32^{*}	(0.17)
Growth	0.43^{**}	(0.19)	0.55^{***}	(0.19)	0.59^{***}	(0.19)
Profitability	1.34	(0.77)	1.16	(0.75)	1.18	(0.76)
Liquidity	-0.23	(0.14)	-0.10	(0.13)	-0.11	(0.14)
Industry`s annual acquisitions	0.08^{***}	(0.02)	0.09^{***}	(0.02)	0.08^{***}	(0.02)
Likelihood ratio test for nested model 1			6.06^{**}		12.51^{**}	
Likelihood ratio test for nested model 2					6.45^{**}	
Wald χ^2 (df)	37.04 (8)***		42.89 (10)***		52.40 (12)***	
Log Likelihood	-138.23		-135.20		-131.98	
Observations (Groups)	178 (36)		178 (36)		178 (36)	

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$ (based on two-tailed significance tests); values in parentheses refer to standard errors

To see whether hypothesis 2a or 2b hold true we provide a simple descriptive overview of all acquisitions involving ESL offering targets from 1998–2006. Although 2a and 2b are competing hypotheses, we can find good arguments for both, since they represent a typical economic trade-off decision. That is why we are interested in the actual behavior of strategic groups within the single high-tech industry setting analyzed.

As can be seen in Table 4, out of the six acquirers involved in ESL takeovers, five had already been offering ESL products prior the respective mergers. Only one company taking over an ESL target before 2003 (in 2000) did not offer any ESL related products. Conversely, firms without ESL products apparently kept acquiring within their already occupied product categories, which means that they followed a more focused acquisition strategy in relation to their core business. Therefore, we can reject hypothesis 2a and note strong support for 2b.

As concerns the control and other variables in the regression model reported in Table 3, *Growth* and *industry's annual acquisitions* continuously show significant positive effects on the number of acquisitions in all models. Their high significance levels clearly hint at a strong relationship between recent business growth and its continuation through corporate takeovers (for the *growth* variable). Moreover, unobserved general dynamics seem to play an important role in addition to our identified industry trend (for *industry's annual acquisitions*). Most other control variables (*R&D intensity, patent stock, profitability,* and *liquidity*) remain insignificant in all tested and reported models.

This can be explained by the analysis' focus on a single industry where the similarities in innovation activities, business models, and utilization of internal resources cannot explain a large portion of the differences between industry players in terms of acquisition behavior. Likelihood ratio tests confirm the superior explanatory power of the largest employed model.

Table 4. ESL deals during the analyzed period from 1998 to 2006

Target	1998	1999	2000	2001	2002	2003	2004	2005	2006	Acquirer
Analogy		1								Avant*
Avant				1						Synopsys*
Axis Systems						1				Verisity*
C Level Design				1						Synopsys*
Cascade							1			Synopsys*
Chrysalis Symbolic Design		1								Avant*
Co-Design Automa-tion					1					Synopsys*
First Earth						1				Mentor*
Get2Chip						1				Cadence*
Orcad		1								Cadence*
Summit Design									1	Mentor*
Verisity								1		Cadence*
Visual Software			1							Xilinx
Total ESL deals	0	3	1	2	1	3	1	1	1	
Total annual deals	19	24	20	10	12	19	14	6	7	
Annual share of ESL deals	0%	13%	5%	20%	8%	16%	7%	17%	14%	

Note: * = Acquirer has been offering ESL software before.

5 Discussion and Conclusion

In this study, we proposed to integrate different explanatory factors for acquisition behavior in order to better understand the dynamics in very dynamic high-tech industries. Our results show that the rise of the 90 nm process for mass production by itself had no significant influence on the number of acquisitions within the EDA industry. Despite the undeniable increase of complexity in chip design, we cannot identify a corresponding change in general EDA acquisition behavior in terms of frequency. A possible explanation could be that the constant pressure to innovate (the so called 'design gap') overshadows the specific effects coming from the described technological change.

Whilst we are far from generalizing the non-impactful nature of any industry trend on acquisition activities in high-tech industries, the insignificant effect of technological change by itself further supports our call to utilize firm-specific characteristics that allow for more differentiated empirical analysis of the acquisition phenomenon. In fact, the confirmation of one of our competing hypotheses, 2b, reveals the existence of behavioral differences coming from strategic positions as mirrored by the different product portfolios. Only by differentiating between different types of acquirers can we show a significant effect coming from a particular technological change within the industry. Moreover, the descriptive overview of ESL targets provides further insights about the takeover behavior of the different acquirers. Apparently, non-ESL firms do acquire significantly more within their already occupied product categories, namely IC-FE and IC-BE, making little attempts to diversify into the promising new ESL fields.

The confirmation of hypothesis 2b instead of hypothesis 2a is very interesting as it indicates that during times of technological change, firms seem to value their competency and expertise in already established product categories higher than any potential revenue growth in new (heavy demanded) but rather unknown product segments. Thus, we can confirm the existence of some basic principles and mechanisms of organizational learning.

More related and hence more secure investments are preferred over more explorative activities [18]. The fact that this behavior happens during a time of greater technological ferment makes sense as competition over technological leadership happens particularly during these periods [21]. The majority of corporate acquisitions take place in related industries. Thus, intra-industry acquisitions should show a similar picture, but just at a different level. Corporate acquisitions serve very well as a valid measure for this kind of conclusion especially when controlled for internal R&D as a potential supplement.

The significant effect of *industry's annual acquisitions* suggests the existence of additional institutional effects in terms of micro- or macro-economic environments even at the level of a single industry. A stronger form of 'herd behavior' could not be identified since we could not find any support for hypothesis 2a. Nevertheless, our initial statement about the complexities involved in corporate acquisition decisions is validated in this control variable. A methodological contribution of our analysis results from the utilization of detailed product information as an indicator of technological competence. Together with a comprehensive qualitative understanding about the actual value creation of the products offered along the chip design process, we were able to provide explanations for technologically motivated acquisitions that extend the literature by relating to more disaggregated levels. This more detailed level of analysis also provides more relevant practical support by acknowledging product related strategic decisions and the resulting actions on corporate acquisitions. However, in order to being able to inform these kinds of decisions, more industries need to be analyzed in a similar manner.

In summary, our analysis focuses on technology-driven acquisitions and provides empirically tested explanations for certain patterns of acquisition behavior of firms within an industry at a particular time. The methodology of a single-industry focus delivers novel insights into the logic underpinning acquisition dynamics. While such an approach is required to do justice to the complex circumstances in each individual (high-tech) industry, it also has its limitations. An analysis at this single-industry level requires detailed data that is not always available, especially in the case of industries that are larger in terms of aggregate sales volumes, less concentrated and/or more fragmented in terms of products. This also applies to a deep understanding of the actual products as well as knowledge of an industry's relationship with its customers.

Other limitations might come from the exclusion of minority stakes and venture capital or corporate venturing investments, which are known to be very common in high-tech industry environments. Although the omission of these activities may be a weakness of our approach, our strict selection criteria allow for a clearer interpretation of the included deals, which would not have been much improved by adding the aforementioned categories since minority stake investments are typically chosen when uncertainty about future developments is quite high.

Conversely, corporate takeovers that result in full formal control over and responsibility for the target can be seen as an ex-post confirmation of an already convincing performance that is worth integrating into the acquirer's existing business. Along the same lines, our analysis also leaves out any form of inter-firm cooperation because again these reflect situations of greater potential uncertainty.

Future research on acquisition behavior might involve a stronger consideration of the various strategic characteristics of industry players. Our analysis has shown that the mere existence of a technological change or trend may not be enough to show any effect on hitherto dynamic industries. We also encourage more empirical research on acquisition behavior in similar high-tech industries to further corroborate and confirm our findings, and provide evidence from beyond the EDA industry. One has to understand the complexities of a firm's business environment in order to evaluate its behavior and ultimately to offer better managerial implications. We hope that the value of following this convincing argument is apparent from this study.

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