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Genetic Codes of Mergers, Post Merger Technology Evolution and Why Mergers Fail

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Genetic Codes of Mergers, Post Merger Technology Evolution and Why Mergers Fail*

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Abstract

This paper addresses the key determinants of merger failure, in particular the role of innovation (post-merger performance) and technology (ex-ante selection) when firms decide to separate. After a brief review of the existing literature we introduce a model of process innovation where merged firms exibit intra-merger spillover of knowledge under different market regimes, depending on whether firms integrate vertically or horizontally. Secondly, we describe an ideal matching pattern for ex-ante selection criteria of technological partnering, abstracting from financial market power issues. In a final section we test the model implications for merger failure for M&A data from the US biotechnology industry in the 90s. We find that post-merger innovation performance, in particular with large spillovers, increases the probability of survival, while we have no evidence that market power effects do so in long run. Additionally, we find extensive technology sourcing activity by firms (already in the 90s) which contradicts the notion of failure and suits well the open innovation paradigm.

JEL-class. O30, L22, L25, C78, L65

keywords: merger failure, innovation performance, technology, matching, open innovation, biotechnology

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1 Introductory note

With the end of Daimler Chrysler decade another "world company" resolved back into its national components. As the Daimler CEO Zetsche states, ratios for the demerger where to be found in "constantly decreasing synergies within the merger", next to the capital market risks related to ongoing financial transfers to support Chryslers lossy production. The former argument is mostly associated with supply side economies of scale and scope in the merged organization and production in the early merger stages. Anyhow, in our study we investigate that the post merger evolution of technology, i.e. technological synergies, may in the long run become a key aspect why former partners separate .

Increasing overall numbers of Multinational Enterprises (MNE), growing volumes of FDI and volumes of trade are persistent phenomena in the process of globalization (Narula and Zanfei 2003, OECD 2007). Multiple attempts have been made to construct efficient "world companies" that can master survival in global competition. International activities reflect that firms are less focused on national resources of production than they were some years before. In particular, the strategic orientation of R&D processes has recently been subject to change (Blanc and Sierra 1999; Granstrand et al. 1993; von Zedtwitz and Gassmann 2002): Some firms opt for new business models such as Open Innovation (Hippel and Krogh 2006; West and Chesbrough 2006) which explicitly tries to capture and complement knowledge sources external to the firm to internal ones, as new combinations of technological components (e.g. Fleming 2001; Rosenkopf and Almeida 2003) may lead to successful further development in the invention process. Hence, these firms engage in screening and sensing (international) technology markets for new potential resources, and cooperate with partners e.g. through alliances, licensing or mergers and acquisitions (M&A). For the latter, the extent of search processes and subsequent selection of partner are partly subject to commitment and strategic beliefs of firms regarding the general value of technological capabilities (Langlois 1992) for success and their own absorptive capacity (Cohen and Levinthal 1990).

Next to non-technological arguments which clarify the original merger decision such as the managers Hybris motive or capital market based ratios (Mueller 2003; Gugler et al. 2006) for behaviour, there is a technological perspective for M&A activity (Hall 1988) where firms source for knowledge globally or locally, and, that not exclusively relates to efficiencies in production or competition effects in post merger markets (Kleinert and Klodt 2002).

In contrast, we suggest that demerger decisions are grounded more deeply in verificable, rationalized facts like innovative or product market performance in the intraperiod of merger existence, and can also be to some extent referred and quantified by the evolution of technology, at least in high-tech industries, as it is well established that demerger may go along with the risk of negative stock market evaluation (e.g. Agrawal et al. 1992), organization reconstruction or even delisting (costs).

Merger targets and acquiring firms typically can be characterized e.g. by size, being small respectively large, or by construction, being vertical or horizontal. In terms of technology, partner choice and post merger innovative performance has been studied intensively by several contributions in the ultimate years: Most of the papers utilize technological relatedness / proximity between partners to describe the relation between technological portfolios of merging firms (for Germany: Hussinger 2005; for cross-boarder mergers: Hussinger and Frey 2006), a concept that brings together per firm (past) patent application counts and technology classification (Jaffe 1986).

Subsequent innovative performance has been another focus of recent research (Hagedoorn and Dyuster 2000; Colombo et al. 2005; sector-specific: Stephan and Gantumur 2007), e.g. by measuring post merger patent intensity, R&D personnel and R&D productivity. Other studies combine both approaches, the selection problem and ex post performance, or most recently investigate competition effects in regard to technological relatedness (Hussinger and Grimpe 2007).

Demerging unlocks resources, e.g. financial constraints and limited human resources, for further search processes and internalization of external technological knowledge through (inhouse) spillovers (Jaffe 1986), hence demerger may not necessarily be caused by the lack of post merger innovative performance and insufficient technology evolution, but may be motivated by completed, successful internalization of technological knowledge, in particular in high-tech industries. Needless to say, demerger must not bear the connotation of (technological or organizational) failure of a riskful merger experiment driven by mismanagement, but may also have a natural date of expiration.

Below discourse addresses the key determinants of merger failure. A second question focuses on the particular role of innovation and technology when firms decide to separate. In section (2) we introduce a model of process innovation where merged firms exibit intra-merger spillover of knowledge under different market regimes, depending on whether firms integrate vertically or horizontally. Section (3) we test the model implications for merger failure for M&A data from the US biotechnology industry in the 90s, section (4) concludes. We find that post-merger innovation performance, in particular with large spillovers, increases the probability of survival, while we have no evidence that market power effects do so in long run.

2 linkages between merger (failure) and innovation

When merger pairs form and possibly separate they run through a process of selection and a process of de-selection. To see what really drives these processes it is necessary to fully understand their motives and causes. The end of a merger is not necessarily the point in time when investigation should end.

Firstly, the selection process may be initiated by a variety of motives. Possibly, these may include individual pursuit of managements, increase in market power or maybe following technology sourcing motives e.g. to amplify a firms technological profile. The causes that finally govern the selection process may differ from original motives of the merger, as, in most cases, capital markets and a firms individual or relative[1] financial power on these markets may even change rational selection decision.

Secondly, the potential process of de-selection is much more complex to analyse as *only one* of the primary sources causing failure may lie in a posteriori misled selection process. General production performance, that is production synergies from post-merger economies of scale and scope, or when focusing on innovation performance, potential process and / or product innovation success, again, by increases in R&D efficiency via scale and scope economies, via a reduction of substitutional research, or via intra-merger spillovers by mutual learning processes in the common labs that, for the case of process innovation, may have product quality-enhancing or production cost-reducing effects. Next to selection and performance causes of demerger, failure may be well intended and can be motivated i.e. by technological restructuring of a company. Still, other motives

[1] The balance between the acquisors and targets financial power i.e. plays a role if the merger is a hostile takeover. Similarly, several acquisors may bid for an interesting target candidate.

to separate include traditionally unexpected failed, bad performance or drastic changes in the market environment itself[2].

2.1 the role of genetic codes of technology and integration choice: market dominance, post-merger performance and merger failure

Grounded on the basic insights of the model from Kamien and Zang (1999, in the following KZ) we develop a two stage game in which a newly formed merger couple can perfom process innovations under different levels of market concentration. On the models first stage the merger entity decides on common R&D investment, then, on a second stage it optimally sets prices and quantities for a given market structure. As all this happens in the post-merger phase, technological codes of merging partners are predefined, that is exogenously given. Still, these codes define the level of intra-merger spillovers due to the level of the partners individual (technological) experience, technological proximity of partners (Jaffe 1986) and common R&D effort of the merger couple (Kim 1998). Referencing on the absorptive capacity paradigma from Cohen and Levinthal (1990) KZ propose a representation of a firms effective R&D effort that incorporates absorptive capacity as a strategic variable, which we take here as predefined and which we will review in the next section, into their research joint venture model. Specifically, they propose that the i-th firms effective R&D effort X be represented by

$$\mathrm{X}_i = \chi_i + (1-\delta_i)(1-\delta_j)\beta\chi_i^{\delta_i}\chi_j^{1-\delta_i}. \tag{1}$$

In our post-merger scenario, given that partners invest symmetrically, the intra-merger spillovers that additionally, with rate ξ, empower the investment level x of the merger pair summarize to

$$X = x[1+(1-\delta_i)(1-\delta_j)\beta] = \xi x \tag{2}$$

with $\chi_i = \chi_j$ and $x = 2\chi_i$. χ_i respectively χ_j refers to each partners own R&D expenditure level or reduction in its unit production costs, with $0 \leq \delta_i \leq 1$, $0 \leq \delta_j \leq 1$ and $0 \leq \beta \leq 1$. Now the exogenously given parameter β is the fraction of one partners R&D effort that virtually spills over to other partners R&D efforts. In the general joint venture literature it represents the involuntary

[2]These changes in framework conditions of the market maybe caused i.e. by disruptive technologies developed by a third party firm, changes in market regulation or unexpected shift of demand.

spillovers from a partners R&D activity that it has only a limited ability to curtail, such as the information disclosed when patents are granted, information provided in trade and scientific publications, information provided through reverse engineering, information disclosed through the migration of employees, suppliers, and customers, and industry-wide rumors and gossip. In our context, we re-interpret the parameter as a measure of technological proximity (Hussinger 2005) between merging partners that restricts or enhances well-intended, intra-merger spillovers, basically saying that partners with technologically closer competences can learn faster and more profound from each other as they are carriers of similar technological regimes (Nelson and Winter 1977; Marsili and Verspagen 2002) and most probably employ members of the same / a similar technological community (Rappa and Debackere 1992).

The term δ, on the other hand, refers to the endogenous control the i-th partner can exert on the spillovers its R&D activity generates through the choice of an R&D approach. A very narrow, firm-specific approach corresponds to $\delta = 1$ and generates no spillovers to others because the information it provides is to some extent irrelevant to them, it can only hardly be decoded and learned. On the other hand, it also limits the firms absorptive capacity. At the other extreme, a totally non-specific approach, i.e. a basic approach, corresponds to $\delta = 0$ and generates the maximum spillover to others but also maximizes the firms absorptive capacity for any level of its R&D spending. Again, as we treat δ as a non-strategic, exogenous parameter, each partners absorptive capacity (AC) is predefinded, so that for partner i respectively j, with symmetric investment, it is given that

$$AC_i = (1 - \delta_i)\chi_i^{\delta_i} \tag{3}$$

and

$$AC_j = (1 - \delta_j)\chi_j^{\delta_j} = (1 - \delta_j)\chi_i^{\delta_j}. \tag{4}$$

In the merger context, absorptive capacities reflect the individual *potentials* for successful technological integration of merging partners, and, hence, may offer a first *ex ante criteria* for profound analysis on technological synergies developed in the post-merging innovation perfomance phase.

When solving the model recursively, we assume a simple, Cournot competition market model where the merger couple faces an inverse, linear demand function, $p = a - Q$, with an *overall* merger output of Q, given that $a > Q \geq 0$. Furthermore, without loss of generality, we suppose a negative demand curve slope of -1.

The mergers profit function π^z as modelled by KZ compounds potential process innovation effects of effective investment reducing common marginal production costs $C(Q,X)$ - from their initial level of A to somewhere below that level -, and an exponential, non-negative cost function for R&D effort[3], $\bar{C}(R\&D)$. More precisely, it resumes to

$$\pi^z = pQ - C(Q,X) - \bar{C}(R\&D) = pQ - [A - X]Q - 0.5\gamma x^2, \tag{5}$$

with $[A - X] \geq 0$ and $\gamma > 0$.

Depending on the structure of the market z, $z = [mon, duo]$, the equilibrium solutions of the game change. Let us suppose that horizontal mergers - more than vertical ones - are associated with larger, immediate market power, i.e. that firms merging horizontally may perform in a monopoly structure while vertical mergers compete with some third party in a duopoly. Then, for the former structure, solving the profit-maximization problem of the horizontally merging entity from equation (5) resolves to

$$\max_x \pi^{mon} = \tfrac{1}{4}(a - A)^2 + \tfrac{1}{4}x[(\xi^2 - 2\gamma)x + 2\xi(a - A)] \tag{6}$$

with an optimal, common investment level $\tilde{x}^{mon}$ of

$$\tilde{x}^{mon} = \frac{(a - A)\xi}{2\gamma - \xi^2} \tag{7}$$

under monopoly pricing and quantities on the second stage, so that profits summarize to

$$\pi^{mon}(\tilde{x}^{mon}) = \tfrac{1}{4}\left\{(a - A)^2 + \frac{[(a - A)\xi]^2}{2\gamma - \xi^2}\right\} \tag{8}$$

Analogeously, under a duopoly scheme, with no spillovers to the third party firm assumed, the profit-maximizing problem of a vertical merger pair on the first stage is

$$\max_x \pi^{duo} = \tfrac{2}{9}(a - A)^2 + \tfrac{2}{9}x[(\xi^2 - \tfrac{9}{4}\gamma)x + 2\xi(a - A)]. \tag{9}$$

Again, the optimal R&D effort $\tilde{x}^{duo}$ derived from the F.O.C. is

$$\tilde{x}^{duo} = \frac{(a - A)\xi}{\frac{9}{4}\gamma - \xi^2} \tag{10}$$

[3]Note that throughout the model it is assumed that different R&D approaches rely on similar R&D cost functions.

respectively, for maxmial profit

$$\pi^{duo}(\tilde{x}^{duo}) = \tfrac{2}{9}\left\{(a-A)^2 + \frac{[(a-A)\xi]^2}{\frac{9}{4}\gamma - \xi^2}\right\}. \tag{11}$$

It is easy to see (eqs. (8) and (11)) that profits under the monopoly scheme are somewhat higher, given identical parameters in both markets, than in a duopoly market, put differently it is always the case $\pi^{mon}(\tilde{x}^{mon}) > \pi^{duo}(\tilde{x}^{duo})$. Anyhow, considering investment incentives under each market regime, $\tilde{x}^z$, it is interesting that even though potential amortization of process innovation efforts seem to be higher due to the larger scale of production as a duopolist, they are outweighed by the option of the monopoly pricing margin as a direct transfer mechanism of R&D costs to consumers[4].

H 1: For an identical set of parameters $[a, A, \gamma, \xi]$ in both market structures, the immediate effect of market power on profits is higher for horizontal merger than for firms merging vertically, given that above market structure - integration type - assumption holds. Hence, horizontal integration may decrease the risk of merger failure in the long-run while vertical integration generates a lower probability of survival.

We find that generated profits from market power may crucially depend on the intra-merger spillover effects $\xi(\delta_i, \delta_j, \beta)$ on process innovations whatever type of merger one considers, when keeping all other parameters $[a, A, \gamma]$ fixed. Then, it may be even the case that due to large spillovers the acquisor may wish to opt for a vertical rather than horizontal partnering firm / target as the market power effect is overpowered by the effectiveness of R&D investment on process innovation and, hence, drastic increases in profits. Conclusively, it will become important to elaborate on *how merger pairs should be formed* that maximize spillovers - if we abstract from the market integration issue-, and, hence, make common R&D efforts more effective and help increase profits from process innovations.

H2: For larger (smaller) values of ξ, that is higher (lower) levels of intra-merger spillovers, the effectiveness of R&D effort is enhanced (reduced) so that the altitude of process innovations and, hence, joint profits should increase (decrease). From a dynamic perspective, this may lower (increase) the probability of merger failure.

[4]These structural results are in the Schumpeterian line of reasoning that more concentrated markets lead to higher levels of innovation.

Different to the KZ model where firms set R&D approaches strategically for the purposes of successful joint venture in research on an additional stage of the model, we apply exogenously set R&D approaches as a key (technological) characteristic in the (strategic) selection process for finding the adequate merging partner, for a given technological proximity of partners. Firms with different R&D approaches are either high or low types, which in our model translates to broader, respectively narrow approaches (smaller or larger δ). Basically, the selection process points towards certain, optimal patterns of matching and technology sourcing (Malerba and Orsenigo 1993) which we will investigate on in the following section.

2.2 positive assortative matching patterns: the role of genetic codes of technology for merger selection and failure

Suppose, we have two types[5], $\delta_i' > \delta_i$ and $\delta_j' > \delta_j$, for each firm i and j as binary gender (either acquisors or targets) in a two-sided model with *assortative matching* (Legros and Newman 2007, in the following LN). Let I be the set of acquisors on one side of the market and let J be the set of targeted firms on the other. The description of a specific economy[6] includes an assignment of individuals to types via maps $\rho : I \to P$ and $\alpha : J \to A$, where P and A are compact subsets of $\mathbb{R}$. To simplify the exposition, we assume that I and J have the same cardinality. The joint R&D payoff function of the matched merger pair is described by the level of spillover exibited due to common R&D effort (eq. (2)), so that the firm-specific utility maxmimization problem ϕ for firm i in finding the optimal matching partner simplifies to

$$\phi(\delta_i, \delta_j, s) = \max_{\delta_j, s}(1-s)\xi x \tag{12}$$

$$s.t. \quad s = \frac{AC_j}{AC_i + AC_j} \tag{13}$$

with the sharing rule s, $0 \leq s \leq 1$, that is implicitely contracted by the predefined absorbtive capacities of each partner (eqs. (3) and (4)). The utility share firm i gets from exibited spillovers is $(1-s)$ while firm j gets a share of s. Obviously, for

[5]De facto we observe the discrete case with a continuum of types.

[6]Two further assumptions are generally made on matching models, namely (1) that the payoff possibilities depend only on the types of the agents and not on their individual identities, and (2) the utility possibilities of the pair of agents do not depend on what other agents in the economy are doing, that is, there are no externalities across coalitions.

non-symmetric cases of ACs firms then profit very differently from spillover effect inside the merger, when, from an evolutionary perspective[7], i.e. the *potentials to learn* from each others technological competences vary. Put differently, the difference in the pace of learning may lead to an asymmetric technological integration success in short- or mid-term run that may be perceived - at least from the partner with minor AC potentials - as a minor level of technological synergies in individual, post-merging innovation performance while the higher AC firm may benefit from this particular formation, even though product market profits from common, *median* process innovation altitude are assumed to remain unchanged in the long run[8].

H3: With significantly different absorptive capacities of merging partners sharing of exibited intra-merger spillovers is asymmetric as they learn at a different speed from each other, which may enforce merger failure in the (early or mid-term) phases of technological integration.

Ideally, the selection process of merging firms should lead to a *positive assortative matching* (PAM) pattern, that is high (low) types will match with high (low) types, as this should maximize spillovers and, hence, altitude of process innovation. This is the case if firm i's utility function from exibited spillover (eqs. (12) and (13)), and analogously firm j's, are increasing (or more precisely, non-decreasing) in type, in other words, if matching with a broader R&D approach partner this should increase the joint spillover payoff. So given that below equations hold

$$\phi_1(\delta_i, \delta_j, s) \leq 0 \tag{14}$$

$$\phi_1(\delta_i, \delta_j, s) = (s-1)(1-\delta_j)x\beta - s'x\left[1 + (1-\delta_i)(1-\delta_j)\beta\right] \leq 0 \tag{15}$$

and

$$\phi_2(\delta_i, \delta_j, s) \leq 0 \tag{16}$$

$$\phi_2(\delta_i, \delta_j, s) = (s-1)(1-\delta_i)x\beta - s'x\left[1 + (1-\delta_i)(1-\delta_j)\beta\right] \leq 0, \tag{17}$$

[7]Rather than focusing on profit-maxmizing product market orientation, this perspective considers the evolution of merger cooperation and its implications for post-merger innovation performance.

[8]Please note that our application of the KZ model does not explicitly consider a specific post-merger phases of technological integration activity. Still, it may be quite useful to think of i.e. post-merger period of re-organization of R&D facilities, general learning on mutual skills and developing a set-up of a common R&D agenda.

individual payoff functions are type increasing as

$$s' > 0, \tag{18}$$

if, and only if

$$1 - \delta_j \geq \frac{1}{\ln(\frac{x}{2})}, \quad 1 - \delta_i \geq \frac{1}{\ln(\frac{x}{2})} \tag{19}$$

which basically requests that a certain level of common R&D effort is made for spillover effects to unfold fully inside the merger.
Additionally, sufficient conditions for PAM according to the *generalized increasing difference conditions* suggested by LN must satisfy

$$\phi_{12}(\delta_i, \delta_j, s) \geq 0 \tag{20}$$

$$\phi_{12}(\delta_i, \delta_j, s) = -(s-1)x\beta + s'x\beta\left[(1-\delta_i) + (1-\delta_j)\right] - s''x[1 + (1-\delta_i)(1-\delta_j)\beta] \geq 0, \tag{21}$$

and

$$\phi_{13}(\delta_i, \delta_j, s) \geq 0 \tag{22}$$

$$\phi_{13}(\delta_i, \delta_j, s) = s'(1-\delta_j)x\beta - s''x[1 + (1-\delta_i)(1-\delta_j)\beta] \geq 0. \tag{23}$$

If eqs. (18) and (19) hold, then it easy to show that $s'' \leq 0$. Generally speaking, condition (20) secures type-type complementarity as commonly used in matching models, while condition (22) secures an additional type-payoff complementarity that guarantees PAM, even in those cases with type-related, limited (or non-) transferability of utilities where agents may be limited in the bidding competition for the higher type partner.

In our context, the implications from the ideal PAM result suggest that for the technology sourcing firm searching for the right partner, technologically most proximate firms with more narrow R&D approaches and firms with broader R&D approaches should match. Technologically-driven merger selection whose success or failure crucially depends on post-merger innovation performance must consider the potential effects of spillovers as well as the aspect of sharing / absorbing these effects in the integration phase.

3 testing

3.1 data description

In order to test the derived hypotheses H1-3 we develop a data set of 3804 M&A deals in the US biotechnology sector, as a high-tech and innovation-driven industry, for the period from 1990 to 2000, excluding cross-boarder transactions, and also well before international stock crisis right after the turn of the century. Additionally, we explicitely focus on those deals in the THOMPSON©SDC Platinum M&A data bank where full legal ownership changed from target to aquiror, that is i.e. 100 % stakes were transferred. The data supplies date of acquisition, industry classification of targets, respectively acquisors, and some general information on primary business activities of both parties. 44 of these deals could be identified as being cases of de-merger for the observed period of time. The rate of failure may seem too low and may contradict other studies on the issue (see for example Porter (1987) who assumes about 50% of mergers to fail) at first sight, but as we assumed that de-merging was present when targets re-appeared[9] on the M&A market for technology after being acquised in the first place, numbers become more reasonable. Most probably, we still may have a certain bias in our data as we solely considers divesture cases where the re-acquised target still had some technological value for others, and we cannot identify those merger failures e.g. were the merger was delisted or even went bankrupt. Figure 1 presents the survival time of these failure cases for the biotechnology industry in comparison to merger life cycles we found in other US high-tech sectors. Table 1 summarizes the biotechnology sample used in the next section.

	vertical mergers	**horizontal mergers**	**overall no.**
failure cases	31	13	44
survival cases	2632	1128	3760

Table 1: Descriptive statistics of US biotechnology domestic mergers (1990-2000) sample. Horizontal merger if target and acquiror have identical SIC / industry class., vertical formation is otherwise assumed.

The cases of merger failure identified were supplemented by a sample of surviving mergers that was drafted randomly, and, both are matched to a separate, extensive patent analysis of 68 companys patent portfolios with USPTO patent data. For the latter analysis we exclusively focused on (US) patent applications -

[9]It is assumed that with the second transaction date the failing merger ends.

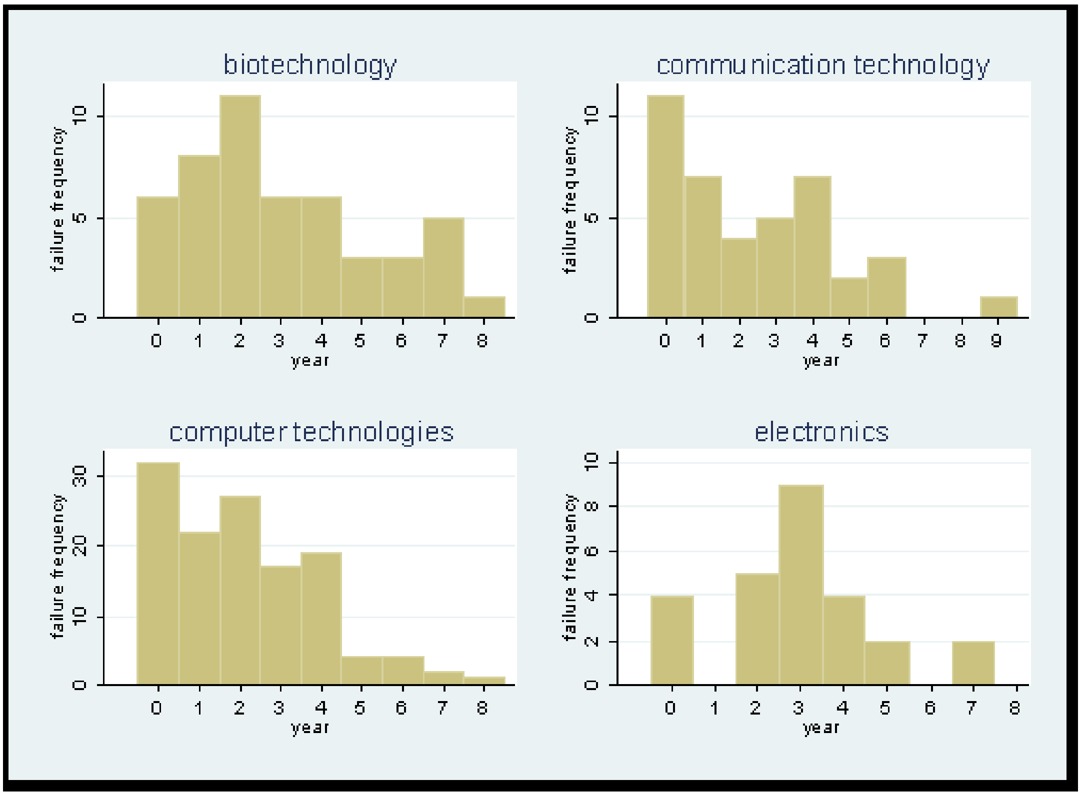

Figure 1: Life cycle / survival time of failed domestic mergers in the US biotechnology, electronics, computer and communication industries, 1990-2000.

as an indicator of the present margin of a firms innovation activity and the firms profile of central technological competences - and, we also assumed a constant depreciation rate of knowledge of .15 when calculating actual patent stocks of each company. Each individual application is assigned to a technology class according to the International Patent Classification (IPC) that covers eight different technology fields, A-H, and an extensive sub-categorization where, for the purpose of our analysis, we applied the 4-digit level. In order to control for the importance of the individual patent classes for the firm the percentage of the firms total patent application stock is used rather than absolute numbers. Relative stocks in each sub-category then map the conclusive technological profile / vector of each firm. Technological proximity β between two firms i and j is defined as the *angular separation or uncentered correlation* measure. Based on their technology vectors F_i and F_j technological relatedness is calculated as

$$\beta = \frac{F_i F_j}{\sqrt{(F_i' F_j)(F_i F_j')}} \tag{24}$$

with $0 \leq \beta \leq 1$.

Additionally, we measure the narrowness / broadness of R&D approaches δ of a firm i by its entropy regarding specific scientific fields l (Grupp 1997), that is a compound measure for *concentration* of a company's innovation activities in terms of broadness and intensity

$$\delta_i = -\sum_l p_{li} \ln p_{li}, \tag{25}$$

where p_{li} is the share of activities of i in patent class sub-category l, given the secondary condition that $\sum_l p_{lk} = 1$ holds. Hence, in the case that activities are concentrated in only one IPC field the entropy index is $\delta_i = 0$, while for an equidistribution of shares in all relevant subcategories the entropy level simplifies to $\delta_i = -\ln(\frac{1}{l})$.

3.2 estimation and results

For testing our merger survival hypotheses we use a Cox proportional hazard model that estimates the probability of survival past time t. It also has the property that it leaves the baseline hazard unparameterized $h_0(t)$, that is there is no assumption about the shape of the hazard over time. This semiparametric model, with coeffients ω'_k and variables x_u, is of the general form

$$h(t|x) = h_0(t)\exp(\omega'_k x_u) \tag{26}$$

Furthermore, we integrate dynamic measures for rates of change (pre- vs. post-merger perfomance[10]) in absolute numbers of patents and in joint entropy of the merger pairs [entro-rate; patnum-rate], as covariates exponentially varying over time. All other static variables [sic-market; proxi; entro-diff; both-entropy] are treated as fixed in the model. After running the estimation (table 2), we test the proportional hazard assumptions based on Schoenfeld residuals (see appendix, table 3) to secure the general validity / non-violation of the global model.

Estimation results suggest that we have no evidence that market power / market relatedness effects play a significant role for demerger [sic-market]. That is saying, matching vertically - having a different SIC industry classification - does not restrict the probability of survival, so H1 can be rejected. This suits well the notion that the effect itself may be a more immediate than long-term one. Alternatively, the above assumption on market power - integration type that

[10]Innovation performance for failure cases is measured for the period of merger duration and for a similar period ex ante, while for non-failure cases we observe four-years performance ex ante including the merger birthdate, respectively ex post.

_t	Coef.	Std. Err.	Haz. Ratio
rh			
proxi	-3.018952†	1.09849	.0488524†
sic-market	.0001819	.0002688	1.000182
entro-diff	.3539174	.5812657	1.424637
both-entropy	.1228839	.2605835	1.130753
entro-rate	24.19165	21.30897	3.21e+10
patnum-rate	-4.511153†	2.044494	.0109858†
t			
entro-rate	-3.156823	2.938956	.0425607
patnum-rate	.5596401†	.2747942	1.750042†

N = 34, time at risk = 46,578, χ^2 = 20.96, † = 95% conf. interval

Table 2: semiparametric Cox proportional hazard model

forms the basis for H1 may be violated.
For H2 the evidence is much harder to grasp fully as the level of spillovers depends on the common broadness of R&D approaches [both-entropy] and technological proximity of merging partners [proxi]. Partly, it must be rejected as entropy measures have no significant impact on hazard rates, even when we adjust for technological proximity. On the other hand, proximity of partners seems to reduce the separation risk as more proximate merger pairs have a hazard of failure that is only about 5 % of the hazard for those who have very technologically distant competence profiles. Intuitively, this results suggest that proximity is enhancing intra-merger knowledge spillovers but it maybe also attributed to some extent to an increase of R&D effiencies inside the merger where similar competences, and hence, R&D resources - clearing of substitutional research - are refocused on existing complementary or new fields of R&D. Hence, H2 is, at least partly, satisfied but still needs further investigation.
Asymmetry in absorbtive capacities has no significant impact on hazard rates, so that H3 must be rejected. As asymmetry [entro-diff] is an ex ante criteria with only early integration stage influence it is of minor importance for long-term failure decisions. Anyhow, lets keep in mind that some of the criteria of selection seem to be essential for the separation process.

Turning to the more post-merger performance orientated criteria, indicators [entro-rate; patnum-rate] suggest that changes in joint entropy are not significant while the effect of absolute patent application number rates is somewhat puzzling. If we treat the rate as a fixed variable in the model we get the general notion that a good innovation performance, indicated by an (100%) increase in applications, should reduce the risk of failure, that is the relative hazard is only 1%. Oppositely, if we assume the variable to vary over time, as we really should expect, the hazard for high-patenting mergers is about 75% higher than the hazard of a minor performance pair. With respect to the data context here (our definition of failure cases) it may be the case that high-performance becomes an indicator of a successful absorption process of the partners technological competences where failure is only a strategic re-orientation of management. The finalization of such a technological sourcing proceedure in the data contradicts the commonly acknowledged notion of bad innovation performance as a cause for failure.

4 conclusive remarks

Federal or European policies of merger control have been mostly concerned with protecting consumer rents from post merger reaping of extra profits from increased market power. If we consider the economic logic of technology sourcing this view may well be short-sighted. Given that mergers are expected to be temporary constructs internalizing technology, and, can be identified ex ante by the authorities, short-term product market profits should not be the only decision principle. Long-term macro effects for sustainable growth in the whole industry that are driven by successful technological change via spillover and increasing innovation may overcompensate the latter effects for consumers.
Similarly, a broader evaluation scheme by stock market analyst can now turn out to be positive, with respect to the technological potential for future firm growth enhanced by demerger. However, the original merger partner choice, whether technologically proximate firms are selected or not, and the continuing analysis of post-merger performance, based on the revealed patterns from Hypotheses (2), should have an impact on firm selection itself and, possibly, stay or exit strategies inserted by managers.

5 appendix

	rho	chi2	df	Prob>chi2
proxi	-0.56779	7.00	1	0.0082
sic-market	0.44505	6.34	1	0.0118
entro-diff	0.37359	5.94	1	0.0148
both-entropy	0.31318	2.69	1	0.1010
entro-rate	0.05758	0.07	1	0.7955
patnum-rate	0.15558	0.32	1	0.5690
entro-rate	-0.08776	0.17	1	0.6793
patnum-rate	-0.19614	0.54	1	0.4637
global test		15.53	8	0.0496

Table 3: hazard assumptions global test by Schoenfeld residuals

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