ON THE COMPANY-SPECIFIC NATURE OF PROJECT SUCCESS DRIVERS IN PRODUCT DEVELOPMENT:
An Empirical Study of a European Technology Manufacturer

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Abstract

A large body of work in new product development (NPD) literature has identified a number of robust success drivers in NPD projects, such as an attractive market, structured project execution with a champion, cross-functional involvement, management support and customer input. The approach is found to be contingent on project newness: Less structure and more exploration is needed in radically new NPD projects.

This article sets out to replicate these success drivers in a large diversified European technology manufacturer, based on 90 NPD projects across many different business units. We find first that a large market does indeed support project success. Second, we identify three predominant project risk profiles: incremental projects, line extensions, and radically new projects. The latter offers highest success, which is consistent with a "risk premium" demanded from high-risk projects, but also reflects the company's project portfolio. The existing portfolio of the firm is concentrated on relatively low-growth and less profitable markets, while radical projects manage to target more attractive markets. Third, we establish three co-existing project management approaches: projects following the formal company NPD process, "pet projects" supported by a high-level sponsor, and "under-the-table projects" driven without official structure by the initiative of an individual low in the hierarchy. Formal projects offer slightly higher product quality and seem to adhere more closely to their schedules. However, the three approaches appear to be used randomly across risk profiles and market characteristics, which weakens their observable performance differences.

Based on these findings, we argue that the "general" NPD success drivers provide insufficient explanation of project success. Success critically depends on company-specific circumstances: the existing product-market portfolio determines the desirable mix of radical and incremental projects. Flexibility and effectiveness of the existing NPD process, characteristics of the established project selection routine, and the existence of linking structures between separate NPD processes influence the performance of the approaches. We believe that these factors represent company-specific constructs that should be included in NPD success driver literature.

1. INTRODUCTION

A wide range literature exists on success drivers in new product development (NPD) projects. This literature has identified a number of "best-practice" success drivers indicating how to conduct such projects (Table 1). The success factors are found to vary somewhat according to the industry (e.g., [9]) and on the newness of market and technology [2, 19]. The question which arises is how applicable such "best practice" recommendations are in a specific organization. This article sets out to replicate the factors in a large European diversified technology manufacturer, based on 90 NPD projects.

We find first that a large market (but not market growth) supports project success, consistent with previous findings (e.g., [4, 31]). Second, we identify three predominant project risk profiles: incremental projects, line extensions, and radically new projects. The latter have previously been found to carry the highest risk, or probability of failure [15]. In our sample, they offer the highest success, which is consistent with a "risk premium" demanded from high-risk projects. However, this success reflects, at least partially, the company's project portfolio. The existing portfolio is concentrated on relatively low-growth and low-profitability markets, while radical projects manage to target more attractive markets. Third, we establish three co-existing project management approaches: projects following the formal company NPD process, "pet projects" supported by a high-level sponsor, and "under-the-table projects" driven without official structure by the initiative of an individual low in the hierarchy. Formal projects offer slightly higher product quality and seem to adhere more closely to their schedules. However, the three project management approaches appear to be used "randomly," that is, not consistent with risk profiles and market characteristics. This untargeted use seems to obscure potential success differences.

Based on these findings, we argue that the "general" NPD success drivers provide insufficient explanation of project success in the specific circumstances of a given organization. Profitability and the risk profile of the existing product-market portfolio determine the desirable mix of radical and incremental projects. Flexibility and the effectiveness of the existing NPD process influence the value of a structured approach. Selection criteria used and the political power distribution in the established project selection routine determine whether high-level sponsoring is attractive. Finally, the existence of a structure to transfer exploration by individuals into the official NPD process influences the value of unofficial "under-the table projects" to the organization. We believe that these factors can be measured, and thus represent company-specific constructs that should complement NPD success driver literature.

We present the relevant literature and formulate hypotheses in Section 2. Section 3 describes the data and outlines the methodology, and in Section 4, we present the results. Implications of this research are discussed in Section 5. We conclude with an outlook of future work.

2. LITERATURE OVERVIEW

Over time, many studies have identified a large number of success factors for new product development (NPD) projects. A selection is summarized in Table 1; however, a complete overview is beyond the scope of this paper. As early as in the 1970s, several management policies, such as the understanding of user needs, attention to marketing, efficiency of development, effective use of outside technology, and seniority and authority of responsible managers (Rothwell *et al.* [27]), were proposed. A classic study by Mansfield and Wagner [20] found that early economic evaluation and a concentration on demand-pull projects enhanced success probabilities.

Success Driver	Study
Market:	
market size	Rothwell *et al.* 1974, Zirger & Maidique 1990 [27, 31]
market growth	Zirger & Maidique 1990, Montoya-Weiss 1994 [31, 22]
market position	Krogh *et al.* 1988 [15]
Product:	
product advantage	Cooper 1987, 1994, 1995; Kleinschmidt and Cooper 1991, Montoya-Weiss 1994 [5-7, 14, 22]
market newness	Krogh *et al.* 1988 [15]
Development process:	
customer orientation, demand pull	Rothwell *et al.* 1974, Mansfield & Wagner 1975, Cooper *et al.* 1987, 1995 [27, 20, 5, 7]
functional competence	Cooper *et al.* 1987, Zirger & Maidique 1990 [5, 31]
cross-functional cooperation	Cooper and Kleinschmidt 1995, Clark and Fujimoto 1991, Moenart *et al.* 1994, Gatignon & Xuereb 1997 [7, 3, 21, 11]
top management support	Montoya-Weiss 1994, Brown & Eisenhardt 1995, Cooper *et al.* 1995 [22, 2, 7]
formalized project selection	Cooper *et al.* 1997, Roussel *et al.* 1991 [8, 26]
planning and execution	Brown & Eisenhardt 1995, Clark & Fujimoto 1991, Cooper & Kleinschmidt 1987 [2, 3, 5]
early specification, tight process with formal measures	Ransley & Rogers 1994, Wheelwright & Clark 1992 [24, 29]
strong project manager	Brown & Eisenhardt 1995, Clark & Fujimoto 1991, Wheelwright & Clark 1992 [2, 3, 29]
Process contingency	Eisenhardt & Tabrizi 1995, Lynn *et al.* 1996, Leifer 1997, Balachandra & Friar 1997 [9, 19, 16, 1]

Table 1: Project Success Drivers From the Literature

Follow-up studies added product superiority, project definition, and synergies with marketing to the list (e.g., [5]). Cooper [4] and Cooper *et al.* [6] find that product superiority, the quality of marketing activities, the quality of project planning and

execution, and the quality of pre-development activities are key success drivers. In addition, market attractiveness supports project success.

Zirger and Maidique [31] build on these earlier studies in their own survey of 330 new products in electronics. They confirm and expand on earlier findings and define three key success factors: *functional competence* of the three functions; *strong communication* with the customer; and finally *strong management execution,* or the ability to hold together the three functions and to steer them in a coherent direction. In addition, external factors such as a large and growing market, or weak competition, increase the likelihood of success in certain development projects.

Clark and Fujimoto [3], in their landmark study of the world auto industry, find that intensive cross-functional cooperation, activity-overlapping, and cooperation with suppliers in design (use of black-box components designed by suppliers) contribute to NPD project success. The benefit of cross-functional cooperation is confirmed by, among others, Moenart *et al.* [21], and Gatignon and Xuereb [11] who find that interfunctional coordination also helps to make the firm's marketing strategies more effective.

In terms of the NPD process, execution is important [4], and in particular, the use of a formal process with formal progress measures (e.g., Ransley and Rogers [24]). Wheelwright and Clark [29] and Clark and Fujimoto [3] stress, in addition, the need for strong project managers. The internal R & D audit process of the 3M company, a very successful practitioner of innovation, supports the usefulness of formal process and measures: program ratings of an internal process audit are good predictors of the commercialization success of a new product (Krogh *et al.* [15]). Important additional predictors of project success, however, are the degree of similarity to existing technologies and products, and the competitive strength of the company in the market into which the new product is introduced. Less familiar products, and products introduced into a market where the company has a weak position, are very risky, and thus have a high probability of failure.

In a recent survey, Brown and Eisenhardt [2] observe the omission of market context variables in NPD performance research to date, such as market growth or strength of market position. They conjecture the existence of an indirect effect of market variables, that is, the market context influences which NPD performance variables have an impact on business success and which do not. In particular, Eisenhardt and Tabrizi [9] find that tight process management and overlapping is less useful in fast-moving ("high velocity") markets.

Balachandra and Friar [1] conclude that not only market variables, but other context characteristics also have an influence. They propose a contextual framework, in which success factors depend on market newness (to the company), technology newness, and product newness (incremental or radical). They hypothesize that, for example, market studies are very important for incremental product and market newness, but less important for radical innovations, where market research is unreliable (see [17]). Similarly, NPD processes are very important for incremental innovations, but less so for new technologies, where development is less plannable.

Leifer [16] and Lynn *et al.* [19] find that "discontinuous innovations," that is, innovations with a very high performance improvement or cost reduction and/or an entirely new set of performance features, must be managed by a process different from the one used for regular development projects: more championing, looser management, the presence of informal networks, and strong top management support are needed. A discontinuous project may have to be separated from the rest of the organization in order to ensure its survival. The working mode is experimental exploration rather than targeted problem-solving.

Hypotheses

The first hypothesis summarizes the expected positive effects of a favorable market environment in terms of size, growth, and competitive position (e.g., [6, 15, 31]). Projects targeted at favorable markets tend to have higher success levels and a higher success probability.

H1. *Market attractiveness.* A large market with high growth, and a strong market position increase a project's success.

High-novelty products (in terms of technology or market) have been found to be more risky, that is, they have a lower chance of success than incremental products [15]. However, we cannot test this finding because our sample consists of projects that were perceived as successful at the time of market introduction. The projects thus represent "survivors" that have not failed through the development stage; in other words, the products work technically, but can still fail in the market. If the chance of failure is still higher, one would expect the more risky projects to promise a higher return potential than the less risky projects, in the spirit of a "risk premium" (further explained in the methodology section).

H2. *Market risk.* Projects with a degree of newness are more risky, that is, they have a higher failure probability in the market, and are thus expected to promise a "risk premium" in terms of product advantage and project returns.

The third hypothesis expresses the expectation that the robust project success drivers observed in previous studies should also be observable in our study [2, 3, 5, 29].

H3. *Project management approaches.* The following drivers improve project success: the use of cross-functional teams, systematic marketing studies, effective development of new technologies, strong project leadership, rich internal and external communication, and senior management support.

The fourth hypothesis postulates that a structured approach (in terms of market research and project leadership) is less important for high-novelty products than for incremental ones, since contingencies during the project cannot be planned for [1, 9, 16, 19].

H4. *Project management approaches contingent on novelty.* Market research and structured processes are less important for high-novelty products than for incremental new products.

3. THE DATA AND ANALYSIS METHODOLOGY

The company with which we conducted this research is a large diversified, European-based, multinational technology manufacturer. The company held an innovation contest during the summer of 1997, in which 280 project teams from businesses across the world participated. Each business division of the company chose finalists, out of which five winners were chosen. Since the divisions had required different project data to be submitted, and used different selection criteria to choose their respective candidates, the company decided to undertake a follow-up study to ensure a learning benefit from the innovation contest.

The source of the participating projects caused two important caveats in the sample, which required careful consideration in the formulation of hypotheses and the ensuing data analysis:

- *Survivor bias.* The participating projects were all at, or very close to, market introduction, that is, they had all survived cancellation during the development phase (although they were still facing the risk of failure in the market). Thus, in the distribution of project success, the likely worst performers had already been eliminated. Although this should bias results toward insignificance (i.e. it is conservative), the bias must be accounted for in evaluating project risk factors. Because of this survivor bias, we cannot test for the success *probability* of risky

projects, but only for their *level* of success, corresponding to a "risk premium" demanded from these (surviving) risky projects.

- *Project success measures are prospective.* Since all participating projects had only reached market introduction, all success measures are projections, and may be biased. More dangerously, the bias may depend on other variables (such as risk or project size). Influences on these projected success measures must, therefore, be mistrusted if they are not consistent over all measures.

In order to test the above hypotheses, we conducted 2-hour semi-structured interviews with eight project leaders to learn how to phrase our questions and to understand what types of measures seemed to be consistently available in the organization. Based on the interviews, we developed a five-page questionnaire (in the headquarter's (HQ) native language and English). The questionnaire was pre-tested and discussed with three project leaders (two in the HQ language, and one international project in English). Changes were made to improve clarity of the questions. Of the 280 projects that had participated in the innovation contest, 71 were excluded because they concerned administrative or procedural innovations which were not relevant to our study. The questionnaire was sent to the remaining 209 project leaders, with a cover letter from a board member emphasizing the importance of the study for the company. 126 questionnaires were received, for a total response rate of 60%. Of these, 28 were focused on process or service innovations (manufacturing or delivery), and 8 were filled out too poorly to be usable. This left us with a sample of 90 usable product development projects.

Three groups of variables were covered in the questionnaire: variables on the project management approach used, on the newness and risk of the project, and variables on (prospective) project success. Exhibit 1 presents the definitions of all the variables. The project approach variables include measures for market orientation (source and market study), project selection (criteria general, specific, and consistency), project support (champion and resource provider), the use of partnering, the use of a formal process and progress control (process, project manager, and control), and the extent of cross-functional involvement.[1]

The project risk variables include various measures of project newness (product-market, product and technical maturity, and new technology) and of market attractiveness (volume, growth, and competitive position). The success variables are financial return, position improvement (market and technology position, and market

[1] In the tables and the following regression analyses, the various variable scales are treated as interval data, an approach which is somewhat controversial in the literature but often applied (see Kidder and Judd [13], p. 217 f.)

share), product quality, and the duration of the competitive advantage (see [12, 18, 28]). Finally, cost and schedule deviations were also measured.

	Project Approach Variables
Sources:	Number of sources (customers, partners, depts., ...) contributing to the project initiation.
Market study:	Time of market study, 1 = before technology development, 2 = before product developmt., 3 = before market introduction, 4 = not performed since market volume was known.
Internal orientation	Project origination: 1 = cust./market, 2 = competit. analysis, 3 = partner, 4 = internal dept.
Criteria general:	Number of criteria used in general for choosing project ideas to be funded.
Criteria specific:	Number of criteria used for this specific project in deciding to fund it.
Crit. consistency:	Number of criteria in common between general and specific.
Financial criteria	0/1 variable indicating revenue, financial evaluation, or cost criteria.
Market criteria	0/1 variable indicating market share, market development, or competitive criteria.
Product criteria	0/1 variable indicating product line extension/completion, or product improvement criteria
Champion:	Hierarchical level of champion (1 = board member - 7 = individual contributor).
Resource giver:	Hierarchical level of resource provider, coding same as champion.
Partner:	Scale of partner usefulness for project execution: 0 = no partner used, 1 = partner jeopardized success, 2 = partner caused complications, 3 = partner increased project complexity somewhat, 4 = project execution was smooth, 5 = project proceeded better than possible without partner.
Process:	Usefulness scale of standard company NPD process. 0 = process was not used, 1 = process was used but not helpful, 2 = process was used and helpful.
Control level:	Hierarchical level of steering committee, coding same as champion.
Control frequency:	Use of a steering committee: frequency of reports per year (0 if not used).
Project manager:	Index of PM power, defined as the sum of: did a project manager exist (0/1), did he/she have budget responsibility (0/1), did he/she have a dedicated team (0/1)? Each for technology management (if applicable) and for product development, respectively. Scores on the individual variables are correlated with 75%.
Cross-fctl. team:	Number of internal departments actively involved in the project (1 - 5).
	Project Environment Variables
Product-line newness:	2 = new customer segments and new regional market, 1 = one of the two, 0 = none new.
Product maturity:	Lifecycle phase of the innovation: 1 = embryonic, 2 = growing, 3 = mature, 4 = aging.
Market newness:	1 = market known, 2 = market new for the company, 3 = market new to the world.
Technical product newness:	1 = existing product with new application, 2 = modified product or service, 3 = new product with possibly new combinations of known technologies, 4 = new product based on new technologies.
New technology:	Was there a new technology developed for this product (1/0)?
Market volume:	Annual market volume in million DM.
Market growth:	Annual market growth in %.
Market position:	Competitive position before introduction of the new product in question: 1 = weak, 2 = tenable, 3 = favorable, 4 = strong, 5 = dominant.
	Project Success Variables
Return:	3 financial measures were normalized on a 1-7 Likert scale and then averaged: Life cycle margins minus investment costs over project costs (%), (ROS x life cycle revenues) over project costs (%), and company-wide standard internal rate of return measure (%).
Δ Mkt. position:	Market position after minus market position before the project, each coded 1-4.
Δ Techn. position:	Technology position after minus position before the project, each coded 1-4.
Δ Market share:	Market share after the project minus market share before the project (%).
Product quality:	Sum over four 1-5 Likert scales: extent of unique product characteristics, product fulfills customer needs better than competitor products, product is of outstanding quality, product solves a problem customers have with competitor products.
Sched. deviation:	Schedule deviation in % of plan (+ = schedule overrun).
Budget deviation:	Budget deviation in % of plan (+ = budget overrun).

Exhibit 1: Definition of Variables

Projects came from 16 different business units. 74 projects were performed in European countries, 6 in the Americas, and 10 in Asia. The average project size was 26 person years (with a standard deviation of 41) and 9.3 million DM (standard deviation of 13 million). The average project duration was 33 months (standard deviation 28). Exhibit 2 shows the means, standard deviations, and correlations among variables within the groups.

The significant correlations that exist are as one would expect: Among the project management approach variables (Exhibit 2-1), the different selection criteria tend to occur simultaneously. High process use is associated with many sources, and early market study, external orientation of the project source, and many market criteria. A high level resource provider is often accompanied by a high level champion (they are sometimes the same), and also with a weak project manager and with less cross-functional involvement.

Among the project risk variables (Exhibit 2-2), product line, technical and market newness are positively correlated among one another, and negatively correlated with product maturity. Market position is negatively correlated with market and product-line newness, which suggests that entering new markets entails a weak market position.

Among the success measures (Exhibit 2-3), improvements in market position, market share and technology position tend to come together. Furthermore, product quality and financial return are correlated, which is consistent with previous observations that product quality is a key driver of profitability (e.g., [4, 5]). Finally, budget and schedule adherence are associated.

For the analysis reported below, we use mainly regression and clustering with mean comparisons across clusters. We make no mean substitution for missing values, which leads to differing sample sizes across analyses (reported each time). For the clustering, variables are standardized (zero mean and unit variance) in order to weigh them all equally. Several cluster numbers have been attempted in each analysis, and the one reported is based on interpretability and significance of cluster mean differences.

Variable	mean	stdv.	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Sources	1.79	.80	90	-													
2. Market study	2.95	1.24	84	-.09	-												
3. Internal orientation	2.23	1.30	79	-.42	.14	-											
4. Criteria specific	2.14	1.34	90	.13	.13	-.20	-										
5. Market criteria	.42	.50	90	.11	.05	-.14	.60	-									
6. Product criteria	.66	.48	90	.10	.12	-.12	.45	.00	-								
7. Financial criteria	.50	.50	90	.04	.08	-.12	.54	.23	-.12	-							
8. Champion	5.16	1.17	69	.00	.06	.13	-.24	-.24	-.05	-.07	-						
9. Resource provider	4.21	1.10	62	.04	.21	-.14	.10	.09	.14	.17	.42	-					
10. Partner	2.94	2.07	85	.00	-.14	.08	-.08	-.09	.05	-.05	-.01	-.07	-				
11. Process	.80	.93	90	.35	-.22	-.22	.09	.21	.10	-.10	.02	.02	-.03	-			
12. Control level	3.56	1.10	45	.09	.16	.02	.08	.07	.08	.11	.26	.24	.14	-.06	-		
13. Control freq.	6.50	15.97	90	-.03	-.05	-.15	.07	.15	-.11	.01	-.02	-.02	.13	.01	.02	-	
14. Project manager	.74	.30	88	.17	-.11	.00	.12	.08	-.01	.15	-.24	.07	.06	.13	.12	-.19	-
15. Cross-fctl. team	2.05	.75	79	.20	-.04	.02	.07	.04	.12	-.14	-.12	-.28	.12	.28	-.06	.08	.10

Exhibit 2-1: Correlations Among Project Approach Variables

Variable	mean	stdv.	N	1	2	3	4	5	6	7
1. Product-line newness	.98	.78	90	-						
2. Product maturity	1.88	.80	83	-.17	-					
3. Market newness	1.72	.87	85	.35	-.57	-				
4. Techn. product newness	2.94	.78	84	.12	-.36	.24	-			
5. New technology	.47	.50	88	.10	-.09	.11	-.01	-		
6. Market volume	554.68	1324.00	73	-.06	.08	-.12	.10	-.12	-	
7. Market growth	18.67	24.50	70	.10	-.26	.38	.07	.05	-.07	-
8. Market position	2.16	1.10	70	-.26	.08	-.29	.01	-.05	-.19	-.13

Exhibit 2-2: Correlations Among Project Risk Variables

Variable	mean	stdv.	N	1	2	3	4	5	6
1. Return (1 - 7)	3.84	1.57	55	-					
2. Δ Marketposition (1-4)	1.63	1.55	75	-.16	-				
3. Δ Technology position	1.95	1.43	75	.03	.57	-			
4. Δ Market share (%)	19.80	25.80	57	.01	.55	.51	-		
5. Product quality (1 - 5)	4.03	.74	72	.33	.14	.17	.15	-	
6. Schedule deviation (%)	17.84	30.05	63	-.11	.11	.10	-.01	-.15	-
7. Budget deviation (%)	19.20	47.75	59	-.05	-.08	-.06	-.05	.07	.46

Exhibit 2-3: Correlations Among Project Success Variables

4. RESULTS

Influence of Market Attractiveness

We use regression analysis to test hypothesis 1, claiming that a large and growing market, as well as a strong market position, increases project success. We run three regressions with financial return, market share improvement, and position improvement as dependent variables, in order to address the caveat that our success measures are prospective, and thus possibly subject to biased reporting. We are looking for consistent results across the three regressions, mitigating this possible bias. The results are shown in Exhibit 3.

All three regressions are significant (the return regression the least, because the return variable is least reported). Market volume seems consistently to imply more success, although only significantly so for market share and position improvements. Market growth, however, is insignificant. Market share in the target market seems to reduce share and position improvement (although not return). A possible explanation is that when share is already high, it is more difficult to improve it farther. There is an alternative explanation, however, which relates to the company's project portfolio, and is in greater detail discussed below, under 'market risk'. The influence of market newness, finally, is inconsistent - it is associated with a lower return, but higher

market share improvement. In summary, hypothesis 1 is only partially supported, with regard to the influence of market size.

Independent Variable	Return	Δ Mkt. share	Δ Position (Market + Technology)[1)]
Market volume	.20	.40***	.22*
Market growth	.12	.15	.15
Market share before	-.23	-.23**	-.43***
Product line newness	.09	.03	.32**
Market newness	-.69***	.34**	-.06
Adjusted R^2	.26**	.42***	.35***
N	36	47	47

Two-tailed significance levels: * = 10%, ** =5%, *** =1%

1) The Kronbach α of this combined item (market and technology position improvements) is 71.5%.

Exhibit 3: Regression Results of Project Success Potential as Determined by Market Attractiveness

Influence of Project Newness and Risk

Using cluster analysis to identify risk profiles from the multiple risk variables, we found a three-cluster solution reported in Exhibit 4. We report only "low/high" for each variable, as they are standardized, and their numerical values have no meaning.[2] The first cluster is characterized by low levels on all newness variables (high levels on maturity also means low newness). It is high only on existing market position. Thus, we name this cluster "incremental projects."

Variables	Cluster 1: "Incremental"	Cluster 2: "Line extension"	Cluster 3: "Radical"
Market growth* **	low	low	high
Market newness* **	low	low	high
Prod. line newness* **	low	high	medium
Market position* **	high	medium	low
Technical product newness* **	low	medium	high
Technology maturity*	high	medium	low
Product maturity* **	high	high	low
New technology* **	medium	low	high
	N = 35	N = 22	N = 33

Means differ across the clusters at significance levels : *** = 1%, ** = 5%, * = 10%.
Cluster analysis based on standardized variables. Where two clusters have the same classification on a variable, their values were not distinguishable.

Exhibit 4: Project Risk Clusters

[2] The average score per cluster for each variable can be obtained from the authors.

The other extreme is the cluster named "radical projects," which is high in all newness variables, except in product line newness. The intermediate cluster represents product "line extensions" with moderate novelty. The three clusters correspond to project profiles quite familiar in product development literature. Although it is no surprise that all three are present in a company of this size, it is nice that we can so cleanly identify them in the sample. The question posed by hypothesis 2 is whether we can identify a "risk premium" (i.e., higher potential success) for radical projects.

In order to answer this question consistently across all our success measures, we have performed a separate cluster analysis, which reveals two clusters shown in Exhibit 5. The "high potential" cluster shows higher means across *all* success variables. This consistency mitigates the possible reporting problem of the bias stemming from the prospective nature of all the measures.

Variables	Cluster 1: "Lower potential"	Cluster 2: "High potential"
Return* **Product quality***** **Δ market share***** **Δ market position***** **Δ technology position*****	↑ **low** ↓	↑ **high** ↓
	N = 51	N = 37

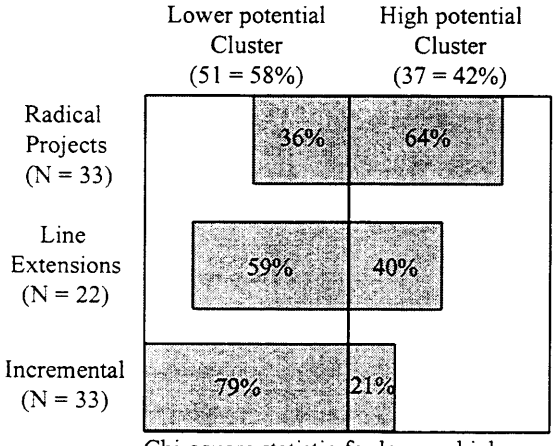
Means differ across the clusters at significance levels : *** = 1%, ** = 5%, * = 10%. Cluster analysis based on standardized variables.

Exhibit 5: Project Success Potential Clusters

We can now assess the relative success of incremental and radical projects and line extensions. Exhibit 6 shows that radical projects look the most and incremental projects the least successful in two ways: first, radical projects have a higher percentage of "successes" (members of the high potential cluster), and second, radical projects consistently have the highest mean on the three success measures of market share and market position improvement, as well as product quality.

Although this looks consistent with hypothesis 2, we can probe more deeply. As was shown under Exhibit 3, a possible explanation of this "superiority" of riskier projects is that they tend to be targeted at markets in which the company has a weaker position, and thus in which more position improvement is possible. This explanation seems reasonable in the light of the overall project portfolio, which contains many projects

targeted at markets with a weak position, and is concentrated on markets with below 20% growth (Exhibit 7: numbers in the cells are numbers of observations).



Chi-square statistic for low vs. high potential counts depending on risk cluster is significant at 1% level.

	Cluster Means		
	Δ market share	Δ market pos.	Prod. quality
Radical Projects (N = 33)	35.1***	2.7***	4.2**
Line Extensions (N = 22)	17.7***	1.3***	4.1***
Incremental (N = 33)	7.3***	0.9***	3.8***

Means across cluster differ at level: * = 10%, ** = 5%, *** = 1%. Differences of variable Return not statistically significant.

Exhibit 6: Project Success Potential Across Risk Clusters

Market Position before Project	0-5	6-10	11-20	21-30	31-40	41-50
dominant						
strong	3	3	3	1	1	
favorable	5	3	3	1	1	
tenable	4	5	6			
weak	6	5	4	3		2

Market Growth (%)

Exhibit 7: Project Portfolio

To test the above candidate explanation, we explore the distribution of radical projects with respect to market position and market profitability (measured by estimated competitors' ROS in the target market), as shown in Exhibit 8. The left-hand side of the exhibit shows that radical projects are concentrated on the low market share ranges, while incremental projects are more evenly distributed (the difference is significant at the 1% level). This supports the suggestion that radical projects manage to improve the market position more because there is more room for improvement. This in itself is, of course, a dangerous strategy.

	0-10	10-20	20-30	30-40	40-50	50-60
incremental projects	6	6	8	1	1	
line extensions	14			1		1
radical projects	18	1	2		1	

Market Share Before Project (%)

	0-10	10-20	20-30
incremental projects	11	2	
line extensions	6	1	1
radical projects	2	2	1

Target Market Profitability (ROS%)

Market share N = 60, Chi-square statistic for dependence of variables significant at 1%.
Target market ROS N = 26, chi-square statistic significant at 5%.

Exhibit 8: Distribution of Project Risk Clusters Over Market Position and Market Profitability

However, the right-hand side of Exhibit 8 gives a more impressive picture of radical projects by comparing the average market profitability of the target markets (measured as estimated competitors' return on sales, ROS, in the target market). The exhibit demonstrates that radical projects manage to target more profitable markets, whereas incremental projects are concentrated on markets with low profitability. Moreover, we find that radical projects target markets with higher growth (significant at the 1% level). We cannot tell how consciously this is achieved, as there are no significant differences across risk clusters in the project selection criteria used (number of market, product, and financial criteria).

Thus, the findings are consistent with hypothesis 2, which predicts a "risk premium" for radical projects. However, this risk premium is attained in a manner very specific to the company's project portfolio: radical projects tend to target markets with a low current position, which can more easily be improved. In addition, these markets offer more attractive profitability than businesses in which the company has a strong position.

Influence of the Project Management Approach

We now turn to the influence of project management approaches on project success. As with project risk above, we identify approach profiles from the many project management variables[3] via cluster analysis. A three-cluster analysis reveals three predominant project management approaches, each used in roughly a third of the sample. They are shown in Exhibit 9.

[3] "Criteria general" and "criteria consistency" were left out of the cluster analysis because they are highly correlated with "criteria specific" and would, in effect, only increase the weight on this variable.

Variables	Cluster 1: "Under-the-table"	Cluster 2: "Pet projects"	Cluster 3: "Formal process"
Control level*	low	high	medium
Resource provider**	low	high	medium
Criteria specific***	high	low	medium
Financial criteria***	high	low	medium
Market criteria***	high	low	medium
Product criteria**	medium	low	high
Market study**	late	medium	early
Intern. orientation***	medium	internal	external
Project manager**	medium	weak	strong
Formal process***	low	medium	high
Sources***	few	medium	many
Cross-fctl. team***	low	medium	high
	N = 25	N = 32	N = 33

Means differ across the clusters at significance levels : *** = 1%, ** = 5%, * = 10%.
Cluster means not different at 10% level for control frequency, champion, and partner.

Exhibit 9: Project Management Approach Clusters

"Formal projects" are characterized by high and gainful use of the company's institutionalized product development process, a strong project manager, an early market study, high cross-functional involvement, and many sources tapped externally in originating the project. Only few (and supposedly targeted) criteria are considered in selecting projects (except for the product-oriented criteria subgroup). The formal procedure makes a high-level resource provider unnecessary. This cluster conforms closely to the recommendations in the literature reviewed.

At the other extreme, we find a cluster named "under-the-table-projects," which corresponds to the company-internal nickname (in the HQ language) for projects done without official authorization. This cluster is characterized by low formalization and low external input on all variables, and by a low hierarchical level of the resource provider and the controlling body (possibly the project group itself). Only the number of selection criteria used is high, which can be interpreted as an attempt to convince potential sponsors.

The third cluster is named "pet projects" because it is characterized by a resource provider high in the company hierarchy and a controlling body reflecting this high positioned sponsor. Project formalization, input, and selection are low. This cluster can be interpreted as a high-level management sponsor driving a project through, bypassing institutionalized routines.

In order to strengthen the rationale for these cluster interpretations, we compare the most-cited success factors and obstacles across clusters, which the participants were asked to fill out in the questionnaire. Exhibit 10 lists them in decreasing order of the number of times mentioned (no. 1 being the most-often named).

	Under-the-table	Pet projects	Formal projects
Success factors	1. personally involved champion 2. product superiority, attractive market 4. technology position of company overall 5. cooperation with external partners 6. cooperation among business units	1. product superiority 2. personally involved champion, technology position of company overall 4. attractive market, cooperation with external partners	1. product superiority 2. team-oriented project organization 3. attractive market 4. customer participation in process 5. knowledge of customer needs, technology position of company overall
Obstacles	1. lack of resources 2. lack of technological know-how 3. problems with partners 4. project management problems 5. missing infrastructure, equipment	1. lack of management encouragement 2. lack of resources 3. weak sales/mrktg. support 4. lack of technological know-how 5. project management problems	1. project management problems 2. lack of resources 3. problems with partners

Exhibit 10: Most-Cited Success Factors and Obstacles by Cluster

First, a "personally involved champion" is at the top of the list in the under-the-table and pet clusters, but not in formal projects (where it only appears as no. 7, along with two others). This cluster is characterized by a "team-oriented structure" and customer participation, as well as good knowledge of customer needs. These success factors support the above interpretation that the formal process clearly delineates responsibilities (making a person less critical as a champion), and that it goes along with formalized cross-functional and customer involvement. The downside is that project management problems are at the top of the obstacle list (resource scarcity is cited as a key problem in all clusters).

Frequent obstacles in the other two clusters are "lack of technological know-how," possibly caused by less involvement of other functions with their expertise. Notably in the under-the-table cluster, lacking infrastructure and equipment are called problems, which is consistent with the bootstrapping nature of unofficial projects. Pet projects frequently complain about "lack of management encouragement" (such as no recognition, no understanding of the struggle, misjudging relevance). Such resistance

may be caused by a high-level resource provider getting the project under way without bringing on board the management surrounding the project team.

To further support the cluster interpretation, we compare the use of the formal development process across clusters. In the formal projects, the process is used to a much higher extent (in 79% of all cases vs. 30% and 24% in under-the-table and pet projects, respectively) and perceived as more helpful as well (helpful in 88% of the usage instances, vs. 42 and 75%, respectively). The most-cited advantages of using the process are structuring (e.g., milestones and checklists, 9 citations) and coordinated proceeding across groups (9), as well as planning (5). 9 projects cite drawbacks of the process. Of these, age ("outdatedness") and inflexibility of the process (4 times) and high process effort (3 times) are the most frequent. These illuminate why "project management problems" might be cited frequently in the formal projects cluster.

After having identified these three co-existing project management approaches, we now wish to test the hypotheses that formal project management is better, but less so in high-novelty projects (hypotheses 3 and 4). However, only weak success differences across the project management approach clusters can be found. The approaches are equally spread across the success clusters in Exhibit 5. Only one success variable exhibits a significant mean difference: product quality is slightly higher for formal projects (mean = 4.15 for formal projects, 4.11 for pet projects, and 3.69 for under-the-table projects, significance level = 10%). Also, formal projects offer some *operational* benefit in the form of the lowest schedule overruns (at 8.4%, difference significant at the 10% level. There is no difference for budget overruns). Thus, hypothesis 3 is supported, but only weakly.

For hypothesis 4, no supporting evidence exists at all. Not only is there no detectable interaction between project management approach clusters and project risk clusters in terms of success, but *there is not even evidence of any targeted use of the project management approaches*. The three approaches are evenly spread across project risk and newness, market size, market growth and profitability. The only difference among the clusters we can find is that pet projects tend to be the biggest (42 PYs) and under-the-table projects the smallest (13 PYs, significant at 10% level), which is no surprise, in the light of the resource control characterizing them.

What is the explanation for the lacking interactions between project management approach and risk? A possible reason for the non-targeted use of the three project management approaches is a lack of understanding of the appropriate context for each approach (i.e., hypothesis 4 is not sufficiently known in the organization). We have

no rigorous backup for this claim, but it is consistent with the multiple interactions we had with managers in different business units of the company. The non-targeted use of the formal process may also contribute to its weak benefits. Although appropriate for projects with intermediate novelty, the formal process may be too heavy-handed for incremental projects (see the above-mentioned citation of too-high costs), and too structured for radical projects, so its untargeted application may muddle its benefits.

5. DISCUSSION AND IMPLICATIONS

The results of this study have two important theoretical implications. First, we find three predominant project management approaches, formal projects, pet projects and under-the-table projects. They are actually not too different from approaches previously identified: formal projects (and the process in place at the company) correspond to the stage gate process recommended by Cooper [4]. Pet projects are reminiscent of managerial commitment to decisions that can lead to the continuation of doomed efforts (see Ross and Staw [25]), and under-the-table projects of "skunk works" [30].

All three approaches offer a potential contribution to NPD performance: the formal process supports professional execution of the majority of all NPD projects [4, 5], under-the-table projects (i.e., small teams and skunk works) can support organizational experimentation for new and unstructured ideas (e.g., Quinn [23], Fujimoto [10]), and pet projects (in our definition they have a high-level sponsor) can be appropriate for difficult undertakings that need very high levels of management support and patience in order to pay off.

However, only a weak success advantage of formal projects emerges from our data, and tellingly, approaches seem to be used indiscriminately across project types and risk profiles. Unselective application muddles success differences. That implies that *success drivers are dependent of the selection of projects and approaches.* The selection of project approaches, in turn, is influenced by a number of characteristics of the organization:

- Effectiveness and flexibility of the process used. For example, is the process perceived as cumbersome and inflexible (see the comments in Exhibit 10)? At what level of project size, complexity and uncertainty is the process targeted? For example, is it a "heavy" process designed for large projects, and thus too structured for exploration, or is it a "light" process with too little structure for large projects? Depending on the positioning, certain projects may be able to be accommodated, or they may need to be shielded from the process.

- Links among different, co-existing, types of project structures. For example, can an initial informal "under-the-table" experimentation be fed into the formal process in a structured way, or does it have to go on forever in order to survive? In the latter case, unofficial projects pose more problems.
- Project selection procedure: First, what are the selection criteria, for example, financial numbers, market share, or the distribution of power in the company? Depending on these criteria, a pet project or unofficial exploration may be the only way to get certain projects under way. In addition, do the project selection criteria also contain recommendations for a project management structure?

These are important (and measurable) constructs with a normative impact on how projects should be performed. They must be included in order to understand project success in greater depth. The generally established project success drivers covered in our hypotheses are insufficient because they do not account for any such company-specific circumstances. It is one thing to design the "ideal" organization and its implications for NPD processes, but there exist extremely few organizations that correspond to such an ideal across the board.

Our second (less important) theoretical contribution is to confirm the result from previous studies that large target markets increase NPD returns. In addition, new markets in which the company has a weaker position, offer higher potential market share gains. Market share gains exhibit "diminishing returns" (in markets where the share is already high, less improvement is possible).

In addition to the theoretical implications, our findings suggest several clear and important managerial lessons for our host company. First, the desired NPD portfolio, in terms of product and market newness, seems to be very sensitive to the structure of the current business portfolio: new markets appear to be inherently more profitable than the markets in which the company is already strong. The most plausible explanation (consistent with previous independent internal investigations) is that the current portfolio is not sufficiently attractive, and thus diversification is needed to find attractive profit potential. In other words, the strategic need for new (and thus risky) products is higher in this company than it may be in others.

Second, the formal process in the company does seem to work (quality and schedule benefits are apparent from the data), but it is used by only one third of the projects in the sample. Most projects are executed as pets or unofficial under-the-table projects. This points to two potential weaknesses in NPD:

- The formal process in this company is a relatively rigid stage-gate process, which is perceived as inflexible in adjusting to specific project needs. This is hinted at by the above citations of process problems, and it is also consistent with

conversations we had with project managers. This may lead to project managers (and sponsors) attempting to "bypass" the official process, resulting in diminished transparency and execution quality. A possible remedy is to either make the existing process more flexible (e.g., design a "light" version for small projects), or to have two process structures run in parallel (one for routine and one for new and uncertain projects).

- A structure to feed unofficial projects into the formal process may be lacking, which would allow under-the-table initiatives, after some initial exploration, to "firm up their case." Thus, entrepreneurial employees may be forced to continue their projects unofficially, which may keep high-potential projects outside the formal process. If experimental investigations by individual employees were officially funded and regularly reviewed, they could be made formal projects, once they have reached a certain level of maturity.
- The undifferentiated use of the three project management approaches emerging from the data suggests that the project selection procedures are weak or incomplete. The project selection and funding procedure has a high influence on project potential (see, e.g., Roussel *et al.* 1991, Cooper *et al.* 1997). For example, if it is political, the identity of the resource provider may become key. If project complexity, newness, uncertainty, and risk are not identified as shaping management approaches, a muddled application of project management results.

6. CONCLUSION AND OUTLOOK

In this article, we have examined the success factors for new product development projects, based on 90 NPD projects in a large diversified European technology manufacturer. As the 90 projects are all at the point of market introduction, market performance forecasts (product quality, financial return, and market share and position improvement) provide success measures. We started with the aim to replicate four findings established previously in the product development literature. We found, however, that the success factors depended on the company's project portfolio and development processes in several ways. Our findings are summarized as follows:

First, a large market, but not high market growth, is associated with increased project success. A strong competitive position even reduces prospective success. This may be related to the fact that once a strong market position is achieved, it is difficult to improve farther. However, it may also be related to the company's business portfolio, which is concentrated on slow-growing and less profitable target markets.

Second, higher project riskiness increases prospective project success. We identify three statistically significant project risk clusters representing the company's portfolio: incremental projects (with low newness across all risk variables), product line extensions, and radical projects (with high newness across all risk variables). This again reflects the company's project portfolio, which is concentrated on relatively low-growth and low-profitability markets, while radical projects manage to target more attractive markets.

Third, we identify three project clusters representing different project management approaches co-existing in this company: "Formal" projects follow the institutionalized product development process implemented throughout the company. This process is characterized by a strong project manager, early market input, and cross-functional involvement. "Under-the-table" projects are characterized by a champion low in the hierarchy, with little supervision and formalization. "Pet projects" are characterized by a resource provider high up in the company's hierarchy who is able to shepherd the project through, with low formalization.

Fourth, we assess the success impact of these project management approaches. From the literature, one would expect that formal project management increases success for projects with moderate newness, but less structure is recommended for projects with very high levels of newness. We find operational success advantages of formal projects: they promise slightly higher product quality, and seem to adhere more closely to their schedules. However, there is no evidence that the company chooses systematically among the approaches depending on project or risk characteristics -- the use of the approaches seems random in the sample. Thus, an undifferentiated application of project management approaches seems to "muddle" their success differences.

We conclude that general variables, such as those used here and throughout the literature on the topic, are insufficient to recommend product development approaches within an individual company. Close attention has to be paid to company-specific circumstances: the conservativeness of the project portfolio influences the value of risky projects. Operationally, the success of project management approaches depends not only on market attractiveness and risk, but also on the structure of the exisiting process, the characteristics of the project selection procedures, and the links between processes (for example, whether under-the-table projects have a systematic path towards becoming official projects).

This study, we believe, calls for research to identify additional constructs that can capture the company-specific circumstances in product development. The constructs

proposed in this study are the profitability and risk profile of the existing business portfolio, flexibility of the NPD process in place, *de facto* used project selection criteria (including political power), and structural links between separate NPD processes. Only when such "idiosyncratic" influences are better understood can we improve the quality of our NPD recommendations in existing organizations.

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