EFFECTUATION IN THE CONTEXT OF R&D PROJECTS: CHARACTERISTICS AND IMPACT ON PROJECT PERFORMANCE

DANIEL KÜPPER
RWTH AACHEN
Templergraben 64, 52062 Aachen, Germany

TINA BURKHART
RWTH AACHEN

ABSTRACT

The aim of this study is to adopt a new theoretical concept called effectuation to the R&D project management research. This concept brings in a new perspective on the issue of how to accomplish successful R&D projects by focusing on the decision making in uncertain situations.

INTRODUCTION

To compete successfully, technology based firms need to be innovative. Considerable resources have to be invested in research and development (R&D) to enable the short term oriented exploitation of the existing product base as well as the long term oriented development of new, highly innovative products. To date it is widely accepted that both exploitation and exploration are required to assure the long term success of organizations (e.g., Benner & Tushman, 2003). However, several authors have stressed that companies are comparably successful in exploiting existing product lines, whereas they face significant obstacles in exploring new businesses and technologies (Dougherty, 1992; Salomo, Weise & Gemünden, 2007).

With this article we intend to contribute to the theory building in the R&D project management literature in three ways.

First, we investigate the effectuation logic as a conceptual basis for R&D projects. We adopt Sarasvathy's theory of effectuation that was originally developed in the entrepreneurship research (Sarasvathy, 2001) and apply it in the context of R&D projects. We describe the characteristics of such a theory along five key principles. These principles are clearly delineated from conventional planning and prediction focused R&D approaches, hereinafter called causation. We show that effectuation can be an important conceptual basis for analyzing R&D projects under uncertainty.

Second, we contribute to the extant literature by precisely developing effectuation and causation measures. A thorough qualitative and quantitative scale development process is applied. Expert interviews and a pilot study (123 R&D projects) are used to develop a multi-factor measurement model of effectuation and causation respectively. These measures are validated in a follow-up study with a larger sample of 400 projects. The newly developed measures are of utmost importance for further research in the field of effectuation. They can serve as a basis for future empirical studies that are required to advance the effectuation research that is so far focused on theory building through experiments and case studies.

Third, the new measures are applied to test two central hypotheses: (a) effectuation is positively related with the success in highly innovative contexts, (b) causation approaches are particularly beneficial in projects with a low level of innovativeness. Structural equation modeling is used to test the hypothesized effects.

THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

The existing R&D literature mostly assumes that a key task of the R&D manager is to discover opportunities and exploit them. With this concept in mind it is easy to see the importance of clear project targets, pre-defined milestones or formal project reviews and other factors that are often cited in the literature. However, the effectuation research offers new thinking that approaches the challenge from an alternative view. While the existing R&D literature is mostly focused on the exploitation of existing opportunities, effectuation assumes that all opportunities need to be actively created. This means that opportunities are not waiting to be discovered but emerge through the R&D activity of an organization and its partners. Effectuation was first introduced in the entrepreneurial context. It was induced from an experiment of entrepreneurship as a form of expertise (Sarasvathy, 2001). However, it quickly gathered interest in different disciplines including management (Augier & Sarasvathy, 2004), economics (Dew, Sarasvathy & Venkataraman, 2004), psychology (Sarasvathy, 2003), and finance (Wiltbank, Read, Dew & Sarasvathy, 2008). We intend to apply effectuation in the context of R&D project management.

The effectuation logic appears to be particularly suitable to form a conceptual basis in the R&D context since the R&D project management can be considered as a specific decision making problem (Dewar & Dutton, 1986). Effectuation in turn shall be a “general theory of decision making in uncertain situations” (Sarasvathy, 2008: 227) that focuses on the human action as the “predominant factor shaping the future” (Sarasvathy, 2008: 87). Effectuation prefers control over prediction: “to the extent we can control the future we do not need to predict it” (Sarasvathy, 2001: 251). These are all aspects that make effectuation promising under uncertainty and in the specific context of R&D projects. In the context of R&D project management it can be regarded as the inverse of causation. Table 1 summarizes the five principles with its effectuation and causation characteristics respectively.

Insert Table 1 about here

Neither effectuation nor causation is hypothesized to be generally preferable. We rather assume that the degree of innovativeness involved in an R&D project plays an important role. The degree of innovativeness is defined as the difference between the status quo and the aspired R&D outcome.

The five principles of effectuation and causation respectively are linked to the R&D project performance as represented in Figure 1. We differentiate two dimensions of R&D project success. The first success dimension, denoted as process efficiency, refers to the performance of the project implementation. It assesses success in meeting schedule and budget goals as well as the operational and technical performance of the R&D process (e.g., Dvir & Shenhar, 1992; Montoya-Weiss & Calantone, 1994; Shenhar et al., 2002). The second success dimension refers to the project’s output (e.g., Shenhar et al., 2002). It includes two sub-dimensions, namely one construct that measures the benefits to the organization in terms of newly acquired experiences and competences and a second construct that measures the perceived value and future potentials of the R&D output.

The differentiation between process- and output-related success criteria is particularly important in this study as some of the five effectuation and causation principles are more process (principle 2 and 5) and others more output (principles 1 and 3) related. Principle 4 is considered to be to the same extent process and output related. Two hypotheses are derived for each principle. The hypotheses with the suffix (a) are related to projects that involve a high degree of innovativeness and assume a positive relationship between the effectuation characteristic of the respective principle and the success dimension. Hypotheses with the suffix (b) denote projects with a low degree of innovativeness. It is assumed that the causation characteristic of each principle is particularly beneficial. We represent hypotheses 1a and 1b as example:

Hypothesis 1a. The effectuation characteristic of principle 1 has a positive impact on the R&D output in the context of high market and technological innovativeness.

Hypothesis 1b. The causation characteristic of principle 1 has a positive impact on the R&D output in the context of low market and technological innovativeness.

The only exception from this logic is hypothesis 4. In this case, we assume that the effectuation characteristic has a positive impact on the R&D output irrespectively of the degree of innovativeness. At the same time we assume that the causation characteristic of principle 4 has a positive impact on the R&D efficiency irrespectively of the degree of innovativeness.

Insert Figure 1 about here

INSTRUMENT DEVELOPMENT AND REFINEMENT

We used existing scales and items to measure the degree of innovativeness and the different success dimensions. Scales for the causation and effectuation constructs are not available. Therefore, the first step entailed the development of new measures. We adopted the following three-step approach for this purpose (cmp. Churchill, 1979).

The scale development process consisted of a qualitative, a first quantitative and a second quantitative analysis. The objective of the qualitative part was to develop preliminary measures that could be applied in a first quantitative test. To finalize the scale development we used a second quantitative analysis to cross-validate the findings of the preceding tests.

Within the first phase, we carried out a rough conceptualization and a qualitative pretest. First, we developed a basic understanding of effectuation and causation. This involved developing a pool of items to start with for each of the five effectuation and causation principles. We contrasted each effectuation item with a causation indicator. We largely used qualitative techniques like literature research, expert discussions and interviews to identify items from different perspectives. Next, we carried out a qualitative pre-test to test all items concerning their content validity and comprehensibility. On the one hand we asked project managers to assess the items for clarity and appropriateness along a 5-point scale ranging from very low to very high. 15 probands were asked to complete a questionnaire that included the items and indicate any ambiguity or other difficulty in responding, as well as offering suggestions for improvement. This approach was iterative meaning that the next respondent had to assess the improved items. On the other hand we asked effectuation researchers to assess the content validity and the delineation of effectuation and causation. The researchers had to assign each item to one of the three categories “Clearly effectuation”, “Clearly causation” and “Could be both”. This test led to a consistent picture. Three effectuation and causation items had to be eliminated due to an insufficient demarcation. In addition the resulting constructs were discussed with academics and scale development experts and finally with yet another set of R&D managers. We asked them to complete a full questionnaire during a phone interview. At this stage, very few concerns were raised and only minor refinements were required.

In the second step of the scale development approach we used a self-administered survey to make a first quantitative test of the new measures (N = 123 R&D projects). A set of commonly used analyses was carried out to test the new scales. First, we assessed the reliability by calculating Cronbach's alpha and item-to-total correlations. Next, we applied an exploratory factor analysis to ensure convergent validity. In addition we conducted a confirmatory factor analysis (CFA). Hereafter, we assessed discriminant validity demanding that each indicator is clearly associated with the hypothesized factor. Additionally we verified discriminant validity on factor level using the Fornell-Larcker criterion (Fornell & Larcker, 1981). Nomological validity requires that the single factors are "confirmed within the context of a larger theory" (Bagozzi, 1979: 14). Therefore, we analyzed the overall fit of the model within a full structural equation model using AMOS. In addition we completed an analysis to identify potential misspecifications along the residuals of the covariance matrix and the modification indices. In total, we eliminated eight effectuation and causation items during this process.

The third and final step of the scale development process contained the same analyses as completed in step 2. However, the sample size was enlarged (N = 400 R&D projects). This enabled a cross-validation of the results of the earlier analyses. All results that we show in the following section could be confirmed with this enlarged set of additional empirical data. An additional elimination of items was therefore not necessary. The final scales can be requested from the authors.

In order to test the hypothesized contingency model, we split the sample into two groups based on the composite score of the two innovativeness scales (market and technological innovativeness) (Song & Montoya-Weiss, 2001). Using the mean score of these two constructs enabled us to differentiate between projects with a low and a high degree of innovativeness.

We used a two-group AMOS model to examine the structural relationships separately and a common χ^2-difference methodology to test for significant differences between the two groups (Bollen, 1989; Song & Montoya-Weiss, 2001). We conducted an overall model assessment for both groups simultaneously (Song & Montoya-Weiss, 2001).

RESULTS

The results suggest that the structural model fits the data very well ($\chi^2/df = 1.59$, $p < .001$, RMSEA = .04 (pCLOSE = 1.0), SRMR = .05, TLI = .95, CFI = .96, GFI = .90). All paths that we hypothesized to be significant differentiators between effectuation and causation show moderated effects.

Specifically, hypothesis 1b is supported (standardized coefficient (SC) .24, $p < .01$) meaning that a causal approach concerning the characteristics of principle 1 has significant advantages in projects that involve a low degree of innovativeness. The path coefficient for the subgroup of highly innovative projects indicates at also supporting hypothesis 1a. However, this path coefficient is not significant. On the other hand, the group comparison shows significant differences in the most successful approaches under low and high innovativeness which in total can be interpreted at least as a weak support of hypothesis 1a. Hypotheses 2a (SC = -.25, $p < .09$) and 2b (SC = .25, $p < .09$) can be both supported at significant levels. The effectuation characteristic of principle 2 is preferable in highly innovative projects whereas causation shows significant advantages under low innovativeness. This can also – at least partly – be concluded when analyzing hypotheses 3a and 3b. The data directly supports 3a (SC = -.14, $p < .05$), i.e., using the effectual characteristics of principle 3 has a positive impact on the R&D output. Analogical to the discussion of hypothesis 1a, 3b can be weakly supported. Hypothesis 4a (Low innovativeness: SC = -.11, $p < .09$; High innovativeness: SC = -.23, $p < .01$) is also directly supported whereas the results for 4b are mixed (Low innovativeness: SC = .02, n.s.; High innovativeness: SC = .28, $p < .01$). Hypotheses 5a and 5b are again both supported. The effectuation characteristics of principle 5 have a significant positive effect on the process efficiency in highly innovative projects (SC = -.19, $p < .05$), the causal approach shows clear advantages in low innovative projects (SC = .22, $p = .15$). This result is additionally supported by the group comparison.

DISCUSSION

The results suggest that non-predictive control approaches consistent with effectuation are an important predictor of successful highly innovative R&D projects. At the same time causation proves to significantly enhance performance of projects that involve a low level of innovativeness. The degree of innovativeness is shown to be an important moderator that needs to be included when analyzing project success factors. The dichotomous concept of effectuation and causation can be a valuable theoretical framework for researchers when analyzing decision making related R&D project management topics.

We achieved the findings of this study by linking two fields of research. We tested the dichotomous concept of effectuation and causation as a potential theoretical framework for the management of R&D projects. This study is to our knowledge the first large scale empirical study that provides newly developed scales of effectuation and causation. With this research setup we intended to contribute to position effectuation as a general theory of decision making in uncertain situations. We did that by clarifying three critical aspects that can be regarded as important towards building a generally accepted theory (House, 1963). First, we showed that effectuation can be delineated from conventional approaches and that effectuation can be measured. Second, it was important to verify effectuation in terms of its relevance. To date only experiments (e.g., Wiltbank et al., 2008), case studies (Sarasvathy & Kotha, 2001) and one meta-analysis (Read, Song, & Smit, 2008) have been used to analyze effectuation. With this study we revealed the relevance of effectuation with a large scale empirical study and found positive impacts of effectuation on performance. Third, we transferred effectuation from its original field of research to another discipline. This helps to broaden the scope of effectuation and thus gives it a more general meaning.

Beyond the contributions in advancing the effectuation theory, the results of this study have important managerial implications as they bring in a new perspective that is at least partly contrary to what is mostly believed to be best practice. A strict process management including concepts like Total Quality or Lean Management dominated the managerial practice during the last two decades. Without doubting that process management activities in the context of R&D have clear advantages in exploitative projects, we have shown in this study that the benefits have to be questioned in exploratory projects. In fact we have shown that R&D managers need to differentiate between projects with a low and a high degree of innovativeness.

With this study we intended to cover a broad field of effectuation and causation characteristics in order to get a first empirical foundation of its key constructs. Of course, this approach was carried out at the expense of a more detailed analysis of each effectuation principle. We strongly recommend additional in-depth analyses on each principle as an interesting future research opportunity. In this context, the analysis of mediating effects appears to be particularly relevant. Beyond a more detailed analysis of the consequences of an effectual approach, it might be interesting to identify specific antecedents that support effectuation (e.g., organizational aspects). In order to be able to successfully implement effectual cells in plan dominated large organizations, it can be assumed that parallel organizational structures are required. The design of these cells is yet another promising future research issue.

REFERENCES AND DEVELOPED SCALES AVAILABLE FROM THE AUTHORS

Table 1: Delineation of effectuation and causation: Key principles

Principle	Effectuation characteristics	Causation characteristics
Principle 1: Means vs. goals	R&D approach driven by given means	R&D approach driven by given project targets
Principle 2: Affordable loss vs. expected returns	R&D approach guided by in-advance commitments to what one is willing to lose	R&D approach guided by expected project returns
Principle 3: Reduce vs. identify uncertainty	Existing uncertainty reduced through partnerships and pre-commitments of stakeholders	Existing uncertainty identified and avoided through market and competitor analyses
Principle 4: Acknowledge vs. overcome the unexpected	Contingencies/surprises seen as source of opportunities	Contingencies/surprises avoided or quickly overcome to reach given project targets
Principle 5: Create vs. exploit opportunities	Human agency seen as prime driver of future developments	Development/trends seen as exogenously given that can be exploited by use of forecasts

Figure 1: Research model