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Exploration and Exploitation within Firms: The Impact of CEOs' Cognitive Style on Incremental and Radical Innovation Performance

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Previous studies have provided valuable insights into how environmental and organizational factors may influence levels of explorative and exploitative innovation in firms. At the same time, scholars suggest that individual characteristics, such as cognitive and behavioural inclinations of top executives, might also have significant impact on the ability of a firm to engage in explorative and exploitative activities. The importance of the CEO is of interest, especially in medium-sized companies, where the CEO appears to be most influential. Very few studies, however, have quantitatively examined the relationship between individual characteristics of top managers and firm-level exploration and exploitation. Most of the existing research focuses on observable managerial characteristics and the composition of top management teams. Therefore, some important psychological issues may have been bypassed. This study complements prior research in two fundamental ways. First, whereas previous studies focus on extrinsic organizational factors that influence individual exploration and exploitation, we rely on insights from cognitive psychology to hypothesize a relationship between intrinsic factors (i.e., cognitive style) and individuals' tendency for exploration versus exploitation. Second, whereas existing research remains silent on the implications of individual CEO characteristics for firm performance, we hypothesize a relationship between CEOs' tendency for exploration or exploitation and firm-level innovation performance.

Introduction

Many scholars (e.g., March, 1991, 1996, 2006; Dougherty, 1992; Levinthal & March, 1993; Eisenhardt & Martin, 2000; Ancona et al., 2001; Benner & Tushman, 2002; Feinberg & Gupta, 2004) stress the need for companies to manage an appropriate mix of explorative and exploitative innovation activities in order to survive in the long term. Explorative activities can be characterized by terms such as search, variation, risk-taking, experimentation, play, flexibility and discovery (March, 1991). Exploitative activities are associated with aspects such as refinement, choice, production, efficiency, selection, implementation and execution (March, 1991).

Although both types of activities are essential for a firm's survival and prosperity (Lavie, Stettner & Tushman, 2010), many scholars have indicated a challenging tension between exploration and exploitation as they compete for the same scarce resources and demand radically different mindsets and organizational routines (e.g., Hannan & Freeman, 1977; March, 1991; Sorensen & Stuart, 2000). Existing research on organizational ambidexterity has provided valuable insights into how structural characteristics of firms or business units influence the ability to combine explorative and exploitative activities (e.g., Duncan, 1976; Tushman & O'Reilly, 1996; Benner & Tushman, 2003; Jansen, Van den Bosch & Volberda, 2005; Jansen et al., 2009). At the same time, scholars suggest that individual characteristics, such as cognitive and behavioural inclinations of senior management, might also have a significant impact on the ability of a firm to engage in

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explorative and exploitative activities (e.g., Lewin, Long & Carroll, 1999; Hambrick, Finkelstein & Mooney, 2005; O'Reilly & Tushman, 2008). However, very few studies have quantitatively examined the relationship between individual characteristics of top managers and firms' ability to engage in exploration and exploitation (e.g., Gupta, Smith & Shalley, 2006; Papadakis & Bourantas, 2007; Raisch & Birkinshaw, 2008). A recent study by Mom, Van den Bosch and Volberda (2009) is a notable exception in this respect. This study demonstrates that managers can substantially differ in their explorative and exploitative behaviour. In addition, they show that managers' individual engagement in explorative and exploitative activities depends on organizational design factors such as managers' decision-making authority.

The present study addresses the question whether the cognitive styles of CEOs influence explorative and exploitative innovation in the firms they lead. We complement prior research on individual exploration and exploitation in two fundamental ways. First, whereas Mom, Van den Bosch and Volberda (2009) focus on extrinsic organizational factors that influence individual exploration and exploitation, we rely on insights from cognitive psychology (e.g., Bruner, Goodknow & Austin, 1956; Witkin et al., 1962; Miller, 1987; Hayes & Allinson, 1994) to hypothesize a relationship between intrinsic factors (i.e., cognitive style) and individuals' tendency for exploration versus exploitation. Second, whereas existing research remains silent on the implications of individual exploration and exploitation for firm performance, we rely on upper echelon theory (e.g., Hambrick & Mason, 1984; Hambrick & Finkelstein, 1987) to hypothesize a relationship between the CEOs' tendency for exploration or exploitation and firm-level product innovation performance.

In order to test our hypotheses, we rely on a unique dataset, containing information on (i) the cognitive style of 122 CEOs of small- and medium-sized enterprises (SMEs) in the Dutch manufacturing industry as well as (ii) their firms' product innovation performance. As previous studies emphasized the decisive role of CEOs in leading organizations with respect to entering new technological domains (e.g., Kaplan, 2008; Tushman, Smith & Binns, 2011), we investigate their particular individual characteristics. We focus our study on SMEs because CEOs have been found to be a major factor in contributing to innovativeness in small manufacturing firms (Lefebvre & Lefebvre, 1992) and more influential than in larger companies (Papadakis & Bourantas, 2007).

Conducting structural equation analyses, our findings show that CEOs with a more analytic cognitive style tend to engage more in activities related to exploitation of existing products and markets, whereas CEOs with a more intuitive cognitive style tend to engage more in activities related to exploration of new products and markets. In line with upper echelon theory, our data also show that such individual tendency towards exploration or exploitation significantly influences the allocation of R&D resources within the firm, which in turn impacts firms' incremental and radical innovation performance.

From a theoretical perspective, our findings point to the relevance of applying insights from cognitive psychology to better understand innovation behaviour of top managers. At the same time, we contribute to integrating insights from upper echelon theory in research on new product innovation, illuminating how individual characteristics, resource allocation decisions and innovation performance are linked to each other. From a managerial perspective, our data suggest that, in the context of SMEs, the intrinsic characteristics of the CEO might have strong predictive value for firms' innovation performance.

This paper is structured in five sections. First, we rely on insights from cognitive psychology and upper echelon theory to develop our hypotheses. Second, the methodology is discussed. Next, the results of the analyses are presented. Fourth, we point to the main theoretical and managerial implications of the findings. Finally, we discuss the study's main limitations, and suggest avenues for future research.

Hypotheses

In this section, we develop hypotheses on (i) the impact of CEOs' cognitive style on their tendency towards exploitation or exploration, and (ii) the effects of such individual innovation behaviour on firms' R&D investments and product innovation performance. Figure 1 provides a graphical illustration of our hypotheses.

The Impact of Cognitive Style on CEOs' Innovation Behaviour

In order to investigate the relationship between CEOs' individual characteristics and their innovation behaviour (i.e., individual tendency towards exploitation and/or exploration), we focus on CEOs' information processing strategies or the way they acquire, store and use knowledge. More specifically, we

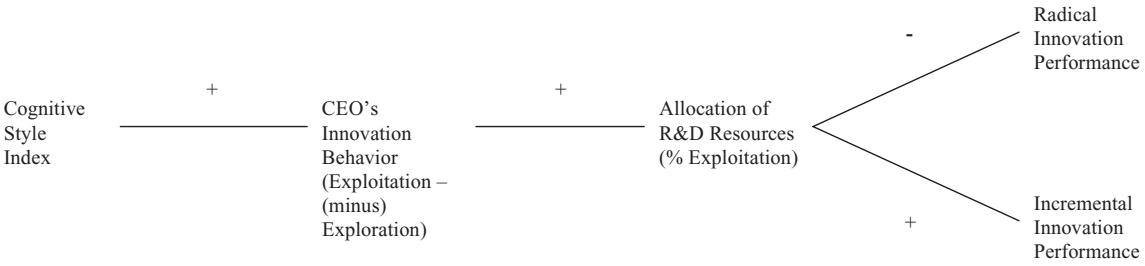


Figure 1. Hypotheses

concentrate on cognitive style, a core concept in cognitive psychology that is defined as 'the consistent individual differences in preferred ways of organizing and processing information and experience' (Messick, 1976). Previous studies on cognitive styles show that human beings can process information in two different ways, pointing to the distinction between intuitive information processing and analytical information processing (Chaiken & Trope, 1999; Armstrong & Priola, 2001).

Several scholars stress the importance of cognitive style to better understand organizational behaviour. Schweiger (1983), for instance, provides the following statement:

> If research indicates [. . .] that particular cognitive styles are more appropriate than others for the conduct of particular managerial activities, then normative recommendations concerning the selection and placement of individuals for these activities may be warranted. In addition, if it is found that cognitive styles are subject to modification, then the development of training programs in the industrial setting, or modifications of current business school curricula in the academic setting, may be critical.

In line with these arguments, scholars (e.g., Kirton, 1980; McHale & Flegg, 1985; Ash, 1986; Mitchell et al., 2004; Armstrong & Hird, 2009) have studied the relevance and consequences of cognitive style in contexts such as training and development and team composition (e.g., Bell et al., 2011; Miron-Spektor, Erez & Naveh, 2011; Post, 2012). Some of these studies have focused on senior managers and entrepreneurs. Allinson, Chell and Hayes (2000), for instance, explored relationships between cognitive styles and entrepreneurial behaviour. Khatri and Ng (2000) reported a moderating effect of environmental stability on the relationship of intuitive synthesis in strategic decision making with organizational performance. Sadler-Smith (2004) found significant relationships between cognitive style and financial performance of SMEs.

Individuals that have an analytical cognitive style prefer to converge information. Analysis refers to judgement based on mental reasoning and a focus on detail. Analysts tend to be more compliant, favour a structured approach to problem solving, depend on systematic methods of investigation, recall verbal material most readily and are especially comfortable with ideas requiring step-by-step analysis (Allinson & Hayes, 1996). Individuals that have an intuitive cognitive style prefer to diverge information. Intuition refers to immediate judgement based on feeling and the adoption of a global perspective. Intuitivists tend to be relatively nonconformist, prefer an open-ended approach to problem solving, rely on random methods of exploration, remember spatial images most easily, and work best with ideas requiring overall assessment (Allinson & Hayes, 1996).

Relying on these existing insights, we expect that CEOs' cognitive style might strongly impact their tendency towards exploration or exploitation. Exploration is rooted in variance-increasing activities and creates futures that may be quite different from organizations' past routines (Smith & Tushman, 2005). It is associated with experimentation, improvisation and creativity (Van de Ven et al., 1999; Chatman & Flynn, 2001; Rivkin & Siggelkow, 2003). For these activities, diverging information is essential (Allinson & Hayes, 1996). We therefore expect that individuals who have an intuitive cognitive style are likely to engage more in explorative activities than exploitative activities.

Exploitation is rooted in variance-decreasing activities and builds on organizations' past routines (Smith & Tushman, 2005). It is associated with efficiency, focus and standardization (Van de Ven et al., 1999; Chatman & Flynn, 2001; Rivkin & Siggelkow, 2003). Hence, for these activities, converging is essential (Allinson & Hayes, 1996). We therefore expect individuals with an analytic cognitive style to be likely to engage more in exploitative activities above explorative activities. Jointly, these expectations result into the following hypothesis.

H1: The more analytic (intuitive) the cognitive style of CEOs, the stronger their focus on exploitative (explorative) activities.

The Impact of a CEO's Innovation Behaviour on R&D Resource Allocation and Firm Innovation Performance

Upper echelon theory (Hambrick & Mason, 1984) states that organizational outcomes such as strategic choices and performance levels are partially predicted by managerial background characteristics such as age, organizational tenure and education. From this perspective, organizational outcomes are viewed as reflections of the values and cognitive bases of powerful actors in the organization. If strategic choices have a large behavioural component, they are likely to reflect the idiosyncrasies of decision makers. March and Simon (1958), for instance, argued that each decision maker brings his or her own set of cognitive bases to an administrative situation, reflected by knowledge or assumptions about future events, knowledge of alternatives, and knowledge of consequences attached to alternatives. They also reflect his or her values: principles for ordering consequences or alternatives according to preference. These are in place at the same time the decision maker is being exposed to an ongoing stream of potential stimuli both within and outside the organization. The decision maker brings a cognitive base (e.g., knowledge or assumptions about future events, knowledge of consequences attached to alternatives) to a decision, which create a screen between the situation and his or her eventual perception of it (Child, 1972; Hambrick & Mason, 1984; Miller & Toulouse, 1986).

Following these upper echelon theory arguments, we expect CEOs' innovation behaviour to have a significant impact on strategic decision making. Building on previous findings by Barker and Mueller (2002), who found that visible CEO characteristics explain a significant proportion of a firm's relative R&D spending, we expect that CEOs' individual characteristics are also reflected in how firms' resources are allocated to different types of innovation activities. Specifically, we hypothesize that CEOs' individual orientation towards exploration and exploitation significantly influences how firms allocate R&D resources to explorative and exploitative activities.

H2: The degree to which CEOs focus on exploitative (explorative) activities is positively related to the percentage of R&D resources that is allocated to exploitative (explorative) activities within the firm.

The distinction between incremental and radical innovation is one of the central notions in the existing literature on technical innovation (Mansfield, 1968; Freeman, 1982). Incremental innovation introduces relatively minor changes to the existing product, exploits the potential of the established design, and often reinforces the dominance of established firms (e.g., Nelson & Winter, 1982; Tushman & Anderson, 1986). This type of innovation is the result of exploitative activities, characterized by refinement and extension of existing competencies, technologies and paradigms, and involves the use and development of things already known (March, 1991). Radical innovation, in contrast, is based on a different set of engineering and scientific principles and often opens up whole new markets and potential applications (e.g., Dess & Beard, 1984; Dewar & Dutton, 1986). These innovations are facilitated by exploration, which is in essence the experimentation with new alternatives and involves the pursuit of new knowledge. Therefore, we expect that the allocation of R&D resources across exploitative and explorative activities substantially influences a firms' incremental and radical innovation performance:

H3a: Higher allocation of R&D resources to exploitative activities increases firms' incremental product innovation performance.

H3b: Higher allocation of R&D resources to exploitative activities decreases a firms' radical product innovation performance.

Methodology

Data and Sample

In order to test our hypotheses, we rely on a sample of Dutch SMEs. To select firms, we started from the Nedsoft database containing company information of 703,432 Dutch companies, which represents 94% of all Dutch companies registered by the Dutch Central Bureau of Statistics (CBS). As this study focuses on product innovation in SME companies, we excluded all non-manufacturing companies and all companies with more than 250 employees. We also removed all companies for which no contact information was available. We sent a questionnaire to the CEOs of the 2,523 remaining companies and a reminder a week after, which resulted in 254 valid responses (10%). Out of these 254 companies, 122 indicated to invest in R&D (48%). This is close to the SME information provided by the Statistics Netherlands agency, which reports an R&D investment percentage of 55%. This

indicates that our initial sample is representative of Dutch manufacturing SMEs.

All data in this research were self-reported and collected through the same questionnaire. Using this method, common method variance may cause systematic measurement error and bias the estimates of the relationships between the study's constructs. To check for this potential bias from using a single method, we performed a Harman's one-factor test on the items that were included in the hypothesized models. This test calculates whether a single factor accounts for most of the covariance in the dependent and independent variables (Podsakoff & Organ, 1986). Conducting a Harman's single factor test, it could be observed that only 26.8% of the variance was explained by a single factor solution, suggesting that common method bias is not likely to be an issue (Podsakoff & Organ, 1986).

Measures

Independent Variable: Cognitive Style

There are many instruments available to measure cognitive style, of which the most commonly used are the Myers–Briggs Type Indicator (Myers, 1962), the Kirton Adaptation–Innovation Inventory (Kirton, 1976) and the Cognitive Style Index (Allinson & Hayes, 1996). To measure CEOs' cognitive style, we adopted the Cognitive Style Index (CSI) from Allinson and Hayes (1996) as it is specifically designed for managerial and professional individuals (Armstrong, Cools & Sadler-Smith, 2011). The CSI measures cognitive style on a bipolar intuitive-analytic dimension and contains 38 items (true; uncertain; false). Some examples of these items include: 'Formal plans are more of a hindrance than a help in my work', 'I am most effective when my work involves a clear sequence of tasks to be performed', 'My approach to solving a problem is to focus on one part at a time', 'I am inclined to scan through reports rather than read them in detail'.

The CSI score is calculated by the sum of all 38 item scores (true = 2, neutral = 1, false = 0), of which some are reverse coded. The higher the CSI score, the more analytic the cognitive style of the respondent. A low CSI score, on the other hand, indicates the presence of an intuitive cognitive style.

As the inter-item correlations of the CSI tend to be low with little variance, Allinson and Hayes used a factor analysis of parcels of items to test the internal structure of the index. Following the proposed method by Allinson and Hayes, we grouped the 38 items into six parcels and performed confirmatory factor analysis to test the structure of the scale. Our results indicate that the hypothesized single factor solution is confirmed and that this accounts for over half of the variance. The CSI scores as composed by our data show a sample mean score of 37.86 (see Table 3). To check for reliability, we computed the Cronbach's alpha (0.75), which is satisfactory.

Dependent Variables: CEO's Innovation Behaviour, R&D Resource Allocation and Indicators of Product Innovation Performance

In order to measure exploration and exploitation on the individual level, we adopted the scale from Mom, Van den Bosch and Volberda (2009). This scale is based on the features by which March (1991) characterized exploration and exploitation, and uses seven items to measure the level of managers' exploration orientation, and seven items measuring managers' exploitation orientation. All items are measured on a five-point Likert scale ranging from 'a very small extent' to 'a very large extent' of engagement in explorative and exploitative activities. Results of factor analysis (see Table 1) confirm a two-factor structure of the data. We removed the first exploration activities item for cross-loading, and the fifth of the exploitation activities items because of low factor loading (<0.5). We checked the reliability of the scale by computing Cronbach's alpha (0.79 for exploration and 0.83 for exploitation).

By combining the scales for exploration and exploitation, we created a measure for CEOs' innovation behaviour. We subtracted the mean score of the six exploration items from the mean score of the six exploitation items. In this way, CEOs with an exploration focus will have a negative score (min. –4) and CEOs with an exploitation focus will have a positive score (max. 4) on this innovation behaviour variable.

We measured firms' R&D resource allocation by asking respondents how, during the past three years, their respective R&D resources were allocated across (i) explorative innovation projects, which were defined as projects focused on R&D activities such as fundamental research, experiments and building of prototypes, and (ii) exploitative innovation projects, which were defined as projects focused on R&D activities such as standardization, optimization, fine-tuning and up-scaling. Based on this information, we constructed the variable R&D Resource Allocation representing the percentage of R&D resources invested in exploitative activities. Variable scores can range from 0 (no R&D resources allocated to exploitation) to 100 (all R&D resources allocated to exploitation).

Table 1. Factor Analysis for CEO's Innovation Behaviour

Items	Factors	
To what extent did you, last year, engage in work related activities that can be characterized as follows:	1	2
A manager's exploration activities (Cronbach's alpha = 0.79):		
Searching for new possibilities with respect to products/services, processes, or markets	–0.487	0.514
Evaluating diverse options with respect to products/services, processes, or markets	–0.397	0.568
Focusing on strong renewal of products/services or processes	–0.296	0.574
Activities of which the associated yields or costs are currently unclear	–0.018	0.684
Activities requiring quite some adaptability of you	0.190	0.703
Activities requiring you to learn new skills or knowledge	–0.027	0.752
Activities that are not (yet) clearly existing company policy	–0.181	0.572
A manager's exploitation activities (Cronbach's alpha = 0.83):		
Activities of which a lot of experience has been accumulated by yourself	0.674	0.002
Activities which you carry out as if it were routine	0.727	–0.213
Activities which serve existing (internal) customers with existing services/products	0.636	0.011
Activities of which it is clear to you how to conduct them	0.806	–0.066
Activities primarily focused on achieving short-term goals	0.390	–0.141
Activities which you can properly conduct by using your present knowledge	0.759	–0.155
Activities which clearly fit into existing company policy	0.629	–0.073

Extraction method: Principal Component Analysis. Rotation Method: Varimax.

Following previous research (Faems, Van Looy & Debackere, 2005; De Visser et al., 2010; Neyens, Faems & Sels, 2010), we used the composition of turnover in 2009 in order to make a distinction between incremental and radical product innovation performance. The proportion of turnover in 2009 attributed to new products that were introduced during the last three years is regarded as an indicator of radical product innovation performance. Likewise, the percentage of turnover in 2009 attributed to improved products that were introduced during the last three years is seen as an indicator of incremental product innovation performance. In order to obtain a normal distribution, our analyses include the logarithm of 1 + the proportion of turnover attributed to (1) new products and (2) improved products.

Control Variables

The period of time a CEO is active in the firm might impact his or her orientation toward exploration and exploitation (Tushman & O'Reilly, 1996). In order to control for this effect, we included a variable measuring how long CEOs have been working in the company. The degree to which a manager engages in risk-taking activities is also influenced by the managers' age (Vroom & Pahl, 1971). Older managers are less likely to engage in risky activities than young managers. As exploration is associated with risk-taking activities (March, 1996), we included a variable to control for age effects on CEOs' innovation behaviour. Education is related to the cognitive ability of individuals to process information and may therefore be related to a managers' innovation behaviour (Papadakis, 1998). We controlled for educational effects on CEOs' innovation behaviour by including a dummy variable measuring whether CEOs have a master's degree or not.

In the innovation literature considerable attention is devoted to the relationship between innovation performance and environmental dynamics (e.g., Sorensen & Stuart, 2000; Jansen, Van den Bosch & Volberda, 2005; Levinthal & Posen, 2009; Sainio, Ritala & Hurmelinna-Laukannen, 2012). Firms that operate in a dynamic environment tend to be more innovative than firms that operate in a stable environment (Hannan & Freeman,

1984). We therefore adopted a four-item scale from Jansen, Van den Bosch and Volberda (2006) to control for environmental factors that might influence radical and incremental innovation performance. To check for reliability, we computed the Cronbach's alpha (0.83), which is satisfactory.

We also expect that R&D intensity impacts innovation performance (Singh, 1986). Therefore, we included a variable measuring the R&D investments/sales ratio to control for this effect. Finally, we controlled for potential industry differences in terms of product innovation performance by introducing industry dummies. A distinction was made among four industries. The 'other' sector was used as the reference category in the study's analyses. Table 2 provides an overview of the frequencies of the different industries.

Results

Descriptive Statistics

Table 3 gives an overview of the most important descriptive statistics. The means for the variables radical innovation performance and incremental product innovation performance are 0.22 and 0.26. Taking into account that this study uses logarithmic transformation for these variables, the implication is that, on average, respondents attributed 26.4% of their sales to new products and 30.6% to improved products. This also implies that on average 43.0% of their sales was attributed to products that were introduced before 2007 and have not been improved since then.

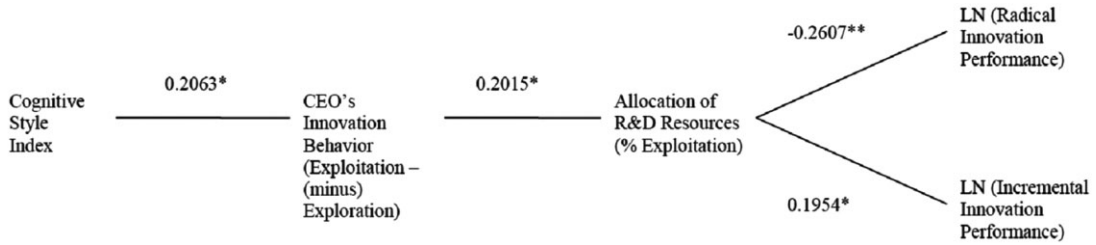
Table 2. Industry Frequencies

Industry	Frequency	Percent
Plastic	11	9.0
Metal	50	41.0
Software	14	11.5
Other	47	38.5

To test the hypotheses, structural equation modelling (SEM) with manifest variables is used. Compared with ordinary linear regression models, this technique has two advantages (Sels et al., 2006). First, the method enables hypothesized relationships between variables to be defined and tested. The output indicates whether the model is supported by the data as a whole and gives a significance test for the various individual relationships. Second, a variable in a SEM can be either dependent or independent. This allows for testing the indirect influence, if any, of certain variables (Faems et al., 2010).

The standardized path coefficients of the theoretical model are listed in Table 4. The goodness-of-fit overview (Table 5) indicates that the theoretical model is not adequately supported by the data. To optimize the model, paths were added from industry, market dynamics and R&D investments to CEO's innovation behaviour and allocation of R&D resources. Paths were also added from CEO's Master's Degree to Incremental Innovation Performance, and from CEO's tenure in the firm to Radical Innovation Performance. The resulting model is presented in Figure 2.

The goodness-of-fit measures in Table 5 indicate that our optimized model is effectively supported by the data. Below, we first discuss the effect of cognitive style on CEOs' innovation behaviour. Subsequently, the effect of CEOs' innovation behaviour on firms' allocation of R&D resources is reported. Finally, we show the effects of a firms' allocation of R&D resources on radical and incremental product innovation performance. The standardized path coefficients of the optimized model are listed in Table 6. The results of the test of the optimized model are also represented in Figure 2.



* $p<.05$; ** $p<.01$

Figure 2. Results of Optimized Model

Table 3. Descriptive statistics and correlations

Variable	Mean	Min/max	S	LN (Incremental Innovation Performance)	LN (Radical Innovation Performance)	Allocation of R&D Resources (% Exploitation)	CEO's Innovation Behaviour (Exploitation – (minus) Exploration)	Cognitive Style Index	R&D Investments (% of Sales)	Market Dynamics	CEO's Age	CEO's Tenure in the Firm
LN (Incremental Innovation Performance)	0.2584	0.00/0.59	0.13120	1								
LN (Radical Innovation Performance)	0.2232	0.00/0.69	0.14268	–0.099	1							
Allocation of R&D Resources (% Exploitation)	53.20	0/100	26.861	0.176	–0.299**	1						
CEO's Innovation Behaviour (Exploitation – (minus) Exploration)	–0.1780	–2.57/2.00	0.98997	–0.161	–0.216*	0.206*	1					
Cognitive Style Index	37.86	13/63	10.680	–0.007	–0.051	–0.055	0.214*	1				
R&D Investments (% of Sales)	2.87	1/4	0.872	0.192*	0.379**	–0.137	–0.193*	–0.025	1			
Market Dynamics	3.55	2/5	0.788	0.073	0.245**	–0.057	–0.248**	–0.141	0.338**	1		
CEO's Age	49.14	29/66	9.217	–0.030	–0.016	–0.005	0.002	0.199	0.082	0.037	1	
CEO's Tenure in the Firm	16.23	1/40	8.915	–0.078	–0.111	–0.082	0.151	0.151	–0.040	–0.042	0.441**	1

* correlation is significant at the 0.05 level (two-tailed); ** correlation is significant at the 0.01 level (two-tailed).

Table 4. Standardized Path Coefficients Theoretical Model

Path from / to	(2)	(3)	(4)	(5)
(1) Cognitive Style Index	0.2165*			
(2) CEO's Innovation Behaviour (Exploitation – (minus) Exploration)		0.2056*		
(3) Allocation of R&D Resources (% Exploitation)			–0.2486**	0.2088*
(4) LN (Radical Innovation Performance)				
(5) LN (Incremental Innovation Performance)				
Control Variables				
(6) Market Dynamics			0.1374	0.0238
(7) Plastic			–0.0472	–0.0425
(8) Metal			0.0104	0.0651
(9) Software			0.1248	0.182†
(10) R&D Investments (% of Sales)			0.2443**	0.1646
(11) CEO's Tenure in the Firm	0.0209			
(12) CEO's Age	–0.0380			
(13) CEO's Master's Degree	0.0753			

† $p < .10$; * $p < .05$; ** $p < .01$.

Table 5. Goodness-of-Fit Measures

Fit measure	Theoretical Model	Optimized Model
Bentler's Comparative Fit Index	0.9090	0.9629
Bentler and Bonett's Normed Fit Index	0.8237	0.9004
Chi-Square Test (p-Value)	0.0578	0.1828

In line with our first hypothesis, we observe a positive relationship between the CSI score and CEOs' innovation behaviour. This result confirms that a more analytic cognitive style has a positive impact on a CEOs' tendency towards exploitation, whereas a more intuitive cognitive style has a positive impact on CEOs' tendency towards exploration. Our data also show a positive relationship between CEOs' innovation behaviour and firms' allocation of R&D resources. Based on how these variables are measured, this result implies that, when the CEO has a stronger focus on exploitation, the share of R&D resources that are spent on exploitative activities will be larger. In contrast, a stronger focus on exploration will trigger an increase in the allocation of R&D resources to explorative activities. These results confirm that, within SMEs, the CEOs' innovation behaviour has a strong impact on firm-level allocation decisions.

As stated in H3, firms that allocate more R&D resources to exploitative activities were expected to perform higher in terms of incremental innovation performance, and lower in terms of radical innovation performance. These hypotheses are supported by our data as allocation of R&D resources (% exploitation) has a significant ($p < 0.05$) positive direct effect on incremental innovation performance, and a significant ($p < 0.01$) negative effect on radical innovation performance.

Regarding our control variables, we did not observe any significant impact of market dynamics on innovation performance. A significant ($p < 0.01$) positive relationship between R&D intensity and radical innovation performance was found; companies that invest more in R&D display higher radical innovation performance. The data also point to a number of industry effects. Compared to other industries, companies in the software industry perform significantly ($p < 0.05$) higher in terms of incremental innovation performance. Finally, CEOs in the software industry demonstrate a significantly ($p < 0.05$)

Table 6. Standardized Path Coefficients Optimized Model

Path from / to	(2)	(3)	(4)	(5)
(1) Cognitive Style Index	0.2063*			
(2) CEO's Innovation Behaviour (Exploitation – (minus) Exploration)		0.2015*		
(3) Allocation of R&D Resources (% Exploitation)			–0.2607**	0.1954*
(4) LN (Radical Innovation Performance)				
(5) LN (Incremental Innovation Performance)				
Control Variables				
(6) Market Dynamics	–0.0463	–0.0463	0.1306	–0.0463
(7) Plastic	–0.1427	0.0849	–0.0199	–0.0690
(8) Metal	–0.0396	–0.0608	0.0136	0.0385
(9) Software	–0.2009*	–0.0985	0.1365	0.2359*
(10) R&D Investments (% of Sales)	–0.1564	0.0649	0.2419**	0.0649
(11) CEO's Tenure in the Firm	0.0457		–0.1290	
(12) CEO's Age	–0.0118			
(13) CEO's Master's Degree	0.1259			–0.1379

* $p < .05$; ** $p < .01$.

lower engagement in exploitative activities compared to other industries.

Discussion and Conclusion

In this section, we first discuss the theoretical implications of our study. In particular, we discuss (i) the relevance of cognitive psychology to better understand CEOs' innovation focus and (ii) the relevance of upper echelon theory to better understand the link between individual innovation focus and innovation performance. Subsequently, we point to the main managerial implications. Finally, we discuss the main limitations of this study.

Implications for CEOs' Innovation Behaviour

Whereas the current literature on exploration and exploitation focuses mainly on factors on the business unit and firm levels, some scholars have suggested the relevance of investigating individual characteristics to explain differences in orientation towards explorative and exploitative activities. Recently, Mom, Van den Bosch and Volberda (2009) identified structural factors that impact a manager's tendency towards exploration and exploitation (e.g., formal structural mechanisms and personal co-ordination mechanisms). This study complements the findings of Mom, Van den Bosch and Volberda (2009), identifying cognitive style as an important personal factor that plays a significant role in explaining individuals' focus on exploration or exploitation.

Our data support our hypotheses that CEOs, who have analytic cognitive styles, prefer to converge information and therefore engage more in exploitative activities than CEOs, who have an intuitive cognitive style. These findings point to the relevance of applying insights from cognitive psychology to better understand innovation behaviour of top managers.

Innovation Performance Implications of CEO's Innovation Behaviour

We contribute to integrating insights from upper echelon theory in research on new product innovation. Our findings illuminate how individual characteristics, resource allocation decisions and innovation performance are linked to each other. The upper echelon approach views strategic choice as a function of the demographic and psychological composition of top managers and suggests several factors that impact the strategic direction and performance levels of a firm, such as age, functional tracks, other career experiences, education, socioeconomic roots and financial position (Hambrick & Mason, 1984). Because of the difficulties of studying the mental representations and other psychological characteristics of the organization's executive members, Hambrick and Mason (1984) advocated indirect methods of cognitive assessment, whereby executives' background

characteristics (e.g., education, functional specialization) are used as proxies for cognitive variables in the prediction of organizational outcomes (Hodgkinson & Healey, 2008).

Using a direct method to assess cognitive style of CEOs, our study supports the view that strategic decision making is influenced by the cognitive base of top managers. In particular, our findings show how cognitive characteristics and individual inclinations for explorative and exploitative activities influence strategic decision making on allocating resources to exploration and exploitation and firms' product innovation performance. Previous studies (e.g., Virany, Tushman & Romanelli, 1992; He & Wong, 2004; Raisch & Birkinshaw, 2008) already pointed to the important role of senior managers in organizations' decisions between investing in exploration and exploitation. Our study emphasizes the relevance of upper echelon theory in explaining these strategic decisions.

Managerial Implications

In drawing practical implications, this paper has underpinned the importance of the CEO in innovation. Our data suggest that cognitive styles of CEOs and their engagement in different types of innovation activities significantly impact resource allocation decisions and innovation performance in SMEs. Although we acknowledge the practical disadvantage of psychological measures compared to demographics, which are much easier to obtain, we argue that, in some situations, special attention should be paid to the relationship between the characteristics of CEOs in cognitive style and organizational contexts. For instance, when a CEO is close to retirement and on the lookout for a replacement, he or she might assess the cognitive style of potential candidates in order to successfully continue the existing strategy of the firm. SMEs that are at the beginning of the innovation lifecycle, with the majority of their products in more exploratory stages, might benefit from an intuitive CEO, whereas small firms that are in later stages of the cycle would benefit from a more analytic leader. CEO characteristics might also be relevant for organizations that face the need to transition into a new strategic configuration. In cases where the cognitive style of the CEO in charge does not seem to be compatible with the strategic transition pursued, this transition could benefit from a CEO with a different style. Finally, our data suggest that, when investors are considering buying stakes in SME companies, it might be interesting to take a close look at the personality of the CEO, as this might provide valuable information on the future innovation strategy and performance of the focal firm.

Limitations and Future Research

A first limitation of our study concerns generalizability. It is an interesting empirical question as to whether our findings are generalizable to larger firms. Compared to SMEs, innovation outcomes at larger firms are often influenced by a broader set of factors besides the CEO's innovation behaviour, such as more complex organizational systems, which make strategic decision making less straightforward. In addition, the influence of the CEO at larger firms may also be affected by external governance pressures from an independent board of directors and shareholders. We expect that the statistical relationships between CEOs' cognitive style, CEOs' innovation behaviour, allocation of R&D resources and innovation performance may not be as strong as we found with our sample of SMEs (cf. Mom, Van den Bosch & Volberda, 2009).

A second limitation is related to the cross-sectional nature of our data. Although we built in time lags between some of our variables, we were not able to assess long-term effects of changes in CEOs' innovation behaviour. Future studies may adopt a longitudinal approach to increase insight into how changes in CEOs' innovation behaviour, allocation of R&D resources and innovation performance causally relate to each other.

Furthermore, we limited the focus of this study by investigating how personal characteristics relate to innovation behaviour and performance, and did not pay attention to how structural characteristics influence innovation behaviour and firm performance. It would be interesting to study how personal characteristics and structural characteristics interact. For instance, we could expect that structural characteristics moderate the relationship between cognitive style and innovation focus. Future research could investigate the interactions between personal characteristics and structural characteristics, such as the formalization of tasks and involvement in cross-functional structures, and how they together affect R&D resource allocation and innovation performance.

In this paper, we have provided a richer understanding of exploration and exploitation within firms, acknowledging the relevance of cognitive style of senior executives in explaining differences in innovation behaviour and their effects on incremental and radical innovation performance. We hope that practitioners in manufacturing firms will consider our

practical suggestions and that our results may motivate researchers to continue exploring micro-level antecedents of innovation in a wide variety of organizational settings.

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