Paper to be presented at the DRUID Academy conference in Rebild, Aalborg, Denmark on January

15-17, 2014

Linkage between CEO characteristics and OI adoption in innovative SMEs

Joonmo Ahn
University of Cambridge
Institute for Manufactering
ja494@cam.ac.uk

Letizia Mortara
University of Cambridge
Institute for Manufacturing
lm367@cam.ac.uk

Tim Minshall
University of Cambridge
Institute for Manufacturing
thwm100@eng.cam.ac.uk

Abstract

In small and medium-sized enterprises (SMEs), where typically the decision making process is highly centralised, important decisions, such as open innovation (OI) adoption, will be strongly influenced by their chief executive officers (CEOs). Using upper echelon theory, this paper attempts to explore how the CEOs? demographic characteristics and personal traits influence the adoption of OI. A regression analysis on 306 innovation-oriented Korean manufacturing SMEs shows that the adoption of OI can be better understood by considering CEO characteristics as important OI determinants. However, the findings also show that the CEO traits affect the adoption of OI in different ways according to the nature of OI, i.e., knowledge flow direction and required skills and experience. This study has practical implications for CEOs who are in the process of implementing OI and for policy makers who are interested in stimulating SMEs? innovation performance.

Jelcodes:O32,M13

Linkage between CEO characteristics and open innovation adoption in innovative manufacturing SMEs

Joon Mo Ahn*, Letizia Mortara, Tim Minshall

Institute for Manufacturing, University of Cambridge, UK

Abstract

In small and medium-sized enterprises (SMEs), where typically the decision making process is highly centralised, important decisions, such as open innovation (OI) adoption, will be strongly influenced by their chief executive officers (CEOs). Using upper echelon theory, this paper attempts to explore how the top executive's demographic characteristics and personal traits influence the adoption of OI. A regression analysis on 306 innovation-oriented Korean manufacturing SMEs shows that the adoption of OI can be better understood by considering CEO characteristics as important OI determinants. However, the findings also show that the CEO traits affect the adoption of OI in different ways according to the nature of OI, i.e., knowledge flow direction and required skills and experience. This study has practical implications for CEOs who are in the process of implementing OI and for policy makers who are interested in stimulating SMEs' innovation performance.

Keywords: Open Innovation, SMEs, Chief Executive Officer, Upper Echelon Theory, Korea

* ja494@cam.ac.uk

1. Introduction

Open innovation (OI), as defined by Chesbrough (2003), has become a widespread business strategy (Dahlander and Gann, 2010, Huizingh, 2011, Gassmann et al., 2010), and many attempts have been made to understand its features and implications. Yet, it is surprising that, despite the growing attention given to OI, the understanding of its adoption, particularly in small and medium-sized enterprises (SMEs), is fragmented (Ahn et al., 2013, Lee et al., 2010, Mortara and Minshall, 2011, Spithoven et al., 2013, van de Vrande et al., 2009). Whilst various organisational level factors, such as internal R&D (Huang and Rice, 2009, Spithoven et al., 2011) and environmental factors, such as market turbulence (Hung and Chou, 2013), have been very much examined, little attention has been paid to the role of human capital in OI adoption (Chesbrough and Brunswicker, 2013, Schroll and Mild, 2012, Wynarczyk et al., 2013).

However, chief executive officers (CEOs) can play a critical role in shaping company strategy (Papadakis and Barwise, 2002). In large firms, the adoption of OI has been highly affected by the extent of top managements' support (Chesbrough and Brunswicker, 2013, Mortara et al., 2011), and this influence can be more important in smaller organisations where CEOs have greater impact on their employees and firm-level decisions (Lubatkin et al., 2006, Miller and Toulouse, 1986a, Thong and Yap, 1995, Papadakis and Bourantas, 1998, Papadakis and Barwise, 2002). As a CEO is at the epicentre of innovation in an SME (Marcati et al., 2008), a firm's strategic decisions are greatly affected by his/her interpretations, which reflects his personal experience, values and perception (Hambrick and Mason, 1984).

This paper attempts to address this research gap by investigating the linkage between the characteristics of CEOs and OI in SMEs. To be specific, by analysing the survey data from 306 innovation-oriented Korean manufacturing SMEs, this study aims to explore how the CEOs' demographic and personal characteristics influence OI adoption. Recognising the heterogeneity of SMEs, the focus of this paper is placed on innovative SMEs. Due to their strong internal R&D, clear focus on innovation, and limited internal resources, such SMEs can be ideal candidates for the benefits of an open approach to innovation. Confining the research focus to this type of SMEs may

enable us to investigate OI adoption determinants more clearly.

This research reported in this paper aims to advance both theory and practice. In terms of theory, an attempt is made to present a full understanding of OI phenomenon by examining an integrated framework, which incorporates CEO characteristics, organisational and environmental factors. As for the practical implications, it is hoped that this work will enable CEOs to realize that their perceptions of OI and efforts to adopt it play a critical role. The findings of this study will be of use in developing policies to support OI in SMEs by targeting CEOs.

The remainder of this paper comprises five sections. In the next section, theoretical foundations are explored and research hypotheses are suggested. The research method and data collection are described in section 3, and section 4 presents the results of the analysis and hypotheses tests. Implications and limitations are discussed in the final section of the paper.

2. Theoretical background and hypotheses

2.1. Upper echelon theory (UET) and SMEs

UET underpins our understanding of the relationships between the most powerful actor, the CEO and his/her firm's strategic decisions (Hambrick and Mason, 1984). According to this theory, CEOs are typically unable to fully appreciate all the contextual aspects within which their firms operate. Their limited awareness makes it more likely that they will perceive a business situation based on their own characteristics and/or past experience, and then interpret it in their own way (Hambrick and Mason, 1984). Consequently, the CEO's personal and cognitive characteristics based on so called 'bounded rationality' (Simon, 1957) can affect a company's strategic choices (Hambrick and Mason, 1984). Studies employing UET suggest that CEOs can play an important role in strategic decisions (Miller and Friesen, 1982), which influence the shape of technology policy (Lefebvre et al., 1997) and affect firm growth (Colombo and Grilli, 2005) and overall performance (Hambrick and Quigley, 2013).

Hambrick (2007) suggested that CEO influence can outweigh other contingent factors in organisations where a high level of CEO managerial discretion and job demands exist (Hambrick, 2007). Hence, when considering the following general organisational characteristics of SMEs, the

impact of two moderators becomes more critical, making UET better fit to SMEs than the competing perspectives (Escriba-Esteve et al., 2009, Miller and Toulouse, 1986b, Papadakis and Bourantas, 1998).

- A high employee turnover rate (Humphreys et al., 2005): Since high employee mobility can result in discontinuity of OI projects, important information will be concentrated in key individuals.
- Simple hierarchy: CEOs can be more frequently involved in everyday business and respond more quickly (Miller and Toulouse, 1986b, Papadakis and Barwise, 2002, Vossen, 1998) by being involved in both strategic and operational function (Lubatkin et al., 2006).
- Long tenure and weak interference: unclear division between the owner/founder and the CEO in SMEs, particularly in East Asian countries (Claessens et al., 2000), can lengthen CEO tenure and weaken BOD influence.
- Scarce resources: As SMEs lack resources and a structured administrative system, they typically rely more on a good leadership to deal with this weakness (Lubatkin et al., 2006, Humphreys et al., 2005, Vossen, 1998).

2.2. Open innovation and its modes

As shown in Table 1, OI encompasses various innovation activities. According to the direction of knowledge flow, OI can be divided into in-bound (or external technology exploration) and out-bound (or external technology exploitation) (Chesbrough and Crowther, 2006, Dahlander and Gann, 2010, Hung and Chou, 2013, van de Vrande et al., 2009).

TABLE 1 Open innovation modes

OI mode by knowledge flow direction		Definition	**OI mode by required skills**
In bound	In-sourcing	Introducing external knowledge to reduce time-to-market and find new ideas by purchasing or paying royalties.	Technological OI
	R&D collaboration	Conducting R&D with external partners	
	Customer involvement	Accessing new ideas by involving customers in the R&D or design process	Strategic OI
Out bound	Licensing-out	Licensing or selling unused technologies to maximize profit	

In-bound OI utilizes external knowledge for the implementation of internal innovation, and in-sourcing, R&D collaboration and customer involvement fall into this category. This type of OI process enables firms to cope with their insufficient resources (Chesbrough and Crowther, 2006, Enkel et al., 2009) by accessing external technologies of suppliers, customers, competitors, universities and other innovation actors (e.g., intermediary or research institution). However, to benefit from external knowledge, firms have to first engage in knowledge acquisition process activities, such as searching, selecting and integrating (Mortara et al., 2012, West and Bogers, 2013). This means that its adoption can be a time-consuming and adjustment necessary process. Not only do firms have to spend much time in searching, identifying and selecting exact information they have been looking for, they also have to overcome the cognitive difference between external and internal knowledge for its successful integration (Nooteboom, 2006, Vanhaverbeke, 2006). In the case of external partners, firms have to establish new rules and protocols in order to collaborate with their partners. Leveraging external partners requires a long building up of trust (Narula, 2004).

Out-bound OI refers to innovation activities attempting to realise profits by commercialising internal knowledge or underutilized intellectual properties (IPs) outside firms (Chesbrough and Crowther, 2006). Knowledge spill-over is an important driver and through this OI mode firms can maximise income, attract potential customers and establish new technology standards (Savitskaya et al., 2010, West and Gallagher, 2006, Dahlander and Gann, 2010). For SMEs, limited resources, especially those in IP management are important factors hindering out-bound OI (Bianchi et al., 2011, Lichtenthaler and Lichtenthaler, 2009). However, when viewed from the perspective of strategic decision making, the fact that high risks can be involved in disclosing internal ideas may further hamper the adoption of this OI mode. Even if an innovative SME has achieved a very high level of internal knowledge enough for knowledge spill over, the SME has to deal with high uncertainty. Exposing internal knowledge will decrease technology confidentiality (Bianchi et al., 2011, Oakey, 2013). Thus, a strong driver beyond knowledge spill-over is needed for SMEs to overcome the high uncertainty embedded in out-bound OI.

To date, a number of contingent factors, such as firms' resources and environmental elements,

have been employed to explain OI (Dahlander and Gann, 2010, Spithoven et al., 2013). However, the knowledge of OI adoption, particularly in SMEs, may be enhanced when the role of a key individual (i.e., a CEO) is fully understood (Bianchi et al., 2011, Wynarczyk et al., 2013). In OI processes, well-managed coordination as well as strong internal support is vital to deal with the challenges involved in collaborations with external partners with different cultures and innovation clock speeds. Also, to cope with an organisation's negative prejudice against the exploitation of external knowledge, a high level of risk-taking propensity and a pragmatic attitude is necessary (Chesbrough, 2003). Thus, the role of CEOs who champion OI is critical, particularly in SMEs where their impacts are highly significant in setting strategic directions (Eisenhardt and Schoonhoven, 1990, Miller and Droge, 1986).

In this context, in order to link OI with the CEO characteristics, we propose an additional classification to distinguish technological and strategic OI activities (see Table 1). The basic premise behind this classification is that OI activities demand different sets of skills and experience. In other words, in its implementation each OI activity involves either greater or lesser weight being put on strategic or technical values. For instance, technological OI refers to innovation activities focusing on technological improvement: in-sourcing and R&D collaboration are examples of it. The main purpose of this type of OI is to solve technological problems by introducing external technology, so skills and knowledge related to technology can be critical for in this OI. On the other hand, strategic OI refers to innovation activities which demand a high level of strategic decision making and managerial/relational skills for its implementation, and customer involvement and licensing-out can be placed within this category. For example, when revealing internal ideas through licensing-out, a high level of knowledge or experience in IP management and awareness of future company plans are critical for its implementation.

2.3. Hypotheses

This paper attempts to investigate both demographic and personal characteristics, selecting a set of variables to link CEO traits with OI adoption in consideration of the following OI characteristics:

- OI is a multi-level complex process involving interaction with external partners.
- OI can involve risks due to its uncertainty and complexity.
- OI can require a high level of technological/managerial knowledge or experience.

Two demographic variables (CEOs' education and prior work experience) and three personal traits (entrepreneurial orientation, perseverance and attitude towards OI adoption) are examined to investigate CEO influence on OI. These choices are further explained below.

Education

Education has been regarded as a good indicator of an individual's value, cognitive preference and perception (Hambrick and Mason, 1984, Hambrick, 2007). The rationale behind this is that a high level of formal education can enhance a firm's knowledge resources (Collins, 1971, Hambrick and Mason, 1984). A high level of CEO education can be viewed as a measure of the initial human capital invested in the firms (Cooper et al., 1994), and it can significantly affect firms' strategic decision (Hitt and Tyler, 1991, Papadakis, 2006). Strong information processing capability enables an individual to search for and analyse complex knowledge and overcome information overload, and good education enables this capability, which is necessary for effective decision making (Carpenter and Fredrickson, 2001, Dollinger, 1984). Much emphasis has been placed on the effect of CEO education in the literature. For instance, Papadakis and Bourantas (1998) found a positive association between formal education and product and process innovation, and similar results (i.e., its impact on technological and administrative innovation) were obtained by Bantel and Jackson (1989). Also, Mcmullan and Long (1987) found a positive linkage between CEOs' educational level and their business strategy planning skills. Similarly, with regard to the academic discipline, Kitchell (1997) observed the positive relationship between education in engineering/technology and technology adoption, and Almus and Nerlinger (1999) found that it had a positive impact on firms' growth. Given the complexity of OI which encompasses various subsets of innovation activities, it is logical to assume that both CEO education level and background may be able to affect their firms' external knowledge exploration and exploitation. Presumably, not only does a high level of education enable CEOs to deal with the

intrinsic ambiguity and uncertainty of OI through their strong information process capability, but their deeper technological knowledge may also help them evaluate any neglected technological OI opportunities which may arise. Similarly, education in management could have a positive impact on the adoption of strategic OI (e.g., licensing-out), in the sense that this type of OI may require more sophisticated managerial knowledge and skills for its implementation. Hence:

H1) CEOs' higher education level will be positively associated with OI adoption.

H2) CEOs' education in a technology discipline will positively impact technological OI adoption.

H3) CEOs' education in a management discipline will positively impact strategic OI adoption.

Work experience

Since CEOs may favour a specific business strategy based on their prior career experience (Hambrick and Mason, 1984), their professional experience, such as the length in the previous occupation and career track within organisations, would be important (Colombo and Grilli, 2005). The basic premise of this argument is that CEOs are imbued with the managerial experience they gained during earlier involvement in specific business function, so they perceive and interpret any situation based on their functional training (Barker and Mueller, 2002, Hambrick and Mason, 1984). Their perspective, shaped by work experience in functional areas, could affect the way in which they identify and solve managerial problems in innovation (Bantel and Jackson, 1989, Hitt and Tyler, 1991). As for functional track, top executives with work experience in engineering/technology recognised better technological alliance opportunities than those with other kinds of experience (Tyler and Steensma, 1998). Lefebvre and Lefebvre (1992) found that work experience in engineering/production contributes to an increase in firm innovativeness. In the Barker and Mueller (2002) study, CEO work experience in output functions (i.e., R&D/ engineering and marketing/sales) was positively associated with R&D expenditure, whilst some of the throughout function [1] experience (i.e., legal and operation/production) were negatively associated with R&D. Similarly, Colombo and Grilli (2005) found that experience in technological areas can contribute to firms' growth. For prior experience,

[1] Here throughout function concerns the improvement of efficiency of the organisation and refers to accounting/finance, production, administration and legal (Barker and Muller, 2002)

empirical findings are less robust. Whether CEOs have prior work experience did not show statistically significant relationships with failure rate (Bates, 1990), survival (Gimeno et al., 1997) or growth (Brüderl and Preisendörfer, 2000). However, Chandler and Jansen (1992) did find that prior work experience is positively correlated with firms' growth, and Colombo and Grilli (2005) discovered that prior entrepreneurial experience (i.e., self-employment experience) can highly influence firms' growth. Similarly, Siegel et al. (1993) found that long industry experience in an entrepreneurial team is an important factor distinguishing high growth ventures with low growth. CEO work experience could hence be an important managerial guideline for OI in SMEs. Long years spent in industry may enable CEOs to deal with the intrinsic uncertainty of OI through their accumulated experience in other firms. Also, work experience can affect CEOs' OI preference. CEOs with technology based experience may favour more technological OI, in the sense that this function is significantly linked with new product development (Barker and Mueller, 2002, Hambrick and Mason, 1984). Similarly, work experience in management functions can provide CEOs with decision making capability necessary for dealing with uncertainty related to strategic OI. Hence:

H4) CEOs' longer prior work experience will be positively associated with OI adoption.

H5) CEOs' work experience in a technology function will be positively associated with technological OI adoption.

H6) CEOs' work experience in a management function will be positively associated with strategic OI adoption.

Entrepreneurial orientation

Since knowledge exploration and exploitation can be stimulated by EO in the pursuit of changes and newness (Cassia et al., 2011), it can be regarded as an 'antecedent' of innovation (Hult et al., 2004, Kitchell, 1995, Moreno and Casillas, 2008, Rhee et al., 2010). EO is an aggregation of three sub-traits, propensity for innovation, risk-taking and pro-activeness (Covin and Slevin, 1989, Miller, 1983, Moreno and Casillas, 2008, Naman and Slevin, 1993), and literature have examined the impacts of EO on innovation, strategy and performance. March and Shapira (1987) observed that CEOs with a

high level of EO do not like to avoid uncertain situations, and it was also found that this type of CEO adopts innovative strategies boldly despite internal resistance (Howell and Higgins, 1990, Khandwalla, 1976/1977, Miller and Friesen, 1982, Miller, 1983). In small centralized organisations CEOs with high EO play a critical role in establishing a more aggressive entrepreneurial posture in a firm (Miller, 1983, Miller and Toulouse, 1986a), and this can significantly affect innovation methods and tool selection at the firm level (Cassia et al., 2011). In the OI domain, the high uncertainty demands that individuals would be more entrepreneurially oriented (Di Minin et al., 2010). Thu, given that OI embraces a variety of risky strategies (Chesbrough et al., 2006), it seems reasonable to presume that CEOs' EO is an important factor in encouraging an SME to adopt OI. As key decision makers in organisations, CEOs' propensity to innovate, take risks and behave proactively can push forward their firms to adopt OI boldly despite the risks involved in opening firm boundaries. Hence:

H7) CEOs' EO will be positively associated with OI adoption.

Perseverance

OI adoption can be not only a challenging but also a time-consuming task. It is a multilevel process encompassing knowledge searching, screening, transforming and integrating, and interactions with external partners are inevitable (Spithoven et al., 2011, West and Bogers, 2013). Internal resistance (e.g., not-invented-here (NIH) syndrome) does matter in OI (Chesbrough, 2003, van de Vrande et al., 2009), but this interactive multi-process nature of OI can be a heavier burden for SMEs. For them, finding trustworthy external OI partners is not easy, and even if they do, OI still requires long adjustments. External knowledge acquisition forces firms to adapt themselves continuously to different configurations, involving time-consuming changes. Firms want to quickly enjoy the fruit of innovation, but they usually do not like the changes and delays that come with it (Schein, 1985). Further, delays can be caused by asymmetric protocols. When two or more different organisations work together, errors can occur iteratively until a tangible positive result is reached. This might be due to different ways of dealing with business and information asymmetry between organisations (Kitchell, 1997, Minshall et al., 2010, Perkmann and Walsh, 2007). For example, when SMEs

collaborate with universities, errors of miscommunication and misunderstanding with academic institutions accumulate because of their different interests and ways of doing research. This may diminish the benefits of collaboration. Whilst delays occur due to the mutual adjustments between different innovation actors and the time consuming knowledge digestion process (Kitchell, 1997), the momentum of OI can be lost due to the accumulated fatigue of changes within the organisations. Thus, a powerful leader, who can break down internal resistance against changes and delays caused by interactions, is essential (Kitchell, 1997). Hence:

H8) CEOs' high levels of perseverance will be positively associated with OI adoption.

Attitude towards OI

Innovation is a process of change, so it demands strong proponents who push forward organisational level changes and disseminate the benefits inside organisations. In SMEs CEO personal traits can moderate technology policy (Lefebvre et al., 1997), as they champion technological innovation, such as increases in R&D investment (Barker and Mueller, 2002, Lefebvre and Lefebvre, 1992, Papadakis and Bourantas, 1998) or the adoption of IT technology (Thong and Yap, 1995). In large firms, it has been already shown that the support of top management increases the satisfaction with OI (Chesbrough and Brunswicker, 2013). CEOs with a positive attitude of OI can be strong advocates who push it as a top priority and overcome internal resistance (Huston and Sakkab, 2006, Kim et al., 2008). According to the theory of reasoned action, "attitude towards an object is viewed as related to the person's intentions to perform a variety of behaviours with respect to that object" (Fishbein and Ajzen, 1975:14). Thus, CEOs' attitudes towards OI can be a good proxy, reflecting the extent of their intention to adopt OI in their firms. A tough question, such as whether to adopt OI or not, will be, in the end, made by the final gatekeepers in the decision making process, CEOs. Hence:

H9) CEOs' positive attitudes towards OI will be positively associated with OI adoption.

These hypotheses are used to construct the research model as shown in Fig 1.

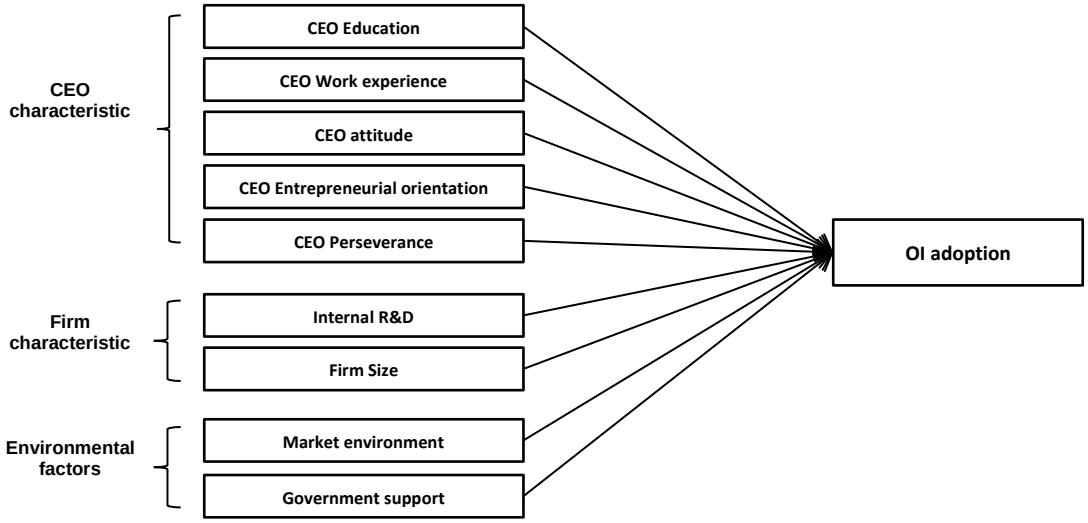

Figure 1 The research model

3. Research Method

3.1. Data and Samples

Data were collected through a survey using the database of the Korean Small and Medium Business Administration (SMBA). The SMBA is a government agency giving a government certificate to innovation-oriented SMEs (so-called 'Inno-biz' firms) to promote their contribution to the national economy. These firms are assessed by the SMBA according to four major criteria[2], innovation capacity, commercialization ability, innovation management and innovation performance, and by the second quarter of 2013 a total of 17,295 SMEs had obtained the inno-biz certification. The inno-biz database contains basic information, such as total revenue and the number of employees, and provides contact details for CEOs. For the main survey, 3,000 manufacturing SMEs were randomly selected from the inno-biz database, and a structured questionnaire was delivered to CEOs of the firms via e-mail. 68 firms were not reached due to errors in contact details. In total 329 responses were collected. This gives a 11.3% response rate. However, 23 responses were excluded from the final sample as key

[2] This evaluation criteria was made based on the OECD Oslo manual.

information about CEO characteristics was missing. So, 306 responses were finally used for the analysis. To examine any non-response bias, the extrapolation method, comparing early and late responding mean values of variables, was used, in the sense that late respondents are likely to have similar characteristics to non-respondents (Armstrong and Overton, 1977). In terms of the number of employees, sales and firm age, no significant difference between the two groups was found; suggesting non-response bias was not a problem.

The sample's average number of employees per company was 28.80, and the average firm age was 11.42 years. The sample firms were highly involved in innovation (i.e., average R&D intensity 11.60). The firm size distribution is shown in Table 2.

TABLE 2 Firm size distribution

[Unit: the number of firm, %]

Employees	1-10	11-20	21-30	31-50	51-100	101-200	200~300
Frequency	80	92	62	37	22	100	3
Percentage	26.1	30.1	20.3	12.1	7.2	3.2	1.0

3.2. Variable measurement

3.2.1. Demographic variables

CEO education

Two education variables, 'degree' and 'discipline', were employed. The 'degree' attempted to measure the level of education attainment using a seven level ordinal scale, where 1 corresponds to secondary school graduate to 7 to PhD degree (Lefebvre and Lefebvre, 1992). The 'discipline' was measured using categorical variables, according to whether the education discipline was technology- (e.g., engineering or science), management-related or others.

Work experience

The experience of CEOs in industry was measured using two variables: 'years' and 'functional track'. The former was measured by the length of work experience using a seven level and the later was

measured using categorical variables, i.e., whether the respondent had prior work experience in R&D, sales/marketing, production, planning/strategy or other areas.

3.2.2. Personal traits

Entrepreneurial orientation

Miller (1983) used three factors of entrepreneurship of dimensions (willingness to innovate, pro-activeness and the degree of risk-taking). Based on Miller (1983) and Coven and Slevin (1989), this study adopted seven sub-indicators - two on the degree of innovativeness, two on the degree of pro-activeness and three on risk-taking propensity – using the 7-point Likert scale for each (i.e., 1: strongly disagree to 7: strongly agree)

Perseverance

The scale suggested by Kitchell (1997) was used. Four factors are employed to ask how reluctant in general a CEO is to give up and how much s/he makes a persistent effort to achieve goals using the 7-point Likert scale (i.e., 1: strongly disagree to 7: strongly agree).

Attitude

Three attitude factors (voluntariness, relative advantage, ease of use) which are originally suggested by Moore and Benbasat (1991) were used. Firstly, the 'voluntariness' which is defined as 'the degree to which the use of innovation is perceived as being voluntary, or of free will' (Moore and Benbasat, 1991) attempts to identify whether a CEO is an initiator of OI by asking whether OI is adopted and implemented in a top-down approach (Mortara and Minshall, forthcoming). The 'relative advantage' is defined as 'the degree to which an innovation is perceived as being better than its precursor' (Rogers, 1983). In this case, we asked whether a CEO was well aware of OI's advantages. Lastly, the 'ease of use' is defined as 'the degree to which an innovation is perceived as being difficult to use' (Moore and Benbasat, 1991, Rogers, 1983) and we asked how difficult a CEO felt about adopting OI. All factors were measured using the 7-point Likert scale (i.e., 1: strongly disagree to 7: strongly agree),

3.2.3. Control and dependent variable

Control variables

Some firm-level (R&D intensity and firm size) and environmental variables (market environment and government support) are controlled due to their significant impacts on innovation. In the literature, intensive R&D is an essential prerequisite of strong absorptive capacity (Cohen and Levinthal, 1990); firm size is significantly associated with OI adoption (van de Vrande et al., 2009); the impact of government support (Kang and Park, 2012) and market turbulence (Hung and Chou, 2013) have been regarded as important external factors affecting innovation. In this study, 'R&D intensity' was measured as the ratio of R&D expenditure to total sales, and 'firm size' was assessed via the natural logarithm of the total employee numbers. 'Government support' and 'market environment' were measured using the 7-point Likert scale, to establish how often the firm received government support[3] and to what extent CEOs felt that the market environment was competitive.

Dependent variables

The OI modes shown in Table 1 were measured using binary variables (where 0 corresponds to 'not adopted' and 1 to 'adopted in the past three years').

3.3. Latent variable assessment

The reliability of the measurement was assessed by Cronbach's alpha, and all constructed latent variables satisfied the recommended level of 0.7 or over (Field, 2009). As shown in the Table 3, the Cronbach's alpha for EO, perseverance and attitude were 0.875, 0.833 and 0.928, respectively. The validity was assessed according to three types of validity, convergent, discriminant and nomological, using confirmatory factor analysis (CFA). The convergent validity was assessed by whether factor loadings of indicators are statistically significant and are higher than 0.5 (Bagozzi and Yi, 1988). All

[3] Encompassing all kinds of government support, such as subsidies, tax deductions, loans, and research grants.

standardized factor loadings were over 0.5 and significant at the 0.001 level. All composite reliability suggested by Fornell and Laker (1981) were also over 0.6, verifying the convergent validity. It can be said that the discriminant validity is guaranteed if "the correlation coefficients between latent variable ± 2 ×standard errors does not include one" (Anderson and Gerbing, 1988), and all the correlation coefficients in our data satisfied this condition. Nomological validity refers to the correlation directions on the basis of theory, and no violation was found in the significance of estimates and their direction when compared with the research model.

TABLE 3 Latent variable assessment

Factor loadings	Standardized estimate	Critical Ratio (C.R)	Cronach's α	Composite validity
Innovativeness 1 ← EO	0.723	12.366***	0.875	0.762
Innovativeness 2 ← EO	0.727	12.425***		
Pro-activeness 1 ← EO	0.757	-		
Pro-activeness 2 ← EO	0.745	12.750***		
Risk-taking 1 ← EO	0.589	9.928***		
Risk-taking 2 ← EO	0.712	12.168***		
Risk-taking 3 ← EO	0.748	12.819***		
Perseverance 1 ← PER	0.866	15.137***	0.833	0.745
Perseverance 2 ← PER	0.886	15.312***		
Perseverance 3 ← PER	0.762	-		
Perseverance 4 ← PER	0.512	8.637***		
Voluntariness 1 ← ATTI	0.832	19.069***	0.928	0.854
Voluntariness 2 ← ATTI	0.865	20.482***		
Relative advantage 1 ← ATTI	0.877	-		
Relative advantage 2 ← ATTI	0.836	19.228***		
Relative advantage 3 ← ATTI	0.844	19.561***		
Ease of use ← ATTI	0.720	14.940***		

*p<0.05, **p<0.01, *** p < 0.001

EO = Entrepreneurial Orientation, PER = Perseverance, ATTI = Attitude towards OI adoption

4. Results and Discussion

A hierarchical binary logistic regression was used to estimate the effects of each CEO factor. At first (i.e., model 1), only control variables were employed, while CEO variables were added in models 2, 3 and 4. Model 2 included three CEO personal traits (EO, attitude and perseverance), and in model 3 work experience variables (i.e., years and functional track) were added. Finally, the education variables (degree and discipline) were included in model 4. Three indices, 'Hosmer&Lemeshow', 'Cox&Snell' and 'Nagelkerke R^2' were used to assess model fit. However, if the added variables did not produce significant changes in terms of chi-square statistics, the newly added variables were not

included at the next model even if an increase in R^2 was observed. Before the regression, multicollinearity was checked. Myers (1990) suggested that a variance inflation factor (VIF) larger than 10 can cause a serious collinearity problem. For all variables, VIF values were between 1.055 and 3.588. Thus, it can be said that there was no serious collinearity problem in the sample.

4.1. In-sourcing

As seen in Table 4, the regression analysis shows that the attitude towards OI and some contingent variables can affect the adoption of in-sourcing.

TABLE 4 In-sourcing adoption

In-sourcing	Model 1a	Model 2a	Model 3a	Model 4a
Independent variables				
EO		-0.138 (0.145)	-0.088 (0.153)	-0.081 (0.166)
ATTI		0.614** (0.193)	0.599* (0.201)	0.608* (0.207)
PER		0.223 (0.173)	0.197 (0.178)	0.170 (0.182)
Degree				0.018 (0.094)
Tech-Edu[a]				0.241 (0.554)
Manage-Edu[a]				0.213 (0.578)
Working years			0.033 (0.098)	
Sales/marketing[b]			0.888 (0.598)	
R&D work[b]			0.331 (0.594)	
Plan/strategy[b]			0.608 (0.728)	
Production[b]			0.575 (0.623)	
Control variables				
Environment	-0.102 (1.019)	-0.076 (0.115)	-0.091 (0.120)	-0.071 (0.122)
Government	0.414***(0.109)	0.264* (0.117)	0.312* (0.123)	0.306* (0.126)
Firm size	0.371* (0.154)	0.382* (0.161)	0.465* (0.179)	0.472* (0.180)
R&D intensity	0.022+ (0.013)	0.025+ (0.014)	0.040* (0.017)	0.039* (0.016)
Model fit				
Hosmer&Lemeshow R^2	0.070	0.156	0.166	0.194
Cox&Snell R^2	0.085	0.177	0.195	0.225
Nagelkerke R^2	0.120	0.249	0.274	0.308
χ^2 change		32.005***	3.833	9.192

Notes: regression coefficient shown are beta coefficient and standard errors are in parentheses; statistical significance +p<0.1, *p<0.05, **p<0.01, ***p<0.001; [a] base variable is 'other academic discipline'; [b] base variable is 'other functions'.

In the models, government support, firm size and R&D intensity are significantly associated with in-sourcing. This suggests that funding from the public sector can encourage external knowledge exploration and medium-sized firms with more abundant resources rather than smaller firms can afford to purchase external ideas. It also suggests that strong internal R&D can help firms to understand and assimilate external knowledge (Cohen and Levinthal, 1990, Spithoven et al., 2011).

As for CEO traits, however, only 'attitude' is significantly associated with in-sourcing. In model 3a, not only do 'work experience' variables not show significant effects, but chi-square changes are also statistically insignificant. Model 4a tested 'education' variables excluding 'work' variables, but it does not show a model-fit improvement in terms of chi-square statistics. Thus, it can be said that buying external ideas can be further encouraged by the positive awareness of a CEO, but is not affected by the other CEO traits.

4.2. R&D collaboration

Table 5 shows the analysis on R&D collaboration. Model 1b shows that, unlike in the case of in-sourcing, among control variables 'government support' is positively associated with R&D collaboration. This suggests that public funding encouraging networking among innovation actors can positively affect R&D collaboration and cooperation between actors can be enhanced in a benign market environment.

As for CEO traits, model 2b shows the significant impact of 'attitude' and 'perseverance', and model 4b indicates CEO education in technology discipline can affect R&D collaboration. However, since model 3b does not generate significant chi-square changes, we conclude that there is no significant influence from 'work experience'.

Findings suggest that CEOs' perseverance as well as their positive awareness of OI is critical factors influencing the adoption of R&D collaboration. Unlike in the case of in-sourcing, R&D collaborations are interactive activities requiring skilled relationship management. When two (or more) companies with different cultural backgrounds, goals and ways of doing research collaborate, they will inevitably face the challenges of progressive adaptation to come closer to each other. In this respect, whether CEOs can wait until there are tangible outcomes can be critical in R&D collaborations (Kitchell, 1997). Further, technology education can also affect the adoption of R&D collaborations. As, in innovation-oriented SMEs, CEOs are often effectively de-facto R&D managers, their education can contribute to knowledge building in their organisations. Extensive knowledge is vital for technological innovation (Dewar and Dutton, 1986), so whether CEOs can provide firms with

the necessary technological resources, can be critical in the adoption of R&D collaboration.

TABLE 5 R&D collaboration adoption

R&D collaboration	Model 1b	Model 2b	Model 3b	Model 4b
Independent variables				
EO		-0.351 (0.295)	-0.255 (0.171)	-0.337 (0.278)
ATTI		0.623* (0.193)	0.565* (0.218)	0.450* (0.225)
PER		0.900*** (0.193)	0.889*** (0.198)	0.896*** (0.202)
Degree				0.124 (0.109)
Tech-Edu[a]				2.356** (0.682)
Manage-Edu[a]				1.763 (1.112)
Working years			-0.051 (0.111)	
Sales/marketing[b]			-1.029 (0.634)	
R&D work[b]			-0.962 (0.632)	
Plan/strategy[b]			-0.559 (0.789)	
Production[b]			-0.842 (0.661)	
Control variables				
Environment	-0.187 (0.114)	-0.169 (0.140)	-0.144 (0.144)	-0.256+ (0.150)
Government	0.944*** (0.133)	0.876*** (0.156)	0.898*** (0.162)	0.833*** (0.162)
Firm size	0.116 (0.160)	0.097 (0.188)	0.024 (0.204)	0.057 (0.202)
R&D intensity	-0.013 (0.014)	-0.024 (0.018)	-0.017 (0.021)	-0.023 (0.019)
Model fit				
Hosmer&Lemeshow R^2	0.176	0.380	0.379	0.420
Cox&Snell R^2	0.216	0.408	0.407	0.439
Nagelkerke R^2	0.288	0.546	0.544	0.588
χ^2 change		85.130***	-8.748	12.754**

Notes: regression coefficient shown are beta coefficient and standard errors are in parentheses; statistical significance +p<0.1, *p<0.05, **p<0.01, ***p<0.001; [a] base variable is 'other academic discipline'; [b] base variable is 'other functions'.

4.3. Customer involvement

As seen in Table 6, the regression results show that both contingent factors and CEO traits can influence the adoption of customer involvement. A hostile market environment is positively associated with this OI mode across all the models at the 0.1 level, but internal R&D is negatively associated with it in models 2c and 3c.

As for CEO traits, the psychological characteristics and functional track affect the OI adoption positively. However, in model 4c the educational traits do not show any significance in terms of regression estimates and chi-square statistics changes. In models 2c and 3c, EO and CEO attitude are positively associated at the 0.001 and 0.1 level respectively. Also, although the length of working experience shows no impact, the work experience in sales/marketing and planning/strategy function are positively and significantly associated with customer involvement.

The results suggest that in a market where competition is fierce CEOs with a high level of EO and positive awareness towards interaction with customers are likely to adopt this type of OI in order to identify fast-changing market needs and deal with their weak internal R&D capacity. Also, experience in sales/marketing or planning can provide helpful background knowledge in managing customer involvement. Innovative and pro-active CEOs may use customers' knowledge in order to obtain fresh ideas and to respond quickly to market changes. In this process their experience in marketing or strategy-building can help them to adopt and effectively implement customer involvement.

TABLE 6 Customer involvement adoption

Customer involvement	Model 1c	Model 2c	Model 3c	Model 4c
Independent variables				
EO		0.647*** (0.147)	0.612*** (0.155)	0.648*** (0.170)
ATTI		0.321+ (0.190)	0.332+ (0.193)	0.296+ (0.175)
PER		0.156 (0.174)	0.119 (0.179)	0.095 (0.184)
Degree				0.006 (0.093)
Tech-Edu[a]				0.316 (0.579)
Manage-Edu[a]				0.058 (0.602)
Working years			0.024 (0.101)	0.027 (0.102)
Sales/marketing[b]			1.023+ (0.568)	1.076+ (0.597)
R&D work[b]			0.960 (0.634)	0.970 (0.636)
Plan/strategy[b]			1.662* (0.759)	1.686* (0.758)
Production[b]			0.746 (0.665)	0.761 (0.676)
Control variables				
Environment	0.121+ (0.067)	0.197+ (0.116)	0.174+ (0.097)	0.170+ (0.093)
Government	0.179+ (0.099)	-0.009 (0.117)	-0.009 (0.122)	-0.018 (0.124)
Firm size	0.000 (0.145)	-0.097 (0.161)	-0.062 (0.178)	-0.056 (0.178)
R&D intensity	-0.018 (0.014)	-0.043* (0.017)	-0.040* (0.019)	-0.038+ (0.020)
Model fit				
Hosmer&Lemeshow R^2	0.016	0.200	0.208	0.206
Cox&Snell R^2	0.020	0.229	0.235	0.235
Nagelkerke R^2	0.028	0.315	0.324	0.323
χ^2 change		72.417***	16.321**	1.251

Notes: regression coefficient shown are beta coefficient and standard errors are in parentheses; statistical significance +p<0.1, *p<0.05, **p<0.01, ***p<0.001; [a] base variable is 'other academic discipline'; [b] base variable is 'other functions'.

4.4. Licensing-out

Table 7 shows the analysis results for licensing-out. The fact that internal R&D is positively associated with this OI mode in all the models suggests, as does the literature (e.g., West and Gallagher, 2006), the importance of knowledge spill-over as a key driver. With regard to CEO traits,

the psychological and functional track show significant effects in models 2d and 3d. Educational traits do not appear significant in terms of estimate coefficient and chi-square changes.

TABLE 7 Licensing-out adoption

Licensing-out	Model 1d	Model 2d	Model 3d	Model 4d
Independent variables				
EO		1.262*** (0.260)	1.385*** (0.287)	1.379*** (0.305)
ATTI		0.562+ (0.291)	0.492+ (0.290)	0.516+ (0.268)
PER		-0.843** (0.259)	-0.891** (0.275)	-0.886** (0.278)
Degree				0.134 (0.143)
Tech-Edu[a]				0.777 (1.174)
Manage-Edu[a]				0.819 (1.187)
Working years			-0.035 (0.148)	-0.013 (0.148)
Sales/marketing[b]			0.205 (0.888)	0.219 (0.894)
R&D work[b]			-0.335 (0.877)	-0.325 (0.883)
Plan/strategy[b]			0.994+ (0.590)	0.964+ (0.510)
Production[b]			-0.411 (0.992)	-0.268 (1.007)
Control variables				
Environment	-0.053 (0.145)	-0.066 (0.163)	-0.075 (0.174)	-0.099 (0.177)
Government	-0.113 (0.147)	-0.155 (0.163)	-0.191 (0.169)	-0.261 (0.183)
Firm size	0.225 (0.202)	0.098 (0.228)	-0.019 (0.249)	-0.042 (0.253)
R&D intensity	0.035 * (0.014)	0.030 * (0.013)	0.052 * (0.021)	0.049 * (0.022)
Model fit				
Hosmer&Lemeshow R^2	0.026	0.291	0.328	0.332
Cox&Snell R^2	0.020	0.229	0.232	0.235
Nagelkerke R^2	0.037	0.315	0.420	0.425
χ^2 change		62.607***	11.254*	1.393

Notes: regression coefficient shown are beta coefficient and standard errors are in parentheses; statistical significance +p<0.1, *p<0.05, **p<0.01, ***p<0.001; [a] base variable is 'other academic discipline'; [b] base variable is 'other functions'.

All personal characteristics are significantly associated with licensing-out, but, interestingly, the directions of association are different. Results show a high level of EO and positive awareness can contribute to licensing-out adoption, but perseverance is negatively associated with it at the 0.01 level. This can be interpreted by understanding the characteristics of this outbound OI. As revealing internal knowledge entails risks, a key decision maker should recognise that disclosing internal ideas is worth doing. If s/he overestimates potential risks and questions the current benefits of revealing ideas, s/he will probably be reluctant to release them in a desire to preserve unused IPs for a future use. Thus, whilst EO can positively affect licensing-out, perseverance can negatively influence it.

As for the functional track, only work experience in planning/strategy shows a positive association with licensing-out at the 0.1 level. This suggests the possibility that the CEOs' work experience in planning/strategy function can help them to realize the advantage of this OI mode. As

firms have to spend financial resources to maintain unused IPs, CEOs with strategy building experience may attempt to realize profits quickly by selling or receiving royalties from dormant patents. CEOs with this type of experience may be better at diversifying innovation routes and strategically optimizing firm resources by releasing internal ideas.

4.5. Findings

The following findings emerged from the results. Firstly, the CEO characteristics are significantly associated with OI, suggesting that our knowledge of OI can be enhanced by including CEO characteristics. The hierarchical regressions show fit indices and the explanation power can be increased by adding CEO factors to the model.

Secondly, however, the impact of CEO factors can vary with the OI mode. This reflects the breadth of OI, which encompasses various subsets of innovation (Dahlander and Gann, 2010). For example, CEO perseverance positively affects R&D collaboration (i.e., in-bound OI), but it is negatively associated with out-bound mode, such as licensing-out. CEO perseverance can be an important factor in resolving differences in different organisations, but CEOs trust more in internal potential may hesitate to release internal ideas and keep trying to achieve innovation internally.

Thirdly, the impact of psychological characteristics is higher in out-bound than in in-bound OI. In fact, knowledge exploration and exploitation are driven by different capabilities (Floyd and Lane, 2000), and they demand different managerial behaviours (Lubatkin et al., 2006). Since the adoption of out-bound OI requires CEOs to perceive innovation routes in a different way so as to make profits outside their firms, it might necessitate a bold strategic posture. This high dependency on key decision makers' personal traits may be one reason why out-bound OI is difficult to investigate. The nature of out-bound OI will only be adequately understood when both contingent and top management variables are investigated.

Lastly, technological and strategic OI demand different CEO skills and knowledge. As shown in the empirical results, CEO education in a technology discipline can positively impact R&D collaboration (technological OI). Similarly, it is shown that career experience in management function

can help the adoption of strategic OI, such as customer involvement and licensing-out. A key decision maker's expertise is likely to be critical under conditions of high uncertainty (Li et al., 2006). Since CEOs often have to be involved in both strategic and operation activities (Lubatkin et al., 2006), their knowledge and experience can be a useful in dealing with risks and deciding innovation routes.

5. Conclusions

5.1. Implications

This paper attempts to advance both theory and practice. As for theory, we investigated one of the under-researched themes in OI, the role of the key individual (Schroll and Mild, 2012, Wynarczyk et al., 2013), particularly the CEO. The focus of previous studies has been placed on firm-level or environmental factors based on new institutional theory or environment determinism. However, we attempted to expand the boundaries of OI discussion to include the role of human capital by proposing an integrated research model encompassing both contingent and CEO characteristics. The fact that our results show the significant impact of both contingent variables (e.g., internal R&D in in-sourcing, market hostility in customer involvement) and CEO traits supports the validity of the proposed model.

Further this research helps building more useful constructs for OI. In addition to knowledge flow direction (i.e., in-bound and out-bound OI), we proposed to categorize OI in a different way according to the nature/skills/expertise required for the various individual OI activities. This was confirmed by the empirical analysis. As CEO education in technology discipline affects the adoption of R&D collaboration (technological OI) and education in management influences M&A/alliancing[4] (strategic OI). Also, the fact that managerial experience is positively associated with some strategic OI (customer involvement and licensing-out) supports this proposition.

The results of this study also provide policy and managerial implications, recognising the role of top management in OI. Our findings suggest that human capital, particularly CEOs, can play an important trigger role in promoting OI in innovation-oriented SMEs. Whether CEOs perceive the

[4] In fact, we also examined M&A/strategic alliancing and spin-off (both are strategic OI). These results were omitted here due to the word limit, but our full-results show that management education can affect the adoption of M&A/alliancing and high academic degree can positively influence the adoption of spin-off. However, the working years did not affect the adoption of any OI mode.

advantages of OI can considerably affect OI adoption in an SME. When they recognise sufficiently the importance of OI, their positive attitude will encourage their firms to adopt it (Rogers, 1983). Thus, direct financial support, such as R&D grants, can be helpful in promoting OI, but policy makers should realise that enhancing CEO awareness of OI could also be good policy intervention. For example, specialised education programmes, which help CEOs to perceive the advantages of OI or enhance their entrepreneurship, could well be considered as effective means to increase the competitiveness of SMEs.

5.2. Limitations and future research directions

Our study has a few limitations. Since this paper firstly attempts to link different domains of the literature, OI and UET, tested CEO characteristics are mainly borrowed from the UET literature. Future research is needed to take into consideration other CEO factors, which may significantly affect OI adoption. Theoretical research attempting to analyse the mechanism of OI adoption or in-depth case-studies which solely focus on the impact of human capital can be helpful in developing new CEO variables missing in the UET literature.

The generalizability of our results can be another limitation as only innovation-oriented Korean SMEs were analysed. As noted by Edwards et al. (2005), a higher level of understanding of SMEs can be achieved by acknowledging the complex connection between an SME and its socio-cultural context. In fact, the impact of CEOs can be different under different national system (Crossland and Hambrick, 2011). In this regard, future research can enhance generalizability by carrying out a comparative study of two or more countries.

Reference

AHN, J. M., MORTARA, L. & MINSHALL, T. 2013. The effects of open innovation on firm performance: a capacity approach. *Science, Technology and Innovation Policy Review,* 4**,** 74-93.

ALMUS, M. & NERLINGER, E. A. 1999. Growth of new technology-based firms: Which factors matter? *Small Business Economics,* 13**,** 141-154.

ANDERSON, J. C. & GERBING, D. W. 1988. Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin,* 103**,** 411-423.

ARMSTRONG, J. S. & OVERTON, T. S. 1977. Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing Research,* 14**,** 396-402.

BAGOZZI, R. P. & YI, Y. 1988. On the evaluation of structural equation models. *Journal of the Academy of Marketing Science,* 16**,** 74-94.

BANTEL, K. A. & JACKSON, S. E. 1989. Top Management and Innovations in Banking - Does the Composition of the Top Team Make a Difference. *Strategic Management Journal,* 10**,** 107-124.

BARKER, V. L. & MUELLER, G. C. 2002. CEO characteristics and firm R&D spending. *Management Science,* 48**,** 782-801.

BATES, T. 1990. Entrepreneur Human-Capital Inputs and Small Business Longevity. *Review of Economics and Statistics,* 72**,** 551-559.

BIANCHI, M., CHIARONI, D., CHIESA, V. & FRATTINI, F. 2011. Exploring the role of human resources in technology out-licensing: an empirical analysis of biotech newtechnology-based firms. *Technology Analysis & Strategic Management,* 23**,** 825-849.

BRÜDERL, J. & PREISENDÖRFER, P. 2000. Fast-growing businesses: Empirical evidence from a German study. *International journal of sociology***,** 45-70.

CARPENTER, M. A. & FREDRICKSON, J. W. 2001. Top management teams, global strategic posture, and the moderating role of uncertainty. *Academy of Management Journal,* 44**,** 533-545.

CASSIA, L., MINOLA, T. & PALEARI, S. 2011. Entrepreneurship, technology and change: a review and proposal for an interpretative framework. *In:* CASSIA, L., MINOLA, T. & PALEARI, S. (eds.) *Entrepreneurship and Technological Change.* Cheltenham: Edward Elgar Publishing Limited.

CHANDLER, G. N. & JANSEN, E. 1992. The Founders Self-Assessed Competence and Venture Performance. *Journal of Business Venturing,* 7**,** 223-236.

CHESBROUGH, H. 2003. *Open innovation : the new imperative for creating and profiting from technology,* Boston, Mass., Harvard Business School Press.

CHESBROUGH, H. & BRUNSWICKER, S. 2013. Managing Open Innovation in Large Firms. Stuttgart.

CHESBROUGH, H. & CROWTHER, A. K. 2006. Beyond high tech: early adopters of open innovation in other industries. *R & D Management,* 36**,** 229-236.

CHESBROUGH, H., VANHAVERBEKE, W. & WEST, J. 2006. *Open innovation : researching a new paradigm,* Oxford, Oxford University Press.

CLAESSENS, S., DJANKOV, S. & LANG, L. H. 2000. The separation of ownership and control in East Asian corporations. *Journal of Financial Economics,* 58**,** 81-112.

COHEN, W. M. & LEVINTHAL, D. A. 1990. Absorptive-Capacity - a New Perspective on Learning and Innovation. *Administrative Science Quarterly,* 35**,** 128-152.

COLLINS, R. 1971. Functional and Conflict Theories of Educational Stratification. *American Sociological Review,* 36**,** 1002-&.

COLOMBO, M. G. & GRILLI, L. 2005. Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy,* 34**,** 795-816.

COOPER, A. C., GIMENOGASCON, F. J. & WOO, C. Y. 1994. Initial Human and Financial Capital as Predictors of New Venture Performance. *Journal of Business Venturing,* 9**,** 371-395.

COVIN, J. G. & SLEVIN, D. P. 1989. Strategic Management of Small Firms in Hostile and Benign Environments. *Strategic Management Journal,* 10**,** 75-87.

CROSSLAND, C. & HAMBRICK, D. C. 2011. Differences in Managerial Discretion across Countries: How Nation-Level Institutions Affect the Degree to Which Ceos Matter. *Strategic Management Journal,* 32**,** 797-819.
DAHLANDER, L. & GANN, D. M. 2010. How open is innovation? *Research Policy,* 39**,** 699-709.
DI MININ, A., FRATTINI, F. & PICCALUGA, A. 2010. Fiat: open innovation in a downturn (1993–2003). *California Management Review,* 52**,** 132-159.
DOLLINGER, M. J. 1984. Environmental Boundary Spanning and Information-Processing Effects on Organizational Performance. *Academy of Management Journal,* 27**,** 351-368.
EDWARDS, T., DELBRIDGE, R. & MUNDAY, M. 2005. Understanding innovation in small and medium-sized enterprises: a process manifest. *Technovation,* 25**,** 1119-1127.
EISENHARDT, K. M. & SCHOONHOVEN, C. B. 1990. Organizational Growth - Linking Founding Team, Strategy, Environment, and Growth among United-States Semiconductor Ventures, 1978-1988. *Administrative Science Quarterly,* 35**,** 504-529.
ENKEL, E., GASSMANN, O. & CHESBROUGH, H. 2009. Open R&D and open innovation: exploring the phenomenon. *R & D Management,* 39**,** 311-316.
ESCRIBA-ESTEVE, A., SANCHEZ-PEINADO, L. & SANCHEZ-PEINADO, E. 2009. The Influence of Top Management Teams in the Strategic Orientation and Performance of Small and Medium-sized Enterprises. *British Journal of Management,* 20**,** 581-597.
FIELD, A. 2009. *Discovering Statistics Using SPSS,* London, Sage.
FISHBEIN, M. & AJZEN, I. 1975. *Belief, attitude, intention and behavior: An introduction to theory and research,* Reading, Mass, Addison-Wesley.
FLOYD, S. W. & LANE, P. J. 2000. Strategizing throughout the organization: Managing role conflict in strategic renewal. *Academy of Management Review,* 25**,** 154-177.
FORNELL, C. & LARCKER, D. F. 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research,* 18**,** 39-50.
GASSMANN, O., ENKEL, E. & CHESBROUGH, H. 2010. The future of open innovation. *R & D Management,* 40**,** 213-221.
GIMENO, J., FOLTA, T. B., COOPER, A. C. & WOO, C. Y. 1997. Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative Science Quarterly,* 42**,** 750-783.
HAMBRICK, D. C. 2007. Upper echelons theory: An update. *Academy of Management Review,* 32**,** 334-343.
HAMBRICK, D. C. & MASON, P. A. 1984. Upper Echelons: The Organization as a Reflection of Its Top Managers. *Academy of Management Review,* 9**,** 193-206.
HAMBRICK, D. C. & QUIGLEY, T. J. 2013. Toward More Accurate Contextualization of the CEO Effect on Firm Performance. *Strategic Management Journal*.
HITT, M. A. & TYLER, B. B. 1991. Strategic Decision-Models - Integrating Different Perspectives. *Strategic Management Journal,* 12**,** 327-351.
HOWELL, J. M. & HIGGINS, C. A. 1990. Champions of Technological Innovation. *Administrative Science Quarterly,* 35**,** 317-341.
HUANG, F. & RICE, J. 2009. The role of absorptive capacity in facilitating" Open innovation" outcomes: A study of Australian SMEs in the manufacturing sector. *International Journal of Innovation Management,* 13**,** 201-220.
HUIZINGH, E. K. R. E. 2011. Open innovation: State of the art and future perspectives. *Technovation,* 31**,** 2-9.
HULT, G. T. M., HURLEY, R. F. & KNIGHT, G. A. 2004. Innovativeness: Its antecedents and impact on business performance. *Industrial Marketing Management,* 33**,** 429-438.
HUMPHREYS, P., MCADAM, R. & LECKEY, J. 2005. Longitudinal evaluation of innovation implementation in SMEs. *European Journal of Innovation Management,* 8**,** 283-304.
HUNG, K. P. & CHOU, C. 2013. The impact of open innovation on firm performance: The moderating effects of internal R&D and environmental turbulence. *Technovation,* 33**,** 368-380.

HUSTON, L. & SAKKAB, N. 2006. Connect and develop: Inside Procter & Gamble's new model for innovation. *Harvard Business Review,* 84**,** 58-66.
KANG, K. N. & PARK, H. 2012. Influence of government R&D support and inter-firm collaborations on innovation in Korean biotechnology SMEs. *Technovation,* 32**,** 68-78.
KHANDWALLA, P. N. 1976/1977. Some top management styles, their context and performance. *Organization and Administrative Science,* 7**,** 21-51.
KIM, S. K., AHN, D. H., SONG, J. G., LEE, J. W., BAE, Y. H. & JUN, J. Y. 2008. Building Open Innovation System: Theory, Practice and Policy Implication. Seoul: STEPI.
KITCHELL, S. 1995. Corporate culture, environmental adaptation, and innovation adoption: a qualitative/quantitative approach. *Journal of the Academy of Marketing Science,* 23**,** 195-205.
KITCHELL, S. 1997. CEO characteristics and technological innovativeness: A Canadian perspective. *Canadian Journal of Administrative Sciences-Revue Canadienne Des Sciences De L Administration,* 14**,** 111-125.
LEE, S., PARK, G., YOON, B. & PARK, J. 2010. Open innovation in SMEs-An intermediated network model. *Research Policy,* 39**,** 290-300.
LEFEBVRE, E. & LEFEBVRE, L. A. 1992. Firm innovativeness and CEO characteristics in small manufacturing firms. *Journal of Engineering and Technology Management,* 9**,** 243-277.
LEFEBVRE, L. A., MASON, R. & LEFEBVRE, E. 1997. The influence prism in SMEs: The power of CEOs' perceptions on technology policy and its organizational impacts. *Management Science,* 43**,** 856-878.
LI, Y., TAN, C.-H., TEO, H.-H. & TAN, B. C. 2006. Innovative usage of information technology in Singapore organizations: Do CIO characteristics make a difference? *Engineering Management, IEEE Transactions on,* 53**,** 177-190.
LICHTENTHALER, U. & LICHTENTHALER, E. 2009. A Capability-Based Framework for Open Innovation: Complementing Absorptive Capacity. *Journal of Management Studies,* 46**,** 1315-1338.
LUBATKIN, M. H., SIMSEK, Z., LING, Y. & VEIGA, J. F. 2006. Ambidexterity and performance in small-to medium-sized firms: The pivotal role of top management team behavioral integration. *Journal of Management,* 32**,** 646-672.
MARCATI, A., GUIDO, G. & PELUSO, A. M. 2008. The role of SME entrepreneurs' innovativeness and personality in the adoption of innovations. *Research Policy,* 37**,** 1579-1590.
MARCH, J. G. & SHAPIRA, Z. 1987. Managerial Perspectives on Risk and Risk-Taking. *Management Science,* 33**,** 1404-1418.
MCMULLAN, W. E. & LONG, W. A. 1987. Entrepreneurship Education in the Nineties. *Journal of Business Venturing,* 2**,** 261-275.
MILLER, D. 1983. The Correlates of Entrepreneurship in 3 Types of Firms. *Management Science,* 29**,** 770-791.
MILLER, D. & DROGE, C. 1986. Psychological and Traditional Determinants of Structure. *Administrative Science Quarterly,* 31**,** 539-560.
MILLER, D. & FRIESEN, P. H. 1982. Innovation in Conservative and Entrepreneurial Firms - 2 Models of Strategic Momentum. *Strategic Management Journal,* 3**,** 1-25.
MILLER, D. & TOULOUSE, J. 1986a. CHIEF EXECUTIVE PERSONALITY AND CORPORATE STRATEGY AND STRUCTURE IN SMALL FIRMS. *Management Science,* 32**,** 1389-1409.
MILLER, D. & TOULOUSE, J. 1986b. Strategy, Structure, CEO Personality and Performance in Small Firms. *American Journal of Small Business,* Winter.
MINSHALL, T., MORTARA, L., VALLI, R. & PROBERT, D. 2010. Making "Asymmetric" Partnerships Work. *Research-Technology Management,* 53**,** 53-63.
MOORE, G. C. & BENBASAT, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research,* 2**,** 192-221.
MORENO, A. M. & CASILLAS, J. C. 2008. Entrepreneurial orientation and growth of SMEs: A causal model. *Entrepreneurship Theory and Practice,* 32**,** 507-528.

MORTARA, L., FORD, S., PROBERT, D. & MINSHALL, T. 2012. Inbound Open Innovation: a Technology Acquisition Process Model. . *Open Innovation, New Insights and Evidence.* Imperial College, London.

MORTARA, L. & MINSHALL, T. 2011. How do large multinational companies implement open innovation? *Technovation,* 31**,** 586-597.

MORTARA, L. & MINSHALL, T. forthcoming. Patterns of Implementation of OI in MNCs. *In:* CHESBROUGH, H., VANHAVERBEKE, W. & WEST, J. (eds.) *Exploring next wave of Open Innovation Research.* Oxford: Oxford University Press.

MORTARA, L., NAPP, J., FORD, S. & MINSHALL, T. 2011. Open innovation activities to foster corporate entrepreneurship. *In:* CASSIA, L., MINOLA, T. & PALEARI, S. (eds.) *Entrepreneurship and Technological Change.* Northampton, MA: Edward Elgar.

MYERS, R. 1990. *Classical and modern regression with applications,* Boston, MA, Duxbury.

NAMAN, J. & SLEVIN, D. P. 1993. Entrepreneurship and the concept of fit: A model and empirical tests. *Strategic Management Journal,* 14**,** 137-154.

NARULA, R. 2004. R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation. *Technovation,* 24**,** 153-161.

NOOTEBOOM, B. 2006. Cognitive Distance in and Between COP's and Firms: Where do Exploitation and Exploration Take Place, and How are They Connected? : CentER Disussion Paper Series No. 2007-04.

OAKEY, R. P. 2013. Open innovation and its relevance to industrial research and development: The case of high-technology small firms. *International Small Business Journal,* 31**,** 319-336.

PAPADAKIS, V. & BOURANTAS, D. 1998. The chief executive officer as corporate champion of technological innovation: An empirical investigation. *Technology Analysis & Strategic Management,* 10**,** 89-109.

PAPADAKIS, V. M. 2006. Do CEOs shape the process of making strategic decisions? Evidence from Greece. *Management Decision,* 44**,** 367-394.

PAPADAKIS, V. M. & BARWISE, P. 2002. How much do CEOs and top managers matter in strategic decision-making? *British Journal of Management,* 13**,** 83-95.

PERKMANN, M. & WALSH, K. 2007. University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews,* 9**,** 259-280.

RHEE, J., PARK, T. & LEE, D. H. 2010. Drivers of innovativeness and performance for innovative SMEs in South Korea: Mediation of learning orientation. *Technovation,* 30**,** 65-75.

ROGERS, E. M. 1983. *Diffusion of Innovations,* New York, The Free Press.

SAVITSKAYA, I., SALMI, P. & TORKKELI, M. 2010. Barriers to open innovation: case China. *Journal of Technology Management and Innovation,* 5**,** 10-21.

SCHEIN, E. 1985. *Organizational culture and leadership,* San Francisco, Jossey Nass.

SCHROLL, A. & MILD, A. 2012. A critical review of empirical research on open innovation adoption. *Journal fur Betriebswirtschaft,* 62**,** 85-118.

SIEGEL, R., SIEGEL, E. & MACMILLAN, I. C. 1993. Characteristics Distinguishing High-Growth Ventures. *Journal of Business Venturing,* 8**,** 169-180.

SIMON, H. A. 1957. *Models of Man,* New York, Wiley.

SPITHOVEN, A., CLARYSSE, B. & KNOCKAERT, M. 2011. Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation,* 31**,** 10-21.

SPITHOVEN, A., VANHAVERBEKE, W. & ROIJAKKERS, N. 2013. Open Innovation Practices in SMEs and Large Enterprises. *Small Business Economics,* 41.

THONG, J. Y. L. & YAP, C. S. 1995. Ceo Characteristics, Organizational Characteristics and Information Technology Adoption in Small Businesses. *Omega-International Journal of Management Science,* 23**,** 429-442.

TYLER, B. B. & STEENSMA, H. K. 1998. The effects of executives' experiences and perceptions on their assessment of potential technological alliances. *Strategic Management Journal,* 19**,** 939-965.

VAN DE VRANDE, V., DE JONG, J. P. J., VANHAVERBEKE, W. & DE ROCHEMONT, M. 2009. Open innovation in SMEs: Trends, motives and management challenges. *Technovation,* 29**,** 423-437.

VANHAVERBEKE, W. 2006. The interorganizational context of open innovation. *In:* CHESBROUGH, H., VANHAVERBEKE, W. & WEST, J. (eds.) *Open Innovation: Researching a New Paradigm.* Oxford University Press.

VOSSEN, R. W. 1998. Research note - relative strengths and weaknesses of small firms in innovation. *International Small Business Journal,* 16**,** 88-94.

WEST, J. & BOGERS, M. 2013. Leveraging external sources of innovation: a review of research on open innovation. *Journal of Product Innovation Management, Forthcoming*.

WEST, J. & GALLAGHER, S. 2006. Challenges of open innovation: the paradox of firm investment in open-source software. *R & D Management,* 36**,** 319-331.

WYNARCZYK, P., PIPEROPOULOS, P. & MCADAM, M. 2013. Open innovation in small and medium-sized enterprises: An overview. *International Small Business Journal,* 31**,** 240-255.