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INNOVATION INTENSITY IN POLISH MANUFACTURING FIRMS AND CEO CHARACTERISTICS

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Purpose: This paper investigates the relationship between observable managerial characteristics and investment in innovation among Polish manufacturing enterprises.
Design/methodology/approach: The study employs the Upper Echelons Theory (UET) to analyse the impact of managerial characteristics on innovation investment in Polish manufacturing firms. Based on data from 1049 enterprises, it uses the Heckman selection model to correct for sample selection bias. This approach examines both the decision to invest and its extent, focusing on the Polish manufacturing sector.
Findings: The findings indicate that CEOs' demographic characteristics, such as age group, gender, and financial benefits, significantly impact R&D&I intensity. However, the influence of specific CEO traits varies across small and medium-sized enterprises (SMEs), highlighting differences in how managerial attributes shape innovation investment depending on firm size.
Research limitations/implications: The study is limited by data availability on CEOs, focusing only on measurable and observable traits while excluding personality traits due to a lack of information. Future research could address this gap by examining how psychological characteristics influence CEO's innovation-related decisions.
Practical implications: Polish manufacturing firms, especially those led by professional managers, should implement financial incentives to promote innovation. HR departments should consider CEO profiles in leadership development, while policymakers can design incentive schemes to boost R&D&I engagement, enhancing competitiveness and economic growth.
Social implications: Encouraging innovation through leadership and incentives can drive technological advancement, job creation, and economic development.
Originality/value: This study offers new insights into the link between CEO characteristics, financial benefits, and innovation intensity, particularly in Polish manufacturing firms. It contributes to corporate governance and innovation management literature, benefiting business practitioners, policymakers, and researchers.
Keywords: CEO characteristics, R&D intensity, small and medium-sized firms.
Category of the paper: research paper.

1. Introduction

The Upper Echelons Theory (UET) posits that a firm's strategic actions and performance are shaped by its CEO's characteristics (Hambrick, Mason, 1984). Strategic actions, including innovation investments, represent long-term organisational initiatives that require significant resources and often involve substantial risk (Hambrick, Mason, 1984; Baker, Mueller, 2002).

Innovation investments are crucial for the development of Polish enterprises. Analysing factors beyond firm-internal dynamics and external environment that influence firms' innovation activity is particularly significant within the broader context of Poland's efforts to transition from the investment-driven development strategy adopted during the early stages of democratic reforms to one centred on innovation. This shift is vital for positioning Poland closer to the world's leading economies (Kravtsova, Radosevic, 2012).

This paper, therefore, investigates the determinants of innovation expenditures in a sample of Polish manufacturing firms. Specifically, we examine the role of CEO characteristics in affecting the firm's R&D&I activity. Due to the scope of the available data, our analysis focuses on observable managerial characteristics of CEOs.

The structure of the paper is as follows: the next section presents the theoretical framework underpinning our research. It is followed by a section detailing the data and model used in the analysis. Finally, the paper discusses the results and provides concluding remarks.

2. Theoretical framework

The theory of upper echelons, introduced in 1984 by Hambrick and Mason, has sparked significant interest among researchers in empirically verifying the relationship proposed by the theory between characteristics of CEOs and various strategic actions shaping the future performance of an organisation (Wang, Holmes, Oh, Zhu, 2016). This theory is based on two interconnected elements: first, the idea that managerial actions are grounded in the personal interpretations of strategic situations they encounter, and second, that these personalised interpretations are shaped by the executives' experiences, values, and personalities (Hambrick, 2007). Hambrick (2007, p. 334) states that the theory is built on the premise of bounded rationality, which posits that informationally complex and uncertain situations cannot be objectively "known" but are instead subject to individual interpretations. Consequently, this reinforces the notion that CEOs' actions are shaped by their personal construal of strategic situations, which are, in turn, influenced by their unique experiences, values, and personalities.

The upper echelons theory thus provides a framework for understanding why some firms choose to engage in strategic actions, such as investing in innovation, by analysing the characteristics of their key decision-makers, such as CEOs. This perspective highlights the role of top executives' attributes in shaping organisational choices and actions in response to complex and uncertain environments.

Empirical studies verifying UET identify two groups of CEO characteristics that influence strategic actions. As outlined by Hambric and Mason (1984), the first group includes measurable and observable traits that reflect a CEO's experience, such as age, tenure in the CEO position, previous leadership roles, social background, and financial standing. The second group consists of personality traits, which are more nuanced and typically require self-assessment by the CEO or responses to comprehensive psychological questionnaires (Wang et al., 2016). These two dimensions provide deeper insight into how executives' attributes shape organisational strategies, such as innovation investments.

3. Data and Research Method

Our analysis of the relationship between CEO characteristics and R&D&I intensity is based on data from a 2018 survey of 1049 Polish manufacturing enterprises conducted as a part of the research project "Intensity of competitive rivalry and innovative behaviour of enterprises". Initially, companies were selected from the InfoCredit database to ensure geographical and sectoral diversity. We engaged directly with managers to maximise participation, as the Computer-Assisted Web Interviewing (CAWI) approach proved limited effectiveness. The survey data was complemented with financial information from the InfoCredit (Orbis) database.

Studies on firms' innovation behaviour often face selection bias, as not all firms engage in innovation. When the decision to innovate is influenced by systemic factors, such as firm size, resources, industry dynamics, or external conditions, the sample of innovative firms is non-random, leading to inferences if selectivity is ignored (Lööf, Heshmati, 2006; Hashi, Stojčić, 2013; Anries, Czarnitzki, 2014). To address this, we apply the Heckman model, which accounts for potential selection bias and ensures robust results. The first equation of the model represents the decision to invest in innovation activities and is defined as follows:

$$D_{RDIi} = \begin{cases} 1 \; if \; D^{*}_{RDI\,0,i} = \beta_0 + \sum x_{1i} \; \beta_1 + \varepsilon_{1i} > \tau \\ 0 \; if \; D^{*}_{RDI\,0,i} = \beta_0 + \sum x_{1i} \; \beta_1 + \varepsilon_{1i} \leq \tau \end{cases} \quad (1)$$

where:
D_{RDIi} expresses the decision to invest in R&D&I (dummy variable),
x_{1i} define explanatory variables,
β_1 are coefficients for specific explanatory variables, and
ε_{1i} is the error term.

Variables such as foreign ownership, exporter status, cooperation in innovative activity, geographic scope of activities, and market concentration determine the likelihood of undertaking R&D&I activity.

The second equation of the model is defined as follows:

$$Inn_{expenditure\ i} = \begin{cases} Inn^{*}_{expenditure\ i} = \beta_0 + \sum x_{2i}\ \beta_2 + \varepsilon_{2i}\ if\ D_{RDIi} = 1 \\ = 0\ if\ D_{RDIi} = 0 \end{cases} \quad (2)$$

$Inn_{expenditure}$ represents innovation expenditure (a continuous variable in logarithmic form), while the vector x_{2i} includes covariates, and β_2 denotes their associated coefficients. The term ε_{2i} is the random error term. The vector x_{2i} encompasses firm-specific characteristics, such as industry classification (NACE Rev. 2), the geographic scope of operations, and whether the firm received public financial support for innovation activities. Crucially for our study, in addition to the above control variables, we incorporate a relevant vector of variables that capture observable managerial attributes, including the CEO's age group, gender, foreign education, and financial and non-financial benefits.

Tables 1, 2, and 3 below present all the variables used in the model, along with their respective explanations and statistics.

Table 1.
Explanation of variables

Variable	Sources	Description
Innovation expenditure (ln)	survey data	A number representing total R&D expenditures during the years 2015-2017, defined as expenditures on five different innovation activities comprising: (i) in-house R&D, (ii) external R&D, (iii) acquisition of machinery, equipment, software & buildings, (iv) acquisition of existing knowledge from other enterprises or organisations (licenses, patents other tech transfer agreements), (v) all other innovation activities including design, training, marketing, and other relevant activities (in the log)
nace_lt	survey data	Dummy = 1 if a company operated in a low technology industry according to NACE Rev. 2
nace_mlt	survey data	Dummy = 1 if a company operated in a medium-low technology industry according to NACE Rev. 2
nace_mht	survey data	Dummy = 1 if a company operated in a medium-high technology industry according to NACE Rev. 2
nace_ht	survey data	Dummy = 1 if a company operated in a high technology industry according to NACE Rev. 2
National market	survey data	Dummy = 1 if a company has sold goods and/or services during the three years 2015 to 2017 in national markets; otherwise, 0

Cont. table 1.

European market	survey data	Dummy = 1 if a company has sold goods and/or services during the three years 2015 to 2017 in European markets; otherwise, 0
All other countries	survey data	Dummy = 1 if a company has sold goods and/or services during the three years 2015 to 2017 in other than European foreign markets; otherwise, 0
R&D State Aid	survey data	Dummy = 1 if a company received any public R&D&I support from the local/regional, national, or EU level from 2015 to 2017; otherwise, 0
CEO age group	survey data	A categorical variable indicating one out of 5 age groups of CEO (group 1 – up to 40 years, group 2 – between 41-45 years, group 3 – between 46-50 years, group 4 – between 51-60 years, group 5 – more than 61 years)
CEO male	survey data	Dummy = 1 if a CEO of a company is a male; otherwise, 0
CEO owner	survey data	Dummy = 1 if a CEO of a company is also its owner; otherwise, 0
CEO foreign education	survey data	Dummy = 1 if a CEO of a company has a foreign education; otherwise, 0
CEO_finan_benefits	survey data	Dummy = 1 if executives/ managers of a company have rewarded financial benefits partly based on their performance and achievement of individual targets; otherwise, 0
CEO_nonfinan_benefits	survey data	Dummy = 1 if executives/ managers of a company have rewarded non-financial benefits partly based on their performance and achievement of individual targets; otherwise, 0
Foreign ownership	survey data	Dummy = 1 if a company reported having a foreign investor; otherwise, 0
Export	survey data	Dummy = 1 if a company reported having export in total sales in 2015; otherwise, 0
Cooperation	survey data	Dummy = 1 if a company reported having innovative cooperation in 2015-2017; otherwise, 0
HHI	Orbis database	A number representing market concentration in 2017 (Herfindahl-Hirschman Index)
SME	survey data	Dummy = 1 if a company is small or medium-sized in 2017; otherwise, 0

Source: Own elaboration based on the survey.

Table 2.
Descriptive statistics of continuous variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Innovation expenditure (ln)	383	11.87096	1.674142	7.600903	14.7318
HHI	1049	165.5965	160.1623	0	3023.88

Source: Own calculation based on STATA 15.

Table 3.
Descriptive statistics of dichotomous variables

Variable	Obs	0	1
nace_lt	1049	695	354
nace_mlt	1049	582	467
nace_mht	1049	854	195
nace_ht	1049	1016	33
National market	1049	46	1003
European market	1049	361	688
All other countries	1049	798	251
R&D State Aid	1049	941	108

Cont. table 3.

CEO age group: group 1 – up to 40 group 2 – between 41-45 group 3 – between 46-50 group 4 – between 51-60 group 5 – more than 61	1049: 75 225 367 191 191		
CEO male	1049	393	656
CEO owner	1049	654	395
CEO foreign education	1049	1021	28
CEOs_finan_benefits	1049	672	377
CEOs_nonfinan_benefits	1049	898	151
Foreign ownership	1049	946	103
Export	1049	591	458
Cooperation	1049	857	192
SME	1049	80	969

Source: Own calculation based on STATA 15.

4. Results

Table 4. reports the results of the estimation procedure. The analysis was conducted for the entire sample of enterprises, as well as separately for the group of small and medium-sized enterprises. The rationale for performing estimations for this group lies in the fact, that in small and medium-sized firms, organisational structures are often flat, and the CEO's managerial discretion is typically high. This may influence the significance of CEO attributes under analysis.

The findings from the selection equations (the lower part of Table 4) suggest that a firm's exporter status, sales of products and services in domestic and non-European foreign markets, as well as engagement in innovative cooperation, positively influence the likelihood of R&D&I activities. Conversely, having a foreign investor and operating in European markets reduce the firms' probability of engaging in R&D&I activities.

Table 4.
Results of Heckman's two-step procedures: factors determining innovation expenditure and the decision to invest in R&D&I for the sample and SMEs subsample

Model	Polish manufacturing firms	Polish manufacturing SMEs
	Dependent variable: **Innovation expenditure (ln)**	Dependent variable: **Innovation expenditure (ln)**
nace_lt	-0.928** (-2.60)	-1.130** (-2.99)
nace_mlt	-0.682 (-1.92)	-0.803* (-2.14)
nace_mht	-0.772* (-2.06)	-0.911* (-2.29)
nace_ht	- (.)	- (.)
National markets	0.156 (0.28)	0.293 (0.52)
European markets	1.178*** (7.78)	1.162*** (7.63)
All other markets	0.992*** (5.68)	0.983*** (5.41)
R&D State aid	0.536* (2.40)	0.924*** (3.74)

Cont. table 4.

CEO group:		
1.	0((.)	0(.)
2.	1.127*** (4.08)	1.377*** (4.84)
3.	0.792** (2.71)	0.900** (3.05)
4.	0.879** (3.22)	0.789** (2.84)
5.	1.261*** (4.52)	1.344*** (4.81)
CEO male	0.680*** (3.45)	1.007*** (4.68)
CEO owner	0.422** (2.64)	0.203 (1.20)
CEO foreign education	-1.041 (-1.39)	-1.266 (-1.71)
CEOs_finan_benefits	0.926*** (6.34)	0.847*** (5.46)
CEOs_nonfinan_benefits	0.217 (0.88)	0.281 (1.09)
Constant (Inrersept)	9.951*** (12.64)	9.599*** (11.47)
	Selection (decision)	**Selection (decision)**
Foreign ownership	-0.381** (-2.61)	-0.584*** (-3.50)
Exporter	0.591*** (6.22)	0.585*** (5.86)
Cooperation	0.789*** (7.53)	0.689*** (6.20)
National markets	0.703** (2.84)	0.635* (2.46)
European markets	-0.432*** (-4.41)	-0.400*** (-4.03)
Other countries markets	0.233* (2.25)	0.226* (2.04)
hhi	0.000234 (0.88)	0.000297 (1.05)
Constant (Inrersept)	-1.223*** (-4.65)	-1.137*** (-4.15)
Number of observations	1049	969
Selected	383	356
Nonselected	666	613
Log-likelihood	-1247.901	-1162.195
Wald chi2(16)	232.42	230.76
Prob > chi2	0.0000	0.0000
LR test on independent equations	(rho = 0): chi2(1) = 12.11 Prob > chi2 = 0.0005	(rho = 0): chi2(1) = 5.57 Prob > chi2 = 0.0183

Note. t statistics in parentheses *p < 0.05, ** p < 0.01, *** p < 0.001

Source: Own calculation based on STATA 15.

The results of the innovation expenditure equation provide valuable insights into the role of control variables. As expected, operating in medium-low-tech and medium-high-tech sectors (compared to the high-tech sectors) has a significant and negative effect on innovation expenditure. In contrast, engaging in foreign markets (both European and non-European) and receiving public support for innovative activities positively influence the expenditure on innovation.

The estimation results of the second equation are crucial in the context of the primary objective of this study, which is to examine the relationship between CEO characteristics and firms' innovation expenditures. The findings highlight the significant role of the CEO's age: CEOs over 40 are more likely to allocate higher expenditures to innovation than younger CEOs. The results of our analysis also indicate that male CEOs are more likely to allocate higher expenditure to innovation activities than female CEOs. Furthermore, our findings indicate that innovative activities in manager-led firms are lower than those in traditional, owner-led firms. Our analysis also suggests that CEO financial benefits may compensate for the risk associated with R&D&I activities, addressing managers' aversion to high uncertainty and potential losses linked to such investments.

Additional model estimation conducted for the SMEs group reveals a similar relationship between R&D&I investments and CEO characteristics as observed in the full sample analysis. However, one notable exception is that the CEO owner variable is statistically insignificant in the case of SMEs.

5. Discussion

This study examines the relationship between firms' expenditures on innovative activities and the characteristics of their CEOs. However, applying the Heckman selection model allowed us to identify factors influencing Polish manufacturing firms' likelihood to engage in R&D&I activities. The results indicate that firms' exporter status, sales of products and services in domestic and non-European foreign markets, and engagement in innovation-related cooperation positively influence the probability of investing in R&D&I. Conversely, firms with foreign investors and those operating in European markets are less likely to undertake R&D&I activities. These findings align with the results of Hashi & Stojčić (2013), suggesting that the competitive intensity in domestic and non-European markets acts as a key driver for firms from CEECs to engage in innovation. The positive relationship between export activity and firms' inclination to invest in R&D&I may be attributed to the heightened international competition, necessitating innovation as a survival strategy. Moreover, exporting firms are more likely to benefit from innovation investments due to their broader access to international markets (Masso, Vahter, 2008).

Similar findings regarding the relationship between foreign ownership and firms' innovation propensity have been reported by Raffo et al. (2008) for Spain. These authors argue that multinational enterprises (MNEs) that entered Spain in the 1980s and 1990s were primarily motivated by low labour costs, which led to a lower likelihood of engaging in R&D&I activities. Additionally, MNEs tend to avoid investing in local R&D units when the domestic market is too small to justify the fixed costs or lacks sufficient academic resources to support innovation. These explanations appear particularly relevant for Polish manufacturing firms.

As anticipated, cooperation and exporter status significantly increase the likelihood of Polish manufacturing firms engaging in R&D&I. The importance of exporting activity can be linked to the pressure exerted by foreign competition, which drives firms to innovate as a means of maintaining their market position (Busom, Vélez-Ospina, 2017). Our findings contribute to the broader literature on innovation determinants by confirming that firms' engagement in international markets and cooperative networks fosters innovation activity. At the same time, foreign ownership may, under certain conditions, have the opposite effects. These insights highlight the need for policies that support domestic firms in leveraging international

competition as a stimulus for innovation while addressing the constraints foreign-owned enterprises face in investing in local R&D&I.

The estimation results of the second equation are particularly crucial for the primary objective of this study, which is to explore the relationship between CEO characteristics and firms' innovation expenditures. The findings emphasise the significant influence of the CEO's age: executives over 40 are more likely to allocate higher expenditures to innovation than their younger counterparts. While this outcome contrasts with the Upper Echelons Theory (UET) (Hambrick, Mason, 1984) and the findings of Baker and Mueller (2002), who reported a strong negative relationship between CEO age and R&D spending, it can be interpreted in multiple ways. One potential explanation is that older CEOs, drawing from their accumulated experience, may be more inclined to adopt risk-intensive strategies (Shen, 2021). Conversely, younger CEOs might prioritise short-term performance improvements over high-risk innovation projects, possibly due to concerns about their future career trajectories (Holmström, 1999).

Our results also suggest that male CEOs are more likely to allocate greater resources to innovation than female CEOs. This aspect of managerial decision-making is not addressed in UET and was not considered in Baker and Mueller's (2002) study. However, our findings align with the research of Faccio, Marchica, and Mura (2016), which suggests that female CEOs tend to adopt more risk-averse strategies than their male counterparts.

The CEO-owner variable provides insight into the relationship between R&D&I investments and the traditional model of owner-led firms versus modern, professionally managed firms. It aligns with the principal-agent model (Milgrom, Roberts, 1992), which explores the mechanisms ensuring that managers act in the best interest of firm owners. Our findings indicate that manager-led firms exhibit lower innovation activity levels than owner-led firms. The inherent risks and uncertainties associated with R&D&I investments may deter professional managers from pursuing such initiatives (Czarnitzki, Kraft, 2004).

Furthermore, our analysis suggests that CEOs' financial benefits may compensate for the risk associated with R&D&I activities, potentially mitigating managerial aversion to uncertainty and financial loss linked to innovation investments.

As observed in the entire sample analysis, additional model estimations for SMEs reveal a similar relationship between CEO characteristics and R&D&I investments. However, a key exception is that the CEO-owner variable is not statistically significant in the SME subgroup. The insignificance may attributed to structural differences between SMEs and larger firms. In smaller enterprises, CEOs often have a more direct personal stake in the company's performance, irrespective of formal ownership status. Their active involvement in strategic decision-making and closer oversight of financial resources may reduce the principal-agent tensions typically observed in larger, manager-led firms. Consequently, ownership status becomes a less relevant factor in explaining R&D&I investment behaviour in SMEs.

6. Summary

Our study confirms that CEO characteristics are crucial in shaping innovation investment decisions in Polish manufacturing firms. The findings indicate that both leaders' demographic attributes and financial incentives significantly influence the level of investment in R&D&I. In particular, the distinction between owner-led and manager-led firms supports the principal-agent model, emphasising the importance of financial incentives in reducing managerial risk aversion.

Our findings have significant implications for both management theory and business practice. In the innovation policy context, appropriately tailored incentive mechanisms can support managerial engagement in innovation activities, particularly in firms led by professional executives rather than owners. Implementing effective compensation programs linked to innovation outcomes could be a powerful tool for increasing R&D&I expenditures.

An important conclusion for business practice, especially for HR departments, is the need to consider the demographic and psychological profile of CEOs in recruitment processes and leadership development strategies. Training and mentoring programs should focus on increasing risk tolerance and developing strategic innovation management skills.

Our study also opens new avenues for future research. It would be interesting to explore the impact of psychological traits on CEOs, such as tolerance for uncertainty, openness to change, and risk-taking propensity, on innovation-related decision-making. Furthermore, additional analyses could examine the influence of organisational culture and the dynamics of management teams on corporate innovation strategies. Comparative studies in an international context (e.g. other CEECs) could provide valuable insights into how different management systems impact firms' innovation activities.

In conclusion, our findings highlight the crucial role of CEO characteristics in shaping the innovation strategies of Polish manufacturing firms while also emphasising the importance of financial incentives and motivational mechanisms. Policymakers and management practitioners can leverage the insights from this study to develop more effective strategies for fostering innovation in the manufacturing sector.

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