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Stage-Gate Framework Application for Innovation Assessment among Small and Medium-Sized Enterprises

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***Abstract*—**The paper explores the Stage-Gate framework application for innovation maturity among small and medium-sized enterprises (SMEs). Innovation management becomes an essential business survival process for all sizes of organizations that can be evaluated and audited systemically. This research systemically defines and assesses the innovation process from the perspective of the company's top management. Empirical research explores attitudes and existing practices of innovation management in SMEs in Baltic countries. It structurally investigates the current innovation management practices, level of standardization, and potential challenges in the area. Findings allow to structure of existing practices based on an institutionalized model and contribute to a more advanced understanding of the innovation process among SMEs. Practically, findings contribute to advanced decision-making and business planning in the process.

***Keywords*—**innovation measure, innovation process, small and medium-sized enterprises, SMEs, stage-gate framework.

I. Introduction

INNOVATION management and its commercialization are well acknowledged as one of the key competitive advantages and source of business growth. It is inseparable business practice which can lead to either new product success or failure, both business opportunities and limitations. Research [1] reported that only one product development project in four achieves commercial success, and almost 50% of resources within firms are devoted to innovation spend. Innovation management becomes an essential business survival process for all sizes of organizations. Thus, it is important for organizations to define and assess the innovation process effectively, following specific principles of application, similarly to the quality or finance management systems and metrics. Yet, researchers [2] report that only a small fraction of businesses follow formalized planning in the process of innovation management which can limit innovation commercialization capabilities. It also encourages the need to strengthen this competence among businesses through standardized operating processes. Use of standardized metrics for innovation process assessment, such as Stage Gate, would deliver improved planning and decision making, along with improved business processes and operations. Theoretical aspects and practical application of Stage-Gate framework among small business is explored in this research. Core milestones of the model and its practical application strengthens business planning competences and accelerates innovation process among SMEs. SMEs are defined as a vital component of most economies and its ability to launch new products efficiently is essential to sustain positive developments in markets [3]. This research aims to address the following problematics: i) explore theoretical and practical application of Stage-Gate framework for innovation process assessment among SMEs, ii) evaluate innovation process management for SMEs based on Stage-Gate framework; iii) reveal attitude to innovation management among SMEs. It contributes to several areas – first, expanding knowledge on innovation management across SMEs, providing holistic approach to innovation management practice from both internal processes (based on stage gate application), to external factors, such as responsiveness to marketplace conditions and barriers' perception. The study empirically assesses each stage of stage gate model and its use in the process of new product development that illustrates strengths and weaknesses in the process. Prior research [4] suggests that it is critical to encourage SMEs to focus beyond simply focusing on technological innovation by adopting a more comprehensive and systemic view of the innovation process. Accordingly, authors [5] advise that a more system and comprehensive conversations regarding innovation in SMEs, its different approaches and realities, should be established.

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II. Theoretical Development and Hypothesis

A. Product Innovation and Its Management: Stage Gate Model

Based on [1] and [6], innovation management is a complex area, defined from different perspectives, from traditional technological product to process mode that are supported by organizational structures, administrative systems, management practices, processes and techniques. It presents the need for integral evaluation of innovation approach among organizations. Similarly, OECD [7] defines innovation management as implementation of new organizational methods in company's business practices, workplace organization or external relations, and the implementation of new methods, that involve significant changes in product development. Research suggests that proper innovation management is a direct predictor of good innovation performance – institutionalizing

innovation management, and making it a core process in organizations can improve the outcome significantly [8].

Stage Gate Model is a 21-step integrated model, developed by [5] and [9] that defines and integrates stages of new product development and can be well applied for manufacturing companies, and is able to bring strategic orientation into new product development. The model is able to provide focus, structure and control and gain speed, productivity and agility. As well, the model is able to capture each step in the process from idea generation to new product launch. Discrete stages are able to clearly identify deliverables that is able to derive plan of actions [9]. Thus, this research aims to explore use of structured approach to new product development and suggests that use of stage gate model is a direct predictor to innovation performance.

B. Challenges and Value Perception towards Product Innovation

Managerial focus towards innovation is considered to be a success predictor in realizing innovations [3], [10], [11]. It is acknowledged that managers in small companies have larger influence on employees than in large organizations. Thus, this research suggests that higher perception of innovation value positively influences innovation performance, and higher willingness to seek for innovation positively affects innovation performance, and positive reasoning to innovation need has a potential to positively influence innovation performance. However, innovation can be considered as a risk to organizations. It is associated with management skepticism, lack of resources and difficulty in production [9]. Thus, this research suggests that higher perception of barrier to innovation negatively affects innovation performance.

C. Attitude to Marketplace, Competition Conditions and Cooperation for Innovation Capacity Improvement

Research [9] suggests that for SMEs, competitive intensity in the marketplace moderates the need for superior product characteristics in new product development. Also, SMEs owners and managers shall understand both market and technical aspects of the product environment. Strong market orientation is suggested [12], [13] to sustain competitive advantage. Market conditions, such as competitive intensity and market uncertainty, based on [12], are the antecedents of product advantage for SMEs. As well, [12] suggests that owners and managers, perceive that meeting customers' needs, matching perceptions and being cost-effective, are central to new product advantage. The study of [8] outlines that visionary leadership, creativity of employees and the participation of customers, suppliers and other partners contribute to pursue of innovation and new value proposition. Thus, this research suggests that higher willingness to network in the market is suggested as a direct predictor of performance, and higher willingness to cooperate for the innovation capacity improvement is a direct predictor of performance. In addition, responsiveness to market conditions is suggested to positively affect innovation performance, thus this research proposes that higher market orientation is a direct predictor of performance, and higher market responsiveness is a direct predictor of performance.

Conceptual research mode is presented in Fig. 1.

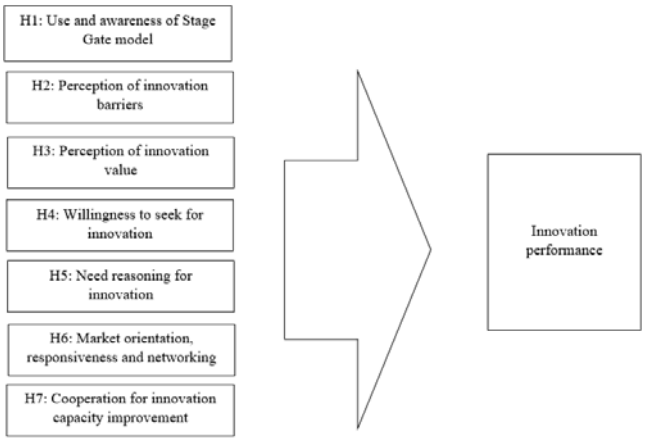

Fig. 1 Conceptual research model and hypothesis

III. Methodology

This research aims to capture attitude to product innovation management among SMEs and applicable practice among them. A unique data sample was created for this research. First, a list of registered SMEs in Latvia and Estonia was obtained from company HitHorizons. The initial sample consisted of total 1477 legal entities - manufacturing companies. Secondly, analysis for the web pages of these companies was performed to obtain email data. This analysis has reduced the sample to total 835 legal entities that had contact data displayed and allowed to gather 1551 email addresses for board members, managing directors, general managers, quality, production and project leads, defined as top management. Expert opinion evaluation was used to collect the data to the topic, using a developed research instrument. Variables were selected based on performed literature meta-analysis and conceptual research model. Operationalization of variables is provided in Table I. The research model was tested by performing diagnostics, followed by a regression analysis. Ordinary least squares regression modeling was performed. Initially, model testing was performed, followed by regression analysis using the statistical package "Gretl", and then standardized β coefficients were compared Statistical significance was observed on levels: *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$. Prior the regression analysis, regression diagnostics was performed, normality of residuals, heteroscedasticity (Breusch-Pagan test), RESET and collinearity tests were performed, model diagnostics outlined in Table II.

IV. Research Findings and Discussion

Research findings allowed to obtain understanding towards product innovation management practices in a structured approach. Table II summarizes applicability to 21 Stage Gate Model steps and its use among explored organizations. Findings reveal that respondents tend to approach Step 11 (establish costs of production), Step 1 (identify customers' needs), Step 2

(identify market opportunities), Step 12 (plan information flow to facilitate production) and Step 13 (configure supply chain activities) are the most frequent because of received highest mean rating among respondents. It allows the conclusion that the screening phase, Step 1 and Step 2, was developed well among explored SMEs. Out of post-incubation period, Step 12 and Step 13 were found to be of frequent use.

TABLE I
OPERATIONALIZATION OF VARIABLES

Operationalization	Reference	Definition	Variable
Stage-Gate model awareness	[14]	Organization is aware of the stage gate model	SG_AWARE
Use of structured approach towards NPD	[14]	Organization is using structured approach during NPD	STR_APPR
Utilization of Stage-Gate model steps	[14]	Application of 21 stages during NPD in the company	SG_S1 to SG_S21
Perception of barriers towards innovation	[15]	Definition of barriers to innovation from company perspective as no barriers, rare barriers, existing barriers, high barriers, significant barriers	NO_BARR RARE_BARR IS_BARR HI_BARR SGN_BARR
Strategic approach to innovation: value in the company	[15]	Role of innovation in the company as an established value, clear role, critical to survival	INN_VAL INN_CL_ROLE INN_CRIT
Strategic approach to innovation: seeking innovation in the company	[16]	Willingness to seek for innovation in the company proactively, reactively, passively	PROACT_INN REACT_INN PASS_INN
Need for innovation in the company	[17]-[19]	Innovation need in the company as a response to environmental fluctuations, comparative advantage, competitive advantage	INN_RESP INN_COMPA_A INN_COMPE_A
Market orientation	[20]	Company presents strong market orientation	M_ORIENT
Networking in the company	[21]	Company is constantly networking in the market	M_NETWR
Response to market dynamics	[15]	Company follows and responds to dynamics of the market	F_MRKT_DYN
Response to competition dynamics		Company follows and responds to dynamics of the competition	F_COMP_DYN
Innovation capacity improvement through cooperation		Company tries to improve its innovation capacity through cooperation with suppliers, customer, universities, research institutions, governmental institutions	SUPPL_COOP CUST_COOP UNI_COOP RESEA_COOP GOV_COOP

TABLE II
EVALUATION OF STAGE GATE STEPS USE AMONG SMES

Stage-Gate Step	Variable	Mean	Stand. deviation	Median
Step 1: Identify customer needs	SG_S1	5,7937	1,3095	6,00
Step 2: Identify market opportunities	SG_S2	5,6508	0,1884	6,00
Step 3: Develop new product concept	SG_S3	5,0952	1,2664	5,00
Step 4: Breakdown the problem across different functions	SG_S4	4,9841	1,3499	5,00
Step 5: Create business case to clarify financial attractiveness	SG_S5	4,5079	1,3499	5,00
Step 6: Create a coordinated plan	SG_S6	4,4127	1,5307	5,00
Step 7: Review and reconsider implications of the design	SG_S7	4,8889	1,4381	5,00
Step 8: Define product architecture for functionalities	SG_S8	5,0000	1,4028	5,00
Step 9: Configure components for upcoming manufacturing	SG_S9	5,4127	1,3030	6,00
Step 10: Plan work schedules and inventory control	SG_S10	5,3968	1,4429	6,00
Step 11: Establish costs of production	SG_S11	6,0476	1,1972	6,00
Step 12: Plan information flow to facilitate production	SG_S12	5,4603	1,3177	6,00
Step 13: Configure supply chain activities	SG_S13	5,4444	1,2544	6,00
Step 14: Perform marketing planning	SG_S14	4,5079	1,6449	5,00
Step 15: Perform shipping design	SG_S15	5,0159	1,4755	5,00
Step 16: Perform marketing strategy simulation testing	SG_S16	3,4286	1,6917	4,00
Step 17: Perform market testing	SG_S17	3,6825	1,8389	4,00
Step 18: Plan launch of a new product	SG_S18	3,6984	1,8107	4,00
Step 19: Perform market and competitive monitoring	SG_S19	4,1452	1,5241	4,00
Step 20: Plan phase-in/phase out	SG_S20	3,9206	1,6393	4,00
Step 21: Prepare for new product discontinuation	SG_S21	4,1905	1,7676	4,00

On the contrary, the least used elements of Stage Gate model are Step 16 (perform marketing strategy simulation testing), Step 17 (perform market testing), Step 18 (plan launch of a new product), Step 21 (prepare for new product discontinuation) and Step 20 (plan phase in/phase out). The latter steps represent post incubation phase and can be defined as rather undeveloped practices among explored SMEs. The findings show that different phases of Stage Gate model are used by businesses to different extent. However, 43.55% respondents agreed and strongly agreed that their company was using a structured approach during creation of product innovation, 35.48% of the respondents were ambivalent, and 20.97% rather or strongly disagreed that such practice is prevailing in their organization. This finding is able to illustrate the potential towards structured product innovation among explored organizations.

Table III outlines and summarizes the main findings of Model 1, followed the conceptual model. OLS regression analysis among variables analysis revealed several significant

direct predictors of product innovation performance.

TABLE III
REGRESSION ANALYSIS, RELATIONSHIP AMONG VARIABLES, MODEL 1

Variable	β coefficient	Standard error	p-value
Const.	3,77737	2,2421	0,11588
STR_APPR *Use of structured approach towards NPD*	-0,46335	0,392801	0,25929
SG_AWARE *Stage-Gate model awareness*	-0,186994	0,152237	0,24111
SG_S1 *Identify customer needs*	0,00093724	0,34957	0,9979
SG_S2 *Identify market opportunities*	-0,660554	0,429452	0,14799
SG_S3 *Develop new product concept*	-0,0241181	0,258789	0,92717
SG_S4 *Breakdown the problem across different functions*	0,0433504	0,222248	0,84837
SG_S5 *Create business case to clarify financial attractiveness*	0,0490587	0,304188	0,87435
SG_S6 *Create a coordinated plan*	-0,287356	0,249898	0,27090
SG_S7 *Review and reconsider implications of the design*	1,00924	0,351225	0,01306**
SG_S8 *Define product architecture for functionalities*	-0,241905	0,316952	0,45896
SG_S9 *Configure components for upcoming manufacturing*	-0,369118	0,219147	0,11596
SG_S10 *Plan work schedules and inventory control*	-0,0727019	0,363323	0,84450
SG_S11 *Establish costs of production*	-0,0734906	0,395229	0,85536
SG_S12 *Plan information flow to facilitate production*	-0,00674089	0,263166	0,97995
SG_S13 *Configure supply chain activities*	0,611888	0,408506	0,15805
SG_S14 *Perform marketing planning*	-0,74087	0,271838	0,01733**
SG_S15 *Perform shipping design*	-0,199869	0,234475	0,40942
SG_S16 *Perform marketing strategy simulation testing*	-0,247429	0,325185	0,46030
SG_S17 *Perform market testing*	0,0584239	0,286719	0,84169
SG_S18 *Plan launch of a new product*	0,355293	0,236069	0,15622
SG_S19 *Perform market and competitive monitoring*	0,258555	0,243317	0,30729
SG_S20 *Plan phase-in/phase out*	0,425082	0,275918	0,14739
SG_S21 *Prepare for new product discontinuation*	-0,00046113	0,185203	0,99805
NO_BARR *Barriers to innovation do not exist*	0,203349	0,146152	0,18747
RARE_BARR *Barriers exist, rarely influence innovation*	0,363575	0,202576	0,09597*
IS_BARR *Barriers exist, influence innovation*	-0,0547354	0,184679	0,77162
HI_BARR *Barriers to innovation are high*	0,0729959	0,36994	0,84663
SGN_BARR *Barriers to innovation are significant*	-0,0369506	0,276022	0,89556
INN_VAL *Innovation is established value*	0,788328	0,380187	0,05856*
INN_CL_ROLE *Innovation has a clear role*	-0,617521	0,322005	0,07738*
INN_CRIT *Innovation is critical to survival*	0,493853	0,289142	0,11139
PROACT_INN *Proactively seek innovations*	-0,487908	0,248981	0,07184*
REACT_INN *Reactively seek innovations*	-0,0621411	0,189153	0,74775
PASS_INN *Passively seek innovations*	-0,184584	0,224754	0,42630
INN_RESP *Need as response to environmental fluctuations*	0,359679	0,449425	0,43791
INN_COMPA_A *Need as comparative advantage*	-1,18124	0,568291	0,05802*
INN_COMPE_A *Need as competitive advantage*	0,331633	0,418878	0,44273
M_ORIENT *Presents strong market orientation*	0,270462	0,241534	0,28307
M_NETWR *Constantly networks in the market*	0,163759	0,207151	0,44340
F_MRKT_DYN *Follow and respond to market dynamics*	1,43515	0,387502	0,00265***
F_COMP_DYN *Follow and respond to competitive dynamics*	-0,781034	0,470662	0,12094
SUPPL_COOP *Cooperates with suppliers*	-0,384691	0,40061	0,35444
CUST_COOP *Cooperates with customers*	-0,0278895	0,383059	0,94307
UNI_COOP *Cooperates with universities*	0,147504	0,176555	0,41855
RESEA_COOP *Cooperates with research institutions*	0,263496	0,294117	0,38660
GOV_COOP *Cooperates with governmental institutions*	-0,0905693	0,280357	0,75179
DCOUNTRY_1 *Country of origin*	-0,832741	0,552718	0,15582
DSIZE_1 *Size of the company*	0,496965	0,550178	0,38281

R2 (adjusted) = 0.34, F-value = 1,85, p= 0,054 (*p < 0.10, **p < 0.05, ***p < 0.01)

Regression analysis revealed few Stage Gate model steps as direct predictors to innovation performance. Findings show that Stage Gate Step 7 (review and reconsider implications for design) is a direct positive and significant predictor to innovation performance. However, Stage Gate Step 14 (marketing planning performing) is a direct negative and significant predictor to innovation performance. This finding reveals that innovation understanding among organizations still needs to be advanced, and there is a potential in institutionalizing innovation management to make it a core process. This research concludes, in alignment with [8], that a gap between current state of innovation management as a core process, compared to other business processes, such as quality management, is existent. Research has also revealed that innovation barriers perception as "existent, but rarely influences innovation" which can be defined as positive attitude to barriers is a positive and significant predictor to innovation performance. This finding supports the suggestion that the less risk is associated with innovation barriers, may predict its positive outcome. Innovation value perception also proved to a be direct and significant predictor to performance. This confirms the suggestion that higher perception of innovation value positively influences innovation performance. Attitude to innovation, having a clear role in a company, also proved to be a direct and significant innovation performance predictor. These findings also support previous research [3], [10], [11]

that suggest that higher perceived innovation value and focus to it is able to deliver positive outcome. On the contrary, willingness to proactively seek innovations was found to be a direct negative and significant predictor to innovation performance. Innovation need, as of comparative advantage to performance proved to have a direct, negative and significant effect to innovation performance. These findings could be associated with market orientation and perceived need to adapt [19], [21], despite rather high prevailing failure rate among new products [1]. The need to follow and respond to competitive dynamics with the impact of innovation was also found to deliver direct, positive and significant effect to performance which can reflect previous findings of research in the area that relate market orientation to positive innovation performance.

This research explored attitudes and existing practices of innovation management in SMEs in the Baltic region and was able to give a structured view on existing practices that showed potential for improvement among explored SMEs. Despite the findings of this research and extant prior explorations, future research could address the topic across different industries, or provide comparison in innovation management practices between large corporations and SMEs to reveal if scarcity is existent.

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