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The Role of Innovation Management Tools in Generating Innovation Market Success

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Abstract

The extensive literature on innovation management lacks a holistic theory, yet offers valuable frameworks, concepts, and tools for analyzing and managing the innovation process. Research gaps are evident in understanding the impact of specific innovation management techniques or tools (IMT) on innovation performance. Notably, limited studies demonstrate the influence of IMT on performance, primarily through qualitative case studies, and there is a notable shortage of diverse methodologies examining the interaction and collective impact of these tools alongside other innovation drivers. This paper investigates the significance of IMT in relation to other factors contributing to Innovation Market Success (IMS). Using Bootstrapped Structural Equation Modelling and Necessary Conditions Analysis on a dataset of 354 medium-sized enterprises in Germany and Austria, the study examines the interconnectedness and significance of IMT with other innovation performance determinants. Findings suggest a need to reassess the perceived importance of innovation management tools, highlighting an overemphasis in current research, while overlooking other crucial success factors. This study enhances understanding of IMT's role and impact, advocating for their strategic use in harnessing a firm's resources and capabilities to generate new competitive advantages, aligning with the Resource-based View of the Firm.

Keywords: Innovation Management Tools; Innovation Market Success; Innovation Culture; Innovation Mindset, R&D-Budget; Goal Orientation; Innovation Obstacles; Structural Equation Modelling.

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1 Introduction

Due to its importance for prosperity and growth, the topic of innovation management (IM) has been intensively researched in various respects in the past decades. The body of literature is impressive, however, certain aspects are underrepresented, especially in-depth empirical evidence about the impact of Innovation Management Tools/Techniques (IMT) on Innovation Market Success (IMS). Though recent systematic reviews and meta-analyses on success factors of innovation usually tackle the overall range of antecedents for innovation success like product-, strategy-, process-, marketplace- and organizational characteristics (Zammar et al. 2023; Evanschitzky et al. 2012) or selected leadership-, competencies-, collaboration- and resources aspects (Singh et al. 2021), these studies do not go into in-depth causal inferences of the impacts of IMT on IMS.

On this background, there are two considerable research gaps when identifying the relevance of dedicated IMT and their impact on IMS:

(1) there is only a handful of papers that present evidence on the impact of IMT on innovation performance, but mostly on the basis of qualitative case studies and
(2) there is a lack of variations in methodology in the composition and interplay of these tools, such as multivariate analyses that simultaneously take into consideration the portfolio of IMT and their role related to other drivers of innovation performance (Zammar et al. 2023).

According to Hidalgo & Albors (2008), IMT are defined as "the range of tools, techniques, and methodologies that support the process of innovation in firms and systematically help them to meet new market challenges." In the related literature (Albors-Garrigos, Igartua & Peiro 2018; Teza et al. 2016; Chai et al. 2010), findings about the utilization and performance effects of IMT are diverse and sometimes contradictory. Hidalgo & Albors (2008) found that the most utilized IMT are project management (82%), business plan development (67%), corporate intranets (66%), and portfolio analysis (60%). In contrast, the less-frequently utilized tools were the Delphi method and lateral thinking (Albors-Garrigos, Igartua & Peiro 2018). Recently, Munck et al. (2020) investigated patterns in the application of 58 management control instruments (MCI) and developed a Structural Equation Model (SEM) to investigate the impact of MCI on New Product Development (NPD) performance, innovation performance, and firm performance. However, the range of MCI analyzed covers far too much generic MCIs like 'Reporting', 'SWOT', 'Business Planning', and 'Budgeting', which unsurprisingly appear amongst the most frequently instruments in their analysis.

Starting from this premise, this paper is aimed at addressing the need for a more in-depth empirical investigation of exploring the link between the application of IMT and IMS and what leverage is exerted by IMT in relation to other success factors of innovation such as Innovation Culture/Mindset (ICM), R&D-Budgeting (R&D), Goal Orientation (GO). The aim is to fill the identified research gaps by assessing the direct and indirect effects of IMT on IMS and their relevance in relation to other important antecedents of IMS. With regards to the theoretical contribution this paper aims at further developing the Resource-Based View (RBV) of a firm as IMT are supposed to be relevant resources to support the process of innovation in firms. On this background, the central research question is:

What is the importance and the role of IMT in relation to other antecedents of Innovation Market Success?

2 Theoretical Framework and Hypotheses Development

2.1 Theoretical Background

An important theoretical foundation of innovation management is the Resource-Based View (RBV) of the firm. The RBV suggests that a firm's resources and capabilities are the key determinants of its performance and competitive advantage (Barney, 1991). According to the RBV, the key to achieving a sustained competitive advantage is to develop and exploit valuable, rare, and hard-to-imitate resources and capabilities. In the context of innovation, this means that organizations must develop and manage resources and capabilities that enable them to create and capture value from new ideas. Insofar, RBV and IMT are related in that they both focus on leveraging a firm's internal resources and capabilities to create a sustainable competitive advantage. The use of IMT can be seen as a way to operationalize the RBV by providing a structured approach for identifying and developing new resources and capabilities that can be used to create value for the firm. Thus, IMT can play a critical role in improving IMS by providing companies with the tools and strategies they need to innovate more effectively. By applying these tools at various stages of the innovation process, companies can increase their chances of success and gain a competitive advantage in the market.

However, there is a considerable research gap in RBV theory related to the question if the use of IMT resources are must-have or should-have capabilities to leverage innovation performance.

According to RBV, not all resources are equal, and the firm should possess resources that are valuable, rare, difficult to imitate, and non-substitutable to achieve sustained competitive advantage. The RBV, as outlined by Kariv et al. (2022), Lukovszki et al. (2021), Paladino (2007), and Kostopoulos et al. (2003), offers already fundamental insights into discerning between essential, must-have capabilities and complementary, should-have capabilities.

Must-have capabilities encompass valuable resources that significantly contribute to the innovation process and outcomes. Fang et al. (2019) and Al-Sharif et al. (2023) both highlight the importance of specific capabilities, such as network structural and relational capabilities and innovation mind-set in driving innovation performance. Other studies exhibit must-have resources such as a team of skilled and creative employees (Kremer et al. 2019; Anderson et al. 2014; Ferruzca Navarro et al. 2013), access to cutting-edge technology (Wang et al. 2015; Witzeman et al. 2006), and robust relationships with key partners (Zhang & Qi 2023; Tomlinson & Fay 2016). Additionally, rare resources like unique patents, exclusive licenses, or proprietary knowledge, are crucial for gaining a competitive edge in innovation (Seokbeom 2020; Hurmelinna & Soininen 2011). Moreover, capabilities that are challenging for competitors to imitate, including a distinctive organizational culture fostering innovation (Alexe & Alexe 2018) or cross-functional capabilities in enhancing overall organizational performance (Chatterjee 2023) are essential. These studies suggest that certain capabilities are essential for innovation success and can be considered as must-have factors.

On the other hand, should-have capabilities, while not as critical as must-have ones, play a supporting role in enhancing the innovation process. These include useful resources like financial resources (Hoegl et al. 2008), efficient project management systems (Kapsali 2011), and a well-established brand that attracts collaborators (Crass 2014). Furthermore, common resources, such as basic research capabilities or standard industry knowledge, are necessary but not sufficient for sustained competitive advantage, as they are more easily acquired or imitated by competitors. Nilsson (2014) and Hintama (2021) caution that the use of innovation management tools and the role of innovation capability in product innovation performance may not always be straightforward, suggesting that these capabilities may be more context-specific and thus should-have factors. Noordin (2013) and Lawson (2009) also underscore the complexity of innovation capability and its role in firm performance, indicating that it may not always be a straightforward determinant of success.

Finally, the classification of IMT themselves as must-have or should-have resources can vary based on factors such as tool characteristics, industry dynamics, and organizational strategic objectives. Regarding must-have IMT, unique methodologies, like proprietary innovation management approaches that are highly effective and challenging for competitors to replicate, qualify as essential bottleneck resources (Hidalgo & Albors, 2008). Should-have IMT encompass commonly available tools widely used in the industry, such as project management software, idea generation platforms, or standard innovation frameworks that can be easily accessed by competitors (Munck et al. 2020). Furthermore, tools that enhance efficiency in innovation processes, even if not entirely unique, play an important role as should-have factors to maintain competitiveness. Examples include widely adopted collaboration tools or data analytics platforms falling into this category.

On this basis, the present paper aims to highlight the importance of IMT in relation to other antecedents of successful innovation and at the same time clarify whether and which IMT serve as must-have factors or as should-have factors in the sense of RBV-Theory.

2.2 Hypotheses development

Literature has been investigated on IMT as well as on other drivers, especially Innovation Culture/Mindset (ICM), R&D-Budget (RD), Goal Orientation (GO), and Innovation Obstacles (IO) to develop different hypotheses (see figure 1). Three different clusters of IMT were identified with respect to their contribution to the central organizational performance variable "IMS", Agile Innovation Management (AIM) Tools, Strategic Innovation Management (SIM) Tools and Creative Innovation Management (CIM) Tools.

All in all, a total of 20 hypotheses have been developed and tested to comprehensively address the concurrence and mutual interplay of IMT with other relevant antecedents of innovation performance in one model.

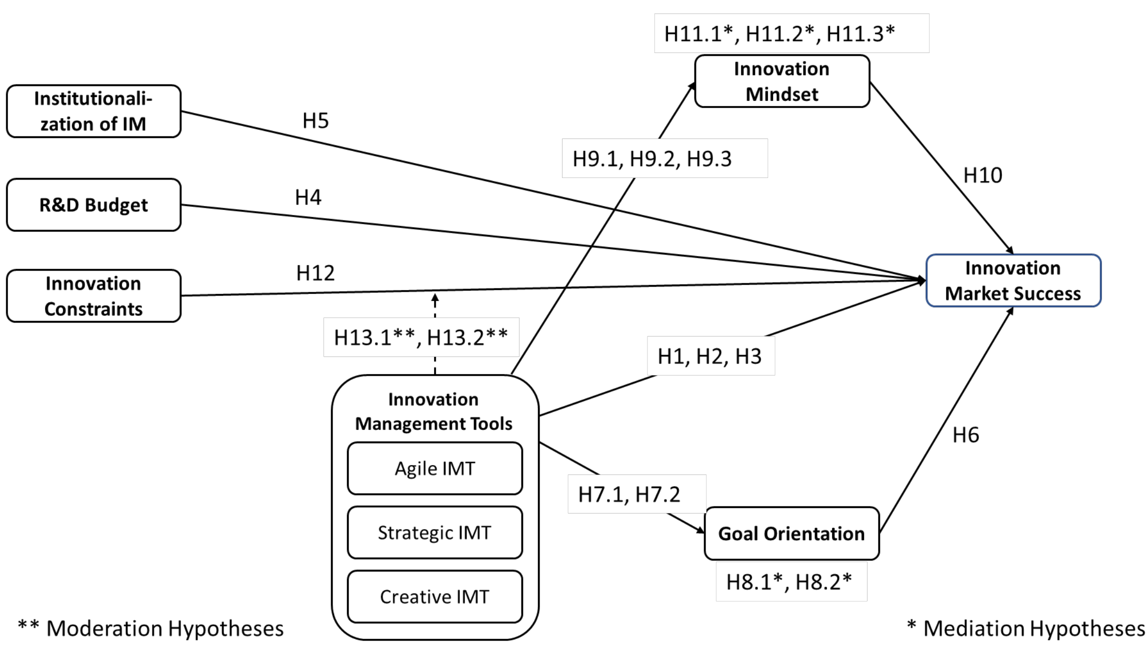

Figure 1. Conceptual Research Model

Innovation Management Tools (IMT)

Agile Innovation Management (AIM) tools comprise iterative and flexible approaches to innovation like Design Thinking (Brown 2008), Scrum (Schwaber & Sutherland, 2020), Kanban (Anderson, 2010), Lean Startup (Ries, 2011), and Agile Project Management (Highsmith, 2004). For instance, Design Thinking is a human-centered approach to innovation that involves empathy, ideation, prototyping, and testing. Design thinking has been shown to improve a firm's innovation performance by increasing customer satisfaction, reducing the time and cost of innovation, and improving the chances of success. Another tool, Business Model Innovation, involves developing new ways of creating, delivering, and capturing value. Business model innovation has been shown to improve a firm's performance by increasing revenue, reducing costs, and creating new sources of competitive advantage (Osterwalder & Pigneur, 2010).

AIM have shown to improve team collaboration, increase efficiency, and reduce time to market. Additionally, the focus on flexibility and adaptability in agile approaches can help organizations respond quickly to changing market conditions and customer needs, which is a key factor in driving innovation success (Van de Ven & Poole, 1995). Serrador & Pinto (2015) found that AIM have a positive impact on project success, including efficiency and stakeholder satisfaction. Hannola et al. (2013) found that AIM can improve the efficiency of the innovation process by providing improvements in organizational practices, transfer of knowledge, and understanding of customer needs. Narasimhalu (2011) suggests that companies can use indexes to measure their innovation agility and improve their ability to assemble innovation teams quickly and reduce the idea to market cycle time.

Recent research also suggests that agility has a positive impact on innovation performance. Lill et al. (2019) found that the use of e.g. interactive project control systems and project-internal belief systems positively influenced innovation project performance. Nemkova (2017) highlighted that agility, driven by creativity and informal planning, can lead to better market performance for born-global firms. Nascimento et al. (2023) found that companies in sectors that produce physical products when developing innovative projects, seek agility by adopting methods and practices from agile project management (APM) theory. Lastly, Lill et al. (2021) emphasized the importance of adapting control mechanisms to foster the benefits of agile projects and improve innovation project performance.

> *$\mathcal{H}1$: An increase in the use of Agile Innovation Management (AIM) tools leads to an increase in IMS.*

Strategic Innovation Management (SIM) tools like Scenario- and Portfolio Techniques or Lifecycle Analyses provide a structured approach to identify, evaluate, and prioritize innovation opportunities that align with an organization's overall strategy. By focusing on strategic alignment, these tools can help organizations identify and develop ideas that are most likely to drive long-term value and competitive advantage (Tidd & Bessant, 2021). The use of SIM can facilitate collaboration and communication among team members, which is a key factor in successful innovation (Amabile, 1996). Van der Duin (2007) and von der Gracht & Stillings (2013) both report successful use of scenarios in innovation processes, with von der Gracht's study showing that integrating expert surveys, participatory workshops, and an open network approach can increase innovation capacity. Hurley (2012) found that the practical value of scenario work depends on how well scenario insights are applied, and Drew (2006) notes that scenario techniques must be integrated with other strategic planning tools to be effective.

Recent research also shows that innovation strategy has a positive direct impact on innovation performance. AlQuershi (2021) found empirical evidence of positive impacts of strategic thinking, strategic innovation, strategic planning on SMEs' performance. Ovuakporie et al. (2021) show that strategic reconfiguration capability has a positive moderation effect on the relationship between Open Innovation Practices and radical innovation outcomes. Alatailat et al. (2021) provide insights about the impact of strategic thinking on organizational performance through the moderating role of high-performance work practices. Finally, Adams et al. (2019) found a positive relationship between a firm's strategic orientation, marketing management in terms of marketing mix tactics, and innovation performance.

> *$\mathcal{H}2$: An increase in the use of Strategic Innovation Management (SIM) tools leads to an increase in IMS.*

Creative Innovation Management (CIM) tools like Brainstorming (Osborn, 1953), Mind Mapping (Buzan, 1996), TRIZ (Altshuller, 1984) and Lateral Thinking (De Bono, 1970) are designed to support and facilitate the generation and development of new ideas. By providing structured processes and frameworks for idea generation and evaluation, CIM can help organizations identify and prioritize the most promising ideas, and to allocate resources effectively (Hitt et al., 2018). Meinel (2016) found that CIM positively affect idea generation. Bharadwaj (2000) found that the presence of both individual and organizational creativity mechanisms led to the highest level of innovation performance. Dul & Ceylan (2014) found that firms with creativity-supporting work environments introduce more new products to the market and have more new product success in terms of sales. Bollinger (2020) investigated tools and practices of management control of innovation processes and found a convergence of tools and practices used, which helps to reconcile management control and innovation activities. Additionally, the use of CIM can foster collaboration and communication among team members, which is a key factor in successful innovation (Amabile, 1996).

> *$\mathcal{H}3$: An increase in the use of Creative Innovation Management (CIM) tools leads to an increase in IMS.*

R&D intensity

R&D intensity is one of those innovation drivers that has been investigated in different branches and businesses for decades. In the majority of related studies significant correlations between the number of R&D resources spent and innovation performance have been found. A core assumption is that with R&D investments new knowledge will be acquired and absorbed, which can enhance the innovative and inventive abilities of a firm (Xu et al. 2021; Noteboom et al. 2006; Cohen & Levinthal, 1990; Alexy, George, & Salter 2012).

More specifically, Love and Roper (1999) found that the effect of R&D on the probability to develop new products and on the probability to innovate was positive. Mansury & Love (2008) examined the innovation performance of 206 US business services firms and found that the presence of formal and informal R&D significantly increases the extent of new-to-market and new-to-firm innovation. To sum up, a larger R&D budget allows organizations to allocate resources to key innovation projects, hire specialized staff, and invest in necessary equipment and infrastructure and overcome obstacles (Tidd & Bessant, 2021). Additionally, a larger R&D budget can provide organizations with the flexibility to explore a wider range of ideas and take more risks, which can increase the likelihood of successful innovation (Van de Ven & Poole, 1995).

The relationship between the size of an R&D budget and the use of strategic, agile, and creative innovation management tools is complex and context-dependent, especially regarding type of organization, industry, and other factors. Thus, a larger R&D budget can provide more resources for implementing various innovation management tools (Bowen et al. 2012). Organizations with greater financial resources may be more capable of investing in agile methodologies, strategic planning, and creative innovation techniques. In technology-intensive industries like pharmaceuticals, aerospace, or information technology, where research and development play a central role, larger R&D budgets are often correlated with a higher adoption of advanced innovation management tools (Petraite 2010). These industries tend to prioritize strategic planning and agility due to the dynamic nature of technology.

> *$\mathcal{H}4$: An increase in R&D budget leads to an increase in IMS.*

Institutionalization of Innovation Management

Based on the seminal work of Burns and Stalker (1961) who drew a distinction between the informal and formal structure of an organization, besides the informal innovation cultur/mindset an additional driver for innovation success is supposed to be the formal organization of the innovation management system *(IM-Institutionalization)*. An innovation management system is a set of processes, tools, and frameworks that a company uses to manage its innovation activities. By having a formal system in place like DIN 16555, ISO 56002:2019 or UNE 166002 for coordination of innovation activities and actors involved, companies can ensure that they are consistently and effectively managing their innovation activities and help companies to better understand their customers' needs and preferences (Martinez-Costa et al. 2019). This can help to reduce the risk of failure and increase the chances of success. Finally, Institutionalized innovation management systems may inspire the use of IMT because they create a culture of innovation within an organization. By formalizing the innovation process, organizations can create a clear framework for generating, evaluating, and implementing new ideas. This, in turn, can lead to more efficient and effective innovation management, as well as improved outcomes. These tools can help organizations streamline the innovation process, identify potential roadblocks or bottlenecks, and track the progress of new initiatives.

$\mathcal{H}$5: The Institutionalization of Innovation Management leads to an increase in IMS.

Goal-Orientation

Locke and Latham (1990) proposed a theory of motivation based on *Goal-Orientation/Setting.* When individuals are committed to achieving a specific, challenging goal, they are more likely to perform better than if they are given a vague goal such as "do your best." This assertion has been supported by more than 500 empirical studies, including those conducted by Locke and Latham (2002). *Goal-Orientation* helps organizations to focus their efforts and resources on specific, measurable, and achievable objectives. A strong goal orientation can provide a clear sense of direction and purpose for innovation efforts, which can help to align and motivate team members and to prioritize and allocate resources effectively. More recent research suggests that goal orientation is important for improving innovation performance. Zhou (2021) found that goal orientation moderates the relationship between creative personality traits and innovation performance. Lu (2012) found that learning goal orientation positively influences innovative performance, with knowledge sharing as a significant mediator. Doan (2020) focused on mergers and acquisitions in the pharmaceutical industry and found that firms with an explicit R&D goal orientation have better post-acquisition innovation performance. Additionally, a strong goal orientation can foster a culture of continuous improvement and progress, which can drive innovation success over time (Lu et al. 2012; Van de Ven & Poole, 1995). Finally, determined *Goal-Orientation* may inspire the use of IMT because it helps organizations stay focused on their objectives while exploring new and innovative ways to achieve them.

$\mathcal{H}$6: An increase in Goal-Orientation leads to an increase in IMS.

The use of innovation management tools can impact goal-orientation in several ways. These tools may provide visibility into progress, help in tracking key performance indicators related to innovation, and facilitate the alignment of individual and team efforts with overarching innovation goals. Conversely, the introduction of new tools may also necessitate a shift in the organization's goal-setting and performance measurement processes to accommodate and leverage the capabilities of these tools. On this background the use of innovation management tools can strengthen goal-orientation, particularly in the context of enhancing innovativeness in enterprises (Khandwalla, 2006). This is supported by the positive effects of learning and proving goal orientations on employees' innovation behavior, especially when combined with psychological capital and a strong organizational innovation climate (Zhen et al. 2022). Considering these findings goal-orientation can potentially mediate the relationship between the use of innovation management tools and innovation performance. For example, if employees are motivated by innovation-related goals and the tools support these goals, it can lead to improved innovation outcomes.

$\mathcal{H}$7: The use of IMT fosters corporate goal-orientation.

Combining H6 and H7 leads to the following Mediation Hypothesis:

$\mathcal{H}$8: Goal-Orientation mediates the relationship between the use of IMT and IMS.

Innovation Mindset

Successful innovation is often associated with a highly *stimulating innovation culture focused on an open innovation mindset.* A positive culture of innovation forms the basis for generating valuable knowledge in every company. Barney (1986) defines organizational culture as a "complex set of values, beliefs, assumptions, and symbols that define the way in which a firm conducts its business". The same applies to the innovation culture, which is subordinate to the concept of corporate culture. because it reflects a culture and attitude that values and supports innovation within an organization. A strong innovation mindset can foster a culture of continuous improvement and progress and encourage team members to think creatively and take risks in pursuit of new ideas (Kuczmarski, 1996). Additionally, a strong innovation mindset can help organizations to break down silos and foster collaboration and communication among team members, which is a key factor in successful innovation (Van de Ven & Poole, 1995).

Tellis et al. (2009) found that corporate culture is the strongest driver of radical innovation across nations. Lee et al. (2017) found that there is a positive and significant association between organizational culture and innovation, and also between organizational learning and innovation performance. Stock et al. (2013) found that innovation-oriented values and norms have a positive effect on product program innovativeness, and that market dynamism and technological turbulence have opposite moderating effects on this relationship. Naranjo-Valencia et al. (2016) found that culture can foster innovation and company performance, or it could also be an obstacle for both of them, depending on the values promoted by the culture. Specifically, an adhocratic culture is the best innovation and performance predictor. Lee et al. (2017) and Hilmarsson et al. (2014) showed that an innovation-friendly culture has a direct positive effect on the performance of product development. Finally, an open innovation mindset refers to the belief that innovation can come from both inside and outside an organization. This mindset encourages collaboration and the sharing of ideas, which can foster the use of IMT (Iivary 2011). In addition, an open innovation mindset may inspire the use of IMT because it creates a culture of openness, transparency, and collaboration. By leveraging these tools, organizations can unlock the potential of their employees and external stakeholders, fostering a spirit of innovation and creativity that can help drive business success.

$\mathcal{H}$9: A focused Innovation Mindset leads to an increase in IMS.

Innovation mindset may also be affected by the use of IMT (Riel et al. 2004). Innovation management tools often facilitate collaboration and communication among team members (Bolstad

& Endsley 2003). This can contribute to the development of an innovation mindset by promoting the sharing of ideas, knowledge, and perspectives. IMT typically also provide platforms for idea generation, capture, and evaluation (Zhu et al. 2023). By offering a structured process for submitting and refining ideas, they encourage employees to actively engage in creative thinking and contribute to the innovation pipeline. The transparency provided by IMT in tracking the progress of innovation projects and initiatives can also foster an innovation mindset. When employees can see how their efforts contribute to overall goals and outcomes, it can inspire a sense of purpose and motivation. IMT also support experimentation by providing a safe space to test and iterate on ideas before full-scale implementation. This can encourage a more risk-tolerant mindset. In addition, the introduction of IMT can signal a commitment to fostering an innovative culture within the organization. When tools are aligned with the organization's values and goals, they can contribute to shaping a culture that values and supports continuous improvement and creative thinking. Finally, IMT often include features for learning and development. Training programs, resources, and knowledge-sharing functionalities can help employees enhance their skills and stay updated on best practices in innovation, contributing to a mindset of continuous learning.

$\mathcal{H}$10: The use of IMT is positively affecting the corporate innovation mindset.

Combining H8 and H9 we also hypothesize that:

$\mathcal{H}$11: Innovation mindset mediates the relationship between IMT and IMS.

Innovation obstacles

Innovation obstacles are challenges or barriers that organizations face when attempting to introduce new products or services to the market. Some common innovation obstacles include internal factors like lack of resources, limited access to information, and resistance to change but also external factors like market entry barriers. Innovation obstacles can severely harm the development of successful new products and services. Also, it can be expected that a positive innovation culture will gradually remove obstacles to innovation.

Strobel & Kratzer (2017) examined typical obstacles in a quantitative survey among 49 small and medium-sized enterprises in Germany. They focused on both internal and external obstacles. The hypotheses on the negative effects of a total of six types of obstacles could be confirmed: Regulation and governmental bureaucracy, lack of know-how, lack of time, capacity overloading, unclear roles and tasks, lack of standards for knowledge management.

$\mathcal{H}12$: *Innovation obstacles have a negative impact on IMS.*

In this context, AIM may help to dampen negative effects from innovation obstacles by emphasizing flexibility, speed, and collaboration. For example, an organization that uses AIM may be better equipped to respond to changes in customer needs or preferences, adapt to technological advancements, and quickly pivot in response to market feedback. This agility can help the organization navigate around or through obstacles that may have otherwise hindered the success of their innovation. In addition, AIM can also help organizations more effectively manage their resources and collaborate across different teams or departments, which can help address issues related to limited resources and siloed information. Overall, by providing a flexible and collaborative framework for innovation, AIM can help organizations overcome or minimize the impact of innovation obstacles on their market success.

$\mathcal{H}13$: *The use of Innovation Management tools dampens the negative relation between Innovation obstacles and IMS (Moderating effect of IMT).*

3 Method

3.1 Sample and data collection

Recently Ahrens, Sala & Schaff (2021) presented a descriptive analysis of the state of the application of IMT in German and Austrian companies using an extended sample of n=354 mainly medium-sized enterprises (with 45,3% up to 5.000 employees, 37,9% up to 250 employees). Based on this datafile, SmartPLS 4 (Vers. 4.0.9.8) was used to conduct a confirmatory factor analysis and PLS path modelling as being recommended to be used for mixed measurement models (reflective/formative), an early theory development study and in case of complex models with large number of variables in hypotheses testing (Hair et al., 2021).

3.2 Measurement scales and models

The questionnaire covered 25 questions with 12 constructs which were measured by mainly 4-point forced Likert-scales, single- and multi-item scales to get specific responses. An example for multi-item forced Likert scales was "Please indicate what goals your company is pursuing in technology and innovation management? Responding options e.g. (1) Increasing the variety of products (2) Expansion of the range of services etc. (Doesn't apply-Rather doesn't apply-Rather applies–Applies). Based on bootstrapped outer loadings, Composite Reliability (CR) and Average Variance Extracted (AVE), an item dropping was carried out until the outer measurement models showed sufficient quality. The check for reliability and validity of the final measurement models showed outer loadings nearby 0.7 or even greater, which suggests sufficient reliability (see table 1). Composite reliability ranged from 0.752 to 0.866, and thus, fall in the desired range of 0.7 to 0.9. Also, the average variance extracted (AVE) for each construct ranged from 0.526 to 0.685, exceeding the recommended minimum value of 0.5.

Table 1. Composite Reliability and Average Variance Extracted

Reliability and Validity	Composite reliability (rho_c)	Average variance extracted (AVE)
IM-Institutionalization	0.866	0.685
Innovation Constraints	0.786	0.554
Instr Agil	0.858	0.549
Instr Creative	0.801	0.668
Instr Strategic	0.769	0.526
R&D Budget	0.752	0.611

The square roots of the AVEs of the reflective indicators exceeded their highest correlation with any other construct (see table 2), which indicates sufficient discriminant validity (Fornell & Larcker 1981).

Table 2. Correlation among latent constructs and Average Variance Extracted

Fornell & Larcker	IM Institutional-ization	Innovation Obstacles	Instr Agil	Instr Creative	Instr Strategic	Market Success Innovation	R&D Budget
IM Institution-alization	**0.828**						
Innovation Obstacles	-0.097	**0.744**					
Instr Agil	0.374	-0.062	**0.741**				
Instr Creative	0.258	-0.156	0.296	**0.817**			
Instr Strategic	0.335	-0.077	0.409	0.339	**0.725**		
Market Success Innovation	0.312	-0.318	0.23	0.181	0.214	**1**	
R&D Budget	0.231	-0.279	0.241	0.092	0.222	0.444	**0.782**

Note: Diagonal elements (bold) are the square root of variance shared between the constructs and their measures (AVE).

3.3 Structural Equation Model

A PLS-SEM model was developed due to prediction orientation of our analysis and a relatively small sample size (n= 354). We applied a PLS-SEM since it also allows to use formative measurement models (for Goal-Orientation and Innovation Mindset), single-item measurement models (IMS), nominal, ordinal and interval-scaled items, and it provides the ability to simultaneously examine a series of interrelated dependence relationships between sets of constructs represented by multiple variables such as mediation and moderation analysis models (Hair et al. 2018; Ali et al. 2018). We also improved the informative value of PLS-SEM method by adding an NCA Necessary Condition Analysis (see chapter 3.5.2) to examine to what extent IMTs have the character of must-have- or should-have factors in the innovation process.

In our PLS-SEM analysis we applied bootstrapping techniques (Hacker & Hatemi-J, 2012) with 10.000 samples ($p < 0.05$) of estimating direct effects and specific indirect effects in simple mediation models (see figure 2):

The R^2adj. (see table 3) for each endogenous construct ranged between 0.123 (Goal-Orientation) and 0.426 (IMS). According to Cohen (1988) this is a strong explanative power of the model for the IMS construct and a moderate explanative power for the Innovation Mindset- and Goal Orientation construct:

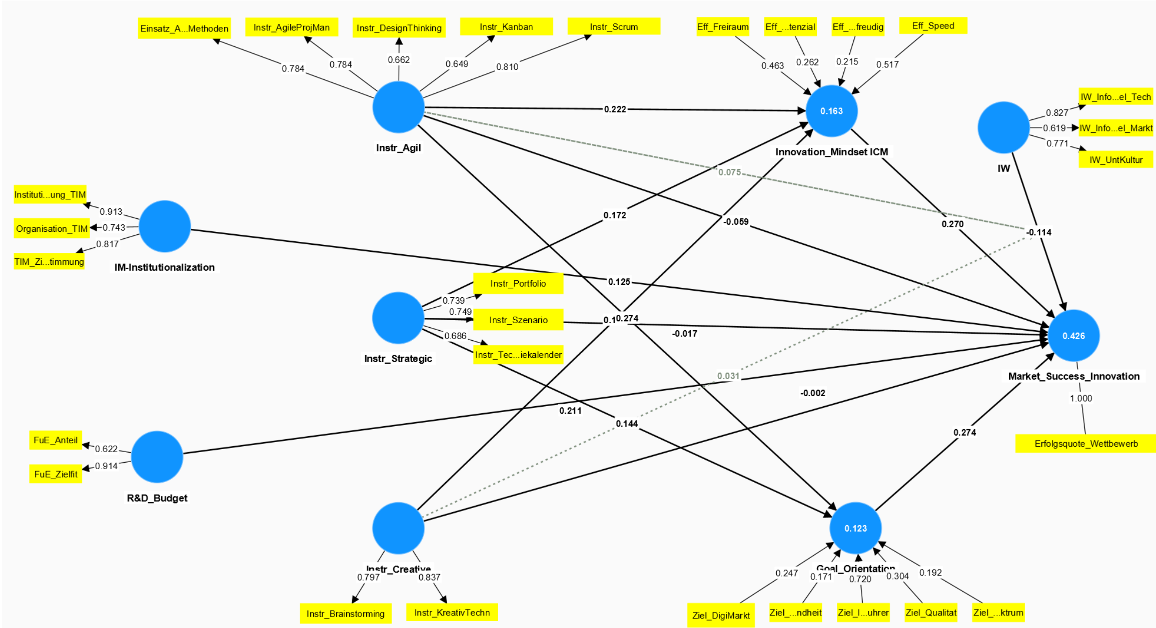

Figure 2. Structural Equation Model (Note: Numbers in inner structural model are β-values, in outer measurement model factor loadings)

Table 3. Coefficients of Determination

Coefficient of Determination	R-square	R-square adjusted
Goal Orientation	0.128	0.123
Innovation Mindset ICM	0.17	0.163
Market Success Innovation	0.443	0.426

The Q^2 values for the endogenous latent constructs were all significantly above 0 (see table 4), thus providing evidence for the model's predictive power (Tenenhaus et al., 2005). Following Cohen (1988), $Q^2 > .02$ represents a "small" effect size, $> .15$ represents a "medium" effect size, and $> .35$ represents a "high" effect size (predictive relevance).

Table 4. Predictive Power

Stone-Geisser Q^2	Q^2 predict	RMSE	MAE
Goal Orientation	0.107	0.95	0.775
Innovation Mindset ICM	0.141	0.93	0.732
Market Success Innovation	0.236	0.88	0.694

In more detail, only 5 out of 10 manifest variables had a higher error in PLS-SEM_RMSE than in the naïve linear Benchmark LM_RMSE indicating a medium predictive power of the model for out-of-sample data.

3.4 Hypotheses Testing

The strongest direct effect on IMS were found for Goal Orientation (β = 0.274; p < 0.001), followed by Innovation Mindset (β = 0.270; p < 0.001) and R&D Budget (β = 0.211; p < 0.001):

Table 5. Path Coefficients

Hypotheses	Direct Effects	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Findings
H1	Instr Agil -> Market Success Innovation	-0.059	-0.062	0.049	1.207	0.227	rejected
H2	Instr Strategic -> Market Success Innovation	-0.017	-0.02	0.045	0.379	0.705	rejected
H3	Instr Creative -> Market Success Innovation	-0.002	-0.004	0.049	0.045	0.964	rejected
H4	R&D Budget -> Market Success Innovation	0.211	0.209	0.043	4.911	0	supported
H5	IM-Institutionalization -> Market Success Innovation	0.125	0.128	0.047	2.652	0.008	supported
H6	Goal Orientation -> Market Success Innovation	0.274	0.279	0.052	5.268	0	supported
H7.1	Instr Agil -> Goal Orientation	0.274	0.28	0.057	4.791	0	supported
H7.2	Instr Strategic -> Goal Orientation	0.144	0.151	0.059	2.438	0.015	supported
H8.1	Instr Agil -> Goal Orientation -> Market Success Innovation	0.075	0.078	0.021	3.533	0	supported
H8.2	Instr Strategic -> Goal Orientation -> Market Success Innovation	0.04	0.042	0.019	2.084	0.037	supported
H9.1	Instr Agil -> Innovation Mindset ICM	0.222	0.225	0.059	3.766	0	supported

Hypotheses	Direct Effects	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Findings
H9.2	Instr Strategic -> Innovation Mindset ICM	0.172	0.177	0.058	2.97	0.003	supported
H9.3	Instr Creative -> Innovation Mindset ICM	0.15	0.152	0.056	2.665	0.008	supported
H10	Innovation Mindset ICM -> Market Success Innovation	0.27	0.273	0.064	4.243	0	supported
H11.1	Instr Agil -> Innovation Mindset ICM -> Market Success Innovation	0.06	0.062	0.023	2.629	0.009	supported
H11.2	Instr Strategic -> Innovation Mindset ICM -> Market Success Innovation	0.047	0.048	0.019	2.409	0.016	supported
H11.3	Instr Creative -> Innovation Mindset ICM -> Market Success Innovation	0.04	0.041	0.018	2.294	0.022	supported
H12	Innovation Obstacles -> Market Success Innovation	-0.114	-0.118	0.046	2.506	0.012	supported
H13.1	Instr Agil × Innovation Obstacles -> Market Success Innovation	0.075	0.074	0.044	1.711	0.087	rejected
H13.2	Instr Creative × Innovation Obstacles-> Market Success Innovation	0.031	0.028	0.046	0.666	0.506	rejected

For AIM-, SIM- and CIM-tools all path coefficients exhibited non-significant effects on Innovation Market Success (see table 5). Thus, H1, H2 and H3 are rejected.

According to the bootstrapping results, H13.1 and H13.2 (Moderation) are rejected. However, to evaluate moderation effects, we rely on Simple Slope Analyses that can demonstrate moderation effects more meaningfully than examining interaction terms (Robinson et al. 2013). This is justified by the fact that when analyzing the moderation effects through simple slopes, the standard

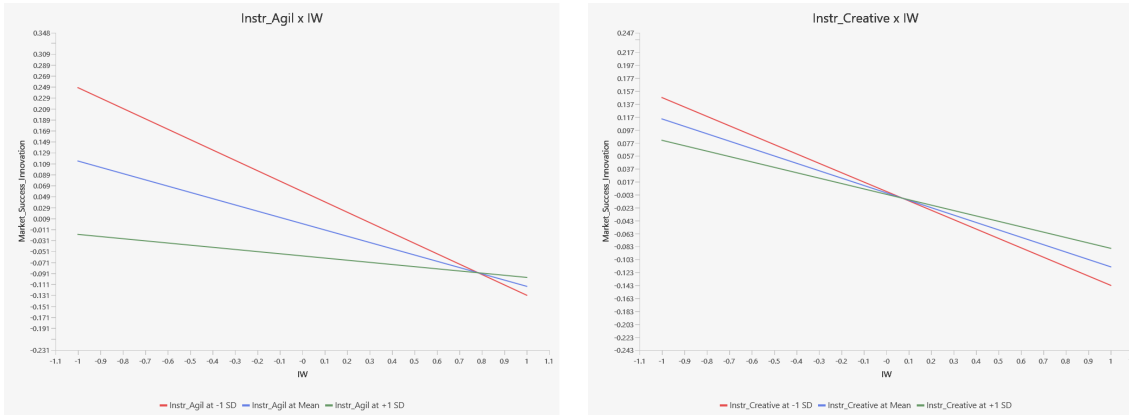

Figure 3. Moderation Effect of AIM (left) and SIM (right)

error is smaller in comparison and the resulting t-value is larger. The non-significant p-values of the interaction terms therefore do not affect the significance of the simple slope analysis in this case. Thus H13.1 is supported since we found a moderating effect of AIM on slightly dampening the negative impact of innovation constraints on innovation success (β = 0.075; $p < 0.1$). In figure 3 (left) the blue line represents the impact of Innovation Constraints on IMS, describing a negative effect of -0.114 (see table 5) for the case that Agile Instruments (AIM) are applied at mean. If the application of Agile Instruments (AIM) is intensified (green line), the negative effect of Innovation Constraints in IMS is dampened, if the application of Agile Instruments (AIM) is diminished, the negative effect of Innovation Constraints on IM will be strengthened (red line has a much stronger negative slope).

The same effect applies for the use of strategic innovation management tools (Figure 3, right), however with a smaller dampening effect on the relationship between Innovation Constraints and IMS.

3.5 Additional Exploratory Data-Analyses

3.5.1 Importance Performance Map Analysis (IPMA)

We performed an additional IPMA to contrast the importance of the different precursors of Innovation Market Success (as measured by their total impact on IMS) to their respective performance (measured by rescaling all item-data to provide performance scores on a scale from 0 to 100). The result is shown in figure 4.

From the IPMA (Importance-Performance Map) in figure 4 it is evident that three of these constructs have a moderate to high importance (β_{tot} = 0.2-0.3) while performing around (Innovation-Mindset; R&D-Budget) and above (Goal Orientation) the 50% line, whereas all other predictors have a significantly lower total impact on the target construct IMS.

- Quadrant I: *Goal Orientation* shows a high performance of around 70% and at the same time a meaningful importance for the target construct IMS (β_{tot} = 0.274). Here, the advice is to "keep up the good work", i.e., maintaining to focus on specific goals as drivers for IMS.

- Quadrant II: The general advice derived from the IPMA is to focus on improving the performance of those constructs that exhibit a moderate to large importance regarding their explanation of the target construct (IMS) but, at the same time, have a relatively low performance. This applies to *Innovation Mindset* (β_{tot} = 0.270; performance = 46,06%) and

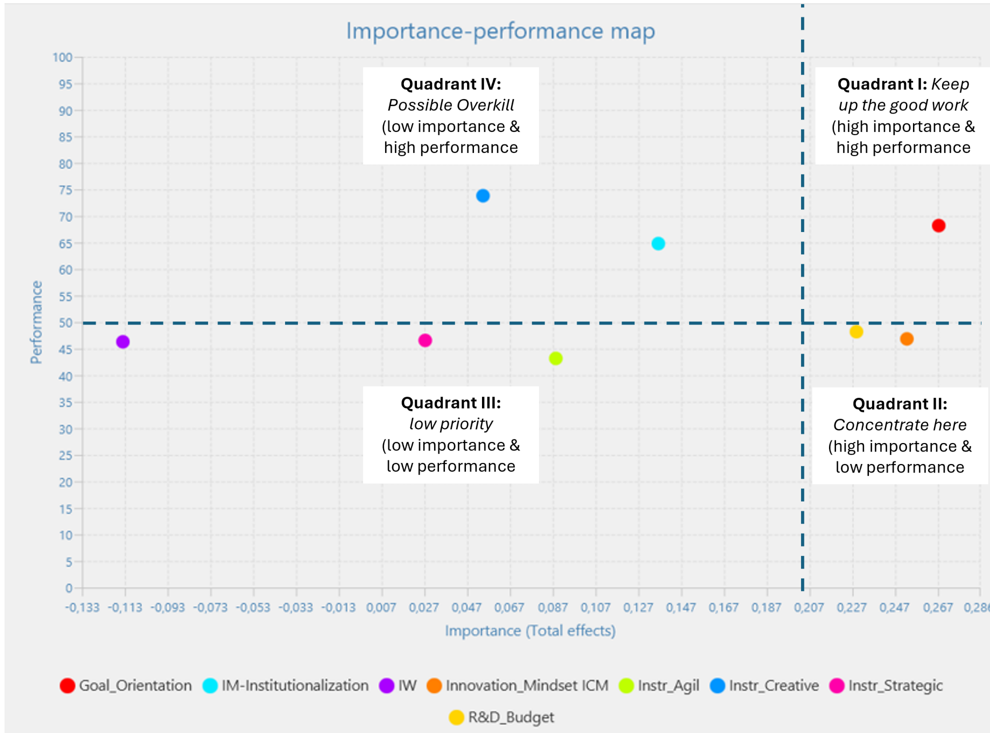

Figure 4. IPMA of Latent Constructs (Target Construct = Innovation Market Success)

R&D-Budget (β_{tot} = 0.211; performance = 48,18%).

- Quadrant IV: In addition, there are two constructs with a high performance and at the same time rather low importance, *IM-Institutionalization* and *Creative Innovation Management Tools*. *IM-Institutionalization* has only moderate importance as measured by the total impact on IMS (β_{tot} = 0.125), but performance is high (around 64%). This reflects a kind of overkill, i.e., spending too many resources on institutionalization while attaining only a low impact on the target construct. As the total effect of CIM on IMS is non-significant, the relatively high performance of CIM of 73% also reveals that too many resources are invested in CIM without unfolding a relevant impact on IMS.

- Quadrant III summarizes the constructs that have low performance and low importance at the same time. These include, among others, two of the three IMTs that have no important effect on the IMS target construct. This again shows, as mentioned above (see table 5 – direct effects), that IMTs may be overestimated in their effect on innovation success.

3.5.2 Necessary Condition Analysis (NCA)

In addition to testing our hypotheses, we also performed a NCA (Richter et al. 2020). The goal of this analysis is to identify the specific predictors that act as bottlenecks – essentially, these are the critical "Must-Have-Factors" that must be present to a certain level to establish the manifestation of outcomes. These essential factors create the necessary environment for the subsequent influence of "Should-Have-Factors" (based on PLS-SEM) enabling them to effectively contribute to IMS. The following diagram represents an example of NCA ceiling lines, displaying the effect size (bottleneck-size) of *Goal-Orientation* as one of the predominant Must-Have Factors.

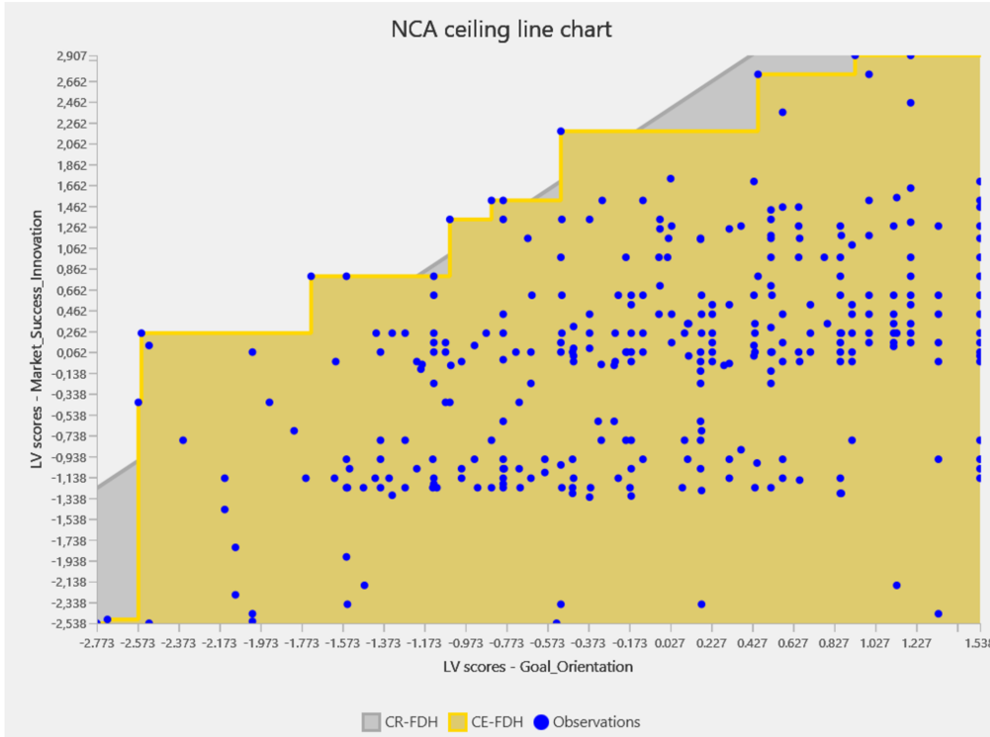

Figure 5. NCA Ceiling lines chart. Goal Orientation
CE-FDH = Ceiling Envelopement-free Disposal Hull Line
CR-FDH = Ceiling Regression-free Disposal Hull Line

Note from figure 5 that, to obtain certain levels of IMS, e.g., around 1,50, a minimum level of around -0.77 for *Goal-Orientation* must be ensured (standardized values), which is the necessary condition. All bottlenecks (in percentiles) are displayed in the following table:

Table 6. Bottleneck Table CE-FDH on the Target Construct IMS

Bottleneck Table CE-FDH	Market Success Innovation	Goal Orientation	IM - Institutionalization	Innovation Constraints	Innovation Mindset ICM	Instr Agil	Instr Creative	Instr Strategic	R&D Budget
0%	-2.538	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10%	-1.994	0.567	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20%	-1.449	0.567	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30%	-0.905	0.567	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40%	-0.36	0.850	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50%	0.184	0.850	0.283	0.000	0.000	0.000	0.000	0.000	3.683
60%	0.729	4.816	0.283	0.000	0.000	0.000	1.700	0.000	5.099
80%	1.274	16.997	0.283	0.000	4.533	0.000	1.700	0.000	11.615
80%	1.818	28.045	4.249	0.000	43.059	32.011	6.799	23.796	62.89
90%	2.363	63.173	4.249	0.000	43.059	46.459	6.799	23.796	63.739
100%	2.907	80.453	4.249	0.000	83.569	84.419	6.799	30.312	88.952

In NCA performance of a construct is measured by rescaling all item-data to provide performance scores on a scale from 0 to 100. The percentiles in the bottleneck table (Table 6) show the minimum levels of the performance of the latent constructs that must be reached depending on the desired level of performance of the target construct (here: IMS). In order to achieve a level of 80% performance IMS, around 63% of the observed cases for „R&D-Budget", 43% for "*Innovation-Mindset*", 28% for "*Goal-Orientation*", 32% for „Use of *Agile IMT*" and 24% for „Use of *Strategic IMT*" did not meet the required minimum level.

When combining the results of NCA and PLS-SEM analyses, the following results arise with much room for interpretation:

Table 7. Evaluation of Must-Have-/Should-Have Factors for Innovation Market Success

NCA / PLS-SEM Results Table	NCA-Analysis		PLS-SEM Analysis		Evaluation
	Original effect size d	Permutation p value	Path Coefficient β	P values	
Goal Orientation	0.271	0.000	0.274	0.000	Meaningful Must-have and Should-have
IM-Institutionalization	0.019	0.804	0.125	0.008	Should-have but not Must-have!
Innovation Constraints	0.000	0.000	-0.114	0.012	Try to avoid innovation constraints!
Innovation Mindset ICM	0.135	0.007	0.27	0.000	Moderate Must-have and Should-have!
Instr Agil	0.086	0.023	0.076	0.145	Must-have but not Should-have
Instr Creative	0.134	0.640	0.038	0.422	not relevant
Instr Strategic	0.075	0.147	0.069	0.190	not relevant
R&D Budget	0.101	0.000	0.211	0.000	Moderate Must-have and Should-have!

Also interesting is the question of how the degree of total impacts of the various drivers on market success correlates with their bottleneck characteristics. The corresponding portfolio is depicted in figure 6.

The results in the following figure 6 show that *Goal-Orientation* represents a quite strong bottleneck (effect-size 0.271***) and a large leverage effect on Innovation Market Success (β_{tot} = 0.274***), thus being a meaningful Must-Have- and Should-Have variable. Innovation Mindset represents a moderate bottleneck (effect-size = 0.135**) and a large total effect on the target construct Innovation Market Success (β_{tot} = 0.270***). R&D-Budget stands out for a moderate threshold (effect-size = 0.101***) with the moderate impact on Innovation Market Success (β_{tot} = 0.211***). Agile Innovation Management Tools is the only construct, which represents a small bottleneck (significant but however low effect-size = 0.086*) within the NCA (see table 7).

The *combined PLS-SEM and NCA-Analysis* (see above table 7 and figure 6) shows pivotal relevance of (in order of prominence) *Goal-Orientation*, *Innovation Mindset, and R&D Budget.* Interpreting the situation where there is a meaningful bottleneck (NCA effect-size > 0.1) along with different levels of leverage effects (as indicated by β-coefficients) on the target construct IMS involves understanding the implications of these findings in the context of three scenarios (see again table 7):

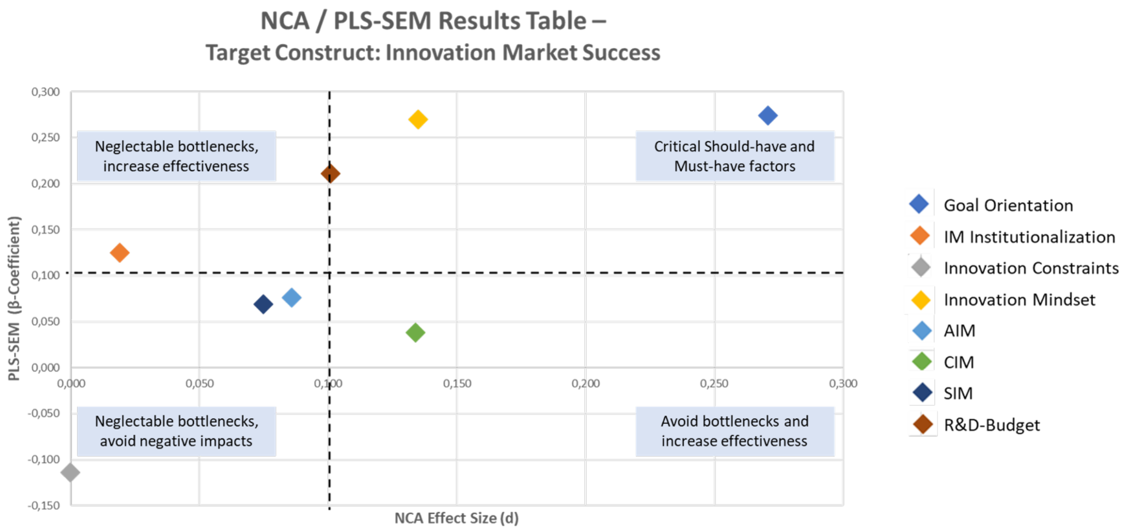

Figure 6. Must-Have- and Should-Have Factors driving Innovation Market Success

- Considerable bottlenecks (NCA effect-size > 0.25) with large leverage effects $\beta_{tot} > 0.2$): In the above-right position we find decisive bottlenecks paired with high-impact variables, which represents a field of action "Critical Must- and Should-Have Factors". In this scenario, we found Goal-Orientation as a considerable bottleneck, at the same time having a large leverage effect on the target construct IMS ($\beta_{tot} = 0.274$). This indicates that not only is Goal-Orientation crucial as a necessary condition (critical must-have), but it also has a direct and meaningful influence on the variations in the target construct (critical should-have). It's a significant driver of the changes in the outcome (IMS). Recommended strategies are here to ensure the persistence of necessary minimum conditions for the respective factor while strengthening the maximum exploitable impact on the target construct.

- Moderate bottlenecks (NCA effect-size $0.1 < d < 0.25$) with large leverage effects ($\beta_{tot} > 0.2$): In the above-middle position we find factors, which in any case should be strengthened in their impact on the target construct. Here we identified two factors that play a significant role both as moderate bottlenecks and meaningful levers in the context of our analysis, *R&D-Budget* (effect-size 0.101; $\beta_{tot} = 0.211$) and *Innovation Mindset* (effect-size 0.135; $\beta_{tot} = 0.270$) having a considerable influence on the target construct (as indicated by the higher β-coefficient > 0.2). This suggests that the individual impact of these antecedents on the target construct are meaningful (moderate should-have) while the factors are also relevant as a necessary condition (moderate must-have).

- In the lower-right position we find a field of action, which we call "Avoid bottlenecks". These factors represent critical bottlenecks but with almost no impacts on the target construct *(example: CIM)*. Since it is assumable that these bottlenecks tie up organizational resources (like support-processes with no value-add functionality), they should be observed and handled carefully. These factors are possible candidates for (structural or processual) change to increase organizational efficiency.

- The upper-left position is characterized by neglectable bottlenecks with moderate to high impact on the target construct. The advice here is to improve effectiveness (*example IM-*

Institutionalization).

- Small or neglectable bottlenecks (NCA effect-size $0 < d < 0.1$) paired with weak or non-significant total impacts on the target construct IMS: Finally, in the bottom-left position we find factors that do not play an important role in innovation management. Factors with critical negative impacts on the target construct should be observed and diminished if possible.

The overarching takeaway from these findings is that – to achieve considerable IMS - a minimum level of resources is necessary, consisting of a portfolio of focused *Goal-Orientation, Innovation Mindset, and R&D Budget*. Based on this portfolio of resources, a meaningful impact on the target construct Innovation Market Success can manifest. *IMT (AIM, CIM, SIM)* and *Institutionalization* do not play a decisive role in this basement resources portfolio.

However, a special discussion of the findings must be given to the construct *AIM - Agile Innovation Management Tools*. From the IPMA we found that *AIM* perform quite poorly around 40% with no direct positive impact on the target construct IMS. However, based on the NCA, with increasing desired attainment level of IMS their minimum level to be ensured increases rapidly up to 84% (see table 7). This might indicate that with high levels of IMS there is no way around AIM. At the same time, we found a significant negative impact of innovation constraints on IMS (see H12, table 5). Although we did not find direct significant levers to improve IMS through AIM, figure 3 (left) and hypothesis testing (see H13.1, table 5) suggest a significant (negative) moderation effect of AIM on the association between Innovation Constraints and IMS. This conveys an important clue for the indispensable role of AIM in dynamic corporate environments with increasing innovation constraints, summarized as a VUCA environment found in other studies (Troise et al. 2022; Bundtzen & Hinrichs 2021).

Our further interpretation of these findings is that those aspects we grouped together as AIM (or: which are necessarily developed with the help of AIM) are the critical hygiene factors, such as flexibility, rule breaking, fault tolerance, etc. This is reminiscent of the many studies that show the value of corporate culture for the IMS: flexibility, rule-breaking, fault tolerance (Wang 2023, Lee et al. 2017; Hilmarsson 2014, Stock et al. 2013). This culture is the essential necessary asset that promotes IMS, which may be entitled as Agile Cultural Mindset. Thus, if this kind of culture isn't there, neither AIM is there, nor IMS.

However, in the light of the findings obtained in this study, in particular because of the still weak direct leverage effects of AIM on IMS, further research is necessary here, which should aim to explore the reasons (e.g., application skills shortages) for the current failure of AIM.

4 Discussion of Results on the Background of RBV-Theory

This paper explores the role and importance of dedicated IMT on IMS compared to other antecedents of innovation success such as IM-Institutionalization, Goal Orientation, Innovation Mindset, and R&D-Budgets. The results of the present study in the context of our sample ($n = 354$ medium-sized enterprises) reveal that the current understanding of the role of IMT needs to be reconsidered significantly. Their importance is overemphasized in existing studies as long as other important antecedents of innovation success - measured by the explained variance of the dependent variable IMS - are ignored.

Unlike earlier research on this topic, we did not find any significant direct impacts of AIM, CIM and SIM on IMS. In earlier studies, the importance of the use IMT for the success of innovation is implicitly assumed or explicitly postulated (Seclen-Luna, Ponce Regalado 2020; Albors-Garrigos et al. 2018; Iguarta et al. 2015; D´Alvano & Hidalgo, A. 2011; Abdalla et al. 2008). Our research demonstrated that utilizing all three IMT tools extensively does not necessarily lead to greater success in innovation. In operational practice, this means to understand that using these methods are much less as a guarantee for innovation success than focusing management on areas that have a proven positive influence on innovation management success.

In contrast to IMT we found evidence for significant effects of other antecedents of IMS, thus confirming results from earlier studies. This applies especially to the importance of *Goal-Orientation* (Zhou 2021; Lu et al. 2012), *Innovation Mindset* (Kuczmarski 1996; Stock et al. 2013), and *R&D Budgets* (Love & Roper 1999, Cohen & Levinthal 1990).

The findings related to certain factors being bottlenecks as per Necessary Condition Analysis (NCA) can be interpreted within the framework of the Resource-Based View (RBV) as follows: In the RBV, resources must meet the VRIO criteria (valuable, rare, imperfectly imitable, and organizationally supported) to confer a competitive advantage. Our study's results, indicating the critical role of *Goal-Orientation*, *Innovation Mindset*, and *R&D Budgets*, align with this perspective, as these elements could be considered valuable and rare resources that are not easily imitable. The RBV framework can be extended to distinguish between "must-have" and "should-have" factors for innovation performance. Must-have resources are those that meet the VRIO criteria and are essential for a firm to maintain its competitive advantage. On the other hand, should-have resources are beneficial but not critical for maintaining this advantage.

In our study, we found *Goal-Orientation, Innovation Mindset, and R&D Budgets* to be must-have and should-have factors as they are pre-conditions for and significantly impact innovation performance. The *institutionalization* of innovation management systems is not a must, but once installed, it has moderate positive effects on IMS. *SIM* and *CIM* prove to be neither must-have nor should-have factors that are not essential for maintaining competitive advantage. However, *AIM* prove to be a necessary condition, particularly at high levels of IMS reflecting hygiene factors of ensuring flexibility, adaptability, fault tolerance etc. in the innovation process while the decisive leverage effects on IMS come from other factors such as those mentioned above.

To further develop the RBV in this context, it would be crucial to focus on identifying and nurturing these must-have resources while recognizing the role of should-have resources in supporting the innovation ecosystem. Moreover, understanding how these resources interact with each other and the external environment would be vital for developing a more nuanced view of innovation performance predictors in light of the RBV-Theory.

5 Managerial Implications

Based on the findings in our study, we suggest a portfolio of measures for each of the 4 identified Must-Have- and Should-Have Factors driving Innovation Market Success targeted to practitioners in the innovation process (in order of prominence):

I. *Strengthen the performance of R&D-Budget* within the framework of Innovation Management requires a strategic approach that aligns R&D investments with organizational goals. This can be achieved by ensuring the R&D budget aligns directly with the organization's innovation strategy and overall goal orientation. Incorporating customer feedback and market research into the R&D process helps understand customer needs and preferences in product and service development. Finally, implementing *AIM* that allow for iterative development and testing helps adapt R&D efforts based on real-time feedback and emerging market trends.

II. *Strengthen focus of Goal-Orientation* within the framework of Innovation Management is crucial for aligning innovation initiatives with strategic objectives. This involves clearly defining the organization's strategic goals and ensuring that innovation initiatives are directly tied to these objectives. Strategic allocation of resources, such as the *R&D budget*, funding, time, and expertise, is essential based on the innovation goals and expected outcomes. It's also important to recognize and reward teams and individuals contributing to achieving these innovation goals, fostering a culture of goal-orientation and encouraging participation in innovation efforts. Additionally, continuously reviewing and adjusting innovation goals is necessary to remain aligned with changing market dynamics, customer needs, and organizational shifts, ensuring goals are relevant and achievable through flexibility and agility.

III. *Foster a straight Innovation Mindset:* within our study, Innovation Mindset was measured as a formative construct embracing complementary indicators like *Room for Experimentation, Risk-Taking, First-Mover's Speed* and *Timeliness/Staying on schedule* (see figure 2). The predominant weights within the measurement model were *Room for Experimentation* (0.575) and *Speed* (0.433). Fostering a "straight" innovation mindset, which implies a focused and determined approach to innovation, involves cultivating a culture that prioritizes innovation efforts, aligns resources, and encourages perseverance.

IV. *Dealing with Agile Innovation Management tools:* Based on the findings from the PLS-SEM and NCA analysis, several recommendations for dealing with *AIM* in innovation management can be derived:

1. *Emphasize* AIM *in VUCA Environments:* Recognize the indispensable role of AIM, especially in VUCA environments. Consider AIM as a strategic tool to navigate challenges posed by innovation constraints, as highlighted by the significant moderation effect (see figure 3) on the association between Innovation Constraints and Innovation Market Success (IMS).

2. *Strategic Integration with IMS:* Acknowledge the rapid increase in the minimum attainment level of AIM associated with IMS as revealed by the NCA (see table 7). Understand that, while AIM may not directly improve IMS, it becomes increasingly necessary as IMS targets rise. Incorporate AIM into innovation strategies, aligning it closely with goals for IMS improvement.

3. *Address the Moderation Effect*: Investigate and address the negative moderation effect of AIM on the association between Innovation Constraints and IMS. Consider leveraging AIM to mitigate the potentially detrimental impact of innovation constraints, enhancing the organization's ability to maintain positive IMS outcomes even in challenging environments (figure 3). This obviously is not a question of applying so called AIM tools but to develop an Agile Cultural Mindset that provides the basis (Must-have) to enable other factors driving the Innovation Market Success (Should-Have factors). Thus, it makes no sense to cook AIM tools from the textbook if the framework conditions are not right.

4. *Further Research and Skill Development:* Recognize the current weak direct leverage effects of AIM on IMS and the potential application skills shortages identified as possible barriers. Initiate further research to understand the reasons behind these shortcomings, which might include inadequate training, skill gaps, or ineffective implementation practices but first of all lack of innovation-oriented cultural development. Invest in organizational development and

skill development programs to bridge these gaps and enhance the effective application of AIM.

5. *Continuous Learning:* Treat AIM implementation as an ongoing process of improvement. Encourage regular assessments, reviews, and adjustments to ensure that AIM is aligned with organizational needs and is effectively contributing to innovation management goals.

6. *Measure and Monitor Impact:* Implement metrics to track the impact of AIM on innovation outcomes over time. Regularly review these metrics to assess the effectiveness of AIM and make data-driven decisions to refine its implementation.

In summary, these findings suggest that while AIM may not directly impact IMS, an Agile Cultural Mindset plays a critical role in managing innovation constraints and maintaining IMS in a VUCA environment. To optimize the benefits of AIM, focus on strategic integration, addressing moderation effects, skill development, and continuous improvement while engaging leadership and fostering continuous learning across the organization.

6 Limitations and future research

Within the present research we did not test for further control variables like gender, tenure or occupational status of the respondents. This was due to software restrictions, although this may have altered the IPMA results.

Finally, it is in the eye of the beholder whether certain leverage effects are to be evaluated as small, moderate or large. In social sciences coefficients of determination around 20% are occasionally meaningful, or even path coefficients of 15%. Future research in PLS-SEM Modeling may be concentrated on relating explanative power and predictive power of the model presented here against each other and to enable Multigroup-Analyses with more than two groups.

To avoid common method bias, we applied different scales (4-point Likert and 3-point Likert) to attract respondent's concentration in the questionnaire.

First, the 3-point scale used to measure the degree of use of AIM, SIM and CIM tools may have been too narrow. The scale "never used", "used occasionally" and "used regularly" has some advantages, such as simplicity and ease of interpretation. However, it also has some disadvantages that indicate limitations in our study:

1. *Lack of Nuance:* This scale offers only three response options, which may not capture the full range of possible behaviors or attitudes. Respondents might have varying levels of frequency or intensity that cannot be adequately expressed within these limited options.

2. *Limited Discrimination:* The scale might not provide enough discrimination between respondents who occasionally apply a practice and those who do so regularly. It doesn't capture the subtleties or degrees of behavior or opinion that a more finely graded scale might offer.

3. *Response Bias:* Respondents might have found it challenging to categorize their behavior or attitudes into one of the three options. They might have chosen an option that is not a perfect fit for their actual behavior or opinion, leading to response bias.

4. *Interpretation Complexity:* Analyzing and interpreting the results might be less straightforward compared to scales with more response options. Respondents might struggle to determine

what constitutes "occasionally" or "regularly" applied in their specific contexts.

5. *Validity Concerns:* Due to the lack of detailed options, the scale might not have accurately measured the construct of interest, potentially leading to validity concerns that we experienced. It might not have effectively captured the nuances and variability in respondents' behaviors or attitudes. We carried out an exploratory factor analysis in advance in order to fathom the structure behind the 29 IMTs queried. However, intensive item dropping had to be carried out in order to be able to develop valid measurement models for the constructs AIM, SIM and CIM.

6. *Cultural and Contextual Difference*s: The interpretation of terms like "occasionally" and "regularly" can vary across cultures and contexts, potentially leading to inconsistencies in responses. Here we should have conducted a Measurement Invariance Test (MICOM) which we missed.

Second, the 4-point Likert scale that has been used widely in our survey (for measuring Goal-Orientation, Innovation Mindset etc.) may have its own set of disadvantages that indicate further limitations of our study:

1. *Limited Sensitivity:* While more nuanced than simpler scales, the 4-point scale might not have captured subtle variations in opinions or attitudes. Respondents might have still felt constrained by the available response options.

2. *Loss of Midpoint Flexibility:* Unlike 5-point scales, a 4-point scale lacks the flexibility of a true midpoint or neutral option. This can be a disadvantage when respondents genuinely feel neutral about a statement.

3. *Limited Statistical Power:* With fewer response options, the statistical power to detect significant differences or relationships between variables might be somewhat limited compared to scales with more options.

4. *Difficulty in Capturing Complex Constructs:* For complex constructs that encompass a wide range of opinions, a 4-point scale might not adequately capture the diversity of responses, potentially oversimplifying the measure.

After reviewing all the findings, a central research question remains that requires further investigation: What is the moderating or mediating role of Agile, Strategic, and Creative Innovation Management Tools on outcomes at different stages of the Innovation Process? While we identified significant bottleneck conditions for AIM with respect to Innovation Market Success, SIM and CIM did not show the same impact. Moreover, we discovered a noteworthy interaction effect (moderation) of AIM on the relationship between innovation constraints and IMS, which we interpret as particularly relevant in the context of volatile, uncertain, complex, and ambiguous (VUCA) environments. Notably, the association between the AIM, SIM, and CIM constructs with IMS was overly generalized. To enhance future research, it is advisable to distinguish the dependent outcome variables, potentially along a Stage-Gate Innovation process, to refine regression effects at a more detailed level.

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Conflicts of Interest

The authors declare no conflict of interest.

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