Agile governance theory: a multi-scenario empirical assessment

Teoria da governação ágil: uma avaliação empírica em vários cenários

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ABSTRACT
Context: Agile Governance Theory (AGT) has emerged as a potential model for organizational chains of responsibility across business units and teams. Objective: This study aims to assess how AGT is reflected in practice. Method: AGT was operationalized down into 16 testable hypotheses. All hypotheses were tested by arranging eight theoretical scenarios with 118 practitioners from 86 organizations and 19 countries who completed an in-depth explanatory scenario-based survey. The feedback results were analyzed using Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA). Results: The analyses supported key theory components and hypotheses, such as mediation between agile capabilities and business operations, through governance capabilities. Conclusion: This study supports the theory and suggests that AGT can assist teams in gaining a better understanding of their organization’s governance in an agile context. A better understanding can help remove delays and misunderstandings that can come about with unclear decision-making channels, which can jeopardize the fulfillment of the overall strategy.

Keywords: agile governance, information systems, software engineering, agile enterprise, agile project management.

RESUMO
Contexto: A Teoria da Governação Ágil (AGT) surgiu como um modelo potencial para cadeias organizacionais de responsabilidade entre unidades de negócio e equipes.
Objetivo: Este estudo tem como objetivo avaliar a forma como a AGT se reflete na prática. Método: A AGT foi operacionalizada em 16 hipóteses testáveis. Todas as hipóteses foram testadas através da organização de oito cenários teóricos com 118 profissionais de 86 organizações e 19 países que preencheram um inquérito explicativo aprofundado baseado em cenários. Os resultados do feedback foram analisados utilizando a Modelação de Equações Estruturais (SEM) e a Análise Fatorial Confirmatória (CFA). Resultados: As análises apoiaram os principais componentes e hipóteses da teoria, tais como a mediação entre as capacidades ágeis e as operações empresariais, através das capacidades de governação. Conclusão: Este estudo apoia a teoria e sugere que a AGT pode ajudar as equipas a obter uma melhor compreensão da governação da sua organização num contexto ágil. Uma melhor compreensão pode ajudar a eliminar atrasos e mal-entendidos que podem surgir com canais de tomada de decisão pouco claros, o que pode comprometer o cumprimento da estratégia global.

Palavras-chave: governação ágil, sistemas de informação, engenharia de software, empresa ágil, gestão ágil de projectos.

1 INTRODUCTION

While governance pertains to organizational structures and controls, agility focuses on adapting to change rapidly, and lean focuses on minimizing wastage (MOE et al., 2021). Agility and lean approaches can sometimes conflict but can be balanced for better results. We adopt a merged approach that combines agility and lean for improved outcomes (WANG; CONBOY; CAWLEY, 2012). Additionally, agility and lean thinking extend beyond agile software development (SAKHRAWI; SELLAMI; BOUASSIDA, 2022) and are relevant in other domains, such as emergent technologies management for business flexibility and security (PAL; TIWARI; HALDAR, 2021).

The Agile Governance (AG) idea emerged initially as a deterministic approach to guide software development (QUMER, 2007), evolving into an adaptive and reflexive approach focused on organizational performance, competitiveness, and sustainability, whose application occurs in different areas (FOOUNOUN et al., 2022). AG is conceptualized as “the capability of an organization to sense, adapt and respond to changes in its

1 Lean is a mindset that involves never-ending efforts to eliminate or reduce “muda” (the Japanese word for waste) and deliver value. “Lean thinking” could be synthesized as an attitude of “doing more with less.”
environment, in a coordinated and sustainable way, faster than the rate of these changes” (LUNA et al., 2016).

Although governance drives organizational performance, its intrinsic controls might limit an organization’s ability to adapt to change quickly. Considering these issues, the Agile Governance Theory (AGT) emerged years ago, aiming to analyze and describe phenomena related to how teams can develop the intrinsic dynamic capabilities2 to sense and respond to organizational or requirement changes (LUNA; MARINHO; MOURA, 2020). AGT seeks to prepare teams to respond and even anticipate those changes in a coordinated and sustainable manner. AGT also provides mechanisms for describing and analyzing the factors and agents that influence agile governance practice in organizations, which can often remain hidden or difficult to notice.

The theory has been conceptualized (LUNA; KRUCHTEN; MOURA, 2015) and operationalized (LUNA; MARINHO; MOURA, 2020) but has not yet been assessed/tested in the real world. Although some studies have tried to investigate whether the principles derived from AGT (HALIM; ASTUTI; UMAM, 2021) are supported in practice, the test of AGT's key hypotheses and core assumptions remains unexplored in depth.

This paper assesses whether the Agile Governance Theory (AGT) reflects practitioners’ experience. We imply that once we have tested the AGT key hypotheses and core assumptions, we can achieve better reliability in using the theory to identify strengths, weaknesses, opportunities, and threats in how organizations deal with fast-changing competitive environments. In this paper, we test the extent to which the whether the behaviors predicted by the AGT are reflected in the experience of practitioners by applying an assessment mechanism developed by (LUNA; MARINHO; MOURA, 2020) in practice and ask:

*RQ: Are the key hypotheses and core assumptions of the Agile Governance Theory supported by practitioners’ experience?*

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2 The term “capability” relates to a feature, faculty or process that can be developed or improved (VINCENT, 2008).
This article is structured as follows. In Section 0, we describe the methods employed. In Section 0, we present the results of this study. Section 0 addresses the research question and discusses the strength of evidence, indications for research and practice, and study limitations. Section 0 concludes the study and considers opportunities for further research on agile governance.

2 METHOD

This study uses a quantitative and explanatory survey to evaluate AGT’s hypotheses and assumptions through empirical research with practitioners. The research framework, shown in Fig. 1, guides the study. The full description of each hypothesis is characterized in APPENDIX D of the Study Technical Report (LUNA; MARINHO, 2023).

2.1 STUDY DESIGN

Using a quantitative inquiry approach, we derive eight Structural Equation Modeling (SEM) models from AGT theoretical scenarios. Our study considers cause-and-effect relationships between variables described by hypotheses. We conducted an explanatory survey (GROVES; JR; COUPER, 2013) to assess the models and answer the research question, consolidating the results to understand the AGT system in action.
In summary, this study conducted a cross-sectional survey to assess representative agents' perceptions regarding agile governance phenomena at a specific time and space. The research employed Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA) (WESTON, 2006) to test the validity of theoretical models and evaluate the relationship between observed variables and their underlying latent constructs. The study focused on eight theoretical scenarios developed by Luna et al. (2020) to analyze the phenomena.

2.1.1 Modeling AGT theoretical scenarios

The AGT's key constructs and core assumptions were transformed into 16 hypotheses, forming a set of theoretical scenarios that resulted in eight theoretical models. To evaluate these scenarios, we collected data from practitioners who represent the phenomena under study. The responses were analyzed using Structural Equation Modeling (SEM) to assess the theoretical models.

We conducted multiple scenario tests to evaluate the AGT theory, which consists of eight dynamic scenarios reflecting an organization's awareness and assimilation of
agile governance. These scenarios capture the development of capabilities required for business agility governance. The manifestation of these events can vary across organizational contexts, and certain constructs and interactions may or may not influence the observed events based on the scenario and organizational state. The Study Technical Report (LUNA; MARINHO, 2023) includes APPENDIX A, which illustrates the different paths for the evolution of AGT's theoretical scenarios, facilitating the analysis of real organizational scenarios. Assessing all eight scenarios provides a comprehensive evaluation of AGT's applicability.

Out of the sixteen hypotheses identified in the AGT theory, hypotheses $H_1$, $H_2$, $H_3$, $H_4$, and $H_{16}$ are considered the most representative. These hypotheses closely relate to the core behavior of the system and accurately assess the theory's plausibility, reflecting its essence as proposed by Luna et al. (2020).

2.1.2 Models derived from the theoretical scenarios of AGT

The formulation of models for each AGT's theoretical scenario involved several steps. Firstly, a paths diagram was created to represent the causal relationships among the constructs in each scenario. Secondly, the hypotheses specific to each scenario were included in the structural sub-model. Thirdly, observed variables identified as empirical indicators were associated with their respective constructs in the measure sub-model. Finally, the complete structural equation model was presented, incorporating both the structural and measurement components. For more details, please refer to Study Technical Report (LUNA; MARINHO, 2023): APPENDIX D for the hypotheses, APPENDIX B for the empirical indicators, APPENDIX E for research models derived from the AGT's theoretical scenarios.

2.1.3 Equations derived from the theoretical scenarios of AGT

A set of linear equations can represent each SEM model and are characterized in APPENDIX F of the Study Technical Report (LUNA; MARINHO, 2023). For instance, the General Equation of the Structural Theoretical Model derived from the most
sophisticated theoretical scenario in Agile Governance Theory, the **Dynamic scenario** ($q_n$), can be expressed in simpler terms as follows:

“Value delivery [R] can be described as the result of the influence of the disturbing Effects of external environmental factors [E], and the restraining Effects of inner moderator factors [M]; as well as the enhancers effects from Agile capabilities [A] and Governance capabilities [G], upon the Business operations [B], and their interactions, into the organizational context under analysis”.

2.1.4 Framing cross-sectional research explanatory survey

The models are tested by comparing them to the collected measurement data to assess their fit (PEARL, 2000). Given the complex and interdisciplinary nature of agile governance and the specific characteristics of the phenomena under investigation, we employ the theory's external boundary criteria outlined in (LUNA; MARINHO; MOURA, 2020) to define the sample and participant profiles, as presented in Table 1.

A convenience non-probabilistic sample (HAIR *et al.*, 2010) was used for this study. The Explanatory Survey was conducted with 956 representative agents of agile governance phenomena, as outlined in Table 1. The sample consisted of experts and researchers identified from Luna et al.’s systematic review (2014), practitioners and scholars involved in AGT development, and practitioners from Professional Groups on Social Networks as described in (LUNA; KRUCHTEN; MOURA, 2015).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C1) Role</td>
<td>Researcher (scholar) and/or Practitioner.</td>
</tr>
<tr>
<td>(C2) Experience in the topic domain</td>
<td>(a) <strong>Governance capabilities</strong>$^3$, and (b) <strong>Agile capabilities</strong>$^4$.</td>
</tr>
<tr>
<td>(C3) Responsibility level</td>
<td>Considering the context of leadership, coordination, management, or direction.</td>
</tr>
<tr>
<td>(C4) Experience in</td>
<td>Worked in: a team, project, business unit, enterprise, or multi-organizational setting.</td>
</tr>
</tbody>
</table>

$^3$ It is the ability to develop competencies related to how an organizational context is conducted, administered, or controlled, i.e., strategic alignment, decision-making, control, compliance ability, steering skills, policymaking, and accountability, among others.

$^4$ It is the ability to develop competencies related to principles, values and practices, from agile, and lean philosophy, i.e., flexibility, “doing more with less”, agility, adaptability, resilience, responsiveness, “coordinability” or “orchestrability”, self-organization, simplicity, readiness, among others.
A total of 281 respondents were obtained, which exceeds the recommended sample size of more than 100 valid cases, according to Westland (2010) (Equation 1). To determine the sample size, the formula \( n = f \times r \) was used, where \( n \) represents the number of manifest variables or items, \( f \) is the number of latent variables or factors, and \( r = p / f \) determines the ratio of manifest variables per construct.

Equation 1. SEM sample sizing

\[
 n_{SEM} \geq 50r^2 - 450r + 1100
\]

Source: (WESTLAND, 2010).

Based on Equation 1, the SEM and CFA analysis for the model which corresponds to the complex scenario of AGT, Dynamic Scenario \( \varphi_n \), consisting of six constructs and 24 manifest variables with a ratio of \( r = 4 \), would necessitate a minimum of 100 observations (valid cases).

\[
 n_{SEM} \geq 50 \times 4^2 - 450 \times 4 + 1100, \therefore n_{SEM} \geq 100
\]

Out of the 281 collected responses, accounting for a response rate of approximately 29.4%, 163 cases were excluded due to not meeting the research criteria (e.g., incomplete survey responses). This resulted in a valid sample of 118 cases (n=118), representing an overall effective response rate of over 12.3%. The resulting sample for statistical analysis, which offered significant geographical coverage, consisted of 118 respondents from 86 different organizations and 19 countries. This sample size is statistically significant, meeting the minimum requirement of at least 100 cases for the chosen assessment methods.

We developed a research protocol for a cross-sectional explanatory survey by adapting techniques and guidelines from various authors. We included survey guidelines from Grossman et al. (2009), reliability testing by Walonick (2012), data collection instrument development with the help of Passmore et al. (2002), and determining the study’s rigor based on guidance from Fowler (2009) and Kitchenham et al. (2002). We also
consulted specialists in the field and made the protocol available online for participants' reference.

The data collection instrument (questionnaire) consists of 41 questions categorized into participant mindset, respondent profile, study analysis, and theory assessment. The theory assessment questions focus on AGT constructs and are rated on a 10-point Likert scale. The questionnaire's design follows the recommendations of Lomax and Schumacker (2012) and Marôco (2014) to align with the chosen statistical method, Structural Equation Modeling (SEM). The specific questions are in the Study Technical Report (LUNA; MARINHO, 2023) in APPENDIX G.

The questionnaire was pilot-tested with 12 scholars and practitioners from the sample population. Their feedback helped refine and improve the questionnaire regarding the questions' clarity, validity, reliability, and relevance.

2.2 DATA COLLECTION

The online questionnaire was administered using SurveyMonkey\textsuperscript{5} to 956 participants organized into 18 distinct sampling subgroups based on interest groups\textsuperscript{6} and stratified by language. A communication plan consisting of invitation emails and reminders was implemented for each subgroup. The researchers also utilized the snowball method, receiving suggestions from participants' contacts who met the criteria outlined in Table 1. Purposive sampling types (PATTON, 1990) were employed, selecting participants based on specific characteristics of interest. Details of the sample analysis will be discussed in Section 0.

2.3 OVERVIEW OF DATA ANALYSIS AND SYNTHESIS

The data analysis from the obtained sample was conducted following steps 4, 5, and 6 of the research framework depicted in Fig. 1. Model estimation results were analyzed using SEM quality indices for model fit, as described by Marôco (2014) (p. 55).

\textsuperscript{5} SurveyMonkey is an online survey software available at https:// surveymonkey.com/\textsuperscript{6} For instance: Authors and Researchers on Agile Governance, Experts, Scholars, and Practitioners from Professional Groups based on Social Networks.
The data synthesis, performed in Step 7, involved assessing study hypotheses and interpreting the results. IBM® SPSS® Statistics 20.0 and IBM® SPSS® Amos 20.0 software were utilized for data analysis. Evaluating hypothesis tests and their significance for the theory was crucial for convergence and synthesis in assessing the AGT. More details about data synthesis can be found in Sections 0 and 0. The models, data, and supporting files for the research findings are available in a study repository described in the Technical Report (LUNA; MARINHO, 2023).

3 RESULTS

A total of 118 individuals met the sample profile criteria outlined in Table 1. All participants were practitioners with 46 (39%) being researchers (scholars) and former practitioners, and 72 (61%) currently active practitioners. In terms of experience in the topic domain, all respondents were experienced, with 32 (27.1%) having up to 10 years of work experience, 38 (32.2%) having between 10 and 20 years of work experience, and 48 (40.7%) having more than 20 years of work experience. All participants had experience in both governance and agile/lean, with 64 (54.2%) having more than six years of governance experience and 44 (37.3%) having more than six years of agile/lean experience. In terms of responsibility level, all participants held leadership positions, with 16 (13.6%) in distinguished leadership job positions, 54 (45.8%) in leadership job positions, and 48 (40.7%) working as coordinators, managers, or team leaders. Additionally, all participants had worked in the organizational contexts described by AGT, such as teamwork, project, business unit, enterprise, and multi-organizational settings. The number of valid cases for analysis exceeded the minimum sample size calculations required by EQUATION 1, and the sample achieved the necessary statistical significance.

3.1 SAMPLE ANALYSIS

The most representative sampling group was "Industry," which accounted for 52 respondents (44.1%) and consisted of practitioners. This was followed by "Academy" with 31 respondents (26.3%), which included scholars and researchers. The "Government" group comprised 20 respondents (16.9%) who were practitioners in the public
administration context. The "Agile governance Researchers and Authors" group consisted of 15 respondents (12.7%) who were authors identified through the systematic literature review (SLR-AG).

The sample analysis can also be categorized according to purposive sampling types, as defined by Patton (1990). The most representative type was "Typical cases," with 89 respondents (75.4%). This type allows for understanding the average or normal responses from representative agents of the studied phenomena. The findings from this study can be compared with other similar samples, but they are not generalized to a population.

In addition to "Typical cases," the study also employed the "Snowball or chain sampling" technique with 14 respondents (11.9%) and "Critical cases" with 15 respondents (12.7%). The "Snowball" sampling involved verifying whether each suggested candidate matched the respondent profile established for "Typical cases." The "Critical cases" represented the top experts in the studied phenomena but had limited representativeness for logical generalizations.

Overall, "Typical cases" represented approximately 87.3% of the purposive sampling types in the survey study, indicating their prominence. The "Critical cases" had limited representativeness but allowed for in-depth exploration of specific cases.

The sample consisted of respondents7 from 19 countries, representing 86 organizations. Of the participants, 71 (60.2%) were in Brazil, while 47 (39.8%) were from other countries across five continents. Canada had the second largest representation, with ten respondents (8.5%), followed by the United States with 9 (7.6%). France had four respondents (3.4%), and the United Kingdom and the Netherlands had three respondents (2.5%). Germany, Malaysia, New Zealand, Switzerland, and Slovenia each had two respondents (1.7%), while Cameroon, China, Croatia, Finland, Italy, Slovakia, Spain, and Venezuela each had one respondent (0.8%). This distribution provides an overview of the geographical coverage of the study.

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7 This analysis was based on the intersection of information provided by the respondent with the Internet Protocol (IP) automatically collected during the questionnaire fulfillment.
Of the participants, 19 (16.1%) chose not to disclose their company information. The study included participants from 86 companies, with a majority (55.9%) working in large organizations. These organizations varied in operating scale, with 24.6% having a multinational or global presence. Participants represented various economic sectors, with the IT industry prominent at 42.4%. Notable companies included IBM, Huawei, Accenture, Furukawa, and others with a worldwide presence. The study also involved scholars from prestigious institutions such as University College London, University of British Columbia, Delft University of Technology, Auckland University of Technology, and Villanova University. Public administration organizations, including British Columbia Housing (Canada) and various departments and courts in Brazil, were also represented. Additionally, companies from different services and industries participated, such as LATAM Airlines, Petrobras, Brasbunker/Bravante, Susquehanna International Group LLP (SIG), Brennand Groups, and more.

3.2 PARTICIPANTS’ MINDSET AND EXPERIENCE

Mindset refers to the mental attitude that shapes how individuals interpret and respond to situations, encompassing beliefs, feelings, values, and behavioral tendencies. The organizational context\(^8\) plays a crucial role in influencing mindset, and in this survey, participants were asked about their chosen organizational context and self-assessment of chaos and order. The most common organizational contexts chosen by respondents were "Enterprise" and "Project," followed closely by "Business unit" and "Teamwork." The data analysis revealed a pattern indicating a broad range of chaos and order within these contexts, with a mean value falling into the chaordic range (LUNA et al., 2014). The prevalence of the "Project" context suggests a heterogeneous nature of projects, while the "Enterprise" context appeared more rigid compared to the "Business unit" context. The participants' governance and lean/agile experiences were also considered, indicating their

\(^8\) In (Q2), we ask the subjects to keep in mind only a unique organizational context when they were answering the questionnaire, aiming to help them to establish a referential to interpret and answer each question, to minimize any misunderstanding, as well as seeking to avoid biases during our data analysis.
knowledge and expertise in the subject matter. These dimensions serve as variables to assess the quality of survey responses, providing insights for further analysis.

3.3 DATA ANALYSIS

This section presents the statistical analysis procedures used to evaluate the collected data set and test the study hypotheses. Eight theoretical models were formulated based on the scenarios derived from the Agile Governance Theory (AGT), specifically targeting the AGT’s key constructs and core assumptions (LUNA; MARINHO; MOURA, 2020). These models were created to assess the hypotheses ($H_1$, $H_2$, $H_3$, $H_4$, and $H_{16}$) by employing Structural Equation Modeling (SEM). The sixteen hypotheses were examined in various combinations within each scenario, providing a comprehensive analysis of the AGT.

<table>
<thead>
<tr>
<th>Measurement instrument</th>
<th>Items Before</th>
<th>No. Items After</th>
<th>No. Items After</th>
<th>Cronbach's $\alpha$ (standardized $\alpha$) Before</th>
<th>Cronbach's $\alpha$ (standardized $\alpha$) After</th>
<th>Reliability analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>24</td>
<td>20</td>
<td>0.914 (0.915)</td>
<td>0.902 (0.905)</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Effects of environmental factors [E]</td>
<td>5</td>
<td>3</td>
<td>0.714 (0.715)</td>
<td>0.725 (0.725)</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Effects of moderator factors [M]</td>
<td>5</td>
<td>4</td>
<td>0.861 (0.861)</td>
<td>0.860 (0.862)</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Agile capabilities [A]</td>
<td>4</td>
<td>4</td>
<td>0.880 (0.883)</td>
<td>0.880 (0.883)</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Governance capabilities [G]</td>
<td>4</td>
<td>3</td>
<td>0.823 (0.835)</td>
<td>0.864 (0.868)</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Business operations [B]</td>
<td>3</td>
<td>3</td>
<td>0.786 (0.785)</td>
<td>0.786 (0.785)</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Value delivery [R]</td>
<td>3</td>
<td>3</td>
<td>0.808 (0.809)</td>
<td>0.808 (0.809)</td>
<td>Very good</td>
<td></td>
</tr>
</tbody>
</table>

3.3.1 Assumptions verification for application of multivariate analysis

Before conducting the multivariate analysis, several assumptions needed to be verified to ensure the validity of the results. These assumptions included: (1) independence of observations; (2) scale recoding and handling of missing values; (3) internal consistency of the measuring instrument; (4) univariate and multivariate normality; (5) non-
zero sample covariance; (6) absence of multicollinearity; and (7) absence of non-standard values (outliers). All these assumptions were satisfied, allowing for the application of Structural Equation Modeling (SEM) analysis to the research data.

For example, the internal consistency of the measuring instrument (assumption 3) was assessed using Cronbach's Alpha coefficient, which measures the coherence of responses for a given variable. The results, presented in Table 2, indicated that Cronbach's Alpha exceeded 0.7 for all variables, indicating good internal consistency of the questionnaire data according to Cronbach and Meeh (1955), and Gliem and Gliem (2003).

To evaluate the assumption of univariate and multivariate normality (assumption 4), the model variation based on the Startup scenario ($\varphi_4$) was adopted. This scenario, referred to as $\varphi_4$, included all constructs and key hypotheses, as well as the necessary independent variables. The $\varphi_4$ model was chosen as the starting point for applying the theory due to its comprehensive nature. APPENDIX G in (LUNA; MARINHO, 2023) depicts the results of the factor validity of the constructs from this study.

3.3.2 SEM analysis and models’ adjustments

The models derived from the AGT theoretical scenarios were assessed using IBM® SPSS® Statistics 20.0 and IBM® SPSS® AMOS 20.0 software, employing the Maximum Likelihood method. A "two-step" approach was followed for model adjustment: (1) adjusting the measurement sub-model; and (2) adjusting the structural sub-model, considering the causal relationships between latent variables. These procedures were applied to all eight SEM models derived from the AGT scenarios, with the model based on the Startup scenario ($\varphi_4$) used as an example.

The quality of model fit was evaluated using indices such as CFI, GFI, PCFI, and RMSEA. The values of these indices indicated a good or acceptable fit for most of the models, with a very good fit observed for some models based on RMSEA, as depicted in APPENDIX J of the Study Technical Report (LUNA; MARINHO, 2023).

To refine the models, Modification Indices (MI) were analyzed based on the CFA results. MI values above 11 (p<0.001) indicated local adjustment problems. After
evaluating the theoretical plausibility of the changes, measurement errors were correlated, resulting in improved adjustment of the measurement model.

The re-specification of the model changed the correlation structure between variables, requiring a reassessment of the reliability of the indicators. Cronbach's Alpha coefficient was used to evaluate the internal consistency of the indicators. The results showed improved internal consistency for some constructs after model adjustments, while the overall sample's internal consistency slightly decreased. After the adjustments, the plausibility of the underlying structures and their relationship with the latent variables of the theoretical model was supported, as depicted in Table 2. The adjusted SEM models for every theoretical scenario designed for AGT are depicted in APPENDIX E of the Study Technical Report (LUNA; MARINHO, 2023), see part A of the figures.

Path Analysis was employed to assess the hypotheses proposed by the AGT, allowing for testing of hypotheses $H_1$ to $H_{16}$. For hypothesis $H_{16}$, the supposed mediation between predictor variable [A], dependent variable [B], and mediator variable [G] was assessed using the Sobel Test for Mediation and Bootstrap Test for Mediation (SOBEL, 1982). These statistical analyses provided insights into the viability of the data set, allowing for the evaluation of the study hypotheses and the theoretical model derived from the AGT.

3.4 PATH ANALYSIS

This section focuses on the estimation of the path analysis for all models derived from the theoretical scenarios. For instance, the adjustment indices for Startup scenario ($\phi_4$) are depicted in Table 3. The SEM quality indices for model fit described by Marôco (2014) (p. 55) and Mulaik (2009) are used to analyze the estimation results of the models. The results of the estimation for every model derived from theoretical scenarios designed for AGT are depicted in APPENDIX E (see part B of the figures), as well as its adjustment indices are presented in APPENDIX K of the Study Technical Report (LUNA; MARINHO, 2023).
Table 3. Quality adjustment indices from the model based on Startup Scenario (ϕ4), (n=118).

<table>
<thead>
<tr>
<th>Group Analysis</th>
<th>Indices</th>
<th>Obtained values</th>
<th>Reference values for Analysis</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit tests</td>
<td>Chi-square ($\chi^2$)</td>
<td>202.300</td>
<td>lower better</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Degrees of freedom (df)</td>
<td>158</td>
<td>≥1</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>0.010</td>
<td>&gt;0.05</td>
<td>OK</td>
</tr>
<tr>
<td>Absolute Indices</td>
<td>Standardized Chi-square ($\chi^2$/df)</td>
<td>1.280</td>
<td>&lt;3</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>Root Mean Square Error of Approximation (RMSEA)</td>
<td>0.049</td>
<td>&lt;0.10</td>
<td>Good fit</td>
</tr>
<tr>
<td></td>
<td>Goodness of Fit Index (GFI)</td>
<td>0.857</td>
<td>&gt;0.90</td>
<td>Acceptable fit</td>
</tr>
<tr>
<td>Relative Indices</td>
<td>Comparative Fit Index (CFI)</td>
<td>0.962</td>
<td>&gt;0.90</td>
<td>Good fit</td>
</tr>
<tr>
<td></td>
<td>Normed Fit Index (NFI)</td>
<td>0.851</td>
<td>&gt;0.90</td>
<td>Acceptable fit</td>
</tr>
<tr>
<td></td>
<td>Tucker-Lewis Index (TLI)</td>
<td>0.954</td>
<td>&gt;0.90</td>
<td>Good fit</td>
</tr>
<tr>
<td>Parsimony Indices</td>
<td>Parsimony GFI (PGFI)</td>
<td>0.644</td>
<td>&gt;0.60</td>
<td>Good fit</td>
</tr>
<tr>
<td></td>
<td>Parsimony CFI (PCFI)</td>
<td>0.800</td>
<td>&gt;0.60</td>
<td>Good fit</td>
</tr>
<tr>
<td></td>
<td>Parsimony NFI (PNFI)</td>
<td>0.708</td>
<td>&gt;0.60</td>
<td>Good fit</td>
</tr>
<tr>
<td></td>
<td>Solution is admissible</td>
<td>-</td>
<td>-</td>
<td>Acceptable Fit</td>
</tr>
</tbody>
</table>

The analysis of the model's fit indices shows that most of the indices meet the recommended thresholds, indicating an acceptable fit. Although the two indices are slightly below the threshold, they are still relatively high. The model adequately captures the data's correlation structure and is deemed suitable for assessing the AGT Startup Scenario. Path coefficients ($\beta$) and their significance levels (p) are examined to test the hypotheses. The hypotheses are considered valid if the p-value is less than 0.05.

The SEM models' fit indices for each scenario are provided in the in APPENDIX J of the Study Technical Report (LUNA; MARINHO, 2023). The significance of direct effects is determined using Bootstrap simulation, with a critical ratio (CR) value greater than 1.96 (p-value<0.05) considered significant at a 97.5% confidence level. The regression coefficients are reported in a standardized form.

For hypothesis testing using the SEM Path Analysis approach, we will provide a detailed analysis for hypothesis $H_1$ in scenario $\varphi 4$ as an example. The hypothesis $H_1$ is supported with a regression weight ($\beta$) of 0.606 and a p-value (p) less than 0.001***. The critical ratio of 4.379 indicates that the probability of obtaining such a large value is less

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than 0.001. This means that the influence of agile capabilities \([A]\) on governance capabilities \([G]\) is statistically significant at the 0.001 level (two-tailed). An increase of one standard deviation in \([A]\) corresponds to a 0.606 standard deviation increase in \([G]\). Thus, based on the data from this study, we can conclude that agile capabilities have a positive and significant impact on governance capabilities in the \(\varphi_4\) scenario.

However, we will not provide here a detailed analysis of every hypothesis in each scenario. The test results for each Startup scenario (\(\varphi_4\)) hypothesis, the Quality Adjustment Indices, and the Hypotheses Test for each AGT’s theoretical scenario are depicted, respectively, in APPENDIX I, APPENDIX J, and APPENDIX K of the Study Technical Report (LUNA; MARINHO, 2023). The overall results of this procedure will be discussed in Section 0.

4 DISCUSSION

The study findings are discussed in this section, considering the variability of the model fit across different scenarios based on the statistical analysis of the empirical data. The subsequent sections elaborate on how these results address the research question.

Fig. 2. Overall hypothesis analysis from the structural equations model based on Dynamic Scenario (\(\varphi_4\)).
4.1 DATA SYNTHESIS: ANALYSIS OF THE STUDY HYPOTHESES

Fig. 2 visually represents the hypotheses using unidirectional arrows to depict the relationships between constructs. Each arrow includes the hypothesis code and the number of times it was supported. It is separated by a slash symbol, indicating the number of times the hypothesis was tested across all scenarios. Supported hypotheses are shown as solid black lines, with the line width reflecting the supported frequency across different scenarios. Conversely, hypotheses that were not supported, indicating no meaningful relationships, are represented by gray dashed lines.

4.1.1 Hypotheses with strong support

Our statistical modeling supports hypotheses $H_1$, $H_2$, $H_3$, $H_4$, and $H_{16}$ in all eight scenarios, indicating support for the key constructs ([A], [G], [B], [R]) and core assumptions of the theory.

(1) The study’s supported hypotheses corroborate the agile governance concept defined by Luna et al. in (2016). This concept emphasizes the organizational capability to sense, adapt, and respond to changes [A] in a coordinated and sustainable manner [G] faster than the rate of these changes. It also highlights the interconnectedness of these constructs with business operations [B] to maximize value delivery [R].

(2) Also, the study supports the characterization and differentiation between the agile governance approach and a specific agile approach, as outlined in Luna et al. (2014). The specific agile approach is limited to localized results within a few stages of the organization’s value chain (PORTER, 1985). In contrast, agile governance encompasses the balanced application of agility throughout the entire organizational governance or steering system, which is responsible for sensing, responding, and coordinating the organization. Hypothesis $H_3$, represents the specific agile approach, while $H_1$, $H_2$, and $H_{16}$ depict the agile governance approach.

(3) To support the plausibility of the AGT and its core components, leading to improved verisimilitude in aspects such as:
a. The 1st Law, as described in APPENDIX D of the Study Technical Report (LUNA; MARINHO, 2023), is directly related to hypotheses \( H_1, \ H_2, \ H_4, \) and \( H_{16} \). The 1st Law states that agile governance is the outcome of the coordinated combination of agile capabilities \( A \) with governance capabilities \( G \), resulting in boosted business operations \( B \) in terms of quality and productivity, ultimately leading to enhanced value delivery \( R \) to the business (LUNA; MARINHO; MOURA, 2020). Both recent and earlier literature findings support this phenomenon, such as:

i. Johns Hopkins University Applied Physics Laboratory researchers propose cybersecurity mechanisms with autonomic properties to establish a resilient infrastructure for mission-critical services in the context of multi-UAS air-traffic control (MAURIO et al., 2021).

ii. Public administration decision-makers aim to implement agile governance mechanisms in smart cities to predict and reduce vulnerability, allowing citizens to actively interact with decision-makers in post-COVID-19 scenarios (FOUNOUN et al., 2022).

iii. The Dutch Tax and Customs Administration seeks higher flexibility and agility in their business process management systems to achieve flexible and agile policy implementation (GONG; JANSSEN, 2012).

iv. Agile governance is used in Japan to overcome transport and mobility challenges, with ongoing analysis and dialogue-based assessments to improve outcomes (JAPAN MINISTRY OF ECONOMY TRADE AND INDUSTRY, 2021).

v. Reflexiveness in enterprise social media enables open strategy and empowers employees to take ownership of their work through feedback loop processes (BAPTISTA et al., 2017).

vi. ITG mechanisms are developed to enhance sensing, deciding, and responding capabilities in dynamic business environments, aiming for resilient competitive advantage in digital governance (VAIA; ARKHIPOVA; DELONE, 2022).

viii. Auditors adopt agile auditing principles from the Agile Software Development Manifesto to provide more value to organizations and stakeholders (TRUONG, 2020).

ix. A Dutch firm and its offshore site in India apply a multisite governance model for global software development based on the Scrum methodology (NOORDELOOS; MANTELI; VLIET, 2012).

x. Agile sustainability governance mechanisms are developed for emerging market supply chains, promoting flexibility and innovation in logistics (SOUNDARARAJAN et al., 2021).

xi. The Israeli Air Force enhances the governance of agile software teams for large-scale projects in the defense industry (TALBY; DUBINSKY, 2009).

xii. The Center for Urban Studies at the University of Amsterdam develops agile organizational capabilities for urban planning, emphasizing collaboration, experimentation, and continuous improvement (HAHN; TE BRÖMMELSTROET, 2021).

xiii. Enterprise Architecture Governance increases strategic agility in organizations across various industries, enabling better responsiveness to changes (AHLEMANN; LEGNER; LUX, 2020).

xiv. Educators propose an agile-based instructional method that fosters innovation in university teaching and learning through self-direction and collaboration (WIRSING; FREY, 2021).

xv. Agile and adaptive responses to the COVID-19 outbreak required agile governance, considering the timing of policy measures, decision centralization, autonomy, and the balance between change and stability (JANSSEN; VOORT, 2020), among others examples.

b. The 2nd Law, as presented in Appendix D of the report (LUNA; MARINHO, 2023), is closely associated with H3. It establishes that a specific agile approach emerges when agile capabilities [A] are directly applied to business operations [B] without the involvement of governance capabilities [G]. This activation or intensification of [B] leads to an increase in value delivery [R].
phenomenon has been extensively observed in the literature, spanning various domains such as agile software development (HENRÍQUEZ; MORENO, 2021), agile project and portfolio management (PLODER et al., 2022), agile manufacturing (KHALFALLAH; LAKHAL, 2021), and agile enterprise and agile enterprise architecture management (ALZOUBI; GILL, 2022), among others. Besides, were also found specific agile applications in new contexts, such as public management (BALAKRISHNAN; AWAMLEH; SALEM, 2022), enterprise social media (PIFAFI et al., 2020), logistics (BLACK, 2022), health care (BATAYEH; ARTZBERGER; WILLIAMS, 2018), and financing management (TOU; WATANABE; NEITTAANMÄKI, 2020), to cite a few.

c. The 6th Law, as presented in APPENDIX D of the report (LUNA; MARINHO, 2023), is closely associated with \( H_4 \). It states that the influence on business operations \([B]\) will have a directly proportional effect on value delivery \([R]\). This law considers the combined effect of all laws of AGT on business operations \([B]\) and their subsequent impact on value delivery \([R]\). Value delivery \([R]\) encompasses generating results for the business, including various forms of value that contribute to the long-term health and well-being of the organization. These results are achieved through the delivery of products and services, which are outcomes of business operations \([B]\). The persistence of benefits resulting from these products and services reflects the obtained results, which can include customer satisfaction, business efficiency, humanitarian aid, and the welfare of citizens. These benefits cater to stakeholders, such as shareholders, customers, employees, partners, suppliers, and society.

d. Theory’s premises published in (LUNA; KRUCHTEN; MOURA, 2015):

i. **Premise 1** introduces agile governance as the balanced application of agility to the governance system, distinguishing it from a specific agile approach. The former aligns with the 1st Law of AGT and is characterized by \( H_1, H_2, \) and \( H_{16} \), while the latter corresponds to the 2nd Law and is depicted by \( H_3 \).
ii. **Premise 2** positions agile governance as a socio-technical phenomenon between agile philosophy's innovation and emergent practices and the established best practices demanded by governance issues. It recognizes the interplay between technical and social aspects, emphasizing the role of people as change agents in organizations, including technology-driven ones.

iii. **Premise 3** defines agile governance as a broad concept closely tied to the supported hypotheses discussed in the topic (1). It also incorporates the meta-principles and meta-values proposed in (LUNA et al., 2016).

(4) The mediation analysis results for $H_{16}$, suggest that the impact of Agility [A] on Business Operations [B] is more substantial when mediated by Governance capabilities [G] compared to direct application to Business Operations [B]. This finding aligns with Premise 1 stated in (LUNA; KRUCHTEN; MOURA, 2015).

4.1.2 Hypotheses with limited support

Other hypotheses were supported in some scenarios, such as $H_5$, $H_6$, $H_7$, $H_9$, $H_{10}$, $H_{11}$, $H_{12}$, and $H_{13}$. These hypotheses involve the interaction between the key constructs and surrounding constructs, such as [E] and [M], representing disturbing and restraining, respectively. It can be inferred that the varying support for these hypotheses in different scenarios may be attributed to the choice of empirical indicators used to measure these constructs. The more generic and abstract the constructs, the more challenging it is to accurately measure them due to their sensitivity to the organizational context boundaries (LUNA; KRUCHTEN; MOURA, 2015). This inference is supported by the relatively lower explanatory power observed for these constructs in each scenario, as they tend to have lower squared multiple correlations. For example, in the Dynamic Scenario ($\phi n$), it is estimated that the predictors of [E] explain only 14 percent of its variance, indicating that the error variance of [E] accounts for approximately 86 percent of its total variance.

Alternatively, without delving into significant details and simply interpreting the results as accurate, it can be inferred that the theory does not hold for each hypothesis in the respective theoretical scenarios where they were not supported. However, it can be implied that the hypotheses from this second group are supported in the respective
theoretical scenarios where they were validated, indicating the plausibility of the depicted behavior in those scenarios. These results, as outlined in APPENDIX D in (LUNA; MARINHO, 2023), have an impact on the assessment of the plausibility of the 3rd \( (H_5 \text{ and } H_7) \), 4th \( (H_6, H_9, H_{10}, \text{and } H_{11}) \), and 5th \( (H_{12} \text{ and } H_{13}) \) Laws of AGT, namely:

- **Law 3** states that internal moderator factors \( (M) \) can inhibit or restrain agile capabilities \( (A) \) and governance capabilities \( (G) \), potentially reducing business operations \( (B) \) and decreasing value delivery \( (R) \).
- **Law 4** explains that environmental factors \( (E) \) can disrupt the organizational context, influencing the effects of moderator factors \( (M) \), agile capabilities \( (A) \), governance capabilities \( (G) \), and business operations \( (B) \), which, in turn, can affect value delivery \( (R) \) to some extent.
- **Law 5** emphasizes that the coordinated combination of agile capabilities \( (A) \) and governance capabilities \( (G) \) can mitigate the effects of environmental factors \( (E) \) and moderator factors \( (M) \) on the organizational context. By working together, \( A \) and \( G \) contribute to reducing inhibition, restriction, or disruption in the organizational context, ultimately enhancing business operations \( (B) \) over time, and increasing value delivery \( (R) \).

However, further studies are necessary to develop a more in-depth analysis and reach more consistent conclusions.

### 4.1.3 Unsupported hypotheses

Finally, only the hypotheses \( H_8, H_{14}, \text{and } H_{15} \) were not supported in any scenario, lacking statistical significance based on the collected data. These hypotheses suggested negative influences of moderator factors \( [M] \) on governance capabilities \( [G] \) \( (H_8) \) and positive influences of \( [G] \) on both \( [M] \) \( (H_{14}) \) and environmental factors \( [E] \) \( (H_{15}) \). This raises reflections on improving the description of the phenomena, considering that \( [G] \) may not extend beyond the organization's internal boundary. It was unexpected that \( [G] \) could not drive \( [M] \) \( (H_{15}) \) since \( [M] \) exists within the organizational environment. Possible reasons for these results include multiple organizational contexts in the data sample, potential question-wording issues in the questionnaire, or misinterpretation of
empirical indicators. Seeking to be impartial, another way to evaluate these results is that the interpretation is correct, and that the theory does not hold concerning these three hypotheses. Further studies are needed to verify these hypotheses and their corresponding scenarios.

The study highlights the complexity of the investigated phenomena and the need for specificity in methodological procedures and data collection. Future studies should tailor the questionnaire to each organizational context, consider the adequacy of the theoretical scenario to respondents' actuality, and use the chaos and order scale to shape the questionnaire and analyze theory properties. The obtained results significantly contribute to advancing the understanding of AGT in practice and improving the development of more reliable evaluation instruments for future studies.

4.2 RESULTS INTERPRETATION

Despite not all hypotheses being supported in every scenario, the Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) analysis provide evidence of theory verisimilitude, supporting the key constructs and core assumptions of the Agile Governance Theory (AGT) in all theoretical scenarios. Consequently, the research question posed in Section 0, regarding the support of the AGT hypotheses and core assumptions by practitioners' experience, can be positively answered. The study's evidence supports the plausibility of the theory components and central hypotheses.

However, it is important to acknowledge the limitations and strength of the evidence obtained in this study, as discussed in subsequent sections. These results indicate the need for further studies to establish a trustworthy theory for describing and analyzing agile governance phenomena. While this empirical study successfully assessed the plausibility of the theory, there is still much work to be done in evaluating and potentially enhancing it. The study provides valuable insights and lessons for researchers to refine and expand future studies in this area.
4.3 STRENGTH OF EVIDENCE

The strength of evidence in this study was assessed using the GRADE working group definitions (ATKINS et al., 2004), which consider study design, study quality, consistency, and directness. The study design employed advanced statistical methods and a cross-sectional explanatory survey, resulting in a moderate initial classification of evidence strength. The study quality was considered high, with a well-planned research framework, clear selection criteria, and a study protocol. However, the non-random selection of participants limits the reliability of the results. The study showed consistency\(^{10}\) in its findings, with good correspondence across the data sample. The results indicate directness\(^{11}\), supporting the key constructs and core assumptions of the theory in each theoretical scenario. Overall, the strength of evidence is moderate, and further research in this area may impact and refine the reliability of the theory. Despite limitations, this study contributes to our understanding of agile governance phenomena.

4.4 LIMITATIONS

The limitations of this research can be examined in terms of construct validity, internal validity, and external validity.

4.4.1 Construct validity

The research limitations in this study stem from the chosen methodological approach, which focused on a quantitative evaluation of a theory derived from mixed methods. To mitigate these limitations, a research framework was developed, rigorous procedures were followed, and a specific protocol was implemented.

However, improvements in the data collection instrument are necessary to enhance data quality in future studies. Certain manifest variables were removed from the models due to inadequate variance explanation by their common factor.

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\(^{10}\) According to Atkins et al. (ATKINS et al., 2004) it refers to the similarity of estimates of effect across studies and or data samples.

\(^{11}\) According to Dybå & Dingsøyr (DYBÅ; DINGSØYR, 2008) it concerns the extent to which the people, interventions, and outcome measures are similar to those of interest.
Additionally, small sample sizes can affect the adjustment of quality indices in structural equation modeling (SEM) analysis. The Bootstrap procedure was employed to minimize this bias.

It is important to recognize that the list of empirical indicators used in this study is not exhaustive and should be tailored to the organizational context under examination. The accuracy of hypothesis testing relies on the appropriateness of the selected empirical indicators. This study emphasizes the significance of selecting empirical indicators that align with the organizational context, surrounding influences, and the understanding of agile governance. The choice of indicators should consider the variations within the contextual factors described by the Agile Governance Theory (AGT).

4.4.2 Internal validity

The research employed various types of purposive sampling instead of random sampling, which may introduce limitations in terms of representativeness. However, given the developing nature of the topic and the scarcity of representative agents, this approach was justified. Future studies should adopt a more selective approach based on recognized organizational contexts for theory assessment.

Although the survey sample size of 118 participants is relatively small, it is still representative and statistically significant for the analysis. The research methodology ensures that the results are at least a representative sampling of the phenomenon under study.

Adjusting quality indices may be influenced by certain explanatory variables, such as participants' experience, organizational context, self-evaluations, and the chosen theoretical scenario, which may introduce biases. Future studies with larger samples should analyze these subgroups separately and compare the results. Developing specific questionnaires with contextuized empirical indicators for different combinations of explanatory variables could also be beneficial.

The data collection instrument (questionnaire) underwent evaluation and refinement through a survey pilot. However, further refinement is necessary to improve

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12 Even by Dubin's criteria of validity and instrument reliability, we added the other two criteria, such as clarity (wording) and relevance for each question.
question-wording and clarify concepts based on the study's results. This will help reduce potential misunderstandings and ensure accurate survey responses.

4.4.3 External validity

The study's findings may have limitations in terms of generalizability due to the predominance of "typical cases" in the survey sample. Therefore, the sample cannot generalize to a larger population. However, according to Patton (1990), it can be illustrative of similar samples. The limitations and potential biases discussed in this section do not substantially undermine the research results. These limitations are outlined to guide future studies in assessing and refining the theory and to share lessons learned with other researchers to improve their theory assessment studies.

5 CONCLUSION

This study assessed the plausibility of the Agile Governance Theory (AGT) by empirically testing its key constructs and core assumptions. One hundred eighteen participants completed an explanatory survey, and the data were analyzed using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM).

The results of the CFA indicated that the correlational structure in each of the eight theoretical scenarios adequately reproduced the empirical evidence from the data sample, with overall goodness of fit assessed as "Good Fit" or "Acceptable fit." The SEM analysis supported the hypotheses related to key constructs and core assumptions of the theory in all scenarios.

This study's findings contribute to evaluating the AGT as a plausible theory to describe and analyze agile governance phenomena. The lessons learned can guide future studies to refine and evaluate the Agile Governance Theory and provide methodological tools for assessing other theories.

The practical implications of the findings suggest that AGT can help organizations improve teamwork, sense-making, and responsiveness, especially in competitive environments or during periods of growth and change. AGT can be applied across different types of organizations, regardless of size or expertise, to achieve these benefits. The study
also emphasizes the importance of establishing a unified view of agile governance practice and promoting dialogue between scholars and practitioners.

Future research can advance using case studies or action research to test further and refine the theory. Cross-checking and analyzing the results of these studies can strengthen or challenge the predicted behaviors of the Agile Governance Theory in different scenarios.

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