Artificial Intelligence in Management Simulators

Nuno Biga

Abstract**—**Artificial Intelligence (AI) has the potential to transform management in a number of impactful ways. It allows machines to interpret information to find patterns in large volumes of data and learn from context analysis, optimize operations, make predictions sensitive to each specific situation and support data-based decision-making. The introduction of an "artificial brain" into the organization also allows it to learn from complex information and data provided by those who train it, namely its users. The "Mastering" Serious Game introduces the concept of a context-sensitive "Virtual Assistant" (VA), which provides users with useful suggestions for optimizing processes and creating value for stakeholders. The VA helps to identify in real time the bottleneck(s) in the operations system so that it is possible to act on them quickly, the resources that should be multi-skilled to make the system more efficient and in which specific processes it might be advantageous to partner with another team(s). The possible solutions are evaluated using the Key Performance Indicators (KPIs) considered in the Balanced Scorecard (BSC), allowing actions to be monitored to guide the (re)definition of future strategies. This paper is built on the BIGAMES© simulator and presents the conceptual AI model developed and demonstrated through a pilot project (BIG-AI). Each Virtual Assisted BIGAME is a management simulator developed by the author that guides operational and strategic decision making, providing users with useful information in the form of management recommendations that make it possible to predict the actual outcome of different alternative management strategic actions. The pilot project developed incorporates results from 12 editions of the BIGAME A&E that took place between 2017 and 2022 at AESE Business School, based on the compilation of data that allows establishing causal relationships between decisions taken and results obtained. Systemic analysis and data interpretation are enhanced in Assisted-BIGAMES through a computer application that the players can use. The role of each team's AV is to guide the players to be more effective in their decision-making, providing recommendations based on AI methods. It is important to note that the AV's suggestions for action can be accepted or rejected by the coaches of each team, as they must take into account their own experience and knowledge to support their decision-making. The "Serious Game Coordinator" is responsible for supporting the players with whom he debates points of view that help make decision-making more robust. All inputs must be analyzed and evaluated by each team, which must add "Emotional Intelligence" - an essential component missing from the machine learning process. The preliminary results obtained in "Mastering" show that the introduction of AV allows for faster learning of the decision-making process.

Keywords**—**Artificial Intelligence, AI, Balanced Scorecard, Gamification, Key Performance Indicators, KPIs, Machine Learning, ML, Management Simulators, Serious Games, Virtual Assistant.

I. Introduction

THE use of management simulators has been progressively consolidated as an effective tool for training managers, boosting the development of their strategic and operational skills. In recent years, the introduction of AI in simulators has given rise to new opportunities for customization and improved accuracy in evaluating complex scenarios. In effect, the application of AI allows for the creation of simulated environments with higher predictive capacity, providing a suitable arena for testing critical decisions and assessing the impact of extreme demanding scenarios, including those generated from projections supported by AI algorithms.

This article describes a pilot project started in 2024, called BIG-AI, which introduces AI into the BIGAMES© simulator, aiming at improving the quality of decision-making in critical contexts of A&E. As part of the BIG-AI project, which is currently in the development phase, concept tests have been carried out that show promising results. Although these tests are preliminary, the AI system is currently undergoing adjustments and optimizations considering the demonstration results.

Business Interactive Games (BIGAMES©) are already an important tool for training managers and executives. These simulators, used in executive training programs and various other training initiatives, whether sectoral or transversal, have proved to be valuable tools for developing leadership and management skills. BIGAMES© allow different strategies to be tested in a simulated business environment, giving participants the opportunity to experiment and observe the impact of their decisions in real time [9], [10]. BIGAMES© simulators are currently recognized for their ability to combine simulation with gamification, providing a competitive environment in which participants can assess the impact of their decisions in a virtual organizational context. In two consecutive years (2023/24 and 2024/25) BIGAMES© was awarded the "Innovation in Managerial Education Solutions" prize by an independent entity based in the United Kingdom (CorporateLiveWire, UK). This paper is built on the BIGAMES© simulator and introduces the conceptual AI model developed, demonstrated through a BIG-AI pilot. This pilot incorporates data and findings from 12 annual editions (2017-2022) of the BIGAME A&E that took place at the AESE Business School. The introduction of AI methods leverages the cross-fertilization of knowledge for more efficient decision-making through a collaborative team approach. The Virtual Assistant developed helps on supporting the queries from players when they need specific support, while the knowledge generated from each player running processes and implementing selected actions in BIGAMES© turns into useful information that is added for future use.

II. Scope and Objectives

The BIG-AI pilot project, developed in the context of BIGAMES©, mentioned above, introduces AI as a support tool

Nuno Biga (Ph.D.) is Senior Teaching Fellow at AESE Business School and Executive Director at Bigadvantage Consulting, Lisbon, Portugal (phone: +351 966 043 060; e-mail: nuno.biga@aese.pt).

that allows users to obtain real-time inputs to guide their decisions. This article is built around the mentioned pilot findings and aims to assess and discuss how AI can be embedded in the management simulator, for improving the effectiveness of decision-making processes in simulated environments. With the introduction of the "BIGAMES Virtual Assistant", the system will be able to provide its users with useful information obtained through algorithms that correlate the variables in question with results obtained in previous editions.

The scope of this study is also to analyze the feasibility of using AI to improve management processes in executive training simulators, especially in operations and organizational scenarios involving other strategic decisions, besides A&E.

The main objectives of the BIG-AI pilot project can be described as follows:

1) To assess the impact of AI on customization (team member personalization) and accuracy of the recommendations provided to users.
2) To explore the potential of AI to adjust simulation scenarios (living labs) in real time, enabling data-centric and more informed decision-making.
3) To analyze the effectiveness of using the BSC approach to measure and optimize the performance of teams using simulators with gamification.
4) To assess the potential of integrating BSC-AI into BIGAMES© management simulators to provide enhanced inputs to support higher quality decision-making.

After the successful pilot and promising results, the full introduction of AI into BIGAMES© is currently in the development phase, and several ongoing tests and adjustments are being made for its full implementation until 2025.

III. State of Art

The effectiveness of using serious games to teach management has been proven by several research studies including [2], [3], [10], [15], [18]-[20]. The use of KPIs has been used in serious games, particularly in the health sector [22], [24]. The application of AI in management simulators has evolved significantly in recent years, with the ability to personalize the user experience and provide real-time structured and unstructured data to support decision-making. According to Klock et al. [21], personalization through AI is becoming a powerful tool for improving the effectiveness of simulators, particularly in the context of gaming, by making it possible to adjust scenarios and challenges based on the individual performance of the players. The use of machine learning (ML) algorithms in management simulators makes it possible to adjust scenarios in real time, based on behavior data and interactions with users. The known literature on gamification suggests that AI and ML techniques are effective in serious game environments, based on the principle that personalized feedback can be given and challenges adjusted according to the skills and abilities shown by the players.

The topic of personalization/customization of serious games, referred to in the literature as "Tailored Gamification", is widely discussed in the literature review prepared by Klock et al. [21]. According to the authors, few methods have been used to promote tailored gamification. The results of the literature review show that most studies applied in training settings are oriented towards a future adaptation aimed at the customization of the basic models used, mentioning the importance of supporting the dynamic modeling of serious games that are adaptive to the users' characteristics and needs. We cite, among others, De Sousa Borges et al. [17], Alahäivälä and Oinas-Kukkonen [1], and Barata et al. [4], who analyzed how personalizing games by adapting them to different user profiles can help improve participant engagement and knowledge retention. De Sousa Borges et al. [17] evaluated how personalized gamification allows players to face challenges suited to their abilities, increasing motivation and performance when carrying out complex tasks. These authors analyzed the use of games in educational environments, concluding that the dynamic adjustment of scores and rewards is an important factor in increasing students' intrinsic motivation, also resulting in greater learning effectiveness. Buil et al. [13] reached a similar conclusion in their study of management students. In the same line of research, Alahäivälä and Oinas-Kukkonen [1] stress the importance of adjusting gamification dynamics to different user profiles, to ensure that rewards and feedback are appropriately customized. These authors focused on the importance of personalizing challenges to different types of users, stressing that this approach contributes to significantly improving the motivation of players. Barata et al. [4] also concluded that personalization can be fundamental in teaching environments, particularly at higher education level, where adapting learning challenges to students' preferences and abilities can significantly improve the results of the educational process. These authors found that personalizing the degrees of difficulty and the rewards given seem to be determining factors in increasing users' levels of academic performance. The various research studies that have investigated the personalization of serious games are unanimous in concluding that adapting approaches to the characteristics and needs of users is a key factor in effective training. The same conclusion is reached by Calabor et al. [14], who emphasizes the need for serious games to meet the specific needs of the areas they are intended to teach.

According to Biga [12], simulators with gamification shows that real-time decisions based on monitoring results of teams' performance at each step represent a distinct feature that challenges the capacity of managers' skills for system auditing, its integrated analysis and synthesis ability to act effectively at each time, namely, to improve and/or optimize the operational system in order to meet clients' needs, well-being and expectation of all stakeholders, while addressing other constraints of multidimensional nature. According to Klock [21], the application of ML algorithms also facilitates the personalization of serious games in real time, adapting simulation scenarios as players interact with the system. Sardi et al. [23] conclude that the use of AI in simulators can significantly improve the quality of feedback provided to users, allowing simulations to adjust challenges based on players' actions and decisions. Personalization in simulators through AI is proving to be a growing area of interest.

Cattinelli et al. [16] earlier addressed the need for computational intelligence for the BSC in the context of enterprise performance monitoring. However, no studies have been found in the literature review on management simulators, with a sound integration of AI and BSC. This seems to be aligned with the previous study by Zóltowski [25] who concluded that “the area of business intelligence and the use of its tools in the support of BSC is still a more general concept than specific and practically applied tools”, outlining the interest of research direction. In 2010, Biga [6] developed BI software that linked various KPIs, an approach that was taken up in the BIG-AI project. The research presented hereafter explores the combination of the above methods, assuming its potential to enhance the way in which BIGAMES© users/ participants monitor processes and teams, as a decisive factor in boosting their performance.

IV. Methodology

The methodology used in BIGAMES© was consolidated over the last few years of implementation [8]-[10], [12]. It is based on an iterative process of continuous improvement: after running each annual edition, specific adjustments or features are introduced in the simulator based on the feedback and data analysis of members’ actions (players/students) to increase personalization in each context. Since their creation in 2015 to the most recent version, the management simulators developed in serious game(s) format have been optimized to ensure a simulation experience that is ever closer to the organizational reality that is intended to be mimic through a living lab. The implementation of the pilot project with AI, called BIG-AI, started early in 2024, as an innovative approach in the field of serious games. Its experimental application took place in the Accidents and Emergencies (A&E) simulator at the AESE Business School [8]-[12]. In a recent initiative called “Mastering” (case study developed in 2024 as part of the BIG-AI pilot project), a specific APP was developed to support the simulator, where the relationship between BSC and AI was tested, that conducted to promising results. The program structure of each edition of BIGAMES© includes the following sequential phases:

1. Drawing of Roles: Participants learn which functional role they are going to play in the simulator; each role derives from drawing lots to ensure randomness in the assignment process and each team member are provided with the “rules of the game”. This stage is essential for defining the roles and responsibilities of each player/participant in the simulator.
2. Self-learning of roles: At this stage, participants have access to manuals and explanatory videos, enabling them to understand their responsibilities and the objectives they need to address. This preparation phase is very important for each participant to become familiar with the respective playing role. The duration of this phase can be longer or shorter, and often takes place in advance or on the same day of the simulation event, depending on the complexity of each BIGAME© living lab.
3. Initial Training Session: Participants can test their functions on the simulator for 30 to 45 minutes. This training phase is a dress rehearsal that allows participants to identify and clarify any doubts on how the simulator works, as well as to fine-tune processes and procedures before the start of the competition sessions - stages 4 and 5.
4. Intermediate Simulation Sessions: Two simulation sessions are held, each lasting 30 minutes. At the end of each of these sessions there is a 30-minute break for the teams to analyze the results obtained and adjust their strategies to the predefined objectives. During these breaks, the teams can use the so-called “Virtual Assistant” [of the simulator] which provides them with feedback based on the data obtained in previous editions (accumulated knowledge) that is used.
5. Final Simulation Session and Debriefing: In the last simulation session, teams apply the lessons learned from the previous sessions. This is followed by a plenary debriefing session in which the results are discussed, analyzing the KPIs and the causal relationships that make it possible to assess the extent to which the decisions taken have contributed to the results obtained. It is in this session that the main conclusions to be retained by the participants are systematized, e.g. the causal relationships between KPIs.

A specific methodology for applying AI to serious games in a simulation context is proposed. The AI methods integrated into BIGAMES© aim to provide relevant information to support participants' decision-making, making the simulation experience more fruitful and effective for each user. This aspect not only helps to increase the effectiveness of the learning process, but also allows managers to test different scenarios without the risks associated with real decision-making. In addition, the integration of the BSC approach into these management simulators makes it possible to monitor multiple dimensions of performance, using KPIs between which it is possible to establish correlations. The BSC, combined with AI, can provide a comprehensive view of the impact of strategic decisions, providing the simulator's users - the players of the serious game - with real-time feedback, allowing for a deeper and more multidimensional analysis of the teams' performance in the game. The use of the Virtual Assistant, which corresponds to the AI based assistant component introduced in these simulators, is one of the main innovations introduced in the BIGAMES© concept. The Virtual Assistant answers the teams' questions based on historical data from previous editions, providing quantitative guidance to support data-driven decision-making.

V. Artificial Intelligence and Balanced Scorecard

In BIGAMES© simulators, the BSC approach plays a central role in monitoring KPIs, as it allows teams to understand the causal relationships between different variables and adjust their strategies based on this information. Existing correlations are determined from historical data on the use of the simulator. The use of AI associated with the BSC in the BIGAMES© simulators allows the system, through the Virtual Assistant, to provide recommendations based on data collected in previous sessions/simulation runs, allowing to extract causal relationships between main variables represented by KPIs to be determined.

		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
V2	R^2	0.754														
	p	0.056														
V3	R^2	0.994	0.738													
	p	0.000	0.062													
V4	R^2	0.802	0.366	0.780												
	p	0.040	0.280	0.047												
V5	R^2	0.821	0.706	0.840	0.647											
	p	0.034	0.075	0.029	0.101											
V6	R^2	0.842	0.565	0.885	0.684	0.919										
	p	0.028	0.143	0.017	0.084	0.010										
V7	R^2	0.725	0.350	0.771	0.733	0.817	0.947									
	p	0.067	0.294	0.050	0.064	0.035	0.005									
V8	R^2	0.599	0.873	0.623	0.222	0.756	0.633	0.415								
	p	0.124	0.020	0.113	0.423	0.055	0.107	0.241								
V9	R^2	0.698	0.354	0.641	0.843	0.367	0.380	0.374	0.118							
	p	0.078	0.290	0.104	0.028	0.279	0.268	0.273	0.571							
V10	R^2	0.307	0.756	0.300	0.024	0.255	0.166	0.035	0.691	0.059						
	p	0.332	0.055	0.339	0.802	0.386	0.495	0.763	0.081	0.694						
V11	R^2	0.006	0.085	0.019	0.024	0.004	0.104	0.204	0.017	0.003	0.180					
	p	0.904	0.635	0.827	0.805	0.923	0.597	0.445	0.838	0.935	0.477					
V12	R^2	0.412	0.047	0.413	0.588	0.137	0.307	0.395	0.004	0.618	0.009	0.290				
	p	0.243	0.725	0.242	0.131	0.540	0.332	0.256	0.921	0.115	0.878	0.349				
V13	R^2	0.196	0.414	0.204	0.001	0.064	0.087	0.010	0.360	0.033	0.739	0.005	0.164			
	p	0.455	0.242	0.445	0.954	0.681	0.630	0.870	0.285	0.771	0.062	0.909	0.825			
V14	R^2	0.899	0.741	0.933	0.624	0.933	0.963	0.831	0.777	0.394	0.329	0.035	0.242	0.194		
	p	0.014	0.061	0.008	0.118	0.008	0.003	0.031	0.048	0.257	0.312	0.762	0.400	0.458		
V15	R^2	0.454	0.785	0.462	0.078	0.350	0.318	0.133	0.751	0.106	0.928	0.031	0.014	0.835	0.497	
	p	0.213	0.045	0.207	0.650	0.294	0.322	0.546	0.057	0.592	0.008	0.777	0.853	0.030	0.184	
V16'	R^2	0.479	0.404	0.553	0.207	0.606	0.754	0.651	0.649	0.047	0.240	0.232	0.109	0.250	0.751	0.754
	p	0.916	0.249	0.150	0.441	0.121	0.056	0.099	0.100	0.725	0.402	0.411	0.588	0.391	0.057	0.056

Fig. 1 Correlations between modelled variables V1 to V16

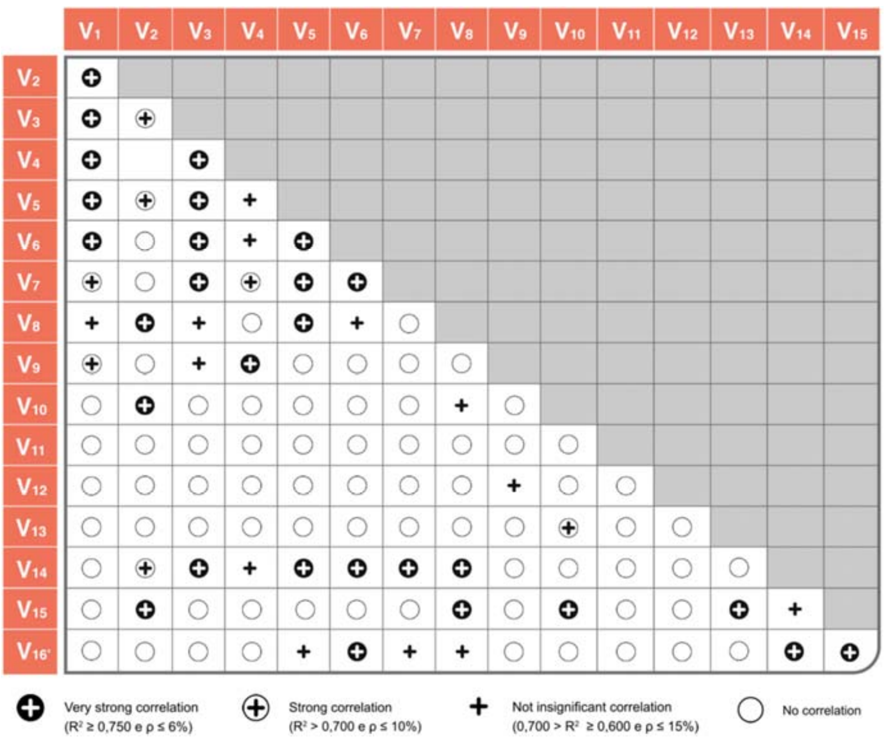

Fig. 2 Relationship strength between variables V1 to V16

In the break periods of sessions, after the intermediate series of a BIGAME, teams can request support from the simulator's Virtual Assistant, who answers specific questions of each team, based on the knowledge accumulated during several previous editions of the simulator's implementation. It is a component that learns progressively with the successive editions implemented. It is important to note that the Virtual Assistant does not suggest solutions as the objective is not to distort the competition, nor does it give opinions, but only provides information that may be relevant for a data-driven decision support. The use of the Virtual Assistant is deliberately limited, with each team only being able to ask 2 questions at each break period. The Virtual Assistant's answer to the questions posed is mostly presented in a closed format (No/Yes/Perhaps), associated with statistical information. Since the Virtual Assistant knows what has happened in previous editions of the simulator, he knows in statistical terms the impact that each change introduced has had on each KPI, used to determine the teams' final ranking.

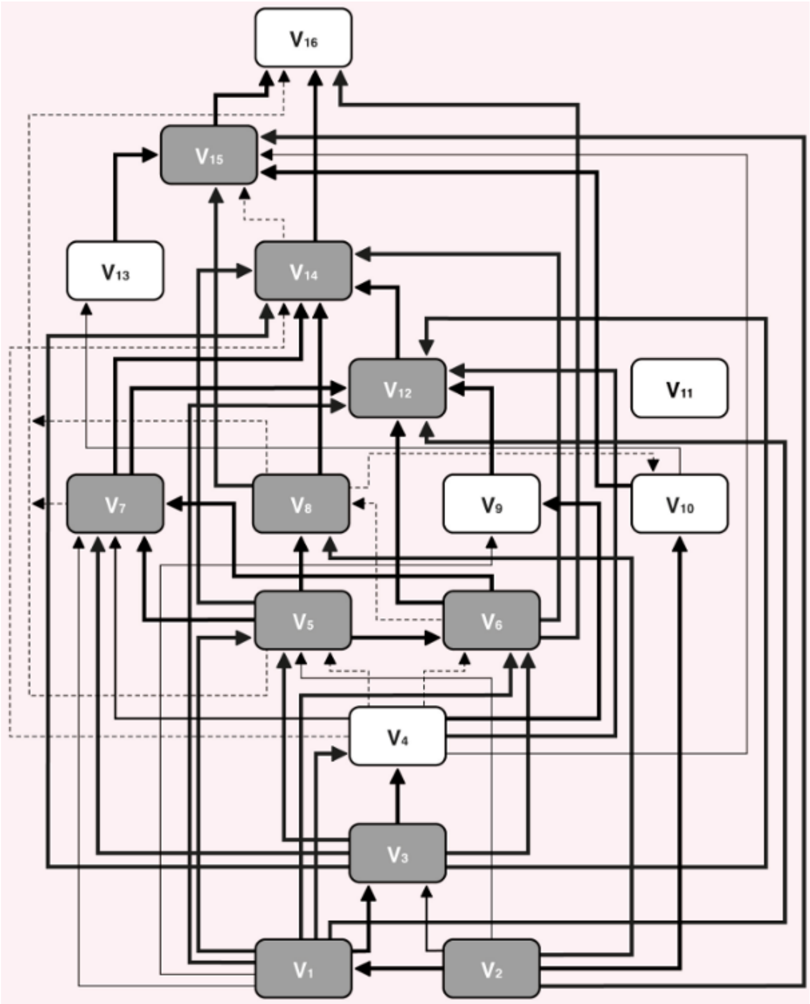

Fig. 3 Representation of the relationship between V1 to V16

The way in which the questions are formulated by the teams is of great importance if the answers are to be more assertive and appropriate. The Virtual Assistant's answer to a given question could be, for example, "30% Yes + 65% No + 5% Maybe". The statistical distribution of each answer is consolidated with ML approaches in successive editions of the simulator's implementation. The causal relationships between KPIs result in a BSC of the variables in play, with the magnitude and sign (positive or negative impact) of these relationships recorded in successive editions of the simulator. These database records allow the Virtual Assistant to provide participants with answers that consider the dynamic BSC underlying the simulator. Each participant team is constantly asking themselves what decisions they need to make during the game to win the competition, a method that fosters collaboration to achieve common goals. To this end, the role of each team's VA is to guide the players to be more effective in their decision making, by answering questions posed by them. It is important to note that the suggestions made by the VA for specific actions, are given through closed answers to questions posed by each team, and these can be accepted or rejected by the CEO of each team.

In the BIG-AI pilot project, AI is supported by an algorithm that uses linear regression models. The model used aims to explain a variable, commonly known as the dependent variable, at the expense of a set of so-called explanatory variables, known as the independent variables. The linear regression model for the generic variables is represented by:

$$Y = \beta 0 + \beta 1.X1 + \beta 2.X2 + ...+ \beta p.Xp + \varepsilon \quad (1)$$

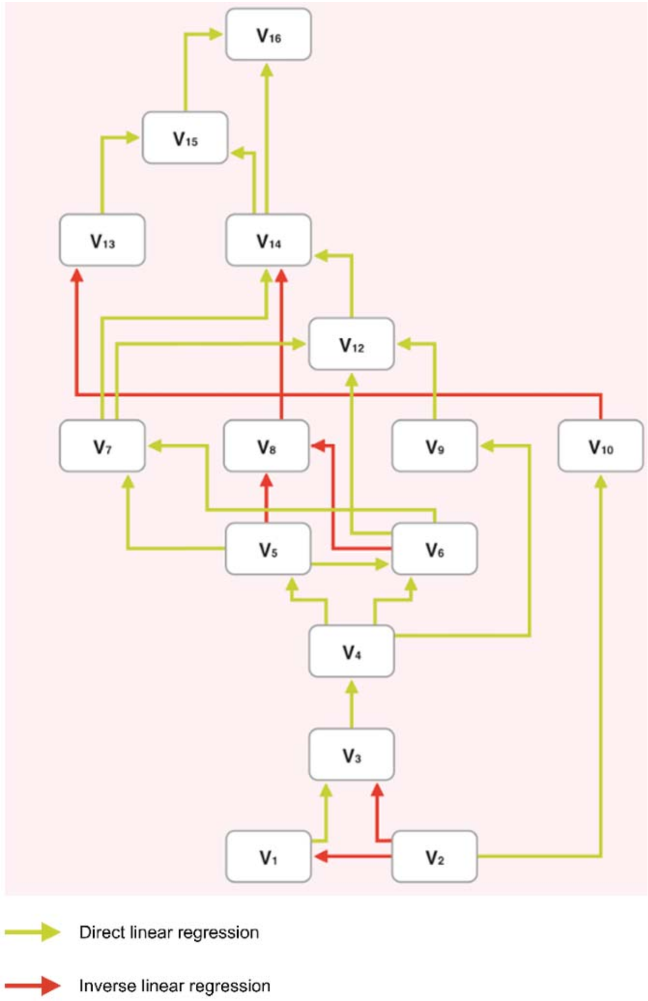

Fig. 4 Causality diagram Vi ↔ Vj: BSC approach

where Y is the dependent variable, X1, ..., Xp are the independent variables, β0, ..., βp are coefficients (with β0 the constant) and ε represents a variable with a normal distribution of zero mean value and constant variance, usually called the residual. The model equation for the set of observations relating to the j^{th} individual in the data set takes the following form:

$$Yj = \beta 0 + \beta 1.X1j + \beta 2.X2j + ... + \beta p.Xpj + \varepsilon j \quad (2)$$

where Yj (Xij, εj) translates the value of the j^{th} individual in the dependent variable Y (value of the j^{th} individual in the independent variable Xi). The residuals associated with different individuals are assumed to be independent random variables (i.e. not correlated with each other), which makes the model's residuals Gaussian white noise. This assumption should be confirmed after adjusting the model to confirm its validity, which will be possible for a larger number of observations (resulting from several editions of the simulator through several serious games). If so, in addition to confirming that the residuals are Gaussian white noise, it is necessary to analyze the significance of the model, i.e. whether any of the explanatory variables included in the model are important in explaining the dependent variable. In the regression considered, statistics with a t-Student distribution are used to test the significance of the parameters and statistics with an F distribution to test the significance of the model, which can be used regardless of the sample size. However, the t-Student and F distributions are associated with the hypothesis that the residuals have a normal distribution and are uncorrelated, and their use is questionable if the validity of the hypothesis cannot be tested. This model is applied to pairs of variables (V_i, V_j), where i ≠ j, to identify significant relationships between different KPIs, and the relationship is considered significant when the coefficient of determination (R^2) reaches values greater than 75%, with a significance level of 5%.

In BIGAMES©, the application of these linear regressions aims to predict the impact of strategic changes based on previous runs of the game. For example, if a team asks the question to assess the impact of increasing the number of resources in a given process to improve its efficiency, the Virtual Assistant relies on the regression models to provide a weighted answer [e.g., “85% Yes, 15% No”: this answer suggests that, considering the historical data from previous editions, there is likely to be a strong direct correlation (85%) between the number of resources allocated to a given process and the efficiency of that process]. These predictions are based on the history of similar decisions and their impacts in previous editions of the simulator. The simulator's BSC is dynamic, with real-time updates every time the simulator is used. This is possible because information on the results obtained in each edition is stored in a database. Obviously, once they have the AV's answer(s), it's up to each team to decide what they want to do, i.e. the decision will always be their own responsibility.

In the BSC of the BIGAMES© simulator, regressions with a coefficient of determination greater than or equal to 75% are considered significant at a 5% significance level, although relationships with a significance level of $p \leq 0.15$ are considered significant if R^2 is higher than 0.60.

Fig. 1 shows, as an example, the strength of the correlation between variables V1 to V16, and Fig. 2 shows the relationship strength between variables. The results obtained corroborate a study carried out by the author in 2007 [7] in which strategic drivers for value creation in organizations were evaluated. Indeed, the pilot project confirmed that the effectiveness of learning the rules of the Game (V1) has a strong direct correlation with satisfaction (V2), which strongly influences motivation (V3) and involvement (V4), with a direct impact on performance (V5, V6). Individual performance has a direct correlation with the effectiveness of processes (V7 to V10), with an impact on customer satisfaction (V12). The economic performance of teams in various dimensions (V13, V14, V15) seems to depend directly on customer satisfaction (V12), resulting in a strong direct correlation with the creation of shareholder value (V16).

Based on the results obtained, a causality diagram is drawn up which outlines the main relationships identified, as illustrated in Fig. 3. This approach is currently being tested on the BIGAMES© simulators, with promising results. Fig. 4 illustrates the simplification of Fig. 3 through omitting redundant causal relationships (for example, if V4 depends on

V3 which depends on V1, it is redundant to say that V4 depends on V1). This BSC is the basis tested in the pilot project and the results obtained point towards its validation in the context of the BIGAMES© simulator.

Figs. 5 and 6 illustrate the causality diagram obtained for the case the VA available to users of the BIGAMES© simulator. The magnitude of the correlation between variables will be marked in the small gray boxes.

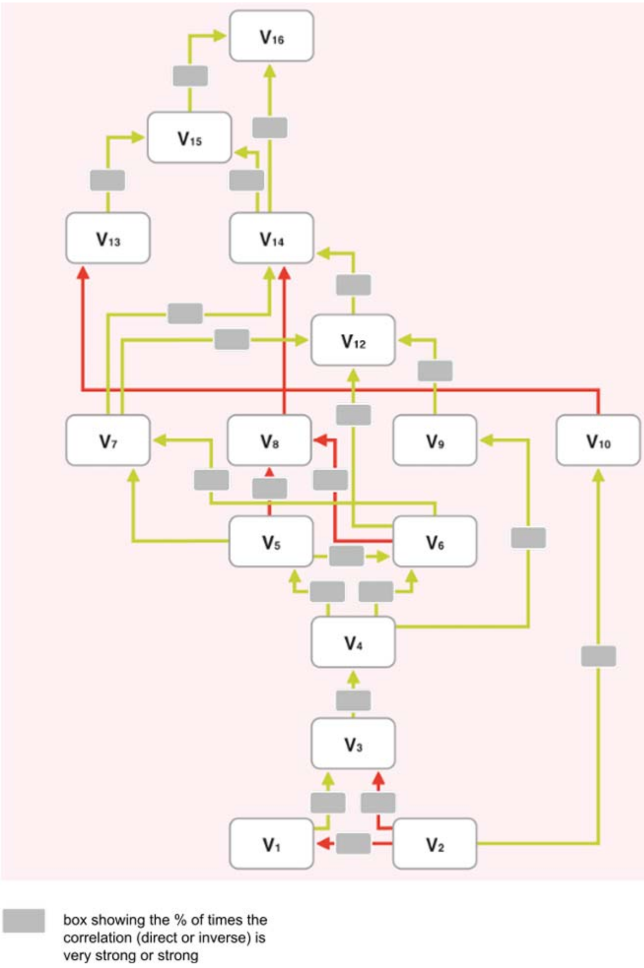

Fig. 5 Magnitude of correlations (schematic representation)

The correlations suggested in Fig. 5 were validated in previous case studies developed by the author [5]-[7] and applied to the BIGAMES© simulator. The number of times these correlations occur in successive editions of the simulator is determined statistically and this information is used by the VA to answer the teams' questions. Participants are encouraged to reflect on the VA's outputs, allowing them to explore different scenarios and solutions in a simulated virtual environment. This approach promotes critical thinking and problem-solving, essential skills in today's educational context [11]. The Mastering computer application will be consolidated so that the interaction between layers and VA is progressively more effective, and this is a future challenge for the BIG-AI project.

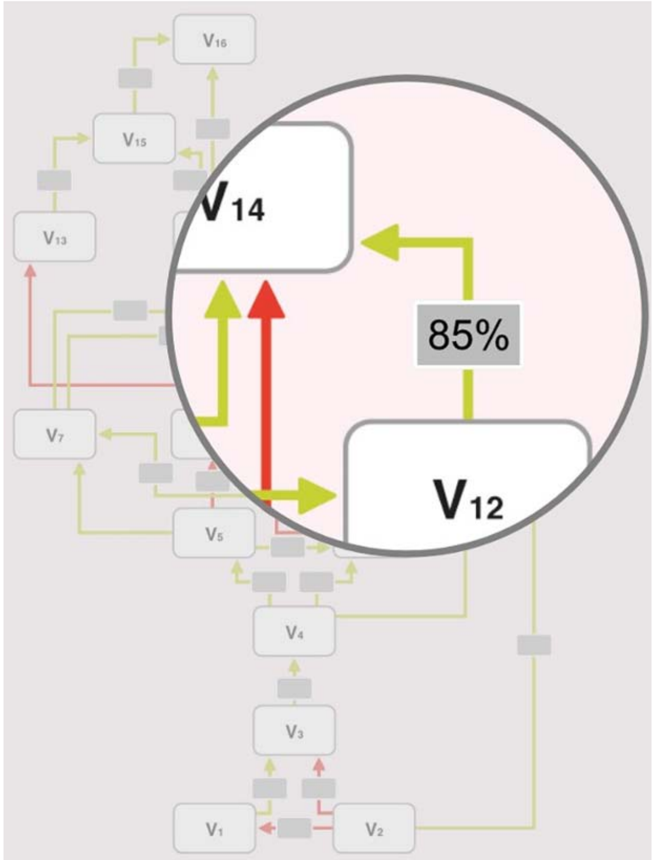

Fig. 6 Magnitude of correlations (correlation V12-V14: zoom)

VI. Conclusion

Findings from the introduction of AI methods in BIGAMES©, as part of the BIG-AI pilot project, reveal that there exists significant potential for improving decision-making processes in simulated management environments. Through the developed Virtual Assistant, fed by historical data and linear regression models, participants in the simulators can access recommendations and answers based on data from previous runs of similar processes, enabling more robust and targeted decision support. The AI based system, currently under development and subject to sequential testing phases, has already demonstrated the ability to optimize the simulation experience by providing quantitative insights that guide the teams' strategies, without detracting from the competitive nature of the games or indiscriminately favoring any of the teams. The team that best knows how to question the Virtual Assistant will also have more competitive advantages from this new component of BIGAMES©. The integration of AI with the BSC in BIGAMES© simulators showed to translate into an innovative way of monitoring team performance in real time. The use of correlated KPIs provides users of the simulator with a comprehensive view of the consequences of strategic decisions in multiple organizational dimensions. The personalization of the feedback provided by the VA, supported by ML, allows teams to adjust their actions based on reliable data, reducing uncertainty and increasing the effectiveness of decision-making. The preliminary test results of the BIG-AI project are promising, showing that the use of AI in management simulators can contribute to increasing personalization/customization within each context and the accuracy of recommendations to support data-centric decision-making. It is important to note that, despite these positive findings, the system is still in the experimental and fine-tuning phase. As such, it is still necessary to continue collecting and analyzing data on a regular basis to consolidate this new functionality. In summary, the combination of AI with BSC in BIGAMES© management simulators seem to provide a new dimension in participants' learning, creating a collaborative, safe and effective environment for the experimental implementation of business strategies. It is expected that the incorporation of AI into BIGAMES© management simulators will become increasingly effective, contributing to the training of leaders and executives in complex organizational contexts.

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Biga, **Nuno** holds a first degree (five-year course) in Civil Engineering from the Instituto Superior Técnico (IST), Technical University of Lisbon (1990). He concluded with merit the 13th Business Management Program (PDE) of the AESE Business School and University of Navarra (1997). He holds a MSc degree in Civil Engineering with a specialisation in Construction Sciences from the Faculty of Sciences and Technology of the University of Coimbra (2001). He developed a PhD thesis on Construction Management at the same University and he was awarded the degree of Doctor in Civil Engineering, achieved with the highest grade – approved by unanimity, with distinction and honour ("Strategic Inducers for Value Creation in Organisations", 2008). He was on the Honour Committee of the International Forum for Construction Management (Lisbon, 2008).

He began his professional activity in September 1990, and since then has sought to develop multidisciplinary skills in technical and management areas. He has more than 25 years of experience on carrying out scientific research in areas related to engineering and management (e.g., construction planning and methods, cross-modal transport infrastructures, process optimisation and management, organisational models, and skills management). Since 2001 he has been teaching in engineering and management related areas, including project management, operations, technology and innovation, seeking to promote the connection between academia and various sectors of the economy. He was responsible for several curricular units in the areas of economics, management and civil engineering, at the University of Coimbra (2001-2016) and at the Polytechnic Institute of Leiria (2011-2014). The complementarity between the various activities carried out in the last 30 years enabled him to acquire and develop further multidisciplinary skills along with the integration of knowledge. He is Founding Partner and, since 2010, Executive Director of the company Bigadvantage Consulting. He has worked as a senior consultant for public and private entities in different sectors of activity, in industry and services. In this context, he has been responsible for more than 25 consultancy projects in the following areas: organizational models, applied research and innovation, technological solutions, training and skills development, enterprise management, technical inspections and management audits. He is also Senior Teaching Fellow of Operations, Technology and Innovation at the AESE Business School, an associated school of IESE.

As a Senior Researcher, Nuno Biga develops applied research in domains related to engineering and management, having developed optimization algorithms for different contexts and goals. He's author of several scientific

papers presented in national and international conferences, including publications in Scientific Journals and books' chapters. In 2015 he started a process of design and development of Business Serious Games for implementation in academic and business environment, simulating organizational models applicable in various economic activity sectors. The Business Interactive Games BI Games© simulation games have been honored since 2019 with award-winning scientific papers at international conferences and in 2024 received the "Innovation Solutions in Management Education" award by CorporateLiveWire (United Kingdon).

Several projects coordinated by him have been awarded prizes by independent bodies to entities to which he has provided specialized consultancy services. In 2020, 2022 and 2023 the company Bigadvantage Consulting, with his leadership, was ranked TOP 5% Best Portuguese SMEs (by Scoring) and was received a Business Award in 2022, 2023 and 2024 (by Dun & Bradstreet). Bigadvantage also won the "Multidisciplinary Consultant of the Year" award for 3 consecutive years (2022, 2023 and 2024) by CLW, attesting to the technical quality of the projects developed and the company's good reputation in the market where it operates. Nuno Biga's professional activity has been recognized by the media in prestigious Portuguese magazines and in 2024 he received the global "Business Management & Education Professional of the Year" award from CLW.