Game-Based Learning for Supply Chain Management:
Assessing the Complexity of Games

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ABSTRACT

Game-based learning has proven to be an effective teaching method in a variety of fields, including supply chain management (SCM). This paper discusses the use of simulation-based business games for training and education in SCM by evaluating the complexity of SCM games. The main contributions of this study are twofold. (1) Creation of a database of available games used for training and education in SCM. For the first time, 40 games were selected, and a comprehensive review of the complexity elements included in these games is presented. (2) Development of a game complexity index to classify, evaluate and order the selected games according to their complexity. The findings of this study will be useful to academics and practitioners interested in logistics and SCM professional training and education. It helps educational institutions how to choose the best game for specific SCM topics.

KEYWORDS

Business Games, Complexity, Game-Based Learning, Management Education, Simulation Games, Supply Chain Games, Supply Chain Management

INTRODUCTION

A supply chain (SC) is a complex system that includes multiple entities and activities involving the movement of goods and the addition of value from the raw material stage to the final delivery stage (Herzog & Katzlinger, 2011). Managing a modern SC is complex and challenging; SC managers must deal with multidimensional problems that have complex side effects and non-linear dependencies (Muller et al., 2015). Because of this complexity, it is difficult to predict the consequences of decisions made. Future SC managers must be trained to make decisions under uncertainty and to consider the impact of their decisions on the entire SC (Baalsrud Hauge et al., 2016).

Modern businesses realise that having a well-trained supply chain management (SCM) team is critical to success (Mandaza & Goriwondo, 2012). Traditionally, SCM training has been limited to cognitive methods of instruction such as textbooks, case studies, and traditional class lectures. Such methods may help students understand SCM's fundamental concepts, but they fail to highlight the bigger picture of the SC and the strategic decisions that must be made (Tobail et al., 2011). It is not enough to simply inform students about how something as vital as SCM works; they must also experience it. In this context, one potentially effective way of increasing the efficiency of SCM

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courses is to incorporate game-based learning (GBL) along with other teaching methods (Cvetić & Vasiljević, 2012; William et al., 2018).

Simulation games represent alternative educational and training methods that can simulate a real-world environment while maintaining a balance between theory and practice (Arora & Saxena Arora, 2015). This allows students to learn through experience, experiment with various decisions, and learn from the feedback (Baalsrud Hauge et al., 2016). Furthermore, simulation games convey not only hard skills, such as the understanding of how complex SC systems operate, but they also mediate soft skills such as collaboration and communication, which is especially important when attempting to implement new concepts such as information sharing and engaging in various coordination and alignment contracts with others.

Several logistics and SCM games can be used in teaching and learning processes. The advancements in computer technology have also contributed to the development of new SCM games as well as the enhancement of existing ones. As a result, the number of SCM games produced every year is growing along with the number of organisations adopting this kind of learning for their staff training programmes. The main question here might be: How to select the most suitable game for specific courses?

Educational institutions are faced with the problem of a lack of a database containing information on existing SCM games. Furthermore, most GBL in SCM focus on only one or a limited number of concepts and scenarios. For example, one of the most well-known games in SCM and part of many SCM curricula is the original Beer Game developed in the 1960s (Sterman, 1989). The game is designed as a pure retail distribution game and does not take product conversion, capacity, and process reliability into account, which limits its implementation (William et al., 2018). This necessitates understanding how complex the models of existing games are to select the best game for a specific course's requirements.

This study adds to the literature by providing a recent database containing 40 games used in logistics and SCM training and education. The review of SCM games allows for the identification of the main development trends of such a training and educational tool. Furthermore, the attributes of the chosen games are considered when assessing the game's complexity and closeness to reality. Games are categorised based on a developed index for each game's technical features and model realism, and finally, the games are compared and ordered based on a developed game complexity index (GCI).

The findings of this study are useful for academics and practitioners interested in the training and education of logistics and SCM professionals. It will help them select the most suitable games for specific courses to deliver appropriate courses in a professional way to future SC managers.

BACKGROUND

Several SCM games have been introduced and discussed in the literature, covering a wide range of SCM concepts and scenarios. When it comes to games for teaching and training, game realism and complexity have long been linked in the literature. The developments in computer technology have created ways to give games a high degree of realism, which represents higher complexity (Leemkuil et al., 2000). Considerable effort has been made in the literature to present some measures or indicators for the complexity of serious games (Deghedi, 2018). However, the issue of comparing the complexity of existing SCM games is limited and still requires further research and discussion.

Some studies have attempted to list and compare SCM games based on various complexity indicators; for example, Corsi et al. (2006) investigated the impact of playing games on developing SC managers' skills, with attention focused on the Global Supply Chain Game (GSCG) and how it differs from other business learning games. Specifically, they compared the GSCG to six other SCM games, including the Beer Game, Logistics Game (LOGA), Littlefield Technologies, the Trading

Agent Competition Supply Chain Management game (TAC/SCM), and the Harvard Global Supply Chain Management Simulation. Their comparison was based on the following game attributes: real-time/turn-based/simulation; global perspective; player interaction during play, web-based; number of players per team; the number of teams possible; echelon focus within the SC; events occurring in the game exogenous to the player's control; pre-planned or computer-randomized demand; static or dynamic pricing; and, finally, the products involved in the game.

Kuijpers (2009) evaluated 10 SCM games to gain inspiration for the design of a serious game to educate SC managers about SC risks. Kuijpers' database contained the following games: the Distributor Game, the Supply Chain Game, the Mango Chain Game, CODEPRO, the Siemens Briefcase Game Supply Chain Simulator, Shortfall, the Distribution Game, the Beer Game, the Risk and Control Game, and the Trust and Tracing Game. The following information was presented for each game: the game title, the institute that made the game, main reference, purpose, audience, computer use, products considered, actors involved, dilemma, risk factors included, competition, external events, miscellaneous, and whether the author had played the game.

Merkuryev et al. (2011) compared the key attributes of 10 SCM games, shedding light on how the ECLIPS game addresses these games' limitations. The reviewed games included the Beer Game, the Internet Supply Chain Challenge Business Scenario Simulation (ISCS), the Blood Supply Game, the Mortgage Service Game, the Supply Chain Game, the SBELP supply chain simulator, the RSS-POD Supply Chain Management Game, Trading Agent Competition (TAC/SCM), the Global Supply Chain Game-Distributor Game, and ECLIPS. To compare the games, the following key characteristics were used: turn-based or continuous-time, software-assisted, web-based, players per team, supply chain echelon focus, pre-planned or random demand, number of products, inventory control strategies (continuous, periodic, or not considered), and supply chain structure (fixed or flexible).

Cvetic´ and Vasiljevic´ (2012) were interested in determining the suitability of the game for the requirements of SCM and logistics specific courses. First, they created a database that contained 47 logistics and SCM games. The following information was provided for each game: the game title, author, topics covered, the type of game (manual, software, or online), the number of players, the duration, costs (free, institution costs, or student costs), the year of introduction, and a link to the game and additional data about it. In a subsequent step, 27 games were chosen for further examination based on the cost-of-use criteria. Then, using a developed game suitability indicator (i.e., a combined weighting of the functionality, simplicity, duration, and ease of setup), they chose eight games to reconsider their suitability based on the specific needs of specific courses.

Alonso et al. (2018) conducted a systematic review of existing serious games for SCM and sustainable supply chain management (SSCM). Specifically, 33 SCM games were analysed and classified. The following information was provided for each game: its name, type (board game, computer game), content, session length, number of players, whether it requires a facilitator or not, computer use, and whether it is competitive or non-competitive. SCM Games were classified based on the game's content and emphasis on one or more of the following dimensions: environmental, economic, social, and risk management.

William et al. (2018) proposed ThinkLog, a board game, as a face-to-face extendable framework to facilitate learning in SCM. They compared their proposed game to four other SCM games, including the Beer Game, the Blood Supply Chain Game, the Mortgage Service Game, and the Distributor Game. Their comparison was based on the following game information: type, platform, technical features, subject or content area, scenario, and learning objective.

This paper adds to the literature by presenting a recently constructed database containing 40 games used in logistics and SCM education and training. The database contains six columns of general data about each game and 13 columns of key attributes used for classifying and assessing the complexity of each game.

METHODOLOGY

To assess the complexity of the SCM games, a three-step research methodology was used. First, a selection criterion for the SCM games to be included in the database was identified. Second, the criterion for comparing and assessing the complexity of the selected games was identified, and a database containing general data and key attributes for each game was created. Third, the data for the key game attributes were used to assess the complexity of each game. Three indexes were developed: the technical features index, the model realism index, and GCI. Games were classified and ranked based on the scores of the three indexes.

The Selection Process of SCM Games

Among the numerous SCM games, 40 games were chosen for evaluation based on the following criteria:

1. The game should be a 'supply chain' type of game. This means that, in order to play the game, products must be bought and sold through a trade network.
2. The data sources must be available.
3. The game has been tested and played either in schools, universities, or private institutions.

Elements Used to Assess the Complexity of the SCM Games

In the first step, general information about the 40 SCM games chosen for inclusion in the database was gathered. This included each game's title, institute, reference, URL, main configuration, and focus area. The games were then compared using the 13 classification variables listed in Table 1 (see Appendix).

Based on the availability of data for the 40 games, the author used a combination of classification variables discussed by Merkuryev et al. (2011) and Corsi et al. (2006), as well as two new variables (capacity and quality), to improve the supply chain game model and provide players with a credible game context. Each classification variable is briefly described below, along with how it contributes to the overall complexity of the game.

Platform

Thierry et al. (2008) classified games into two types based on the complexity of their model: board games and sophisticated (or digital) games. Board games, also known as 'paper games', have a simple enough model to be played with tokens or pieces placed on or moved across a 'board'. While lacking in realism, these games are centred on round-based decision-making through the comparison of simple business processes and typically involve a small number of players (Barjis et al., 2012).

Digital (or computer) games are those that are played online or offline with the help of a computer or another electronic device (IGI Global, 2021).They have a more realistic model, so they can handle increased business-process complexity, and more players can play the game at the same time.

Web Technology

Web-based or online games are those that are played over a computer network, most commonly the Internet. They differ from computer games in that they are typically platform-independent. Online games can range from simple text-based games to games with complex graphics and virtual worlds populated by multiple players who can play simultaneously around the world. Online games that simulate a real-world 24/7 environment, allow for continuous decision-making and provide a high level of realism (Barjis et al., 2012).

Proceeding Time in Simulation

Based on the proceeding time in simulation, games can be classified to turn-based games or continuous or real-time games. Turn-based games allow players to 'pause' the game's world in some way so that they can make decisions at their own pace; they then receive a set of metrics detailing their performance and the consequences of their decisions at a later point in time. Participants can adjust their strategy/decisions for the second round of play based on this information and feedback. In continuous or real-time games, the game moves slowly enough over the course of a week or two that participants can log in to a website, check the status of their team, and make necessary adjustments. The game is stopped by the instructor after the allotted time has expired, and the teams are ranked (Corsi et al., 2006).

Number of Players

Games can also be classified as single-player or multiplayer. Single-player games are stand-alone games in which the player acts alone, and the game's decisions and outcomes have no implications on other players. Multi-player games typically involve two or more players playing simultaneously. Players may act together, and the decisions or actions of one player usually have an impact on the other players so they are more complex (de Souza & Lindawati, 2017).

Interaction Between Players (Information Sharing)

Asymmetric information is inherent in SCs because different players in a SC have different states of private information that others do not have to make good decisions (Simatupang & Sridharan, 2001). In the real world of SCM, chain members are usually reluctant to share their private information with other chain members because of the economic value of that information. Games that allow participants to share information allow them to investigate the impact of sharing information on the entire SC.

Number of Products

SC games may differ depending on whether the SC model describes the journey to the market for a single or multiple products. However, being multi-product complicates the SCM process. In this paper, one product that has different types or quality variations is treated as multiple products.

Market

SCs that include international partners or markets are referred to as global SCs. They source and supply goods and services across multiple continents and countries. They involve the global flow of information, processes, and resources. As a result, they are more complex than local SCs, where the entire SC is located within the country in which an organisation is based. This often provides a clearer visibility of the entire SC-from the raw material to the consumer (CIPS, 2021).

Supply Chain Structure

In a fixed-SC structure game, the number of tiers in the SC network, as well as the type of facility to be installed in each one (e.g., factories, warehouses, and distribution centres), are primarily predetermined (Montagna & Cafaro, 2018). Such games mainly perform 'optimization' by starting with a single SC design and optimising specific variables to achieve the best possible performance from that design. A flexible SC structure game, on the other hand, primarily performs a 'simulation,' which demonstrates how different SC designs work in terms of costs and performance levels, this results in more efficient results (Mhugos, 2018).

Risk

Peck (2006) defined SC risk as anything that disrupts the flow of information, material, or product from the original suppliers to the delivery of the finished product to the ultimate customer.

A disruption event affecting an entity in the SC is shared and transferred along the chain as SCs become more complex. As a result, SC managers are faced with the increasingly challenging task of managing their SCs. Using games to train employees is a promising 'bottom-up' risk management strategy that organisations can use to create 'risk awareness' and a 'risk culture' among their employees, causing them to react proactively rather than reactively to risk (Kuijpers, 2009).

Demand

If customer demand is deterministic, all produced/supplied products are sold, and there is no risk. On the other hand, stochastic demand is often associated with the risk of overestimation or underestimation, and this uncertainty adds to the game model's complexity.

Pricing

Pricing policies can be classified into two categories: fixed pricing policies and dynamic pricing policies. Fixed pricing, also known as static pricing, is a pricing strategy in which a retailer establishes a fixed price point for a product and maintains it for an extended period of time. Dynamic pricing, also known as demand-based pricing, is a pricing strategy in which prices are adjusted at regular time intervals in response to real-time supply and demand data (Feldmann, 2008). In achieving revenue and profitability targets, dynamic pricing provides significantly more flexibility than fixed pricing (Matt Ellsworth, 2020), especially when the capacity is tightly constrained and the capacity and demand are variable (Simchi-Levi, 2000).

Capacity

One important feature of SC networks is the limited capacity of manufacturing plants and distribution centres (Cannella et al., 2018). Many companies have faced capacity constraints due to material shortages as well as a lack of staff, cash, and the capacity to meet renewed demand, particularly following the COVID-19 pandemic.

Despite the significant impact of capacity constraints on SC performance (Shukla & Naim, 2017), many studies in the SC field assume unconstrained production, distribution, and storage capacities. Simulation games allow researchers to investigate the implications of capacity limits on the SC response to model a real-world system.

Quality

Quality management is the supervision of the manufacturing and distribution of products, starting with the order for raw materials and continuing through the after-sales service phase, to ensure that the product conforms to what the customer intended. This difficult task necessitates the collaboration of SC members to create a quality chain (Mahdiraji et al., 2012; Kim et al., 2016). Games can be an effective tool in this context for raising SC managers' awareness of quality issues, how they spread across the chain network, how they affect overall SC costs, and how collaboration among chain members improves the overall quality levels provided by the SC.

The Game Complexity Index (GCI)

Data on the classification variables listed in Table 1 (see Appendix) were gathered for the 40 games chosen to represent complexity indicators, and the complexity indicators were then classified into two groups. The first group reflects the technical features of the game (i.e., the game dynamics or the way that players interact with the game), including the platform used as well as whether the game is digital or not, web-based or not, is played in real-time or is turn-based, allows for multiple players or a single player, and allows for interaction and sharing information between players or not. The technical feature of a game is evaluated using scores of 0 or 1 as shown in Table 1 (see Appendix). The maximum value of the technical features index is 5. A game receives a score of 5 if it is suitable for distribution (a computer game), allows web-enabled use, allows for real-time advance, allows multiple players to represent different roles in the SC, and allows for collaboration and information-sharing among participants.

The second group of complexity indicators is SC content-related and reflects the game's model realism (i.e., variables included in the game model that increase its usefulness and make the game closer to reality). This includes the number of products in the game (single or multiple), the scope of the SC market (global or local), the structure of the SC (flexible or fixed), the inclusion of some stochastic variables such as risk and demand, dynamic pricing, and whether the game considers or ignores capacity constraints and quality issues. The inclusion of these elements in the game model aids in providing players with a credible game context. As a result, the model realism index reflects the level of complexity of a game model, with a maximum value of 8 if the game includes multiple products, has a flexible SC structure, includes risk factors, deals with demand as a stochastic variable, takes into account dynamic pricing, capacity constraints, and finally takes into account quality issues.

The GCI is the sum of the technical features and model realism indexes for each game, with a maximum value of 13. In this paper, the GCI index was used to rank the games from most complex to least complex.

RESULTS

Table 2 displays general information about the 40 SCM games (see Appendix). Each game's title, institute, reference, URL, main configuration, and focus area are listed in the table.

Table 3 compares the key attributes of the described games (see Appendix). The table displays the data for the complexity indicators used in each game as well as the corresponding GCI. Figure 1 depicts a breakdown of the complexity indicators for the selected games.

Figure 2 shows how the 40 SCM games were classified based on their calculated technical features and model realism indexes. Games with technical features index scores less than 3 were considered as having low technical features, and games with model realism index scores less than 4 were considered as having low realism. Figure 2 shows that eight games were classified as "low technical features /low model realism", 12 games were classified as "low technical features /high

Figure 1. Break down of complexity indicators for SCM games

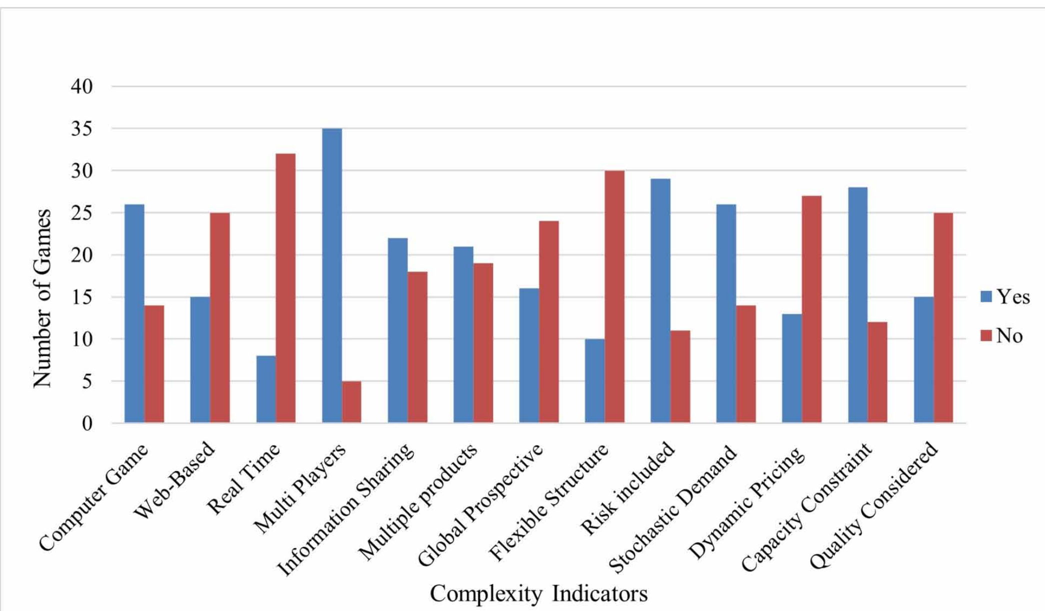


Figure 2. SCM games technical features-model realism matrix

Technical features \ Model realism	Low	High
High	Beer Game Littlefield Technologies Mortgage Service Game SC-Mark Shark Tank Game SUMAGA ISLAND (Supply Chain Management Game) The Quebec Wood Supply Game (QWSG) The RSS-POD Supply Chain Management Game The X-Supply Game (XSG)	Beware Distributor Game Internet Based SC Simulation Game (ISCS) SCM GLOBE Shortfall The Chain Game The Cool Connection The ECLIPS Game The Fresh Connection The Lean Leap Logistics Game The Supply Chain Game Trading Agent Competition Supply Chain Management Game (TAC/SCM)
Low	Business on the Move Emergent Logistics Game (LoGA) SBELP "Supply Chain Simulator" The Coffee Chain Game The Poker Chip Game The Quality Intelligence (QI) Game Think Log	CODEPro Disaster Relief Game Harvard Global SCM Simulation Mango Chain Game Siemens Brief Case Game (BCG) Supply Chain Simulator Supply Chain Risk Management Game The Blood Supply Game The Cell Phone Game The SCOR Model Supply Chain Game The Service Supply Chain Game (SSCG) The TimeWise Simulation Game Trust & Tracing Game (T&T Game)

model realism", eight games were classified as "high technical features /low model realism", and 12 games were classified as "high technical features /high model realism".

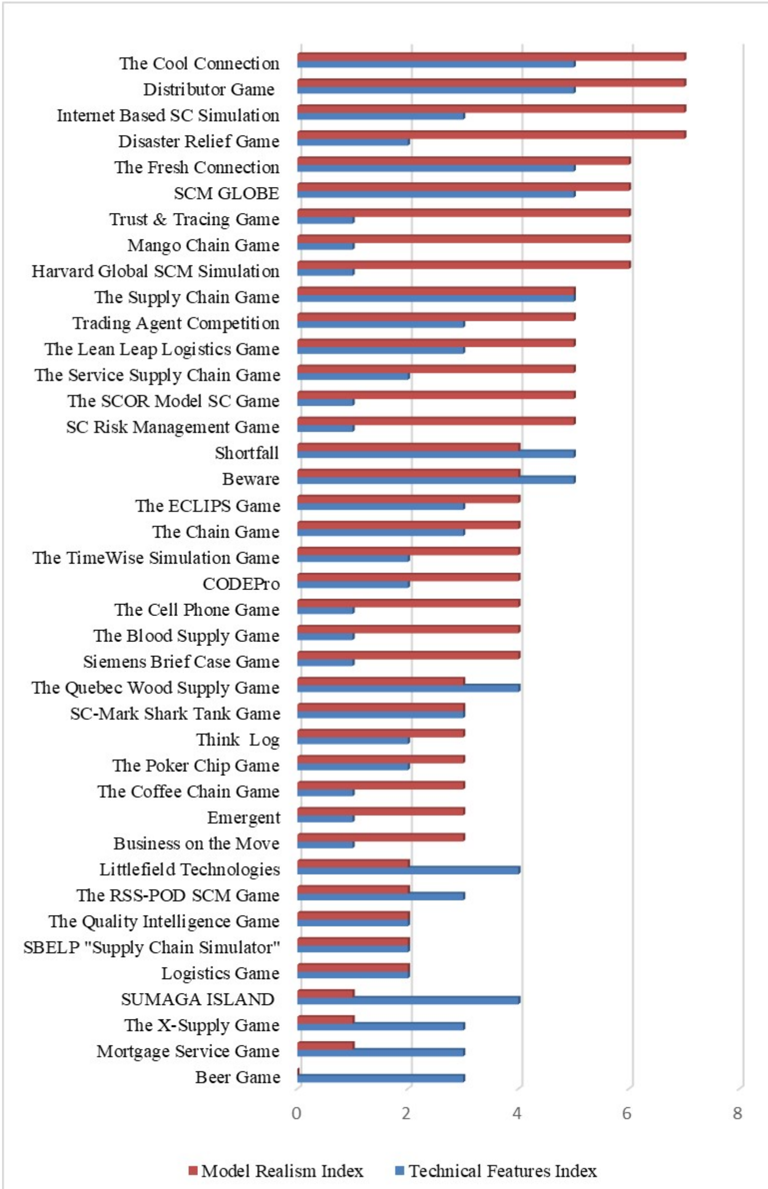
The technical features and model realism indexes of the 40 games are depicted in Figure 3. Games are ranked from high to low in terms of model realism index scores, and Figure 4 shows the games ranked from high to low in terms of total GCI scores. The most complex SCM games among the 40 considered are The Distributor Game and The Cool Connection.

DISCUSSION

In this paper, 40 games from the fields of SCM and logistics were chosen to demonstrate their properties and assess their complexity. Only nine games focused on logistics, including Business on the move, Disaster Relief Game, Logistics Game, Siemens Brief Case Game SC, SUMAGA ISLAND, The Quebec Wood Supply Game, The Service Supply Chain Game, The Supply Chain Game, and Think Log. A few games covered a broader range of topics; for example, two games, Shortfall and the X-Supply Game, are concerned with studying sustainable supply chain management (SSCM), and Business on the Move combines logistics and SSCM.

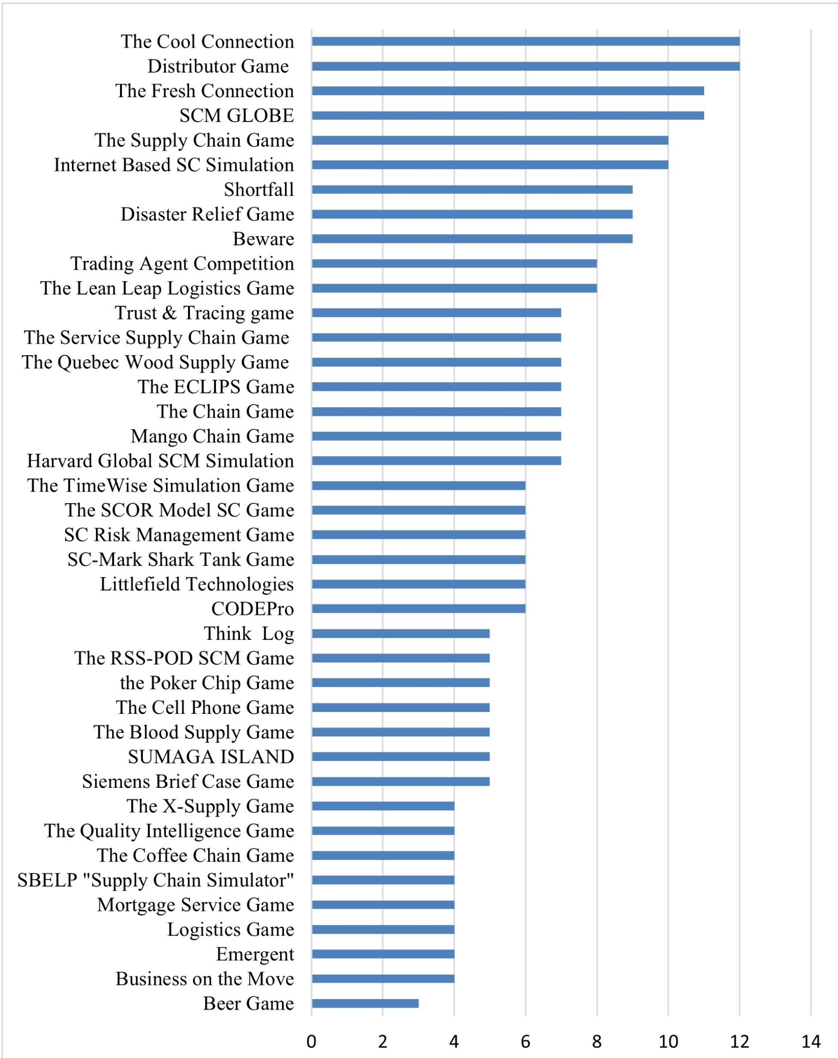
The selected games emphasised the bullwhip effect, information sharing, collaboration, operations management, risk management, quality management, inventory management, global SC trading, trust, fairness in SC, SCM strategies, service SC, and SC finance. Some games focused on a single dimension, whereas others focused on multiple dimensions.

Figure 3. The model realism and technical features indexes of the selected SCM games



From the 40 SCM games displayed, 26 (65%) are computer games, while the remaining 14 (35%) are board games. Only 15 (58%) of the 26 computer games are web-based, accounting for 37.5% of the total games. Moreover, only 8 (53%) of the 15 computer and web-based games are real-time games, accounting for 20% of the total games. Most games (35; 87.5%) are multiplayer games, with only the Mortgage Service Game and the RSS-POD Supply Chain Management Game available as single or multiplayer games. Additionally, 21 games (52.5%) consider multiple products, while 19 games (47.5%) only consider one product. Most games (24; 60%) are global SC games, and the majority of games (30; 75%) have a fixed SC structure. Risk factors are included in 29 games

Figure 4. SCM games ordered according to the total game complexity index



(72.5%), demand is a stochastic variable in 26 games (65%), while it is pre-determined in 13 games (32.5%). There was insufficient information to determine whether Beware game uses a stochastic or pre-determined demand pattern. Prices are dynamic in only 13 games (32%) and static in 20 games (50%), with insufficient information to determine whether seven of the games use dynamic or static prices. Moreover, there are 22 games (55%) that allow information-sharing among players, 16 games (40%) that do not allow information-sharing, and only two games (e.g., Business on the Move and the Cell Phone Game) that do not specify whether they allow for information-sharing or not. Additionally, 28 games (70%) consider capacity constraints, while 8 games (20%) assume an unlimited capacity. There was insufficient information to determine whether four of the games take capacity constraints into account. Quality issues are considered in only 15 (37.5%) games.

Considering the scores of the technical features and model realism indexes of the 40 games, it has been noticed that some are very rich in model content despite being simple board games, such as the Trust and Tracing Game and Mango Chain Game, or single-player computer games, such as the Disaster Relief Game and the Harvard Global Supply Chain Management Simulation. The low technical features index of such games affected their ranking in terms of total GCI when compared to other games. Some games, on the other hand, had a high technical features index but a low model realism index, such as SUMAGA ISLAND, the X-Supply Game, and the Mortgage Service Game. Some games, such as the Beer Game and the Quebec Wood Supply Game, had a high technical features index because they have computer or online versions that were evaluated.

According to their GCI, the Distributor Game and the Cool Connection Game were discovered to be the most complex SCM games.

The Distributor Game is a subset of the Global Supply Chain Game (Corsi, et al, 2006). It is concerned with the distribution process in a global real-time SC. The game's goal is to demonstrate the trade-offs between global and local sourcing in a complex market with products that quickly lose their value (i.e., computers and computer components). Players must deal with market fluctuations and competitive industry pricing dynamics, so each team of players must develop a strategy for what to buy, when to buy, and where to buy. The architecture of the game allows it to provide games for a wide range of problem contexts and scenarios in a distributed, web-enabled setting (van Houten et al., 2005).

The Cool Connection is a web-based business simulation that connects the financial and physical SC. Service levels, delivery methods, production intervals, and warehousing are typical SC topics linked to financial topics, such as payment instruments, financing, and cash management. The game challenges players to make strategic decisions in the management of a personal care product manufacturing company. As teams work together to turn the company around, they will face a variety of real-life, real-time dilemmas. The game's complexity increases as the rounds progress; additionally, the game can be tailored to its participants' objectives, ensuring that they have enough (simulated) reality.

The GCI revealed that the Bear Game had the lowest level of complexity. The reason for this is that, when calculating the model realism index, only the basic assumptions of the original Beer Game developed by Sterman (1989) were considered. Many authors have improved the game, adding to its complexity by relaxing some of its basic assumptions; as a result, it was a challenge to be confronted with many different versions of the game and thus different complexity indicators, which, if taken into account in the calculated model realism index, could change the results. However, the Beer Game, in its most basic form, is still widely used for SCM training and education due to its simplicity.

The following are the steps for selecting the best games for SCM courses:

1. Determine the intended student and program. More complex games are better suited to master's programs or specialized training, whereas simpler games are better suited to bachelor's programs. The findings of this study will be extremely useful because they classify and order the games based on their complexity, allowing the user to narrow the list of games based on the desired level of complexity.
2. Determine the learning objectives for the course involved and decide whether a SC game would help to meet the objectives. The database created for this study may help academics and practitioners in that regard by identifying the main configuration and focus area of 40 SC games covering a broader range of topics. For example, if the goal is to introduce students to the bullwhip effect and how information sharing can help solve this problem, a variety of the suggested games may be useful. Given the varying levels of complexity, a simple game such as the beer game may be appropriate for undergraduate students, whereas more complex games such as The ECLIPS Game and The Quebec Wood Supply Game may be appropriate for master students and more sophisticated programs.
3. Once the target students have been identified and the objectives have been established, it is time to identify the game characteristics. This study presents 13 attributes of the selected games, including technical features and model realism; any desired combination can be selected.

4. Once you've decided what you're looking for, you can begin looking for games that meet your criteria. The review in this study provides descriptive information for 40 SC, including the publisher of each game, as well as important links and references where you can find more information about how to obtain the game. Some factors, such as price, may influence the selection decision. Furthermore, the games' logistics and usability should take into account classroom realities as well as time constraints in schools.
5. Finally, the chosen game must be integrated into the educational context so that learning becomes enjoyable while playing the game.

CONCLUSION

As the complexities of global business have increased, the valuable competencies of logistics and SC professionals have become increasingly important. Educational institutions are faced with the challenge of providing SC managers with the appropriate courses in a professional manner. Game-based learning is a promising tool for studying SCM complexity, especially with the recent increase in computing power, the development of the Internet, and the increase in interactivity, which all have enabled game developers to create more complex game exercises, with games thus getting closer to simulating the complexity of SCM.

This paper presents a database that academics and practitioners interested in the game-based enhancement of teaching logistics and SCM may find useful. The review of SCM games allows for the identification of the main development trends of such a training and educational tool. Instead of focusing on a single phenomenon or representing some aspects of reality while ignoring others, modern simulation games tend to cover a broad range of SCM topics. The decision of which features to include versus exclude will determine the game's complexity and closure to reality.

Because the market for SCM games is sufficiently large and rich, instructors may need to identify a suitable set of games by determining which SCM topic needs to be 'trained.' This paper's review of 40 SCM games assists with this by providing instructors with the important aspects of each game as well as an approximation of their complexity level, allowing them to select the appropriate game for their intended course.

COMPETING INTERESTS

The author of this article declares there are no competing interest.

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APPENDIX

Table 1. Criterion for comparing SCM games

	Classification variable	Attributes	Index
Technical features	Platform	Board	0
		Computer	1
	Web technology	Not available	0
		Available	1
	Proceeding time in simulation	Turn-based	0
		Real-time	1
	Number of players	Single	0
		Multiple	1
	Interaction between players (Information sharing)	Absent	0
		Present	1
Model Realism	Number of products	Single product	0
		Multiple products	1
	Market	Local	0
		Global	1
	Supply chain structure	Fixed	0
		Flexible	1
	Risk factors	Not included	0
		Included	1
	Demand	Deterministic	0
		Stochastic	1
	Pricing	Static	0
		Dynamic	1
	Capacity	Unlimited	0
		Limited	1
	Quality	Not considered	0
		Considered	1

Table 2. General data for the selected SCM games

No.	Game name	Institute	Reference	URL	Main Config.	Focus Area
1	Beer game	Massachusetts Institute of Technology (MIT)	(Sterman, 1989)	1	SCM	Bullwhip effect
2	Beware	BIBA	(Hauge et al., 2008)		SCM	Quality & risk management
3	Business on the move	The Very Enterprising Community Interest Company		2	SSCM+ Logistics	Global SCM- logistics-sustainability
4	CODEPro	University of applied sciences, Finland	(Korhonen et al., 2007)		SCM	Cooperation-information transparency
5	Disaster Relief Game	The Logistics Institute Asia Pacific	(de Souza et al., 2018)		SCM+ Logistics	Humanitarian logistics
6	Distributor Game	Delft University	(Corsi, et al, 2006)	3	SCM	Global SCM
7	Emergent	Stoken Games		4	SCM	SC network strategy
8	Harvard Global SCM Simulation	Harvard Business School		5	SCM	Operations Management
9	Internet Based SC Simulation Game		(Zhou et al., 2008)		SCM	SCM strategies
10	Littlefield Technologies	Responsive Learning Technologies		6	SCM	Operations & inventory management
11	Logistics Game	Michigan State University	(Bowersox et al., 1986)		SCM+ Logistics	SCM-logistics
12	Mango Chain Game	Wageningen University	(Zúñiga-Arias et al., 2007)		SCM	Fairness in SC - risk management
13	Mortgage Service Game		(Anderson & Morrice, 2009)		SCM	Bullwhip effect-service SC.
14	SBELP "supply chain simulator"	King Fahd University of Petroleum and Minerals	(Siddiqui et al., 2008)		SCM	Bullwhip effect
15	SCM GLOBE	SCM Globe	(Mhugos, 2018)	7	SCM	SCM
16	SC-Mark Shark Tank Game		(Arora & Saxena Arora, 2015)		SCM	Bullwhip effect-Marketing -Service SC
17	Shortfall	Northeastern University-National Science Foundation	(Corriere, 2003)		SSCM	SSCM
18	Siemens Brief Case Game SC	Siemens (private company)	(Mehring, 2000)		SCM+ Logistics	SCM-Logestics
19	SUMAGA ISLAND	BIBA		8	SCM+ Logistics	Bullwhip effect
20	Supply Chain Risk Management Game		(Kuijpers, 2009)		SCM	SC risk management
21	The Blood Supply Game		(Mustafee & Katsaliaki, 2010)		SCM	perishable goods Supply & demand
22	The Cell Phone Game	APICS		9	SCM	SCM
23	The Chain Game	TNO with other international partners	(Muller et al., 2015)		SCM	SC visibility-collaboration-global trade transactions.
24	The Coffee Chain Game	Oxfam	(Dalton et al., 2005)	10	SCM	Fairness in SC
25	The Cool Connection	Inchainge B.V., SCF Academy		11	SCM	SC Finance

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Table 2. Continued

No.	Game name	Institute	Reference	URL	Main Config.	Focus Area
26	The ECLIPS Game	ECLIPS project-European Commission	(Merkuryev et al., 2011)		SCM	Bullwhip effect
27	The Fresh Connection	NITL, SCALA Consulting.		12	SCM	SCM
28	The Lean Leap Logistics Game		(Holweg & Bicheno, 2002)		SCM	Collaboration-bullwhip effect
29	The Poker Chip Game		(Cox & Walker, 2006)		SCM	Inventory/risk management- bullwhip effect
30	The Quality Intelligence Game		(Stiller et al., 2014)		SCM	Quality management
31	The Quebec Wood Supply Game	FORAC	(Horne & Marier, 2004)	13	SCM+ Logistics	Bullwhip effect-logistics
32	The RSS-POD SCM Game		(Chan et al., 2009)		SCM	Inventory management-information sharing
33	The SCOR Model Supply Chain Game		(Webb et al., 2014)		SCM	SCOR model-operational management
34	The Service Supply Chain Game	Gordian Logistic Experts, Invocate, Florie Logistiek Advies,		14	SCM+ Logistics	Service SC-collaboration-bullwhip effect
35	The Supply Chain Game	Responsive Learning Technologies	(Kanet & Stößlein, 2007)	15	SCM+ Logistics	Inventory management-logistics
36	the TimeWise simulation game	MEP-MSI	(Mishra et al., 2003)		SCM	lean SCM
37	The X-Supply Game		(Salman & Alaswad, 2018)	16	SSCM	SSCM
38	Think Log		(Lindawati et al., 2017)		SCM+ Logistics	bullwhip effect-risk management, humanitarian logistics
39	Trading Agent Competition SCM Game (TAC/SCM)	Carnegie Mellon University & the Swedish Institute of Computer Science	(Sadeh et al., 2003)		SCM	SC trading-risk management
40	Trust & Tracing game (T&T game)	Wageningen University	(Meijer & Hofstede, 2003)		SCM	Trust

1 http://web.mit.edu/jsterman/www/SDG/beergame.html [accessed September 15, 2022]
2 www.businessonthemove.org [accessed September 15, 2022]
3 www.gscg.org [accessed September 15, 2022]
4 https://boardgamestrategy.blog/2018/02/12/emergent-a-supply-chain-strategy-game-rulebook/ [accessed September 15, 2022]
5 https://hbsp.harvard.edu/product/8623-HTM-ENG [accessed September 15, 2022]
6 http://responsive.net/littlefield.html [accessed September 15, 2022]
7 https://www.scmglobe.com [accessed September 15, 2022]
8 https://www.biba-gaminglab.com/en/our-games/sumagaisland/ [accessed September 15, 2022]
9 www.apics.org/supplychainstem[accessed September 15, 2022]
10 https://resources4rethinking.ca/en/resource/the-coffee-chain-game [accessed September 15, 2022]
11 www.thecoolconnection.org. [accessed September 15, 2022]
12 https://www.thefreshconnection.biz/ [accessed September 15, 2022]
13 https://www.forac.ulaval.ca/en/transfer/wood_supply_game/description/ [accessed September 15, 2022]
14 https://sscgame.nl/ [accessed September 15, 2022]
15 https://responsive.net/supply.html [accessed September 15, 2022]
16 https://istm.zu.ac.ae/xsg [accessed September 15, 2022]

Table 3. Complexity indicators and GCI for the selected SCM games

		Game attributes													
		Technical features					Model realism								
No.	Game name	Computer game	Web-based	Real Time	Multi players	Information sharing	Multiple products	Global prospective	Flexible structure	Risk included	Stochastic demand	Dynamic Pricing	Capacity limited	Quality considered	Game complexity Index (GCI)
1	Beer game	1	1	0	1	0	0	0	0	0	0	0	0	0	3
2	Beware	1	1	1	1	1	0	1	0	1	_	_	1	1	9
3	Business on the move	0	0	0	1	_	1	1	0	1	0	0	_	0	4
4	CODEPro	0	0	0	1	1	1	0	0	1	0	_	1	1	6
5	Disaster Relief Game	1	0	0	0	1	1	1	1	1	1	1	1	0	9
6	Distributor Game	1	1	1	1	1	1	1	1	1	1	1	_	1	12
7	Emergent	0	0	0	1	0	0	1	1	0	0	0	1	0	4
8	Harvard Global SCM Simulation	1	0	0	0	0	1	1	0	1	1	1	1	0	7
9	Internet Based SC Simulation	1	1	0	1	0	1	1	0	1	1	1	1	1	10
10	Littlefield Technologies	1	1	1	1	0	0	0	0	0	1	0	1	0	6
11	Logistics Game	1	0	0	1	0	0	0	0	0	1	0	1	0	4
12	Mango Chain Game	0	0	0	1	0	1	1	0	1	0	1	1	1	7
13	Mortgage Service Game	1	0	0	1	1	0	0	0	0	0	0	1	0	4
14	SBELP "supply chain simulator"	1	0	0	0	1	0	1	0	0	1	0	_	0	4
15	SCM GLOBE	1	1	1	1	1	1	1	1	1	1	0	1	0	11
16	SC-Mark Shark Tank Game	1	0	0	1	1	1	0	0	1	1	_	0	0	6
17	Shortfall	1	1	1	1	1	0	0	0	1	1	1	1	0	9
18	Siemens Brief Case Game	0	0	0	1	0	1	0	0	1	0	0	1	1	5
19	SUMAGA ISLAND	1	1	0	1	1	0	0	0	0	1	_	0	0	5
20	SC Risk Management Game	0	0	0	1	0	0	1	1	1	0	1	1	0	6
21	The Blood Supply Game	1	0	0	0	0	0	0	0	1	1	0	1	1	5
22	The Cell Phone Game	0	0	0	1	_	0	0	0	1	1	0	1	1	5
23	The Chain Game	1	0	0	1	1	0	1	0	1	1	_	1	0	7
24	The Coffee Chain Game	0	0	0	1	0	0	1	0	1	0	1	0	0	4
25	The Cool Connection	1	1	1	1	1	1	1	1	1	1	0	1	1	12
26	The ECLIPS Game	1	0	0	1	1	0	0	1	1	1	0	1	0	7
27	The Fresh Connection	1	1	1	1	1	1	1	0	1	0	1	1	1	11
28	The Lean Leap Logistics Game	1	0	0	1	1	1	0	0	1	1	0	1	1	8
29	The Poker Chip Game	0	0	0	1	1	1	0	0	1	1	0	0	0	5
30	The Quality Intelligence Game	1	1	0	0	0	0	0	0	1	0	0	0	1	4
31	The Quebec Wood Supply Game	1	1	0	1	1	1	0	0	0	1	0	1	0	7

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Table 3. Continued

		Game attributes													
		Technical features					Model realism								
No.	Game name	Computer game	Web-based	Real Time	Multi players	Information sharing	Multiple products	Global prospective	Flexible structure	Risk included	Stochastic demand	Dynamic Pricing	Capacity limited	Quality considered	Game complexity Index (GCI)
32	The RSS-POD SCM Game	1	0	0	1	1	0	0	0	0	1	_	1	0	5
33	The SCOR Model SC Game	0	0	0	1	0	1	0	0	1	1	1	0	1	6
34	The Service Supply Chain Game	0	0	0	1	1	1	0	0	1	1	1	1	0	7
35	The Supply Chain Game	1	1	1	1	1	0	1	1	1	1	0	1	0	10
36	the TimeWise simulation game	0	0	0	1	1	1	0	0	0	1	0	1	1	6
37	The X-Supply Game	1	1	0	1	0	0	0	1	0	0	0	0	0	4
38	Think Log	0	0	0	1	1	1	0	0	1	1	_	_	0	5
39	Trading Agent Competition SCM Game	1	1	0	1	0	1	0	0	1	1	1	1	0	8
40	Trust & Tracing game	0	0	0	1	0	1	0	1	1	0	1	1	1	7

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