This article is a part of a symposium titled: *Selected Proceedings from the 45th ISAGA Conference, July 2014, Dornbirn, Austria*

Simulation & Gaming
2016, Vol. 47(3) 324–345

DOI: 10.1177/1046878116633971
sag.sagepub.com
SAGE

Investigating the Winner's Curse Based on Decision Making in an Auction Environment

Christian K. Karl[1]

Abstract

Background. The majority of **bidding models,** such as those developed by Friedman and Gates focus on the **mark-up decision**. Despite a large body of literature, particularly related to the **construction** industry, these **bidding models** largely ignore human behavior.

Aim. This article has two aims. The first is to contribute to the potential use of **business games** to study the results of **auction behavior** in a **construction business environment.** The second is to investigate the **winner's curse** and its effects on individual companies and the **market**.

Method. The methodology for this study is rooted in **game theory**. The reasoning which leads to the **winner's curse** is explored through a behavioral multi-actor experiment. I developed a database-driven, online multiplayer auction game which served as a laboratory experiment. The study included 42 participants. Data were collected during the **game**, and **debriefing** results were analyzed.

Results. The results show that **contractors** suffer from the **winner's curse** for a variety of reasons including their own **bidding strategy**, **strong competition** within the **construction market,** and **inaccurate estimates** of **project costs**. These reasons affect the **behavior of contractors** and the intention to win the **project's bid** as well as their willingness to take risks.

[1]University of Duisburg-Essen, Germany

Corresponding Author:
Christian K. Karl, University of Duisburg-Essen, Faculty of Engineering, Department of Civil Engineering, Construction Technology & Construction Didactics, Universitätsstraße 15, Essen, 45141, Germany.
Email: christian.karl@uni-due.de

Conclusion and Recommendations. The approach outlined in this article contributes to decision-making research in the context of the 'reverse' auction low bid method. I recommend that future researchers consider second-price, sealed-bid auctions (Vickrey auctions); this type of auction is also easy to implement.

Keywords
auction, behavior, bidding strategy, business games, construction business, construction market, contractors, debriefing, decision, game theory, inaccurate estimates, mark-up decision, online game, project bid, project costs, strong competition, system dynamics, winner's curse

This article provides the findings of the online game, OPEN CHAMELEON (V1.4). In this game, the results of real interactive human behavior are used to investigate bidding decisions within an auction environment, especially regarding the construction industry. The approach introduced here provides a valuable contribution in the fields of decision making and teaching by clarifying causalities and interdependencies and making them comprehensible, e.g. the elucidation of the risk situation of a company, the identification and evaluation of market risks or to improve the understanding of decision making process in detail. The auction environment used in this study is based on a common bidding method for construction projects - the 'reverse' auction low-bid method. The majority of bidding models, such as those developed by Friedman (1956) and Gates (1967), only focus on the mark-up decision (Wanous, Boussabaine, & Lewis, 2000). Despite a large body of literature, particularly related to the construction industry, these bidding models largely ignore human behavior (Ahmad & Minkarah, 1988).

Literature Review

The following section reviews key terms including 'winner's curse', 'auction types' and 'auction types in the construction industry' as related to this article.

The Winner's Curse

The winner's curse, first introduced by Capen, Clapp, and Campbell (1971), is based on a scenario in which the bidder with the lowest bid wins an auction under the condition that the submitted bid is underneath the true costs, i.e. the project's construction costs. Often, these costs are not certain at the time the contractor bids. A bidder will most likely earn negative or below-expected profits. The fundamental basis for the investigation of this phenomenon are auction methods, which are a well-known and established market mechanism. They are at the center of research in the field of economics and of vast interest in the areas of marketing and consumer behavior (Kagel, 1995; Kagel & Levin, 1986; Wilson, 1992).

Auction Types

Auction types can be distinguished in terms of price and value. Related to price, auctions are typically classified into four major types:

a. Ascending price auction (English auction)
b. Descending price auction (Dutch auction)
c. First-price sealed-bid auction
d. Second-price sealed-bid auction (Vickrey auction).

These basic auction mechanisms are well grounded in theory (Kagel, Harstad, & Levin, 1987; McAfee & McMillan, 1987).

Auctions are classified into two main value types; private value auctions and common value auctions. In a private value auction, the bidders know their own value of the item being auctioned with certainty, but they do not know other bidders' values. In contrast, in a common value auction, the item being auctioned has the same value to everyone, but none of the bidders know this value with certainty. As a result, each bidder develops an independent strategy they use to estimate the true value, and the winner is the one with the most appropriate information to such true value (Kagel & Levin, 2002).

Auctions in the Construction Industry

With respect to the construction industry, contractors have three sources of information for estimating their bids: a) realized project construction data from past projects, b) actual project construction data from ongoing projects, and c) data from their competitors' estimates of project construction costs. Construction projects are usually unique; these three sources of information provide only guide values, therefore, the information used is incomplete. Due to the unknown true cost of construction projects, which cannot be estimated with certainty until completion of the project, construction bidding should be considered as a common value auction (Dyer & Kagel, 1996).

One key difference between most auctions, in which the highest bid wins (highest bid method), and construction project bidding is that construction project bidding is performed as a 'reverse' auction (low bid method). Referring to Ioannou and Awwad (2010) this is the most common bid method for construction contracts in the U. S., but also in Germany, and in many other countries in the world. Therefore, the bidder with the lowest bid is the winner. This competitive bidding environment is the reason that construction companies suffer from underestimated project costs; the true cost of construction is usually not known until the completion of the project. Nevertheless, every bidder must estimate the prospective costs and has to take into account a variety of constraints, dependencies, and internal and external risks before setting a bid. With the low bid method, the bid based on underestimated project costs will be selected to undertake the project. Hence, the winning contractor will most likely earn negative or below-expected profits (the winner's curse).

Given the aforementioned relationships, I developed a dedicated research methodology which is described in the following section.

Research Methodology

In the engineering and construction industry, conflict and strategic interactions between project owners and contractors are very common (Levitt, Wang, Ho, & Javernick-Will, 2011). Based on this, the investigated environment includes a variety of different parties acting against each other. Hence, this study employed game theory, which can be defined as "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson, 1991). This theory is common in fields like economics and business, political science, computer science, and philosophy. In this research, it is used as a multiplayer decision theory where the choices of each player affect the payoffs to other players, and the players take this into account in their choice behavior (Sejwal, 2014).

Simulation and gaming allows us to conduct experiments with sociotechnical systems and is already used to investigate e.g. bargaining power or as a research tool for testing social theories (Noy, Raban, & Ravid, 2006; Van den Hoogen, Lo, & Meijer, 2014; Zúñiga-Arias, Meijer, Ruben, & Hofstede, 2007). A multi-actor behavior experiment with 42 participants was designed to stimulate the required behavior. All of the participants were students in a Master's course in construction management.

Although gaming simulation is widely used as a training instrument, its application as a data-gathering tool is relatively new. Meijer and his colleagues proved that it has been possible to test hypotheses using data gathered in gaming sessions (Meijer, 2011).

A database driven online multiplayer auction game was developed for two reasons: a) computerized simulations are widely used today in academic courses and in professional training, and b) a database driven solution enables researchers to collect decision related data continuously (Noy, 2014). Additionally, the debriefing was an important source for gaining insights into the decision making processes during the game.

The online auction game lasted nine quarters. It was played with 14 companies (three participants in each company). To counter a potentially negative influence on the auction game results, at the beginning of the seminar the participants were told that the game would last at least 12 quarters. The participants were told that the game would last longer to prevent them from making unrealistic decisions that could potentially impact their results.

The data records acquired in the auction game activities are analyzed for each quarter according to different operating figures, including:

$Bs(c,q)$= number of submitted bids by company c in quarter q,
$\Sigma Bs(c,q)$ = sum of all submitted bids by all companies in quarter q,
$Ba(c,q)$= number of successful bids by company c in quarter q,
$\Sigma Ba(c,q)$ = sum of all successful bids by all companies in quarter q,

Ra(c,q)= ratio of successful bids for company c in quarter q
= Ba(c,q) / ΣBs(c,q)
ΣRa(c)= mean ratio of successful bids for company c in the game
= ΣRa(c,q)/ q
Σt(q)= sum of all available tenders in quarter q
RA(q)= ratio of acceptance in quarter q
= ΣBa(c,q) / Σt(q)
Rc(q)= ratio of competition in quarter q
= ΣBs(c,q) / Σt(q)
M(c,q,Σb) = mean margin [%] for company c in quarter q in all bids
M(c,q,Σbs) = mean margin [%] for company c in quarter q in all successful bids

The design of the employed auction environment and its implementation as an online auction game is described in the following section. To understand how relevant data are acquired, the section also provides a short introduction to the basic activities which occur during gameplay.

The Employed Auction Environment

In general, the aim of the employed auction environment is to study economic questions. The collected data can be used to estimate effect size, to test the validity of economic theories, and to explain market mechanisms. As a result, the employed auction environment is an experimental economics method. This method features an environment that is controlled by the facilitator (scientist) conducting the experiment and places a set of human players within a real economic context that can be identified and reproduced (Barreteau, 2003).

The first step in designing such an experimental economic environment is to identify the demands on the auction game. Therefore, researchers must decide which auction type fits into the focused industry as outlined in the previous section. The bidding strategy is an important part of any construction company's overall business planning (King & Mercer, 1985). It is necessary to understand the contractor's motivation for participating in an auction, the reasons for the desire to win, and which constraints, dependencies, and internal and external risks might affect the bidding behavior and therefore, the decision making process. The company's risk-taking background is particularly interesting because decision making under risk can be viewed as a choice between prospects or a gamble (Kahneman & Tversky, 1979).

Contractors may be motivated to win project contracts: a) increasing earned profit, b) minimizing losses, as contractors must keep their firms intact even during recession periods, and c) minimizing the profits of the competitors in order to maintain a long-term good competitive position within the construction market (Gates, 1967). In order to specifying existing constraints, dependencies, and internal and external risks, it is necessary to examine the auction good itself – the construction project. Due to numerous events that may occur during the construction project's life cycle the contractor has to face a high level of uncertainty, such as the inevitable and unforeseen increase

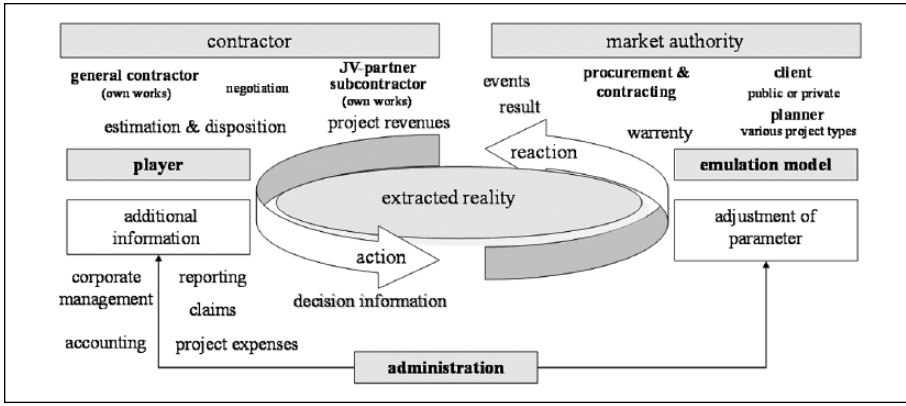


Figure 1. Process and factors of a construction-oriented auction game.

of material and labor costs or changed construction conditions resulting from changed requests or weather issues. During bid preparation, contractors have to take such effects into account, especially those with a) high probability, b) high amount of loss, and c) long term influence on project costs. Because of these dependencies, the construction industry relies on estimates of project costs which are based on the contractors' experience and available past and current information.

I included the identified demands on the auction environment based on an empirically validated procedure (Karl, 2012). The course of events during the auction game is illustrated in Figure 1.

During the gameplay, the contractors have to face different tasks and challenges. Within the decision-making process they have to consider factors such as estimated project costs, the disposition of resources, real project revenue compared to revenue forecasts, and events influencing projects, the company, or the whole market.

The market is defined, among other factors, by supply and demand, as well as by the types of projects available. Different project categories exist, such as residential housing, office buildings, industrial buildings, hospitals, adding cultural buildings. This adds to the perceived realism and acceptance of the gaming simulation. Each construction project is dependent on its properties and these, in turn, depend on the local market (country x, country y, etc.) in which the project is to be realized. Local market prices and their development for concrete, steel, labor costs, as well as local market risks, project, company, and their resulting events take into account the uncertainty in decision making. As a result, they play a substantial role in the auction game.

The projects generated in the auction game are implemented in the form of public, limited, or private lump-sum contracts. The contractor neither has an influence on the method of construction, nor on the employed material. Therefore, technical issues as well as quality issues are neglected. However, the contractor can accelerate or slow down projects by varying the personnel resources. This presumes that a) sufficient resources are available in the company or b) further resources are available on the

market. Beyond these elements, risk areas are defined for each subsystem. These areas can be assigned to the market, the project, or the company itself, and influence each contractor individually. In particular, the game design considers ratios of increase or decrease in project costs in order to depict the effects of different project risks.

Based on the aforementioned fundamental design, an online auction game was developed for the following reasons: a) in contrast to board-based auction games, online games are particularly well-suited for longer session duration, which is important for investigating decisions with long-term influence, b) a longer auction game session reinforces the individual experience of consequences arising out of cyclical parameters (common in economic systems), and c) every input parameter can be logged within a database. This is very helpful for analyzing the decisions taken at specific moments.

Playing the Auction Game

Figure 2 schematically illustrates the activities participants were required to complete during the auction game.

At the start of the game, the auction game supervisor generates projects and places information at the disposal of the participants. This pool of orders is the basis for project acquisition. Contractors submit their bids to show their desires to carry out a construction project for an agreed price (Park & Chapin, 1992). To address the aspect of time pressure in decision making, a further constraint is implemented within the auction game. The bids need to be submitted by a specific deadline (Fayek, 1998; Kahneman, 1973). Thus, the game supervisor is able to pressure the participants to take their decisions in a limited time frame.

By this time, as supported by Bagies and Fortune's (2006) research, every contractor is thinking about a variety of critical decision options, such as a) the bid or no bid decision, in which the contractor considers many factors which would help to determine the expected benefits from a construction project and b) the mark-up decision, which is related to the bidding strategy. The bid or no bid decision is particularly influenced in this game; every submitted bid immediately causes the corresponding offer costs. The offer cost in the game depicts the effort that a company makes to offer proposals. In reality, not every offer will be followed by a contract or project. A company has to prepare multiple bids or offers for different projects (and every bid has his own effort and therefore, preparation cost), but only one of them will result in a contract. As a result, the offer costs of preparing the other bids has to be earned with the project(s) that the company obtains. This circumstance has a big influence on business costs and bidding strategy. After submission, the contracting follows with the lowest bidder. Accordingly, the winning contractor is expected to conduct the project based on the agreed price and schedule.

In order to begin work, the contractors need to plan the employment of resources for the projects they won. Decisions regarding the availability of resources should be completed during bid preparation. The resources are allocated by the system or, if necessary, missing quantities are complemented, incurring additional charges (according to the configuration of the game). If resources exceed the current need, they are

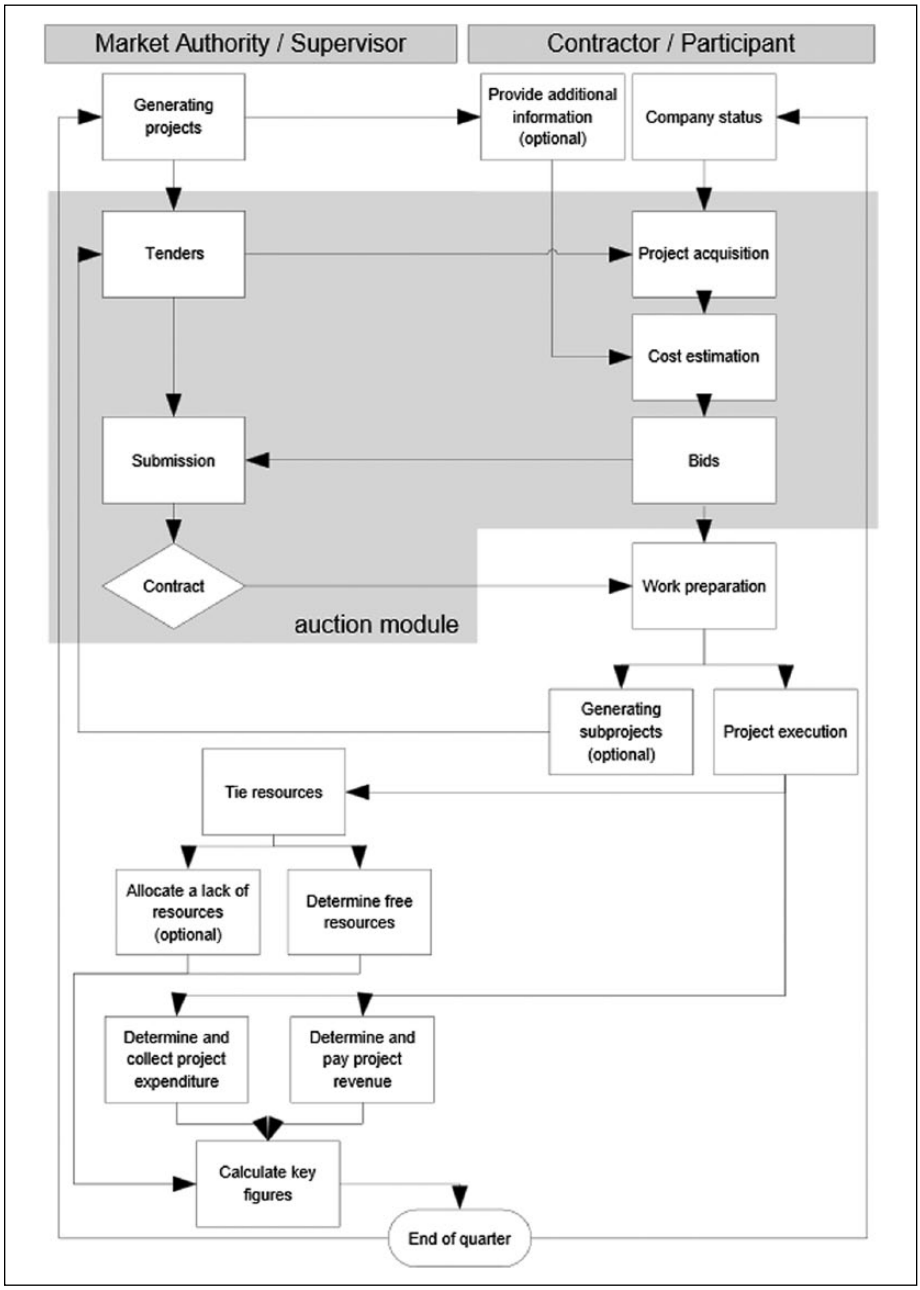


Figure 2. Auction environment activity diagram.

also considered, and potential costs for the provision or standby availability are determined by the system, as are revenue and project expenses. As each company uses an individual bank account, the revenue and the expenses or costs can be viewed from different role-dependent perspectives: a) company-wide, b) per cost center (e.g. general business expenses, material costs), and c) per construction site. These overviews can be displayed as quarterly summaries. All data generated in this phase is continually logged in a database as company or project operating figures, and are available as a company status report after the end of the quarter.

Analysis of Decisions and Company Developments

The following section introduces the employed auction environment and practical implementation of the game. Company developments are investigated in detail.

General Overview

On general inspection, it becomes apparent that a multitude of tenders does not necessarily result in an increase of successfully submitted bids in a quarter. Although it would have been expected that a high number of potential projects increases the average probability of an acceptance, the results show something else. The quota of successfully placed bids in the market is dependent on multiple factors including the general corporate strategy, the previous development and business utilization rate of the company, and the individual financial situation. Even when there are a variety of potential tenders on the market, companies operating at full capacity are not likely to place more bids unless expansion is their principal aim. The success ratio of submissions is strongly influenced by the activities of the company's competitors. Do they tender for the same projects? What are their chosen margins? Are there any projects several companies or no companies are bidding for? The latter is quite possible, as it is not transparent during the tender phase who places bids for which project. Such information is only accessible for the participants after the submission phase. Thirty-five tenders were generated for the 14 companies in quarter 0. For this quarter, 83 bids were placed by 12 companies, 19 bids were accepted and the projects granted, and no bids were placed for 16 of the projects ($Rc(0) = 0.34$, $RA(0) = 0.54$). Companies do not submit bids for all projects if there are several available (e.g. to economize offering expenses), and not all tenders could be granted. Consequently, the ratio of successful bids was only 26% in this quarter. If every company had placed a bid on two specific, 'company connected' tenders, in theory, every company could have had two contracts at the end (that would be planned economy). However, only a few companies got projects and the rest failed in this competition.

The Winner's Curse and Its Influence

During gameplay, huge amounts of data were stored in the database for each company and quarter. To investigate the winner's curse and its effects, I selected companies with

Table 1. Company Configurations.

Company ID	Personnel	Cranes	Excavators	Trucks	Cash
115	100	14	10	10	6,838,428
210	100	30	40	30	8,329,652
212	65	25	40	35	6,277,383

the following characteristics for further analyses: a) they are in direct competition with each other, b) they participated until the end (no bankruptcy), c) the participants were able to give valid explanations for their decisions during the debriefing (no gambling). Three companies, 115, 210, and 212, matched these criteria. Therefore, they were selected for the following more in-depth discussion. All three companies differ both in their size and in their development; see Table 1.

Company 115 – Suffered the Winner's Curse

The development of company 115 is marked by significant losses. At the start of the auction game session, the members of company 115 announced their objective: high market shares. They attempted to reach this aim with competitive and advantageous bids in the beginning of the game. Even though the company had a good ratio of successful bids ($Ra(115,1) = 0.4$; $Ra(115,4) = 0.5$; $Ra(115,9) = 1.0$; $\sum Ra(115) = 0.63$), it was not able to acquire projects with sufficient profit margins ($M(115,1,\sum bs) = -26.6$; $M(115,4,\sum bs) = -13.9$; $M(115,9,\sum bs) = -4.5$). To reach their objective, company 115 placed bids under the estimated construction costs, which resulted in the winner's curse. As compensation actions, profit margins of up to 44.7% in one project were calculated in the third quarter, but could not be achieved in the market due to increased competition ($Rc(3) = 2.50$).

The result was an insufficiently low number of projects for the available resources as confirmed by the participants during debriefing. Additionally, no active acquisition took place in quarters four through eight, even though the running costs of the company still had to be paid. Quarters six and seven would have been of particular research interest due to decreased competition ($Rc(6) = 0.75$; $Rc(7) = 0.54$). The reason for the increased inactivity was the tendency to resign after the fourth quarter, as the participants revealed during the debriefing. This passiveness as a result of bad decisions combined with the delayed layoff of personnel was responsible for the failure of company 115. An early and adequate adaptation of the previous strategy was not implemented either.

The development of company 115 demonstrates how unfavorable it is to operate with such small margins within the bidding process, even if it appears to be strategically important. However, the consideration of excessive margins in a period with only limited tenders is an equally detrimental option. In the next section, the discussion includes the impacts of company 115's behavior and resulting winner's curse on the market and on other companies.

Company 210 – Financial Situation Harmed Due to Company 115's Strategy

Company 210 is characterized by a rather small number of acquired projects, but with higher profit margins (M(210,0,∑bs) = 4.7; M(210,5,∑bs) = 0.0; M(210,9,∑bs) = 4.8). Although company 210 aimed to use its full capacity, success was not possible due to the limited number of acquired projects. In contrast to 115, 210 sold unnecessary pieces of equipment early, and thereby improved their liquidity, which influenced the bidding strategy of their company.

Unfortunately, company 210 did not participate in quarters 1, 6, and 7, which had fewer competitors and therefore, decreased competition (Rc(1) = 0.80; Rc(6) = 0.75; Rc(7) = 0.54). Hence, bidding activities would have been sensible in this time. One reason which was voiced by the participants for the increasing inactivity was the negative market situation. This impression was mainly due to the fact that company 210 was underbid by company 115 in quarter three, and thus did not acquire the only project offered. The margin calculated by company 210 was only 1%, but it was underbid by 115 with a margin of −8.1%; due to the strong will to win this project and thereby to minimize the running costs of their company, as revealed by the participants during debriefing.

The consequences of losing the bid in quarter three became obvious in quarter five, in which 210 offered with a margin of 0% and was successful, probably due to the fact that 115 did not participate in this round. The decreased income and massive personnel layoffs starting in quarter five, resulting in a high amount of layoff costs (It reflects the fact, that in Germany compensations must be paid for employees who worked several years for one company). This placed additional burdens on the financial situation. Due to the unfavorable market development, which can be traced back to companies like 115 who suffered from the winner's curse, 210 was not able to rely on its own value creation but on the sale of company assets.

Company 212 – Competed Against Company 115 but Was Not Influenced by the Winner's Curse

In contrast to the two aforementioned companies, 212 developed favorably. It is remarkable that company 212, which was a small business at the beginning (in terms of staff), developed into a major corporation. The participants realized their goal of stimulating the company's growth.

The company actively participated in the market and submitted bids in nearly every quarter. This resulted in the successful acquisition of projects, most of which had very high profit margins (M(212,0,∑bs) = 12.6; M(212,4,∑bs) = 3.0; M(212,6,∑bs) = 20.0; M(212,7,∑bs) = 19.9; M(212,9,∑bs) = 43.1).

These projects were intentionally characterized by intensive long-term deployment of personnel and equipment. One issue was the partly unfavorable plan for income and expenditure of individual projects. These projects demanded significant payments in advance and relatively late incoming payments. That might be one reason that such

projects were not the preferred focus of other companies, which resulted in less competition.

Company 212 opposed company 115 in two projects in quarter three (project ID 96 and 98). Company 212 offered with calculated margins of 4.6% and 4.8%. Company 115, however, offered with margins of −8.1% and −19.7%. In contrast to company 210, this event had no further influence on the strategy and decisions of the company. Despite this experience, 210 participated continually and was able to acquire projects with very high margins in the following quarters.

The Overall Picture

The results clearly show the connections and influences of different decisions. The success as well as the failure of the individual contractors does not only depend on one's own (even if appropriate) actions, but also on the activities of the other participants – no matter whether reasonable or accidental like inaccurate estimates of project costs. It is this fact which complicates the successful implementation of a strategy for some companies.

At first glance, it is interesting that the company with the lowest mean ratio of successfully submitted bids ($\sum Ra(212) = 0.29$) performed better than the company with the highest mean ratio of successfully submitted bids ($\sum Ra(115) = 0.63$). Company 212 was active in nearly every quarter, which explains its strong performance. They submitted 44 bids in the game, 13 of which were successful. In contrast, company 115 submitted 14 bids, from which 9 were successful, but had insufficient profit margins. Companies without direct competition with company 115 were able to achieve margins from 20% to more than 40%, which shows that these companies were not influenced by the winner's curse of company 115. They compete mainly with companies whose strategy was not to underbid in order to acquire projects.

Apparently, the following notions are primary factors of success: precise and realistic definition of corporate objectives (e.g. a pure focus on market shares without any regard to further parameters is not realistic), retention of internal operating figures (internal focus), continuous observation of the market, and constant market activity (external focus) as well as management flexibility. In contrast, a passive and expectant attitude – possibly even combined with a high quantity of unused resources, few acquired projects, and lastly, insufficient profit margins which result in the winner's curse – is to be seen as far from promising in the long term.

Debriefing

For gaming sessions, the debriefing is seen as crucial. It serves the purpose of training and education, during which participants learn and reflect on the experiences (Crookall, 2010; Lederman, 1992). Debriefing gives the participants space and time to recapitulate what happened during the game and to reflect on their learning experiences, and thus to gain a deeper understanding of the subject matter (Hill & Lance, 2002; Kriz, 2010;

Peters & Vissers, 2004). Additionally, in this case it provided insights into the decision-making process.

The debriefing method considers the learning process as well as decision making based on participant experiences. It consists of the following elements: a) pre-questionnaire, b) post-questionnaire, c) debriefing for each group (company), d) debriefing with the class, e) assessment of course and facilitator quality, and f) developing a formal construction market model with the class.

Pre-Questionnaire/Self-Assessment I

An online platform is integrated in the course, which makes a standardized online assessment a very suitable tool for the self-assessment. This allows researchers to question the participants at different points of time and to record the development of competencies and make them measurable. The goal of this assessment is to verify the realization of teaching and learning objectives as well as the recording and measurement of competencies by monitoring and analyzing the progress of subjective competency developments over time. As an example, an excerpt from the survey form is shown in Figure 3.

Post-Questionnaire/Self-Assessment II

A post-questionnaire was used to determine the subjective change in the development of competencies by using the competency development ratio (cdr):

$$cdr = \frac{v_1 - v_2}{v_1} = \begin{cases} > 0 \rightarrow \text{increase of competence} \\ = 0 \rightarrow \text{stagnation of competence} \\ < 0 \rightarrow \text{decrease of competence} \end{cases} ; v_1 \wedge v_2 \in [1,5]$$

v_1: assessment value at time t_1, v_2: assessment value at time t_2, $t_1 < t_2$

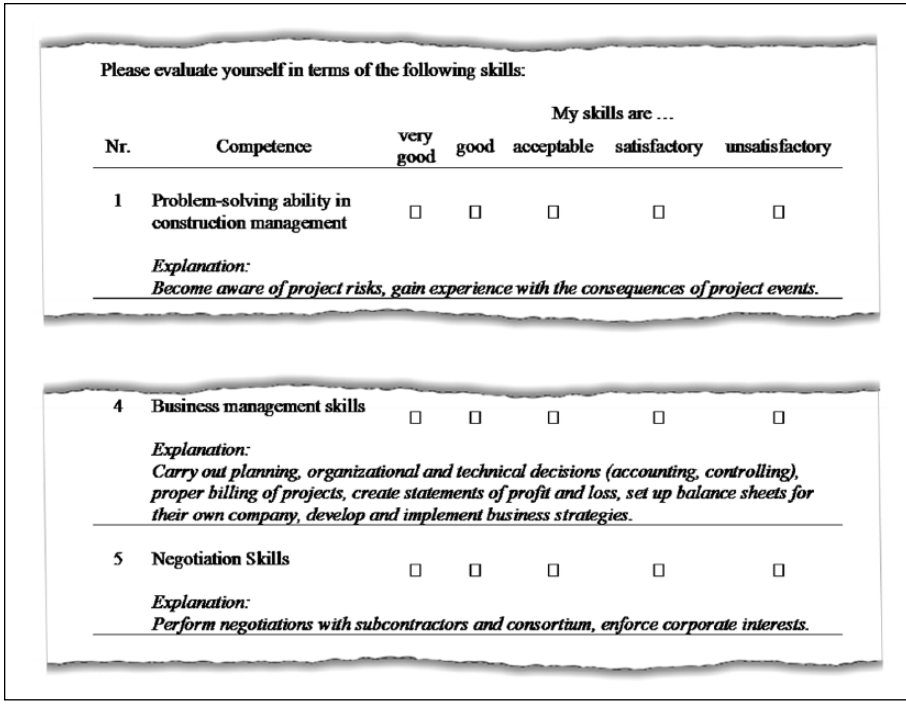
Values v_1 and v_2 depend on the evaluation scale:

very good (1), good (2), acceptable (3), satisfactory (4), unsatisfactory (5).

The pre- and post-questionnaire used the same questions.

As no data regarding previous experience (studies, practical professional experience etc.) was collected for the establishment of the initial state, it cannot be determined whether individual participants displayed notions of modesty in the competency assessment of their own skills and abilities.

However, the difference between the initial state and the final state (Figure 4) can be used to derive that a subjective increase is perceived. The inclusion of further data and the discussions after the game leads to the suggestion that these increases have less



Please evaluate yourself in terms of the following skills:

Nr.	Competence	My skills are … very good	good	acceptable	satisfactory	unsatisfactory
1	Problem-solving ability in construction management	☐	☐	☐	☐	☐
	Explanation: *Become aware of project risks, gain experience with the consequences of project events.*					
4	Business management skills	☐	☐	☐	☐	☐
	Explanation: *Carry out planning, organizational and technical decisions (accounting, controlling), proper billing of projects, create statements of profit and loss, set up balance sheets for their own company, develop and implement business strategies.*					
5	Negotiation Skills	☐	☐	☐	☐	☐
	Explanation: *Perform negotiations with subcontractors and consortium, enforce corporate interests.*					

Figure 3. Evaluation sheet excerpt.

to do with a growth of self-perception only (in the sense of self-confidence), but more with a real development of competencies. This conclusion correlates with the results of the examination carried out after the course: failure rate 3 %; overall average grade 2.3; best grade 1.3; worst grade 4.0 (best possible grade 1.0, failed 5.0).

Debriefing for Each Group (Company)

During this phase, open interviews with the participants took place. I conducted one-hour, personal interviews with every company. Before the interview, I analyzed the available data from the database to be able to draw a general picture of the company and its surroundings. The topics discussed in the interview were group dynamics and the division of responsibilities (to consider aspects of social and cooperative learning (Slavin, 1990), company development, experiences, and details regarding different decisions during gameplay).

Debriefing With the Class

After the personal interviews the participants met in class as a group. They explained the development of their company and explored different strategies, decisions, and

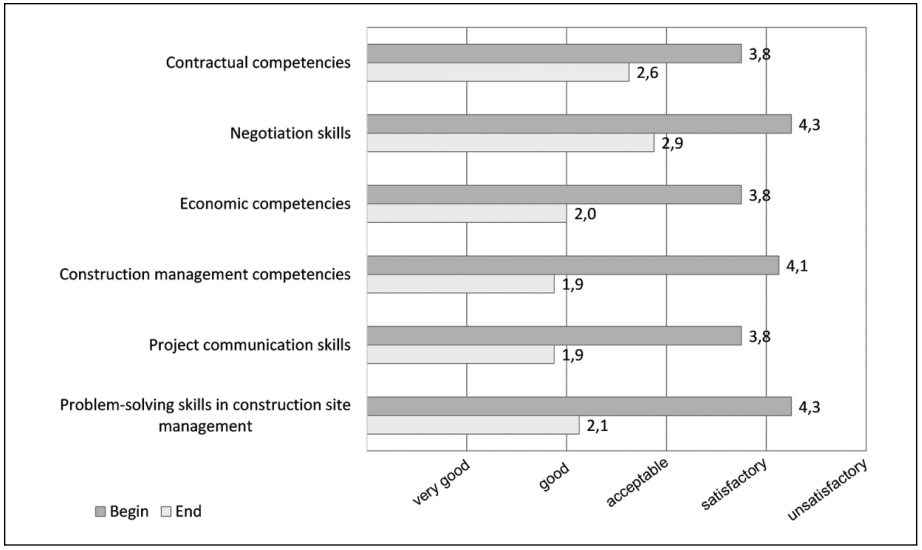


Figure 4. Result of pre- and postquestionaire.

influences on each other. Participants also discussed differences and similarities between the game and reality. Finally, they defined the key lessons they learned from the simulation game.

Assessment of Course and Facilitator Quality

Included within the debriefing of the course is an assessment that focused on the quality assurance of the course as well as the game and the facilitator. A new questionnaire was used with the following results (Table 2 & 3).

Data shows that the course, game, and the performance of the facilitator were rated as good. Potential areas for improvement include course organization and the personal learning success of the participants. Because this questionnaire was conducted anonymously and independently, no connection between performance in the game and learning success can be made. Therefore, the questionnaire design should be improved, too. The game's playability and online interface should also be improved.

Developing a Formal Construction Market Model

Duke and Geurts (2004) emphasize that the gaming simulation approach is relevant for strategic problem solving. It enables decision makers to analyze a multi-agent, multi-faceted, real-world problem. To make this multi-agent, multi-faceted, real world understandable and comprehensible for the participants, I developed a first market model. It was based on the general model of the game and the results of the data analysis. The System Dynamics (SD) approach was used for modeling. SD is a system-oriented and

Table 2. Course Evaluation (Scale: 1.0 = Very Good, 5.0 = Unsatisfactory).

criteria	valuation
didactic design	1.89
use of media	1.56
organization of the course	2.44
moderation of the course	1.67
personal learning success	2.44
relevance for my job	2.33
average	2.06

Table 3. Game and Facilitator Evaluation (Scale: 1.0 = Very Good, 5.0 = Unsatisfactory).

criteria	valuation
playability of the simulation	2.44
interface design	2.44
practical relevance	2.14
preparation by the facilitator	2.00
assistance by the facilitator	1.88
average	2.18
Would you participate again?	100%

computer-based problem-solving approach which particularly addresses the analysis and design of decision-making rules. It attempts to comprehend the behavior of complex systems over time and addresses feedback loops and time lags affecting the whole system. For this purpose, models are developed which can, due to their inner structural properties and data, reproduce the real system (for further details regarding modeling and simulation of dynamic systems refer to Sterman (2004)).

The construction market model aimed to provoke discussion among participants as well as to potentially resolve validity and veracity of the model in a debriefing session under my guidance (Van den Hoogen et al., 2014). Special relevance was given to the experiences that the participants acquired during gameplay. The decisions of specific companies appeared to be critical because of their influence on other companies and the market as a whole.

The investigation of the winner's curse and the decision-making process are the main focuses of this article. Therefore, only the debriefing element f) will be discussed in more detail in the following section. The other elements, although potentially important in a course, will be neglected; the discussion of the competency development and the learning outcomes in detail is in Karl (2013). The result of the discussion with the participants was a refined market model which includes 60 feedback loops, as presented in Figure 5.

A company's success and failure depend strongly on their decisions and the decisions of their competitors within the common market. If competition increases, the

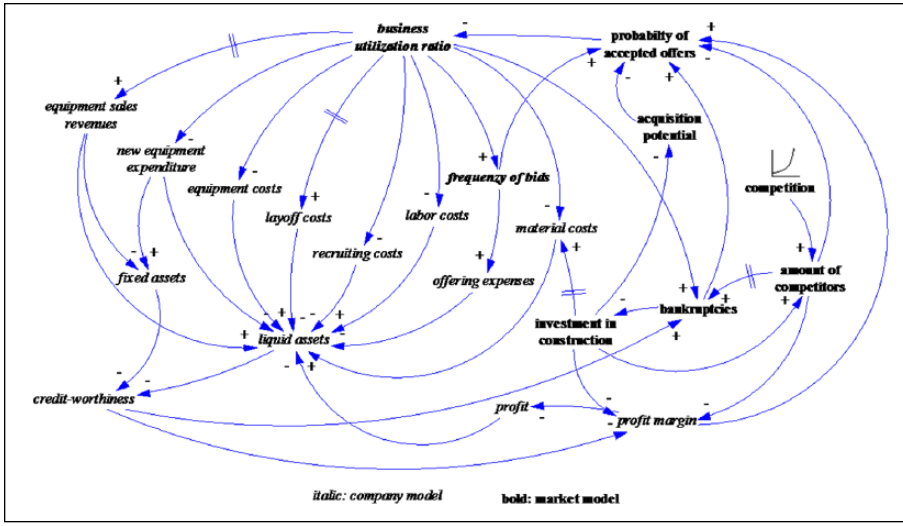


Figure 5. Auction game-developed construction market model.

profit margin of a company might decrease to make sure that the company acquires enough projects. This increases the probability that the company will suffer from the winner's curse and influences the amount of profit, which results in decreased liquid assets. Decreased liquidity negatively influences the credit-worthiness of a company. A further effect of increased competition is an increased number of bankruptcies. Due to the fact, that the decisions and (re)actions within a company are time-dependent, the increasing number of bankrupted businesses will appear with a delay mark in the model (parallel, double bars on the arrow). The amount of liquid and fixed assets, especially the revenue and expenditure of ongoing projects, are further factors which influence the duration of the delay. Interestingly, higher competition decreases the probability of accepted bids for each company at one time, but also might increase the amount of bankrupted businesses, which in turn relaxes the competition and increases the probability of accepted bids. Assuming that the demand does not change and all other factors remain unchanged. The aforementioned delay between competitors and bankrupted businesses seems to warrant further research in future sessions of the game.

Because of a decreased probability of accepted bids, the business utilization rate will fall. One decision might be to raise the frequency of bids. The company will try to place more bids within one period to raise the probability of acceptance. Simultaneously, bidding expenses will increase, which negatively impacts liquid assets. Companies may include very small profit margins within the bids, which increases the likelihood that their bids will be accepted. Low-profit strategies might be very risky, but in some cases they seem inevitable. Another, more classic strategy would be to reduce costs and increase income. Quickly selling unused equipment to avoid further depreciation losses also immediately increases the company's liquidity and reduces its fixed assets. This also

decreases long-term equipment, and particularly maintenance, costs. The same effect can be achieved by laying off unused personnel. Although it saves labor costs in each quarter, layoff costs immediately reduce liquid assets. Companies face the challenge of choosing the right time to pay to keep idle employees and forestall paying layoff charges.

The model does not claim to account for every economic issue. However, it illustrates how relationships can be identified and modeled out of an auction game; especially if the relationships were not clearly understood before. With the help of further gameplay, the model can be improved and ratios and probabilities can be determined more accurately. Through this formal model, the participants are able to gain a deeper understanding of the subject matter.

Discussion

This article introduced a method for using business games to investigate the winner's curse based on real interactive human behavior, with special regard to the construction industry. The results show the effects of the winner's curse on a contractor and the firm's market.

The winner's curse is based on the situation when the bidder with the lowest bid wins an auction by underbidding the true project costs. Game play revealed that the reason for this is threefold. The bid is underneath the true project costs because a) the real costs are influenced by a variety of unknown events during the construction period which results in increased costs or b) strong competition influences the strategy of the bidder which results in 'strategic bidding', i.e. bidding underneath the assumed project costs and hoping that the others will do not the same, or c) the bidder underestimates the project costs.

Contractors suffer from the winner's curse for the following reasons:

a. The contractor neglects the variety of risks that might influence the costs during the project.

Every bidder must estimate the prospective costs and has to take into account internal and external risks before setting a bid. Within the game, three risk areas are designed. They influence the project, the company and the market. Hence, it is necessary to consider a summary risk margin within the bid. In life and in the game, the determination of such a risk margin is influenced by a variety of constraints, dependencies, and coincidences, which leads to uncertainty in decision making. Although the determination of a certain margin was not part of this experiment, the method introduced here might be applicable for future investigations.

b. Due to strong competition within the construction market, 'strategic bidding' becomes an acceptable method.

Some participants recognize that carrying out projects underneath the calculated project costs lead to losses, but the losses are less than the summary costs of unused

equipment and labor. The latter has to be paid even if they are not involved in any project. Gameplay revealed that such a strategy might work in the short term but for the long term, further decisions must be taken, such as the early layoff of unused personnel or sale of equipment. Doing this requires a fundamental change in corporate strategy. To make matters worse, it is difficult to decide when this strategy change should be made, especially when the bidder repeatedly hopes to acquire projects in the next round.

c. Inaccurate project cost estimates.

This reason might be trivial, but it can lead to unexpected losses. The resulting actions are more or less the same. Bids cannot be withdrawn, so the contractor has to decide how they will compensate for this mistake with other projects, in which they want to include higher profit margins in the bid. Precise market observation and niche determination are important factors for success in an auction with a relatively high bid. At the end, a fundamental change in corporate strategy will be an inevitably occur.

The aforementioned reasons affect the behavior of contractors and their intention to win projects, as well as their willingness to take risks. The following text belongs not to the text before.

There seems to be evidence for the high relevance of and need for online, database-driven, auction games. Context is important when modeling human behavior (Luke, 2004). The same is true for decisions which are a result of human behavior. Identical choices in games result in different behavior and decisions when they are framed differently or conducted in different contexts (Kahneman & Tversky, 1979). Therefore, describing the environment in which a person makes his or her decisions plays a critical role in studying and understanding the decision-making process.

Collecting context-related data can significantly help to draw a picture of the sphere in which different decisions were made. Hence, online database-driven games can play a vital role in future research and the design of blended learning scenarios. The latter is a combination of traditional and online teaching and learning methods (Lang, 2006). In this context, blended learning scenarios will benefit by including online games as a further teaching and learning method. By applying this method in conjunction with a database, researchers can permanently collect market and business developments, as well as the most interesting variety of user decisions. The analysis of this data will help researchers to understand the decision-making process in detail and human behavior in general.

In general, business games may offer a greater benefit, particularly in the exploration of relationships (a quite similar discussion can be found in Karl, 2014). Games and simulations are frequently used for professional training or academic education and knowledge building (Klabbers, 2001; Rafaeli, Raban, Ravid, & Noy, 2003; Wolfe & Bruton, 1994). This article described a setting in which a business game can also be used as a serious research tool.

Conclusion

In Detail, this article contributes to the potential use of business games to study the results of auction behavior in a construction business environment and to investigate the winner's curse and its effects for a company and a whole market. Its primary contribution is to the field of business gaming. Although it might be of interest for behavioral science, the article does not intend to provide substantial and generally-valid knowledge to this field. The introduced auction environment is based on the common bidding method for construction projects; the 'reverse' auction low-bid method. Studying further auction methods would enable investigations into the bidding behavior in different auction settings. Additionally, it would allow researchers to compare the results from various scenarios and studies.

I recommend that further research consider second-price sealed-bid auctions (Vickrey auction); this type of auction is also easy to implement. My first hypothesis would be that Vickrey auctions potentially reduce the probability for companies to suffer due to underestimated project costs. The second hypothesis would be that the bidding strategy of every company would be influenced using the Vickrey auction method. The introduced auction environment might be modified to include the additional auction modules, shown in Figure 2. This would enable investigations into the bidding behavior in different auction settings, as well as results comparison with other studies and scenarios.

Acknowledgments

I would like to thank Prof. Richard D. Teach for his inspiration to conduct research on auctions and decision making processes and for the valuable discussions during my time at the Georgia Tech Center for International Business Education & Research and thereafter. I would like to thank further Prof. Raymond Levitt from Stanford University. His openness and spirit as well as his valuable feedback and brilliant ideas during the practical testing of my online game provided new insights and further opportunities. Additionally, I appreciate the valuable feedback given by the reviewers of this article as well as the professional writing assistance I received from Christina Boyes. This article is an augmented and enhanced version of a paper presented at the 45th annual international conference of the International Simulation and Gaming Association (ISAGA), Dornbirn, Austria, July 7-11, 2014.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

References

Ahmad, I., & Minkarah, I. (1988). Questionnaire survey on bidding in construction. *Journal of Management in Engineering, ASCE*, *4*, 229-243.

Bagies, A., & Fortune, C. (2006, September 4-6). Bid/no-bid decision modelling for construction projects. In D. Boyd (Ed.), *Proceedings 22nd Annual ARCOM Conference* (pp. 511-521). Birmingham, UK: Association of Researchers in Construction Management.

Barreteau, O. (2003). The joint use of role-playing games and models regarding negotiation processes: Characterization of associations. *Journal of Artificial Societies and Social Simulation*, *6*(2). Retrieved from http://jasss.soc.surrey.ac.uk/6/2/contents.html

Capen, E. C., Clapp, R. V., & Campbell, W. M. (1971). Competitive bidding in high-risk situation. *Journal of Petroleum Technology*, *23*, 641-653.

Crookall, D. (2010). Serious games, debriefing, and simulation/gaming as a discipline. *Simulation & Gaming*, *41*, 898-920.

Duke, R. D., & Geurts, J. (2004). *Policy games for strategic management*. Amsterdam, The Netherlands: Dutch University Press.

Dyer, D., & Kagel, J. H. (1996). Bidding in common value auctions: How the commercial construction industry corrects for the winner's curse. *Management Science*, *42*, 1463-1474.

Fayek, A. (1998). Competitive bidding strategy model and software system for bid preparation. *Journal of Construction Engineering and Management*, *124*, 1-10.

Friedman, L. (1956). A competitive-bidding strategy. *Operations Research*, *4*, 104-112.

Gates, M. (1967). Bidding strategy and probabilities. *Journal of the Construction Division, The American Society of Civil Engineers*, *93*(CO1), 74-107.

Hill, J. L., & Lance, C. G. (2002). Debriefing stress. *Simulation & Gaming*, *33*, 490-503.

Ioannou, P. G., & Awwad, R. E. (2010). Below-average bidding method. *Journal of Construction Engineering and Management*, *136*, 936-946.

Kagel, J. H. (1995). Auctions: A survey of experimental research. In J. H. Kagel & A. E. Roth (Eds.), *The handbook of experimental economics* (pp. 501-586). Princeton, NJ: Princeton University Press.

Kagel, J. H., Harstad, R. M., & Levin, D. (1987). Information impact and allocation rules in auctions with affiliated private values: A laboratory study. *Econometrica*, *55*, 1275-1304.

Kagel, J. H., & Levin, D. (1986). The winner's curse and public information in common value auctions. *American Economic Review*, *76*, 894-920.

Kagel, J. H., & Levin, D. (2002). *Common value auctions and the winner's curse*. Princeton, NJ: Princeton University Press.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision making under risk. *Econometrica*, *47*, 263-291.

Karl, C. K. (2012). Additional benefit through competency-oriented business simulations. *Developments in Business Simulation & Experiential Exercises*, *39*, 35-46.

Karl, C. K. (2013). Integrative learning: Exploring opportunities in business simulations. *Developments in Business Simulation & Experiential Exercises*, *40*, 48-57.

Karl, C. K. (2014). Solving the simulation paradox—How educational games can support research efforts. *Developments in Business Simulation & Experiential Exercises*, *41*, 132-139.

King, M., & Mercer, A. (1985). Problems in determining bidding strategies. *Journal of the Operational Research Society*, *36*, 915-923.

Klabbers, J. H. G. (2001). The emerging field of simulation & gaming: Meanings of a retrospect. *Simulation & Gaming*, *32*, 471-480.

Kriz, W. C. (2010). A systems-oriented constructivism approach to the facilitation and debriefing of simulations and games. *Simulation & Gaming*, *41*, 663-680.

Lang, M. (2006). Blended learning. In F.-J. Kaiser & G. Pätzold (Eds.), *Wörterbuch Berufs- und Wirtschaftspädagogik* (2nd ed., pp. 195-196). Bad Heilbrunn, Germany: Klinkhardt.

Lederman, L. C. (1992). Debriefing: Toward a systematic assessment of theory and practice. *Simulation & Gaming*, *23*, 145-160.

Levitt, R. E., Wang, C.-M. A., Ho, S. P., & Javernick-Will, A. (2011, July). *A contingency theory of organizational strategies for facilitating knowledge sharing in engineering organizations* (Working Paper #64).

Luke, D. (2004). *Multilevel modeling*. Thousand Oaks, CA: SAGE.
McAfee, R. P., & McMillan, J. (1987). Auctions and bidding. *Journal of Economic Literature*, *25*, 699-738.
Meijer, S. (2011). Testing hypotheses using gaming simulation-Qualitative and quantitative research in supply chains and networks. In F. Trautwein, S. Hitzler, & B. Zürn (Eds.), *Planspiele - Entwicklung und Perspektiven* (pp. 143-167). Norderstedt: BOD.
Myerson, R. B. (1991). *Game theory: Analysis of conflict*. Cambridge, MA: Harvard University Press.
Noy, A. (2014). A computer-assisted educational auction simulation. *Simulation & Gaming*, *45*, 371-393.
Noy, A., Raban, D. R., & Ravid, G. (2006). Testing social theories in computer-mediated communication through gaming and simulation. *Simulation & Gaming*, *37*, 174-194.
Park, W. R., & Chapin, W. B. (1992). *Construction bidding: Strategic pricing for profit, Second edition*. New York, NY: Wiley.
Peters, V. A. M., & Vissers, G. A. N. (2004). A simple classification model for debriefing simulation games. *Simulation & Gaming*, *35*, 70-84.
Rafaeli, S., Raban, D. R., Ravid, G., & Noy, A. (2003). Online simulations in management education about information and its uses. In C. Wankel & R. DeFillippi (Eds.), *Educating managers with tomorrow's technologies* (pp. 53-80). Greenwich, CT: Information Age.
Sejwal, R. (2014). Game theory and human behavior. *International Research Journal of Management Sociology & Humanity*, *5*, 360-364.
Slavin, R. E. (1990). *Cooperative learning: Theory, research, and practice*. Englewood Cliffs, NY: Prentice-Hall.
Sterman, J. D. (2004). *Business dynamics: Systems thinking and modeling for a complex world*. Boston, MA: McGraw-Hill.
Van den Hoogen, J., Lo, J. C., & Meijer, S. A. (2014). Debriefing in gaming simulation for research: Opening the black box of the non-trivial machine to assess validity and reliability. In A. Tolk, S. D. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, & J. A. Miller (Eds.), *Proceedings of the 2014 Winter Simulation Conference* (pp. 3505-3516). Piscataway, NJ: Institute of Electrical and Electronics Engineers.
Wanous, M., Boussabaine, A. H., & Lewis, J. (2000). To bid or not to bid, a parametric solution. *Construction Management and Economics*, *18*, 457-466.
Wilson, R. (1992). Strategic analysis of auctions. In R. J. Aumann & S. Hart (Eds.), *Handbook of game theory with economic applications* (pp. 227-280). Amsterdam, The Netherlands: Elsevier Science.
Wolfe, J., & Bruton, G. (1994). On the use of computerized simulations for entrepreneurship education. *Simulation & Gaming*, *25*, 402-415.
Zúñiga-Arias, G., Meijer, S. A., Ruben, R., & Hofstede, G. J. (2007). Bargaining power and revenue distribution in the Costa Rican mango supply chain. *Journal on Chain and Network Science*, *7*, 143-160.

Author Biography

Christian K. Karl is assistant professor in the Department of Civil Engineering at the University of Duisburg-Essen in Germany. His aim is to improve today's project related industries through simulation and gaming. He served as a board member within the Association for Business Simulation and Experiential Learning (ABSEL) and as a program committee member within the International Simulation and Gaming Association (ISAGA). He is winner of the German Simulation and Gaming Award 2015. He is also working as a consultant and trainer in continuing education and business.

Contact: christian.karl@uni-due.de, www.chkarl.de

DOI: 10.1177/1046878116633971
URN: urn:nbn:de:hbz:465-20221020-112411-7