The Sustainable Port Game: Moral Decision-making about Climate

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ABSTRACT
In this paper, we report on the development of the Sustainable Port video game, which encourages players to reflect on ethically significant issues, such as climate change, technological breakthroughs, and policy developments, modeled to reflect the real-life setting at an undisclosed maritime port. We describe our method, which involves engaging with real-world stakeholders, on the history of this development, the mechanics of the game, and how they encourage reflection. We also present some quantitative data about the game's usability and players' experiences.

Keywords
Moral decision-making, Complexity, Logistics, Maritime Port, Climate change

INTRODUCTION
In 2019, the European Commission launched *The European Green Deal*, a portfolio of policy documents for a range of interconnected industries (finance, transport, energy, agriculture, etc.), which have an impact on climate and are economically important. Its aim is to facilitate a change to climate neutrality for the European Union by 2050. The undisclosed maritime port, anonymized for the purposes of this paper, (Port, from now on), which is the one of the biggest maritime ports in the world as measured by container TEU (Twenty-foot Equivalent Unit), is a key player in that transition, given its strategic importance, carbon footprint, and connection to other important aspects of the European economy.

The Port plays a strategic public role in the European economy, and it is also a business, with shares owned by both private and public investors. Given this, the challenges faced by the Port's decision-makers are multi-faceted, complex, and sometimes opaque to those without their specific decision-making competence. Maritime logistics, including port-side operations, are a truly global business, which affects and is affected by many aspects of the global economy. This makes strategic decisions in the Port particularly complex. Direct decisional challenges are connected to the size and diversity of the workforce, the number of subsidiaries and facilities involved, and the volume of cargo throughput. These challenges are compounded by factors outside the decision-making process, such as fuel costs, weather conditions, availability of talent, and geopolitical events. These complexities are further complicated by legislative and policy directives at local, national, and international level, such as *The European Green Deal*.

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A tabletop game *Sustainable Port* was developed by The Barn (http://thebarngames.com/) from Delft, Netherlands in collaboration with a team from Delft University of Technology. In can be used to introduce players to the to the complexity of decision-making in a maritime port. The complexity of the game also reflects some of the key aspects of the decision-making ecosystem of the Port. The game design pays special attention to the introduction of new policies and technological advancements that affect that ecosystem. Specifically, it embodies the goals of *The European Green Deal* of minimizing carbon-dioxide emissions and technological advancements in hydrogen storage and processing for energy, while taking the added value for the business into account. The original tabletop version of the game is a tool that can be effectively used to start a discussion among employees, raising awareness about aspects of the decision-making of the port. The idea is that dialogue would improve the decision-making process, collaboration, and mutual understanding.

The aim of this paper is to report on the status of the development of a digital version of the *Sustainable Port*, which facilitates behavioural experiments, data collection, analysis, and science-based understanding of the cognitive dimension of decision-making in the Port's decision-making ecosystem. The *Sustainable Port* video game is an example of an Ethically Notable Game (Sicart 2010; Zagal 2009) in the sense that its design "facilitates ethically significant gameplay – defined here to mean in-game actions that provoke moral reflection" (Staines et al. 2019, 272). However, nothing about the game is overtly moral, in the sense of signaling that any in-game decision is morally "right" or "wrong" or being measured as a part of moral decision-making processes. The moral aspect of in-game decisions depends on its salience to the player (Joeckel et al. 2012). For example, if fairness/reciprocity is important to the player (Haidt and Joseph 2004), it can become a part of the macro-level of decisions in the game. Players that focus exclusively on the procedural level of the *Sustainable Port* and never reflect in this broader sense, will focus only on short-term goals and be less prepared for dramatic changes in the game introduced by events. Given this, the *Sustainable Port* invites its players to think strategically and long-term, and then may reward them if they do. Doing so will engage their Moral Sensitivity (Katsarov et al. 2019; Ryan et al. 2016). We have independent reason to believe that at least some players will indeed engage our game morally (Greitemeyer and Mügge 2014). We know, for example, that if given an opportunity some players are more likely to make in-game decisions that are in line with their moral values, even if it will lead to in-game net loss (Krcmar and Cingel 2016). Also, in the *Sustainable Port* players are invited to break out of the "magic circle," where decisions are inconsequential (Linser et al. 2008; Nay and Zagal 2017). They are put in control of the Port of Rotterdam, which they likely know about or visited. They likely know about *The European Green Deal*, about the effect of CO_2 on global warming and climate change. In-game mechanics of the *Sustainable Port* make these issues salient.

METHODS

The Sustainable Port Tabletop Game

The *Sustainable Port* is played with a deck of event cards, a deck of building cards, a board, and physical tokens (Figure 1).

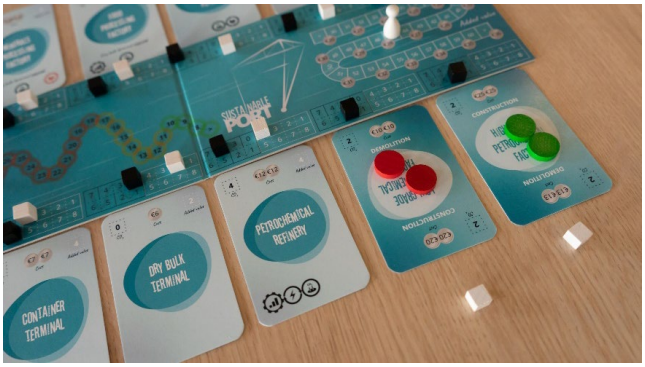

Figure 1: The *Sustainable Port* tabletop game.

The game is played in 10 rounds in which players need to develop their port towards a certain CO_2 target while maintaining a healthy economic added value. Each round players make decisions of the following types: build a facility, upgrade a facility, close a facility, and demolish a facility. Depending on what they decide, different cards and tokens are added to or removed from the tabletop where the game is played, and the score is changed. Tokens are placed on cards and the board and moved around to indicate: the amount of CO_2 that all facilities are emitting, the number of rounds before a facility is built or demolished, the amount of revenue that facilities earn each round, etcetera. Other tokens inform about CO_2 emissions and added value that a facility has or rounds left during its construction or demolition. All players make decisions at the same time and start new turns in unison.

Importantly, each round begins with the drawing of an event card, which affects the state of the board either now or in future turns. For example, an event card might inform players that in five rounds CO_2 emissions must be below a certain threshold, given new policy, or that a new technology has become available, which means that a new type of facility can be built. Four upgrades with limited availability are introduced during the game: process optimization, on-site renewable energy, CO_2 capture and storage, and CO_2 reuse. These can be used once per facility already built in the port; doing so increases added value or reduces CO_2 emissions of that facility. Added value total generated by the port determines the amount of money that the player gets in the beginning of a round (half of the added value plus five) and which can be used to make decisions. Players typically spend all the money they have each round, since the remainder does not carry over to the next round. By the end of round 10 each player should reach a CO_2 level less than or equal to 10 in order not to outright lose and their score is calculated as total added value minus total CO_2 emissions. The player with the highest score wins.

The Sustainable Port Video Game

The digital version of the *Sustainable Port* was developed by a team from Tilburg University, Netherlands in collaboration with The Barn, and a team from the Port. Players interact with mechanics of the game by using a computer mouse to interact with digitally rendered objects on a virtual tabletop. The video game takes up the entire area of a computer monitor, and its playing area is divided into three sections, each with its own distinct in-game purpose, which is meant to represent an important element of the decision-making ecosystem of the Port (Figure 2).

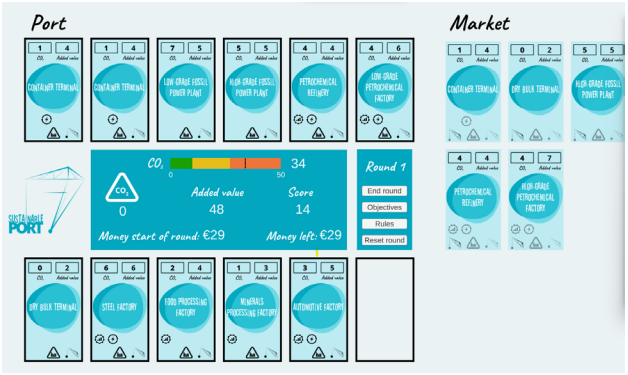

Figure 2: The *Sustainable Port* video game.

The first and largest area is "Port." It consists of twelve rectangles, which may or may not be filled with cards that represent a facility, such as a container terminal or a petrochemical refinery. Each card contains information about the facility, such as its cost, the amount of CO_2 that it emits, the amount of added value (revenue) that it generates, the number of turns it takes to demolish it, and whether it can be upgraded. Each turn players can choose to upgrade, begin to demolish, or do nothing with any of these.

The second section of the playing area is the "Market", which contains cards representing facilities that may be built in the twelve rectangle spaces of the "Port" area if they are empty. As the game progresses, new cards may be put into or taken away from the market as the result of game-related events or player actions. For example, if the player decides to build a dry bulk terminal, that card will be taken off the market. If an event of a technological breakthrough in biochemical production occurs in the game, an entirely novel facility type may be put into the market. However, unlike the board game, the upgrades are not in the "Market", but represented as icons on each facility card along with prerequisites for the upgrade.

The third section of the playing area is the information hub in the middle. Here are represented the score; sum-totals of added value and CO_2 generated by facilities each round; the amount money available this round for game-related actions, such as building, upgrading, or destroying facilities; the amount of money that will be made available at the start of the next round; and the round number. This area also contains pushable buttons, which allow the player to end their round, reset the round (reverting the board to its state at the beginning of the current round thus reversing all decisions made so far), and be reminded of objectives and rules of the game with pop-up text.

As in the table-top version, the game lasts 10 rounds. But the video game's design focuses on transparency of game mechanics, since, unlike the tabletop version, it is single player only. For example, events are not represented by a card-draw at the beginning of the round but appear as objectives each round in a text box. This and similar design choices facilitate data collection about gameplay and player behavior, but also have their downsides. A streamlined single-player video game eliminates discussion among players, perhaps making it more difficult for them to see important aspects of the complex decision-making that goes on in the Port. That said, the video game retains key aspects of the decision-making process that the table-top game had. The most important of these is the interplay between added value and carbon emissions of the Port. As in the table-top game, this interplay is a part of every in-game decision and constitutes the main measure of player performance.

Measurements

A total of 75 (Nmales = 27, Nfemales = 47, Nnd = 1; Mage = 21.2, SD = 3.40) participants were recruited to play the digital version of the Sustainable Port. Starting from the introduction of round 1, the players took on average 18.23 min (SD = 5.87) to finish the game; however this information does not keep into account the time required for the game's introduction and to read the instructions. First, participants were asked to read an informed consent form and sign it, if they still agreed to be participants. Then, they were asked to read the instructions for the *Sustainable Port* video game displayed on a computer screen. Once they read them and communicated their understanding by pressing a virtual button ("start the game"), the *Sustainable Port* at Round 1 appeared (Figure 2) on the screen and play started. Typically, the experiment lasted approximately 60 minutes. At the end participants are informed about their final score (added value minus carbon-dioxide emissions) and whether they reached the required CO_2 emissions threshold. Then they completed the System Usability Scale (SUS) questionnaire (Brooke 1996) and were also asked to answer to what degree they agree or disagree (7-point scale from "Strongly Disagree" to "Strongly Agree") with statements about the game they just played. For example, they were asked whether they became more aware of the complexity of Port dynamics, if they found the game entertaining, during which round they started to developed confidence about the game mechanics (in terms of where to click to perform which action), and if they were motivated to play the game; this specific variable was collected to evaluate if it has an impact on the score obtained and the awareness about port's dynamics raised by the game. The questions asked to the players at the end of the game can be found in the Appendix. Missing data for one participant that did not reply to one of the SUS questions and another one who did not fill in the port awareness related question were filled-in using an iterative imputer in Python, a method that considers the value of other features. The analysis reported where run transforming the Likert scale answer into number between 1 and 7.

RESULTS

The requirement of less than or equal to 10 CO_2 emissions in the Port was reached by 69 out of 75 players. This demonstrates that most players played the game as intended. The scores obtained by the players ranged from 0 to 57 (M =28.76, SD =16.95), summarized in Figure 3.

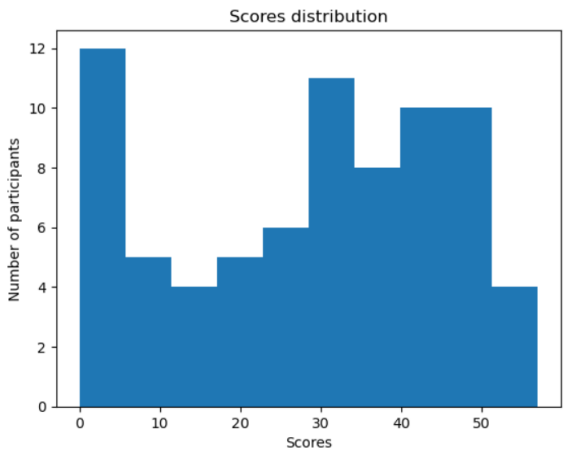

Figure 3: Total added value minus CO2 distribution across all participants.

The distribution of scores has a wide range with two clusters: a big cluster at the 35-50 range at the high-end of scores and a smaller cluster of twelve players at the lowest 0

end. We can infer from this that many players made in-game decisions that aimed to optimize the relationship between added value and CO_2 emissions, thus increasing their score. The other, smaller cluster of players indicates a style of play that prioritized either an added value increase at the expense of increasing CO_2 emissions, or the other way around. To assess whether this could reflect no engagement with the game at all the relationship between the time required to fulfil the game and the final score obtained was assessed, but insignificant (r = 0.10, p = .37). Further analysis, running a non-parametric Mann-Whitney U tests, to evaluate if the time spend playing the game and the players motivation can justify the difference between the players obtaining 0 and the players obtaining a score different than 0 suggests that there was not different in the time spent playing the game (U = 257.0, p = .52) between the first group (Mdn = 16.64) and the second group (Mdn = 19.40). The same result was obtained when looking at their motivation (U = 267.0, p = .62). Players who obtained a score different than 0 Mdn = 6). where not more motivated than players who obtained a score equal to 0 (Mdn = 6). Overall, 84 % of the players were to some degree motivated ("Somewhat agree", "agree", or "strongly agree") to play the game.

The game obtained a marginal usability score of 55.0 (SD = 20.2) suggesting that players had a procedural understanding of the game. Indeed, most players (68%) developed confidence in the game's mechanics before round 5 (N = 51) and only twelve reported no understanding of them at all. 61.3% of players found the game entertaining to some degree ("Somewhat agree", "agree", or "strongly agree"). Most importantly, 76 percent of players raised their awareness of the complexity of the decision-making process in the Port (Figure 4). This means that playing the game made players, in this case college students with little to no knowledge of maritime logistics and the Port's business, appreciate that the decisions made in a maritime port are complex and potentially difficult.

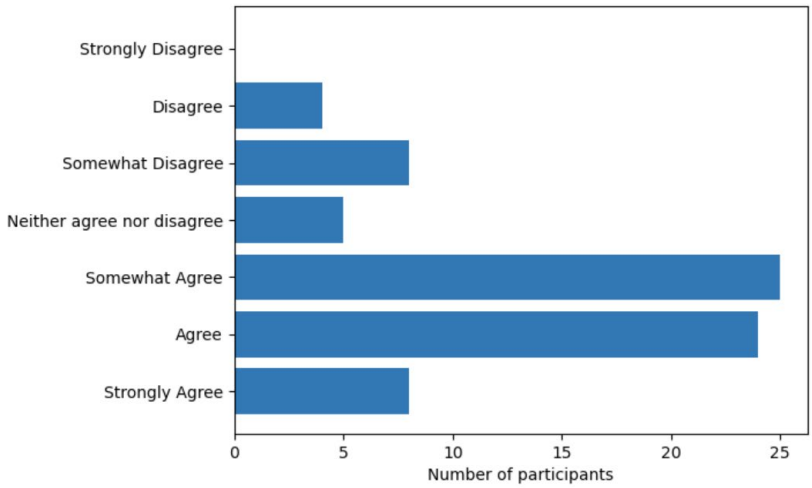

Figure 4: Player awareness level of port-related decision-making complexity on a 7-point scale

To further investigate the relationship between port awareness and the other variables of this study we ran a Spearman's rho correlation analysis. A significant positive correlation was found between the SUS scores and the 'port awareness' scores (ρ (rho) = 0.24, p = .04) and marginal positive correlation was found between 'port awareness' and motivation (ρ (rho) = 0.22, p = .06), but no significant correlations were found between the raised awareness and how entertaining the players rated the game (ρ (rho) = 0.17, p = .13) or the final obtained score (ρ (rho) = - 0.08, p = .47).

DISCUSSION

Given that the central feature of decision-making that was modeled in the game was the interplay between CO_2 emissions and added value, we can safely assume that players become aware of that aspect of this complexity. In other words, they become more aware of the way in which considerations that pay attention to shareholders interact with considerations that pay attention to other stakeholders, such as the general public that would be affected by climate change. The emergence of distinct clusters, and a high variability in the score, is also an indication that players deployed strategies in their decision-making, suggesting a high level of engagement with the game. We realize that there is more that may (and perhaps should) be added to make the *Sustainable Port* reach its potential as a morally engaging game. This is corroborated by our results, which show that players that perceived the game as has having better usability were more likely to have their awareness about complex decision making in port's environment raised. Therefore, further work on good design of the *Sustainable Port* with the moral sensitivity lens may raise awareness about the environmental aspects even more.

One key limitation of the *Sustainable Port* is its marginal usability, as indicated by the SUS score. That said, even in its current state the game makes players more aware of the complexity of the decision-making process in a maritime port faced with issues, such as policy developments and climate change. This complexity has a moral dimension. This is because it exists in the context where the in-game mechanics that create that complexity correspond to stakeholders' interests that are at stake in the real world, faced with climate change policies.

At this point of development, we expect insights about the direction of development to come in part from the results of behavioral experiments. One source of these will be player in-game actions and their features. Another will be physiological responses, including eye movements and facial expressions. Finally, we may use psychological measurements of morally relevant traits (Ryan et al. 2020) and other factors that determine individual players' decision-making styles.

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APPENDIX

Port-related awareness: *“The game raised awareness about the complex decisions characterizing a port's development.”*

Entertaining: *“I found the game entertaining.”*

Round when confidence in the game mechanics: *“During which round did you develop confidence in the game mechanics? (for example: which button or option is associated to specific actions)”*

Motivation*: “I was motivated to play the game at the best of my capabilities.”*