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STRATEGIC PLANNING: THE ROLE OF HYBRID MODELLING

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ABSTRACT

Strategic planning using simulation is an increasing field of practice mostly driven by the big consulting firms. While System Dynamics is a widely used simulation method in strategic planning given its advantage on global aggregates and deterministic model, hybrid modelling can achieve similar popularity. This paper presents some suggestions on how to use hybrid modelling in strategic planning.

1 INTRODUCTION

Strategic management helps companies to form their vision, analyze its internal and external environment, and select strategies to create value for shareholders and customers (Ireland et al. 2008). However, businesses are complex systems and operate in a dynamic environment. Consequently, it is challenging for managers to develop strategies for companies effectively (Kunc and Morecroft 2009). Under this circumstance, simulation can be a tool to support managers to make complex and challenging decisions, since simulation can predict both macro and micro business performance (Kunc 2018).

Traditionally System Dynamics (SD) has been used as a methodology to support strategic management and policy analysis (Sweetser 1999; Kunc et al. 2018; Kunc et al. 2018). Dierickx and Cool (1989) first pointed out that SD could assist strategic planning since the company's strategic assets result from accumulation processes over time. By using SD, managers understand whether the current strategy provides benefits over time and take actions to mitigate problems (Kunc and Morecroft 2007). To further evaluate the functionality of SD in strategic development, Torres et al. (2017) divided the use of SD in strategy development into three areas: testing strategy theories, learning and developing strategic thinking and assisting strategic planning within companies.

Although Hybrid Simulation is widely used modelling technique in business, after reviewing the literature, the application of Hybrid Simulation in strategic management has not been performed previously (Mustafee et al. 2017; Brailsford et al. 2019). Thus, the motivation of this paper is to propose a modelling development process to be used in business to support strategic decisions. In this paper, I used a case study of a betting company for illustrating the use of a hybrid simulation (HS) model to test strategies.

2 LITERATURE REVIEW

2.1 The role of simulation in strategic planning

Dyson and O'Brien (1998) argue that strategic development can be viewed as a feedback process for a corporate journey in which there is a similar need to set direction, look ahead, monitor performance, take corrective action and respond intelligently to changes in the environment. The feedback paths in strategic development can be viewed as learning processes. Whenever the outcome of an initiative does not work out as intended it suggests there was something faulty about people's original ideas and expectations.

However real-world feedback cannot always be relied on to alter people's strategic misconceptions because the relevant performance information is not available until implementation is well underway, and for one-off strategic decisions that is often too late (Kunc and Morecroft 2006). In order to overcome this issue, organizations may look for comparable cases elsewhere in the industry or even run pilot projects. However, the need for valid analogies brings us to modelling and its role in strategic development (Kunc and Morecroft 2006).

One way to use models is for rehearsal – to test strategic initiatives for their future impact before rolling them out in the organization. This modelling capability introduces a new feedback path in the strategic development process. Here strategic initiatives are fed into models of the organization specifically designed for assessing strategic ideas (Kunc and Morecroft 2006). Use of the models by the management team leads to an imagined outcome and virtual performance for comparison with strategic direction and goals. Such rehearsal introduces fast-acting 'virtual feedback' with which to adjust strategic initiatives in order to anticipate and avoid implementation problems (Kunc and Morecroft 2006). What can be imagined (and how vividly) depends on the modelling approach and the effort expended. Some models take the form of simple diagrams and maps while others involve simulations. Some models are particularly good for assessing a firm's positioning in a competitive industry while others are helpful for assessing internal strengths and weaknesses. Some models reveal problems of coordination between functions while others point to internal political barriers that may block initiatives.

System dynamics has been widely used for strategy support to test market growth (Forrester 1968), professional staff development (Kunc 2011), diversification (Gary 2005), and alliance formation (Kapmeier 2006) to name just a few. Such modelling work typically takes shape around dynamic behavior associated with the specific business change under investigation. However it is also useful to see modelling in the larger context of strategic development through which companies continuously adapt to a changing business environment.

SD can combine with the scenario theory, which considers the external environment dynamic of the company, to better assist managers to formulate and understand the strategies adopted in the firms (Torres et al. 2017). Kunc and O'Brien (2017) suggest a methodology that integrates the scenarios with the resource map to rehearse a firm's strategic performance using SD technique. Carlisle et al. (2016) evaluated and analyzed strategic planning in a complex coastal urban leisure space, using the SD model to test the robustness of the strategy.

One of the critiques to SD models is the treatment of systems mechanistically, so it is not an appropriate paradigm for modelling systems where individuals within the system are highly differentiated, or when behavior is best defined by people (and other entities) rather than the state variables themselves. SD is a "top-down" modelling approach, and thus requires extensive knowledge about how the state variables of the system interact with one another manner (Dooley 2002, p.10). Therefore, the use of additional modelling methods, such as Discrete Event Simulation or Agent Based Modeling, can provide more realism and support the analogies used to evaluate the strategies during strategic development processes.

2.2 Hybrid Modelling

In a panel paper given at the 2017 Winter Simulation Conference (Mustafee et al. 2017) Andreas Tolk defines a hybrid, technically speaking, as "… the result of merging two or more components of different categories to generate something new, that combines the characteristics of these components into something more useful. A mule is a biological hybrid, the crossbreed of a donkey and a horse with better endurance and a longer useful lifespan than its parents. Crops grown from hybrid seeds produce plants of higher quantity and quality than the originals. A hybrid car combines the advantages of gasoline engines and electric motors. Hybrids take two – or more – components and create something better. (Adapted from Tolk's section of Mustafee et al (2017), p. 1640).

With the development of hybrid models, Mustafee and Powell (2018) identified these three types of hybrid simulation model:

1. Models that contain both discrete and continuous elements, e.g. a model combining DES and SD.
2. A hybrid simulation model composed of elements that are either continuous or discrete, but not both, e.g. a model combining Agent Based Simulation (ABS) and Discrete Event Simulation (DES).
3. Type 1 joined with Type 2, e.g. a model combining ABS, SD and DES.

The most promising part of the integrated modelling approach is its flexibility that can handle dynamic and evolving requirements of a system. SD can deal with aggregates at the highest abstraction level while DES can be used at middle levels of abstraction and possibly at lower levels as well. ABS can be used across all levels of abstraction (Wang et al. 2014, p.78). An integrated approach using these three models can reflect the micro and macro changes that can vary depending on a situation, such as the implementation of a new policy after a project is underway (Jo et al. 2015, p.1866). Barabba et al. (2002) used the multimethod approach to assess the influence of a new business model which eventually helped in making correct strategic choices.

3 ILLUSTRATING THE APPLICATION OF HYBRID SIMULATION IN A COMPANY

3.1 The company

This case study is based on public information and it has been prepared as part of coursework so the development of the model is for exploring the issues related with the process of modelling rather than providing a forecast or an exact evaluation of a set of strategies on the future performance of the business. William Hill PLC is one of the world's leading gaming companies and the most trusted brands, enjoying around 25% of market share. It was founded in 1934 and has become the largest operator in the UK now. William Hill has several business divisions. Retail is the largest division which generates 54% of Group net revenue in 2017 (William Hill Plc, 2018). In retail shops, people can gamble on gaming machines, horse racing, etc. Online is the second important division generating 36% of revenue (William Hill Plc, 2018) where players can play Sportsbook, Vegas and Casino using the website.

3.2 Model conceptualization

Robinson (2008) states that, "Conceptual modelling is the abstraction of a model from a real or proposed system and is independent of the model code or software". In terms of modelling a company, Kunc has developed an approach called resource mapping (Kunc and Morecroft 2009; Kunc and O'Brien 2017) to represent the company as a set of accumulation processes involving financial, technological, operational resources leading to the accumulation of customers. Resource mapping lends towards the use of SD to model the whole system without too much detail, but DES and ABS are used to model some subsystems contained within the company in more detail.

For example, the number of *WilliamHillCustomers* and *WHOnlineCustomers* which are used in SD are from ABS and DES respectively. The ABS model includes market aspects which provide the amount of new *WilliamHillCustomer* as the output. The DES model contains new added online customers *completeAsANewCustomer* as the output. The SD model takes the customers change as the input and combines the financial, technological and operational sectors to assess the performance of the business systems. The information about financial, technological and operational performance is then taken back by the ABS and DES models as an input that influences customer's preferences. The development of William Hill's *OnlinePlatform* will affect the capacity to offer games to online customers and their level of service in DES.

An overview of the input and output parameters and their interactions that have been used to develop the tool is shown in Figure 1. The model has six sub-models divided into four SD models, one ABS model and one DES model. There is a sub-model for the financial sector that contains the information about the assets of the company, investment, marketing activities and link with the sub-model for the technological sector through the investments, as well as the operational sector. Finally, a SD model from the market sector is connected with the financial sector through the revenues generated. In the market sector, there is information about the average spent per customers and the market for gambling. However, the critical sources of information for this sector are originated from an ABS model of the potential market and a DES model for the behavior of customers in the online platform.

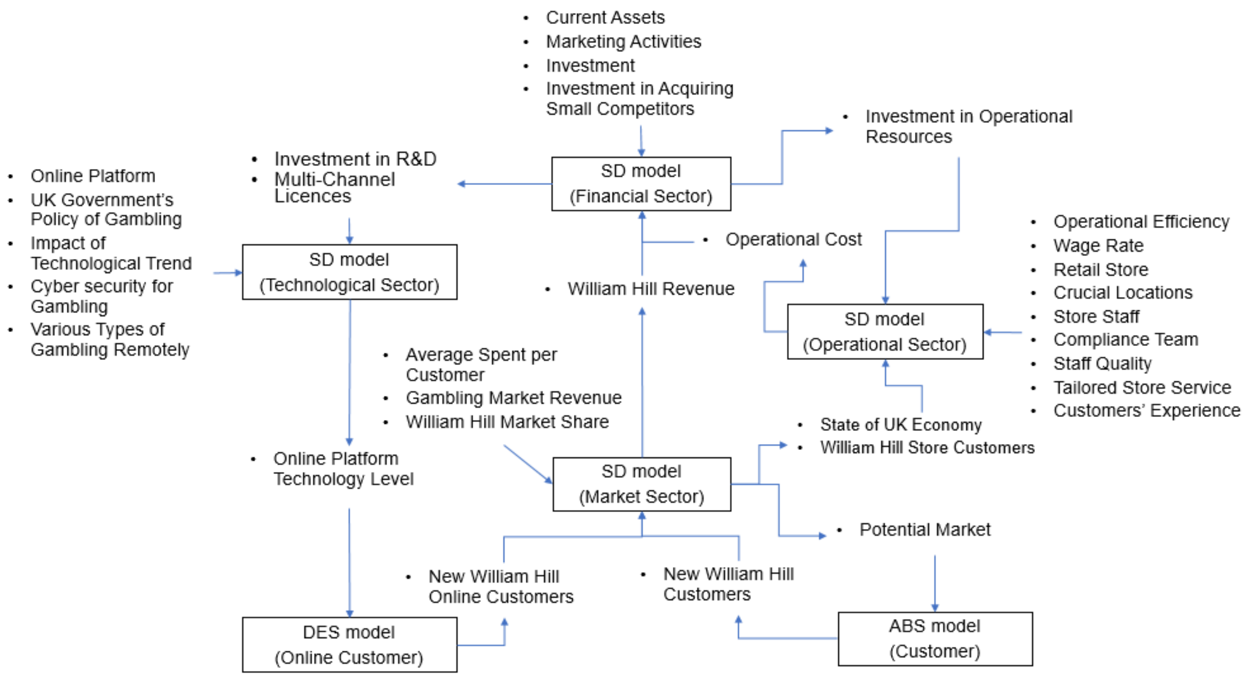

Figure 1: Conceptual model.

3.3 Model development

Figure 2 shows a screen shot for the financial sector. The financial sector accounts for investment on the operating licenses to establish betting products. The financial dynamic model is based on *CashInflow* from *WilliamHillRevenue*, and *CashOutflow* from I*nvestment* and *OperationalCost*. *Investment* includes *InvestmentinAcquiringSmallCompetitors* and internal investment comprised by *InvestmentinR_D*, *InvestmentinOperationalResources* and *MarketingActivities*. Investment rate is the proportion for each investment. With *InvestmentinAcquiringCorporations*, William Hill gets some *Multi_ChannelLicences* in different businesses. *WilliamHillRevenue* and *OperationalCost* are shadow variables selected from market dynamics and operational dynamics respectively to connect financial dynamics with other two.

Figure 3 presents a screen shot for the operational sector which focuses on Operational Costs and Efficiency. The former one contains Wages, Rents, Training costs and Fines, which all increase the variable *OperationalCost*, but operational efficiency decreases the cost. The *OperationalEfficiencyDecreaseRateOfEfficiency* depends on *OperationalEfficiency* with coefficient 0.5. *TrainingCostPerStaff* will improve *StaffQuality* and then improve the *OperationalEfficiency*, so does *InvestmentInOperationalResources*. *WageRate* is directly correlated with the *StateOfUKEconomy*. *ComplianceTeam* is a resource supervising operations in order to avoid fines (*AvoidViolationCostAbility*). The more *WHStoreCustomers*, the more *NetHiringStoreStaff* and *NetNewOpeningStores*, but the number of new staff or stores follow a goal-seeking behavior. *InvestmentInOperationalResources*, *StateOfUKEconomy* and *WHStoreCustomers* are shadow variables to connect operational dynamics and other two. *InvestmentInOperationalResources* is from financial dynamics and the others are from market dynamics.

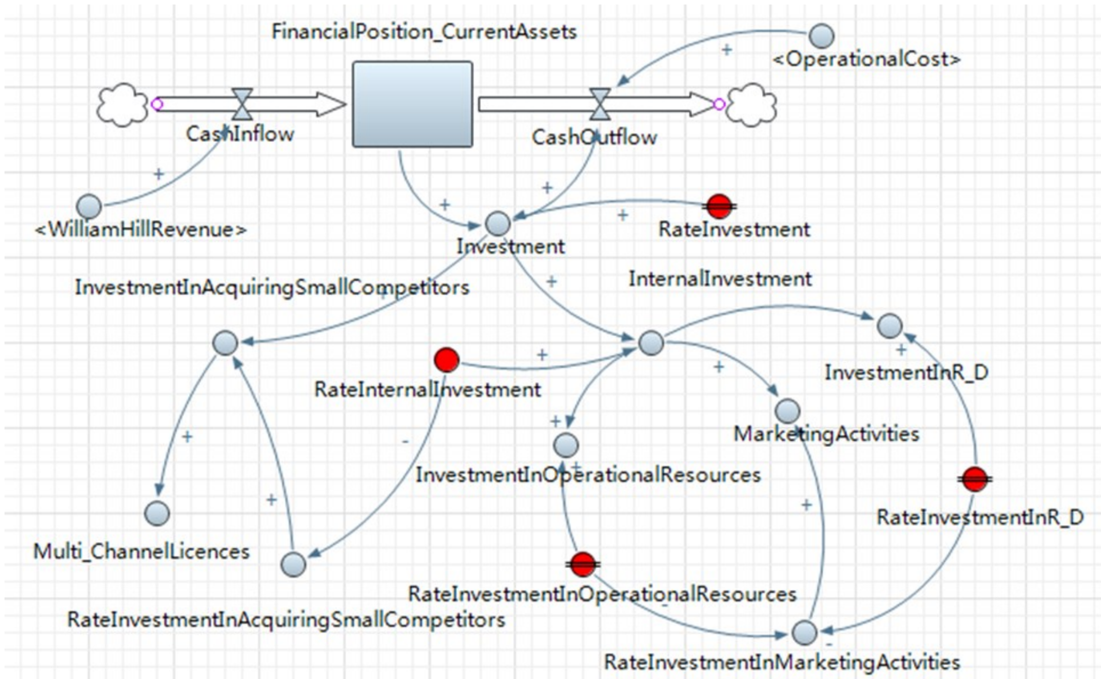

Figure 2: Screen shot of the SD sub-model Financial Dynamics in Anylogic.

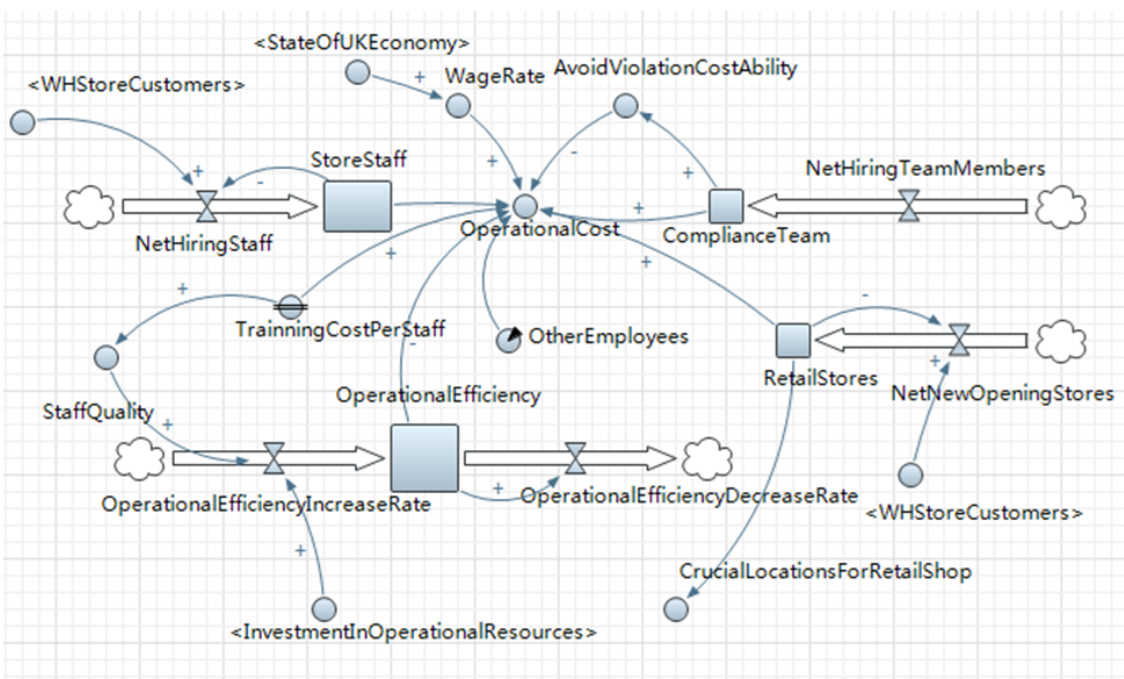

Figure 3: Screen shot of the SD sub-model Operational Sector in Anylogic.

The Technological sector focuses on the development of *OnlinePlatform*, which includes *EnsureOnlineGamblingSecurity* and *VariousTypesOfGamblingRemotely*. *OnlinePlatform* depends on *InvestmentInR_D*, *ImpactofTechnologicalTrend*, and *CybersecurityforGambling* (online payment and personal information security). *UKGovernmentRulingPartyPolicyOfGambling* and *ImpactofTechnologicalTrend* both have an impact on the variable *CyberSecurityForGambling*. The *TypesOfGamblingRemotely* is decided by the level of *OnlinePlatform* and the number of licenses together with the government policy on gambling. *InvestmentInR_D* and *Multi-ChannelLicences* are shadow variables connecting technological sector and financial sector. If William Hill increases the *RateInvestmentInR_D*, more money will be spent on technology development and the online platform will be improved. When William Hill acquires a company and gets a license that William Hill does not have, then it can run expand the offer on gambling to customers. The more licenses William Hill has, the more types of games it can operate. See Figure 4.

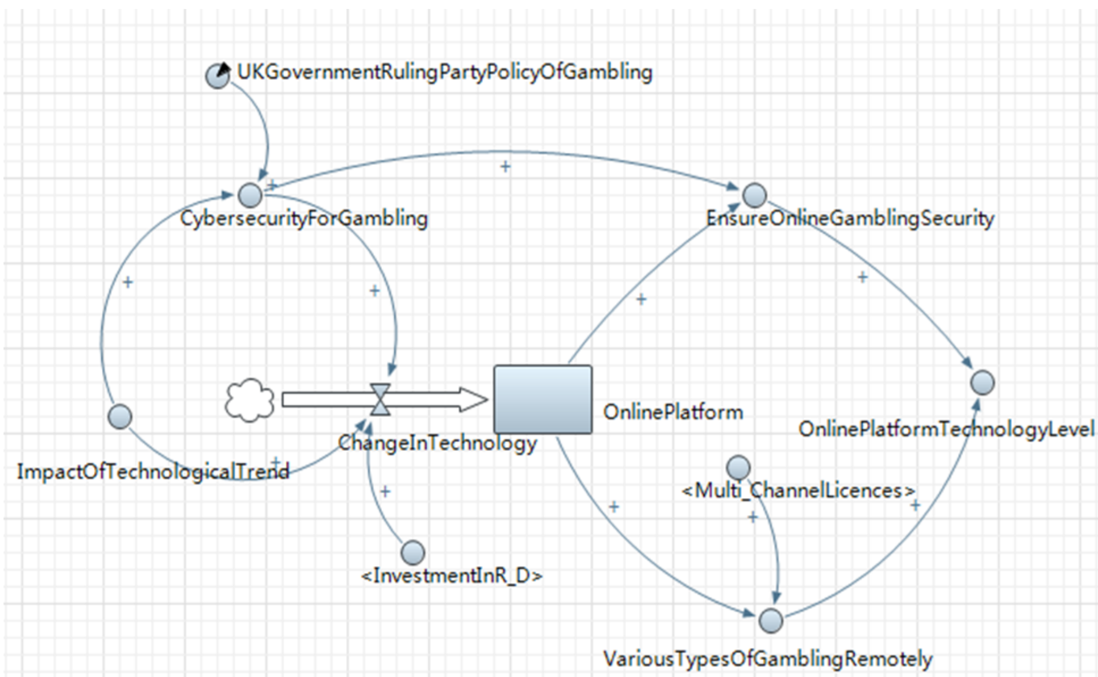

Figure 4: Screen shot of the SD sub-model Technological Sector in Anylogic.

The DES sub-model represents the process of gambling on the William Hill platform. See Figure 5. Like all gambling websites, it allows people to view the website and choose what they are interested in, but the online platform have website capacity which is affected by the level of online platform technology. With an increasing number of visitors browsing, searching, navigating or playing, website might become slow or irresponsive which could slow down the user experience. In more detail, customers are assumed to be an unknown number of people, who does not necessarily interact each other (so the choice of DES instead of ABS), that want to gamble on the website and they enter the process in accordance with an arrival rate. Then, they will spend 3 to 6 minutes to *accessTheWebsite* with a limited capacity so they sometimes need to queue. The website capacity is influenced by the Online Platform Technology Level. However, there is a probability (40%) that they will quit and leave. Since the playing time is not standard, time to play games follow a uniform distribution from 10 to 30 minutes. After playing the game online, those people become new loyal customers and an action is active to assign this value to stock of loyal online customers in the SD model.

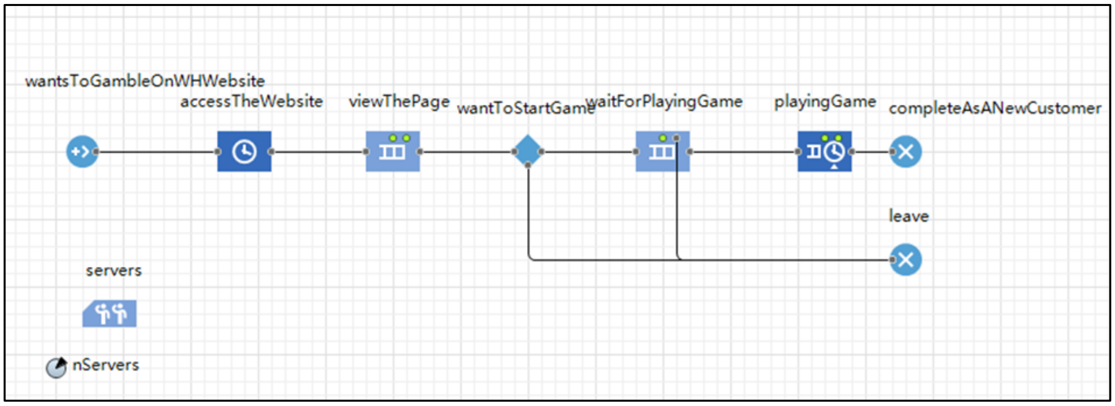

Figure 5: Screen shot of DES sub-model in Anylogic.

The ABS model is presented in Figure 6.

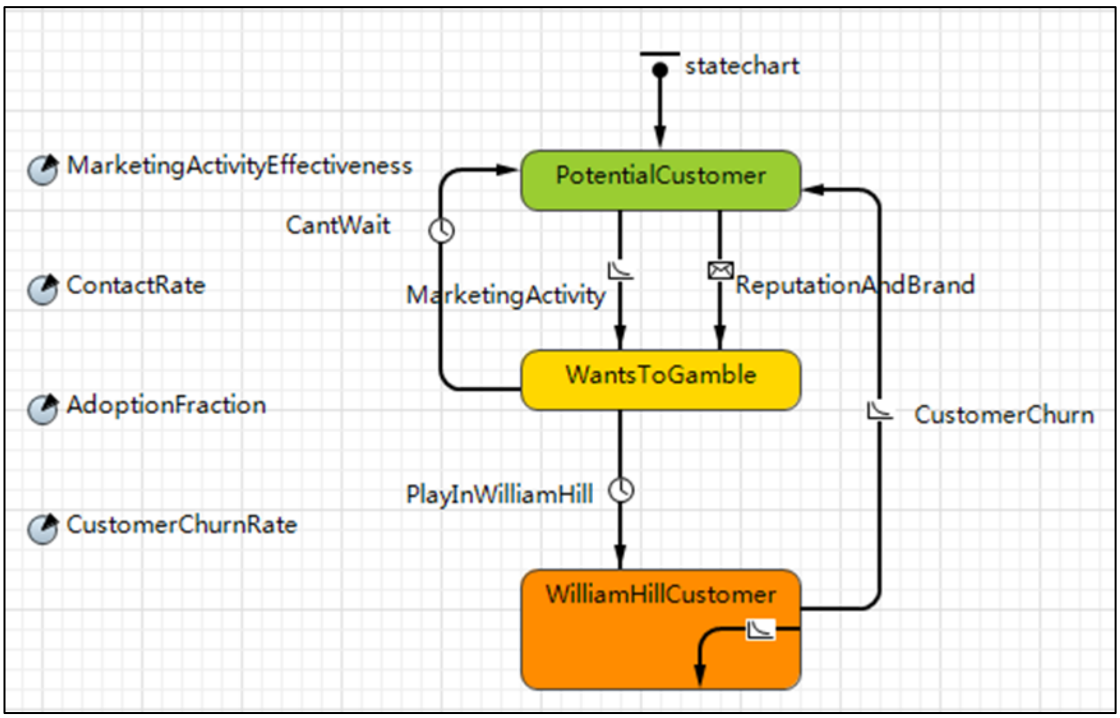

Figure 6: Screen shot of the ABS sub-model.

The ABS model starts with *PotentialCustomer*, where the agent animation appears in a flow chart in the Market Sector, the shape's colour is yellow green. The transition from *PotentialCustomer* to *WantsToGamble* in William Hill state reflects how *ReputationAndBrand* (message) and *MarketingActivity* (triggered by Rate, set at 0.01) lead to a future store customer (an agent) to gamble in a store owned by William Hill. When *MarketingActivity* and *ReputationAndBrand* influence an agent to gamble, the agent's state *WantsToGamble* becomes active, the state's Entry action is executed. *WantsToGamble* acts like a transfer station, because after people arrive at this state, they normally spend less than one hour to choose the next action – *CantWait* or *PlayInWilliamHill* and leave. Agents, who want to gamble, may leave and choose competitors' service if they wait too long, which is performed as *CantWait* (which follows a triangular distribution with an average of one day and a possible variation to up to 15 percent). Others will proceed to the state *WilliamHillCustomer*. Over time, *WilliamHillCustomer* may also switch to other companies, that is CustomerChurn. *NWilliamHillCustomer* is a variable which stores the William Hill's customers each year. This variable connects to flow *NumberOfNewCustomer* in SD. In the Market Sector page, the whole process of ABS model is visualized by a flow chart, once you click the agent animation in each state, the page will jump to the corresponding state in ABS model. *NWilliamHillCustomer* is a variable showed in Market Sector page which stores the William Hill's customers each year. This variable connects to flow *NumberOfNewCustomer* in SD. See Figure 7.

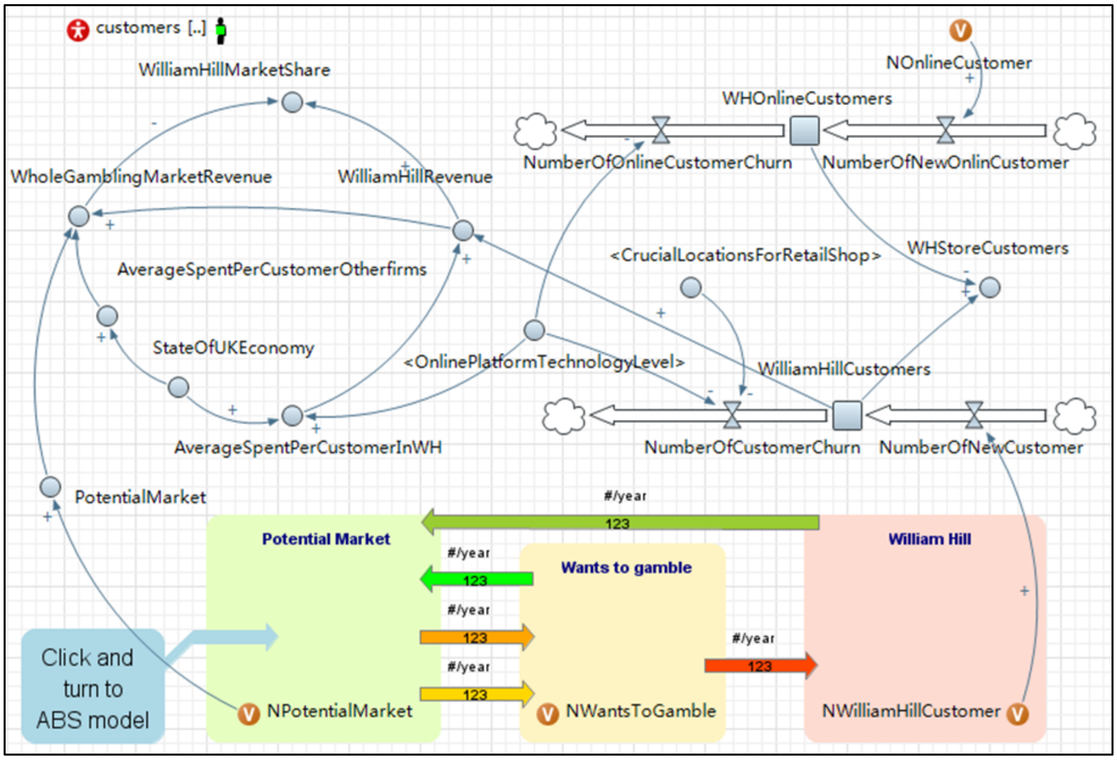

Figure 7: Screen shot of the SD and ABS sub-models' linkages.

3.4 Model implementation

The model is implemented in the multi-paradigm simulation software AnyLogic, which is the established platform for hybrid modelling (Brailsford et al. 2019). The simulation time is 14 years from 2014 to 2027 to test strategies in long term. The integration method is Euler+Newton, which is standard in Anylogic, and the dt is 0.0078125. The model includes all the process in the SD, DES and ABS components. The data was obtained from financial statements, websites and assumptions. While the linkages are presented in Figure 1, Table 1 has a more detailed information for the linkages.

Table 1: Linkages between sub-models.

Sub-model Origin	Sub-model Destination	Variable	Comment
DES	SD – Market Sector	*NOnlineCustomer*	This variable captures the agents that use the website and moves it as an inflow into the stock of Online Customers in the SD sub-model.

ABS	SD – Market Model	*NWilliamHillCustomer*	This variable captures the agents that play in store and moves it as an inflow into the stock of William Hill Customers in the SD sub-model
SD – Operational Model	SD – Market Model	*OnlinePlatformTechnology*	This variable links the resource Online Platform with the outflows from the Online Customers.

Validation and Verification (V&V) is an important part in any simulation modelling but it has not been well-developed in hybrid modelling and scholars tend to use one of the V&V methods existing in the modelling method of one of the sub-models (Braislford et al 2018). In this case, the approach taken was influenced by the process performed in the SD field. Firstly, the evaluation is the boundary adequacy and structure verification where the structure of the model is analyzed. The model represents the company using four areas: Financial, Operational, Technological and Market, which interact with each other. While Market has two sub-segments represented by DES (online customers) and ABS (store customers) models, the rest of the segments are based on SD using established methodologies, such as resource mapping (Kunc and O'Brien 2017). Secondly, there is an evaluation of the dimensional consistency and parameter verification together with behavior under extreme conditions. Most of the equations are dimensionally consistent but a number of variables are based on assumptions due to the lack of detailed data to behave correctly under extreme conditions; consequently parameters cannot be completely verified. Finally, the behavior of the model has been compared in terms of trends with aggregated financial data (4 years back) and it follows the growth trends.

3.5 Experimentation and Results

We used a TOWS analysis to design some suitable strategies, which were implemented into the model, (Kunc and O'Brien 2017). TOWS analysis involves the development of a matrix where the Threats and Opportunities arising from the analysis of the external environment are matched with Weaknesses and Strengths of the company to generate strategies (Weihrich 1992).

One strategy is called "increasing compliance by direct supervision of operations". The company remains committed to maintaining the standards required in all of its licensed regions. Holding licenses in key markets is an important part of William Hill's development strategy. In addition, it is also essential to carefully manage the regulatory complexity of multiple jurisdictions. In order to continuously monitor the changing legal environment and adapt its strategy to regulatory changes on a country-by-country basis, William Hill needs to maintain dialogue with regulators and other key stakeholders in internationally licensed regions. Given the breadth and scope of the William Hill business, as well as the multiple regions and regulated markets in which it operates, it needs sufficient talents to master the comprehensive knowledge to meet business needs. Currently, William Hill has established compliance processes and controls throughout the group. The compliance function is independent of operational management to support management's compliance obligations and to ensure compliance meet local requirements (William Hill Plc 2018). The method to test this strategy is to increase the resource associated with the Compliance team and to show an improved ability of avoid fines. These changes mainly affect operational costs.

A critical variable in the model is the patience of the customers, which is captured in the variable *MaximumWaitingTime*, that affects their acceptance of the level of service provided by the company that depends on the investment in resources. Figures 8 and 9 show two screen shots of the interface for experimenting with different values and their impact on the performance. This is approach is usually used to engage the models with the final users (Kunc and Kazakov 2013).

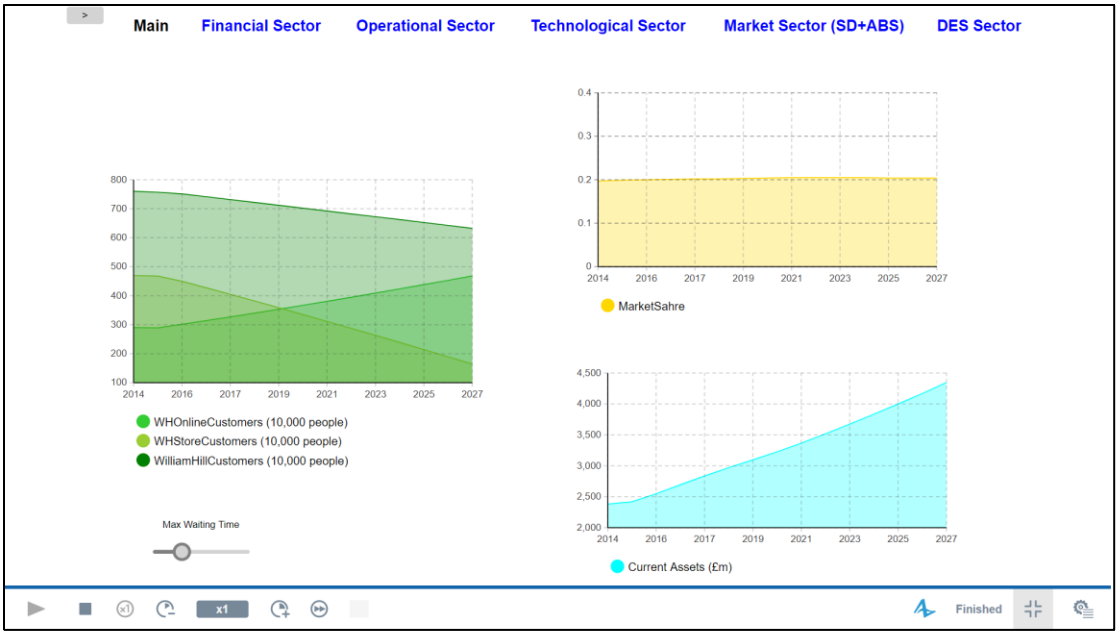

Figure 8: Simulated results: Customers expect to play quickly.

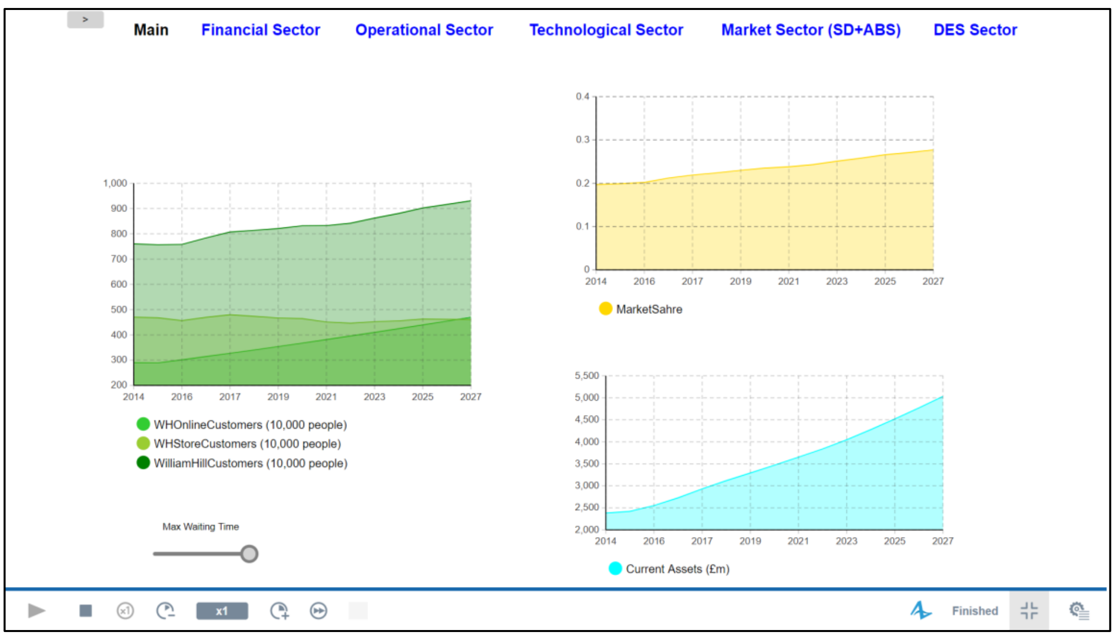

Figure 9: Simulated results: Customers can wait for a while to play.

4 CONCLUSIONS

Firstly, previous studies have illustrated that the hybrid modelling can enhance the strengths of each individual simulation method and the ability of simulating the complex system (Morgan et al. 2017). However, few papers provide a theoretical framework for designing a three-paradigm hybrid model. This study introduces the general process of developing HS models for strategic planning, which contributes to hybrid modelling from a practical and technical perspective.

Furthermore, this study is the first application integrating three major simulation methods to analyze a complex business issue, such as one strategy. The hybrid solution combining SD, DES and ABS to evaluate a complete company according to the concepts of strategic management, e-commerce and marketing is demonstrated step by step, which can be used for further research and application. This study verifies the capability of hybrid modelling in a real-world system application and shows its practical significance in addressing business problems.

In this study, the model results have similar trend with official reports, but not all of data have reliable sources for model configuration. So, the next step may be to align the model with other models that capture operational characteristics better. The comparison of the results to models will help to improve the robustness of this model.

Another limitation may be the complexity of DES and ABS in the hybrid model. Current DES and ABS are simplified due to limited understanding of individual behavior, limited availability of appropriate microdata, and the difficulty of quantifying factors. If the gap between knowledge and data can be bridged, complex proxy decision rules will be developed to explore complex research problems with more refined models.

4.1 Future research

One of the characteristics of companies is the existence of different levels of analysis: operational and strategic. These levels occur at different level of detail, e.g. micro processes for operations and macro processes for financial issues, and at different times, e.g. operations occur instantly but decisions for investment may be sporadically. Therefore, this conceptual paper generates some interesting issues, which were identified by the reviewers, for the design of HS models that contemplate the complexity existing in companies such as time, linkages between models/sectors, use of discrete and continuous variables, integration methods and time steps. Future research should take into consideration and provide answers to these issues.

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