AGENT-BASED SIMULATION AND THE AUDITOR GOING CONCERN OPINION – A CASE STUDY OF FRONTIER AIRLINES

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Abstract

The complex and interconnected world in which organizations operate presents many challenges to organizational sustainability and the traditional approaches audit firms use to assess the ongoing viability of their clients. We propose agent-based modeling (ABM) as a viable tool for auditors to account for the interaction of local and environmental factors to determine organizational success. To illustrate, we developedan ABM of the 2007 consumer airline market for Frontier Airlines. Frontier is impacted in the model by internal policies, competitors, and environmental factors such as fuel costs, federal regulation, and credit availability. The model incorporates this myriad of factors to simulate the market for a single year and produces an anticipated market share. The model estimated a 17.64% average market share for 2007 over the course of 90 runs – less than 0.20% different than actually earned by Frontier.We conclude with a discussion on how ABM can be effectively incorporated as a decision support tool into the going concern opinion auditors are required to issue on U.S. public companies.

Introduction

Today, organizations face a completely new business environmentthat is complex, service-oriented, connected, global, in a constant state of flux, and built on individual and organizational knowledge. In this new knowledge-based economy, interactions with customers, clients, regulatory agencies, diverse financial markets, political bodies, environmental organizations, etc. impact long-term success more so than ever before. Commonly referred to as "wicked" problems (Rittel and Webber, 1973) or ill-structured problems (Mason and Mitroff, 1973), these decision-making scenarios are highly uncertain, difficult to define, inextricably connected to their environment, and possess irreversible solutions. However, decision makers' traditional knowledge sources and endowments may not be sufficient (Rodgers et al., 2008) to address problems that are more socially-oriented and are thus considered semi-structured or unstructured.

This complex environment poses a significant problem to the public accounting firms tasked with auditing public companies in the U.S. The Statement on Auditing Standards No. 59 *The Auditor's Consideration of An Entity's Ability to Continue As a Going Concern* (SAS 59) requires auditors to gain an understanding and assess existing conditions that affect an organization, including those of others in the industry and the economy in general. From an auditor's perspective, that means there are more variables than ever before that must be considered when assessing their clients' ability to continue on (i.e. are they a going concern?). Why is this important? When companies fail shareholders look to someone to assume blame and financial recompense. Unless there has been fraud, the management team cannot be held personally liable for bankruptcy.

Once the company has entered bankruptcy the chances that shareholders will receive much, if any, of their initial investment are slim. That means the auditor is a natural target for lawsuit. If the auditor issued a favorable going concern opinion (i.e. does not expect the company to fail within the next 12 months) and the company in fact goes under, shareholders can (and have) sued for negligence. The question becomes, how can auditors wrap their minds around so many factors that may affect a client's future business prospects? Research has shown that the human mind struggles to capture and process excessive amounts of information and have difficulty "connecting the dots" of cause and effect relationships when numerous factors come into play in a decision-making scenario (McKee, 2003; Kuhn et al., 2010). Courtney (2001) called for a new decision-making paradigm for decision support systems to adequately address wicked problems in complex contexts that brings in the perspectives of many stakeholders. This provides greater insight into the nature of the problem, relationships among the connected elements in the wicked system, possible solutions, and downstream effects of implementing various solutions. In this paper, we identify a simulation tool (Agent-Based Modeling) specifically designed to examine the interactive effects of multiple stakeholders (i.e. agents) and discuss the use of it in an illustrative case study. ABM assists in the discovery of patterns a "system" can potentially take. Thus, our case study explores the future possibilities for Frontier Airlines, a discount airline, based on the simulation results from the ABM.

Research Problem and Background

Although not explicitly expected to predict future conditions or events by auditing standards, auditors historically have relied upon bankruptcy prediction models due to the ease of use and ability to fall back on a model rather than mere gut feeling. The most common one used in practice is the Altman (1968) Z-score model (Dugan and Zavgren, 1988; Grice and Dugan, 2001; Grice and Ingram, 2001; McKee 2003). However, McKee (2003) notes that the common bankruptcy prediction models have an inherent flaw where they do not necessarily account for the cause and effect relationships between factors (i.e. interactive effects) that may be a major cause of or at least related to the bankruptcy. That same study examined 146 U.S. public companies that filed bankruptcy during 1991-1997. In only 54% of the cases did the auditors actually report a going concern problem.Other research asserts that the models auditors employ rely on restrictive assumptions such as linearity, normality, and independence among predictor variables (Zhang et al., 1999). In particular, the accuracy of the Altman Z-score has been called in to question (Grice and Ingram, 2001) as have other frequently-used models, the Zmijewski(1984) and Ohlson(1980) models (Grice and Dugan, 2001). All three models have been shown to suffer from the inability to generalize across industries and time periods other than the data originally used in the development of the models (i.e. where U.S. manufacturing firms dominated).

The business environment most definitely has changed and now consists of connected knowledge-based organizations and economies that require more holistic research approaches. Auditors are not required to use statistical modeling techniques for the going concern assessment. Some choose to perform analytical procedures such as historical trend analyses on operating losses, working capital deficiencies, negative operating cash flow, and adverse key financial ratios. They augment these financial reviews with examination of operational factors (e.g. labor work stoppages and dependence on the success of particular projects) and external circumstances (legal proceedings, changes in legislation, loss of a principal customer or supplier, or a natural disaster) and of course their own personal experiences with the client as well as past clients. Discussions with three partners from an international public accounting firm highlighted that every client is unique and therefore factors may be weighted differently in their assessments from client to client. However, all three agreed the primary indicator of potential business distress relates to the ability to pay short-term debt. Therefore, the level of working capital (current assets – current liabilities), operating losses, and cash from operations receive the most attention. Driving working capital is the ability to generate sales that can be converted to cash. Thus, a key component in an auditor's going concern assessment is the anticipated percentage of sales in the industry or industries in which the company operates relative to its competitors – commonly referred to as expected or projected market share. Our ABM is designed to produce an estimated share of the airline market that Frontier will earn in 2007 based on the interaction of consumers, the airline's internal policies, competitors, and environmental factors.

Agent-Based Modeling Simulation

ABM is a stochastic simulation modeling approach that provides the unique capability to explore the non-linear, adaptive interactions inherent to complex systems(Srbljinovic and Skunca, 2003). When creating an ABM, the researcher must clearly identify and program the individual agents in the model make decisions and how they interactwith other agents and the environment.

Patterns or structures (i.e. trends) may emerge at the system-wide level due to the actions/interactions of these agents and the environmentat the lower level. This allows the user of the model to identify possible system states that may not have been considered otherwise, thus enhancing decision making effectiveness (Kuhn et al., 2010). Some unique advantages of ABM include 1) the possibility of modeling fluid or turbulent social conditions when modeled agents and their identities are not fixed or given, but susceptible to changes that may include birth or death of individual agents, as well as adaptation of their behavior; 2) the possibility of modeling boundedly rational agents, making decisions and acting in conditions of incomplete knowledge and information; and 3) the possibility of modeling processes out of equilibrium (Cederman, 1997).

Next, we present the details of an ABM designed to assist in estimating the market sharefor the routes that Frontier Airlines serviced in 2007. This key figure would help auditors better predict next year's revenues which is the single most important line item on the income statement as it drives financial performance. The model includes agents that represent the consumer travelers, Frontier Airlines itself, United Airlines (the primary competitor in Frontier's markets), the collective group of other airlines servicing the same routes, and the environment (proxied with agents for fuel costs, federal regulation, and availability of credit).

Frontier Airlines ABM and Simulation Results

Frontier Airlines is a discount fare based in Denver, Colorado and services the U.S., Canada, and Mexico. At Denver International Airport (DIA)Frontier only lags United Airlines in market share. For the previous several years, Frontier has increased its year-over-year capacity significantly by expanding in to new markets and creating additional routes to current markets. As a heavily-regulated industry that services the general populace and is susceptible to external forces (e.g. oil prices), the airline industry (and Frontier, specifically) presents an interesting topic for ABM simulation. We programmed the Frontier ABM model using the Recursive Porous Agent Simulation Toolkit (Repast Symphony). Unlike all other ABM software, Repast offers a Visual Editor option where the developer can create decision trees similar to flowcharts that automatically create underlying Java program code (see Appendix A for a screenshot). There is no need to know how to program computer code. Our ABM was created completely in the Visual Editor and is now being used as an examplar in the ABM and Repast training sessions held at the Argonne National Laboratory. Following simulation modeling best practices, an ABM developer and Repast instructor at the Argonne assisted this project by performing structured walkthroughs of the code to verify the programming worked as intended.

Agents in the Model

The concepts of agent memory and decision rules lie at the foundation of any ABM. In the Frontier model, both consumer and airline agents 'remember' past experiences and apply simple decision rules when considering future opportunities. For example, once a consumer who has traveled recently decides to travel again, the consumer agent looks to see if the last experience was good or bad. If good, the consumer flies with the same airline and the trip will be registered as good or bad, affecting the next decision. If the last trip experience was bad, the model looks at how frequently the agent flies (i.e. customer loyalty such as frequent flyer programs) to determine if the agent might be susceptible to switching airlines. The environmental agents, on the other hand, are considered "proto-agents" in that the environment only "behaves" and does not change behavior due to the actions of consumers and airlines.

Consumer agents only care about personal consumption satisfaction and the decision time frame can range from one week to a year. The frequency of travel (a probability) included in the agent decision rules was based on a research study of airline consumer traveling frequencies conducted by the Cornell University School of Hotel Administration(D. K. Shifflet, 2008). After deciding to travel, consumers base purchase decisions on past purchasing behavior (who they flew with) and related experiences (was it good, bad, or neither).

Airline agents concentrate on attracting as many travelers as possible to increase revenue. Looking at the Denver market since that is where Frontier operates its sole hub, United dominated the with 56.4% of all passengers while Frontier earned 20.7% and the remainder was split amongst a number of other airlines (City and County of Denver, 2006). Therefore, we created airline agents for United, Frontier, and Other. The airlines in the model are not simple bystanders in the sense that they wait for consumers to decide to fly and then with whom to fly with. Through advertising,the airlines may persuade some consumers to switch airlines (from the previous trip) or solidify existing consumer loyalty. Similar to real life, money for advertising does not come from an infinite pool.

Airlines therefore conduct marketing decisions on a regular basis throughout the 52 week simulation, analyzing their current market share compared to internal goalsas well as monitoring the environmental factors that can affect the availability of capital.

By nature, the airline industry is extremely sensitive to external economic and environmental factors that can drastically impact ongoing operations and financial stability of the airlines. Based on discussions with an executive at one of the largest U.S.-based airlines, we identified three primary external factors that every airline is subject to and created proto-agents for each to represent the environment that the model agents will interact with. Fuel costs represent the single largest individual operating expense item for nearly every airline and Frontier is no exception (Frontier Airlines Holdings, 2006; 2007). Both the Frontier and United 2006 annual reports comment that heavy federal regulation resulted in operating cost increases in the past and may do so in the future. Again, noted in both the Frontier and United 2006 annual reports, both suffer from minimal available credit and must rely on existing cash and generation of operating cash flows to support operations. How does an airline earn cash? Through revenues – hence the need for auditors of airline companies to fully understand the impact of these external factors on their clients' future viability. These three environmental agents each randomly start with a dichotomous value of good or bad (which collectively affects how the airlines make advertising decisions) then have the potential to randomly change throughout the 52 week simulation.

Simulation Results

The Frontier ABM simulation is designed to generate a market share percentage that the company could potentially earn over a 52 week period. Inherently, future system states of a complex environment can vary wildly based on the non-linear interactive effects of agents and the environment. Therefore, numerous 'runs' of the ABM are required to discover a general trend or most likely outcome (North and Macal, 2007). Furthermore, scaling could be important to the results so differing the numbers of agents included in the model is also necessary. For our simulation, we executed 30 runs in succession as a 'batch' and nine batches total that differ based on the total number of consumers (1,000; 10,000; and 100,000) as well as the states of the environmental factors (unconstrained, all set to good, all set to bad). Allowing the factors to be unconstrained (start with a random value and can change over time) provides a most likely scenario.Forcing the factors to remain at certain levels allows the modeler (or auditor) the ability to identify worst and best case scenarios.

Tabulation of the unconstrained model results identified an expected market share for Frontier that ranged from 15.74% - 19.33%, with an average of 17.64%. The Bureau of Transportation Statistics reported that Frontier actually earned 17.46% of the market share for the routes serviced (Bureau of Transportation Statistics , 2008). Thus, the most likely scenario the model generated was very close to what actually occurred. The worst case scenario where the environmental conditions prevented Frontier from advertising due lack of available funds resulted in Frontier earning 16.03% of the market. An independent-samples t-test comparison of mean values revealed that the two sample means are statistically different ($t = 14.782$, $p < .01$). The best case scenario allowed Frontier to advertise at will, whenever the agent felt the need, due to an unlimited supply of funds. This group of runs produced a 21.25% market share for Frontier. Once again, an independent-samples t-test comparison of mean values revealed that the two sample means are statistically different ($t = -35.388$, $p < .01$). These two analyses indicate that the ability to advertise due to environmental factors can statistically impact, negatively or positively, Frontier's ability to attract new and/or retain existing customers.

Discussion and Conclusion

Historically, financial auditors of public companies have relied on outdated, unrealistic bankruptcy prediction models and/or key ratio analysis and 'gut feel' when evaluating the going concern status of their clients. Incorrect opinions can result in costly lawsuits filed against the accounting firm by disgruntled shareholders. Substantive research has shown the bankruptcy prediction models are inaccurate and the human mind struggles to comprehend cause and effect relationships when numerous factors interact in a decision-making scenario. We propose that auditors take advantage of advanced information technologies such as agent-based modeling that are designed to capture these complex interactions and can handle massive amounts of data in order to assist in decision-making. To illustrate, we developed an ABM simulation for Frontier Airlines that generates an anticipated market share percentage that the company could potentially seein the subsequent year. This would aid the auditor in estimating the most important yet most difficult to determine financial line item of them all, revenues, when developing their mandatory going concern opinion.

After many simulations, the ABM produced a most likely market share for the next year that was only 0.17% higher than what Frontier actually earned in 2007. Furthermore, we were able to identify a worst case scenario that the auditor can use to see what may happen to the company financially should this come to fruition. Many times, companies present a very rosy picture of the future in the annual report's Management Discussion and Analysis section. The best case scenario would allow the auditor to determine if the company's projections are reasonable. Overall, the Frontier model and analysis described in this paper illustrates some of the advantages and capabilities that ABM can offer in a complex decision-making scenario. Thanks to software like Repast, the creation of an ABM is relatively simple since no programming experience is required. This makes the use of ABM a more viable option to audit firms as well as other organizations that face complex decisions.

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APPENDIX A: REPAST S SCREENSHOT