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Career-centric, student-specific and supply chain-oriented simulation for Business School Students: The Milk Distribution Game Experiment

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Abstract: Globalization, evolving technologies, workforce demographics and the recent pandemic are the major contributors to the career choices business school students have and make across the world. The business school education, traditionally, has been using interactive lectures, case- studies, and project-based approach to impart knowledge and career specific-skills. Off late and in certain contexts, to enhance hands-on learning, simulation tool has been found to be more effective. In this article, we focus on a simulation game called the Milk Distribution Game (MDG), which is an extension of the famous Beer Distribution Game (BDG). We have developed the MDG to help students learn the career aspects of the supply chain industry, which includes, pricing, inventory, distribution, and time-management. The MDG extension entails addition of three products, milk powder, condensed milk, and clarified butter (Ghee), instead of one in the BDG, and a limited raw material as milk. The simulation experiment required the students to understand the original BDG, and successfully articulate the dynamics of supply chain's bullwhip effect of the MDG. We conclude by discussing the career-centric applications of the MDG that demonstrates the cascading effect of hype in the demand of one product and its respective influence on the rest of the supply chain participants.

Keywords: Career-oriented teaching, simulation, experiential learning, bullwhip effect, Milk Distribution Game (MDG), Beer Distribution Game (BDG).

Introduction

Today's dynamic industries and economy demand a unique blend of skillful, knowledgeable, and career-focused professionals (Betsy et al., 2013). The notion that is often cited while discussing about the fresh graduates and their career prospects claims that the current economy does not have enough jobs for fresh students, however, this notion was debunked by the research conducted by the Center for Education and the Workforce at Georgetown University, which emphasized that industries have been creating a lot of jobs which required well trained and career-specific candidates (Betsy et al., 2013; Carnevale, Smith, & Strohl, 2010). Zinser (2003) emphasized on the consensus that employability skills and career aspects should be taught in high schools, and that can be achieved through education and business partnerships. Similarly, a career-focused training and education would assist students to choose their preferred professional path and further help them to focus on a specific industry of their choice (Catherine et al., 2017). A study conducted for entrepreneurship education by Rodriguez et al., (2020) highlighted that entrepreneurship focused education had significant and positive contribution to students' critical thinking, problem-solving, communication and collaboration abilities.

The presented research focuses on business school students' experiential learning and its impact on their career choices and career growth. For the part of experiential learning, we focus on the technique of simulation, which provides students with hands-on experience of different business-related decision-making choices to represent a real-life business scenario. Sierra (2019) studied the usefulness of simulations for learning economics, the study revealed that students had a changed understanding about the real-world problems' complexities, and they were in a better position to comprehend the details of problems at hand through simulations.

The research focuses on the simulation-based supply chain-centric experiment, which is based on two important points, one is the bullwhip effect and the second is the famous Beer Distribution Game (BDG), developed by Massachusetts Institute of Technology. Bullwhip effect plays a significant part in understanding of the supply chain mechanism (Sukcy, 2009). The bullwhip effect disrupts supply chain management and increases costs at each level of the flow of materials (Ouyang and Li, 2010). The business school students, while learning about bullwhip effect would gain insights on career-focused aspects such as dynamic pricing, customer service, inventory management, production schedules, transportation challenges, revenue generation and timely decision making (Wu and Katok, 2006)

The bullwhip effect can be better captured by creating a simulation and analyzing the outcomes during the process (Chatfield, 2012). The BDG described the bullwhip effect in demands at various levels of a supply chain, further, BDG puts forward various hidden problems that arise in the system of the flow of goods to consumers (Paik and Bagchi, 2007).

In the present research, it is endeavored to study the impact of the bullwhip effect in two scenarios. One is by adding backward integration in terms of raw material in the supply chain and second is analyzing cross-section impact in multiple products. In the real world, common raw material serves multiple industries and an increase or decrease in their supply creates a different impact on these industries. Similarly, increased demand for one of the products of these industries may have effects on the others. These factors have not yet been studied through the extensions and variations made in the BDG. Our research, therefore, focuses to develop a model that can gauge the impact of these modifications, which can be further utilized to study the bullwhip effect in supply chain management.

To provide the business school students with career-focused experience, we have designed a simulation which is an extension of the BDG. We call this extended simulation Milk Distribution Game (MDG), which models three supply chains of three different products, with a common raw material – milk. The three products are Clarified Butter (Ghee), Condensed Milk and Milk Powder. Detailed information on the MDG, the experiment set up, details of the student participation, important results and career-focused learning are discussed further.

Literature Review

Contribution of effective teaching for preparing business school students for desired careers has been acknowledge by Mittendorff et al. (2012) and Brekelmans et al. (2005). To understand the teacher-student relationship and its effect on career prospects, we did investigate a several researchers works quoted here. Wells (2007) emphasized that teachers should build meaningful connections between and among experiences, ideas, and texts. Jago (2008) and Romano & Chambliss (2000) mentioned that it is very important for a teacher to deliver the learning and experience in such a way that it is perceived as authentic by the students. Gray et al. (2021) created a Career Student Planning Scale to understand college students' career planning, the study highlighted that planning for the future careers would help students face fewer career difficulties, and it would provide students with practical information and confidence about the career directions.

With increasing scope of Supply Chain Management (SCM), simulation is widely used by researchers to unveil complex problems present in the chain. Oliveira et al. (2019) studied the role of simulation and optimization methods in supply chain risk management and concluded that flexible and hybrid optimization using simulation models could improve the organization's decision-making process. Use of simulation tool helps to critically analyze the complex SCM decisions and is also helpful in understanding the rationale of the decision makers in adopting a policy or a process (Spagnoletti et al., 2014). For instance, company A, a global manufacturer of high-tech products, has a plant in Singapore, the company aims to improve its supply chain efficiency and thereby its performance in

terms of inventory management and forecast accuracy, a study conducted using discrete simulation modeling, explained that due to the seasonal uncertainty of demand the service level of the company remains low (Cao & Zhou, 2018).

A simulation model has been developed for the supply chain of food enterprises and was used to study the quality management in the network. The results, as proposed by (Li & Song, 2009) illustrated that rewards and punishments drove the force of quality management for the food enterprises. However, the research assumed that higher quality resulted in higher revenue for the enterprise owners, which proved to be the incentive for quality management. Yu et al. (2019) analyzed how unexpected changes can disrupt the SCM and therefore emphasized the need for better SCM. The supply chain collaboration can be effective when the supply chain processes adopted were assessed regularly and a continuous performance improvement was practiced by the organizations (Ramanathan & Gunasekaran, 2014).

El-Tannir (2017), used simulation to validate the mathematical model, which yielded surprising results for implementing a new strategy to reduce the bullwhip effect in the conditions where information sharing, and vendor Inventory management had failed. Similarly, Christodoulou & Vlahos (2000) highlighted, citing examples; the need for simulation modeling tools to enable the policy makers in defining the relationship among various factors in an industry environment. The Beer Distribution Game (BDG) has also been modified with different variations and extensions by researchers. Jacobs (2000) demonstrated an internet version of the BDG to enable quicker set up, playing time and faster analysis. A simulation tool was developed on the principles of the BDG, considering the virtual variables in a virtual enterprise (Spagnoletti et al., 2014). The principles of a service-oriented supply chain were tested by modifying the BDG into the Mortgage Service Game, the results can be used in decision making of SCM in the service industry as well as the make-to-order industry environment (Anderson Jr. & Morrice, 2000). Further, the variations suggested by Mortgage Service Game in the BDG provided a complementary framework to illustrate supply chain management difficulties in industries that do not have finished goods inventory. Liu et al. (2009) simulated the BDG in four complex demand patterns namely, one step demand (demand changes only once in entire simulation), stationary demand (pattern follows normal distribution), uniform demand (random fluctuations in a specified range) and cyclical demand (seasonal variations), this detailed approach could be useful to business school students to understand various aspects of SCM and bullwhip effect.

The bullwhip effect is not only the result of operational shortcomings in the supply chain instead it has also a lot to do with the decision maker's tendency to undermine the supply chain (Croson & Donohue, 2006). Four causes of the bullwhip effect have been identified by various research studies, namely, demand signal processing (natural

demand forecasting), order batching (order frequency and evenness of order arrivals), price fluctuations (short-term changes in price as a part of sales promotions) and shortage gaming (order cancellation policy) (Lee et al., 1997). Ye & Wang (2013) suggested that measures such as information sharing models and establishing strategic alliance would help in reducing the bullwhip effect. Chen & Samroengraja (2000) proposed framework to quantify the bullwhip effect with different number channel members, with sharing demand information at each stage of the supply chain; can reduce the variability in orders placed but does not eliminate the bullwhip effect from the system. The spreadsheet solution illustrated how the bullwhip effect in the supply chain can be minimized with greater inventory fluctuations and a reduced customer service (Boute & Lambrecht, 2009).

Lee et al. (1997) highlighted that the bullwhip effect paralyzed the SCM and the penalties in terms of higher costs were borne by all its members. However, due to various incentives and promotional offers made by upstream members to downstream members (wholesaler' discounting pricing to retailer, the option to return the unsold goods, etc.) the burden of penalty was borne more by the upstream players. Similarly, Saitoh (2014) used a knowledge sharing simulation model (Elman Network) that aimed to improve the decentralized information sharing and thereby controlling the bullwhip effect within the chain. Wangphanich et al. (2007) proposed model that illustrated the bullwhip effect in a supply chain network with three retailers to one manufacturer: three different products and assuming same forecasting technique. The model had been validated using 'ROO Water' and hence can be used by decision makers for real life SCM. All the presented studies highlight different dynamics to the problems arising in a supply chain and the corresponding bullwhip effect. We aim to study the bullwhip effect arising out of introducing a new level in the supply chain and extending the game to multiple products with focus remaining on career-oriented experiential learning.

Experiment Design and Objective

Our experiment is based on detailed literature review, which focused on how simulations could be useful for effective career-oriented teaching. Some of the notable reviews are mentioned here. Cant & Cooper (2017) did an extensive literature reviews on simulation in teaching, the reviews reported that students showed strong satisfaction with simulation-learning and it improved their confidence and critical thinking abilities connected with their future careers. Simulations and experiments are being used as teaching tools to promote career-oriented skills such as team dynamics and teamwork (Stanley & Latimer, 2011; Wang et al., 2016), soft skills such as leadership, self-reflection, collaboration, and project management (Hanning et al., 2012; Wang et al., 2016) and action-oriented, reality-based activities (Geithner & Menzel, 2016; Vlachopoulos & Makri, 2017) emphasized that games, experiments, and simulations could leave positive impacts on the students' career-centric learning objectives.

We designed the experiment keeping in mind the career-centric learning students can derive out of the experiment. The objective is to provide students with learning on supply chain management perspectives such as pricing, inventory, transportation, distribution, and time-management through a simulation.

The experiment designed is an extended version of the popular beer distribution game (BDG). We named the new game- 'The Milk Distribution Game' aka MDG, which models three supply chains of three different products, with a common raw material – milk. The three products are Clarified Butter (Ghee), Condensed Milk and Milk Powder. It has thirteen players, Retailer, Wholesaler, Distributor and Manufacturer for the three supply chains and a Dairy Farmer for all three products.

Detailed Description of the Experiment

In total 3 groups of 12 students each participated in the simulation experiment. We have computerized the simulation whereby the simulation is run with the help of Java software and back-end MYSQL.

The Milk Distribution Game consists of 3 supply chains of three different products from the same industry i.e., Dairy, with a common raw material provider, who is the farmer. The three products are Ghee, Condensed milk and milk powder. It has thirteen players, Retailer, Wholesaler, Distributor and Manufacturer for the three supply chains and a farmer.

The student participants are asked to sit in columns whereby each column represents a supply chain. There are 3 such columns with 4 levels in each supply chain. There is 1 farmer who caters to the demands of all the manufacturers of supply chains.

Of the total units of milk produced, 54 % is used for these three supply chains and the remaining 46 % is utilized as fluid milk for domestic consumption.

The entire supply chain of Ghee will have 9 units in their inventory, delay 1 and delay 2, placed already. Similarly, Condensed Milk's supply chain will have 2 units in their inventory, delay 1 and delay 2. Whereas, there will be 1 unit in the inventory, delay 1 and delay 2 of the Milk Powder's entire supply chain.

The retailer enters the order received manually according to the instructions given by the instructor of the game in the ratio of 9 or 2 or 1 unit(s), depending on the supply chain he/she is in. The demand is catered and the backlog is recorded automatically.

According to the order received the student participant places a relevant order which is then catered by the wholesaler. The wholesaler, distributor and the manufacturer follow the suit. The demand is catered and the backlog is recorded automatically. According to the order received the participant places a relevant order to the next member of the supply chain. The farmer on receiving orders from all the three suppliers; divides the limited supply of milk between them in the ratio of 9:2:1. The number of

milk units a farmer can supply is 314 with a standard deviation of 10 % (i.e., 31.4 units) in a normal distribution curve. These get converted into respective product units based on milk requirement in each product.

Rationale for the Extension

Even today, the original beer distribution game serves the purpose of demonstrating some inherent problems involved in supply chain management. However, the simulation has to adapt to changes to remain relevant and to display a better picture of the supply chain in other industries also. The proposed study asks the following changes to make the original model look more suitable to the current scenario:

1. The simulation focuses on the distribution of milk and milk products.

2. Dairy farm or association is the raw material provider, which serves to Milk Powder, Condensed

Milk, and Clarified Butter (Ghee) industries.

3. Unlike the original version, manufacturers are not allowed to produce as per their wish, but they have to compete with the other two industries to receive raw material.

4. The raw material is supplied in the proportion of orders placed by three manufacturers.

Goal for players

The objective of the student participants within the game is to minimize the overall cost (holding and backlog) incurred in the entire supply chain.

How to Play

Customer demand arises at the retailer, who replenishes its inventory from the wholesaler, the wholesaler from the distributor, and distributor from the manufacturer, the manufacturer from the dairy farmer. The three supply chains work parallel. The factories restock milk from farmer and produce their respective products. In each period, channel members must decide how much to order from their respective suppliers. Factories need to decide how much to produce, from the limited supply of the milk and how much to order from the farmer. Material supply is subject to two delay points. Holding costs are incurred at each station for their available inventories and backlog costs are also incurred for their respective customer’s back orders.

Learnings

Phase – 1 and its learnings

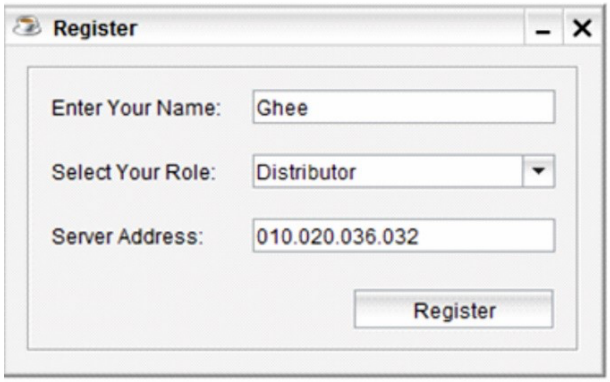
The primary design was tested for 4 iterations, and the flow of orders and shipments was observed for one, two, and three supply chains. At the end of this phase, the supply of dairy farmer was decided. Further, it was decided that the game needs to be computerized to expedite the process and avoid calculation errors. It was observed that students could understand the scope of an established simulation and could think through the relevant extension. They discussed the addition of constraint of the raw material supply and multiple products, as in the Beer Distribution Game. They envisaged the contextual relevance in terms of milk as the raw material, milk powder, clarified butter, and condensed milk as three products. They calculated the conversion ratios for all three products and designed a board game (manual simulation).

Phase – 2 and its learnings

In the second phase, MS Excel (Figure 1) was used to digitize the simulation and to facilitate calculations. Six iterations were offered using this format of the simulation (Figure 2). Students realized that to make 28 players work on a board game, calculations become a challenge. To expedite the calculations and avoid errors, they translated the board game into a combination of inter- connected worksheets and tried MDG.

Figure 1: MDG in Excel (student participants are shown here

Figure 2: MDG in Java-based Simulation



Phase – 3 and its learnings

The entire simulation was computerized using Java and MySQL. The application collected the data on a server, this has eased data collection for the team. In the first phase, data collection was time consuming and difficult for the participants to comprehend. Excel worksheets had short comings of integrating data across different files. Students decided to design a full-fledged application. With the guidance of faculty, they designed a Java web application with MySQL as the back end and implemented the simulation again with a group of students. It is really motivating for a teacher to learn that students, with some encouragement and guidance from teacher, can branch out their learning in various areas of development.

The bullwhip effect of three supply chains

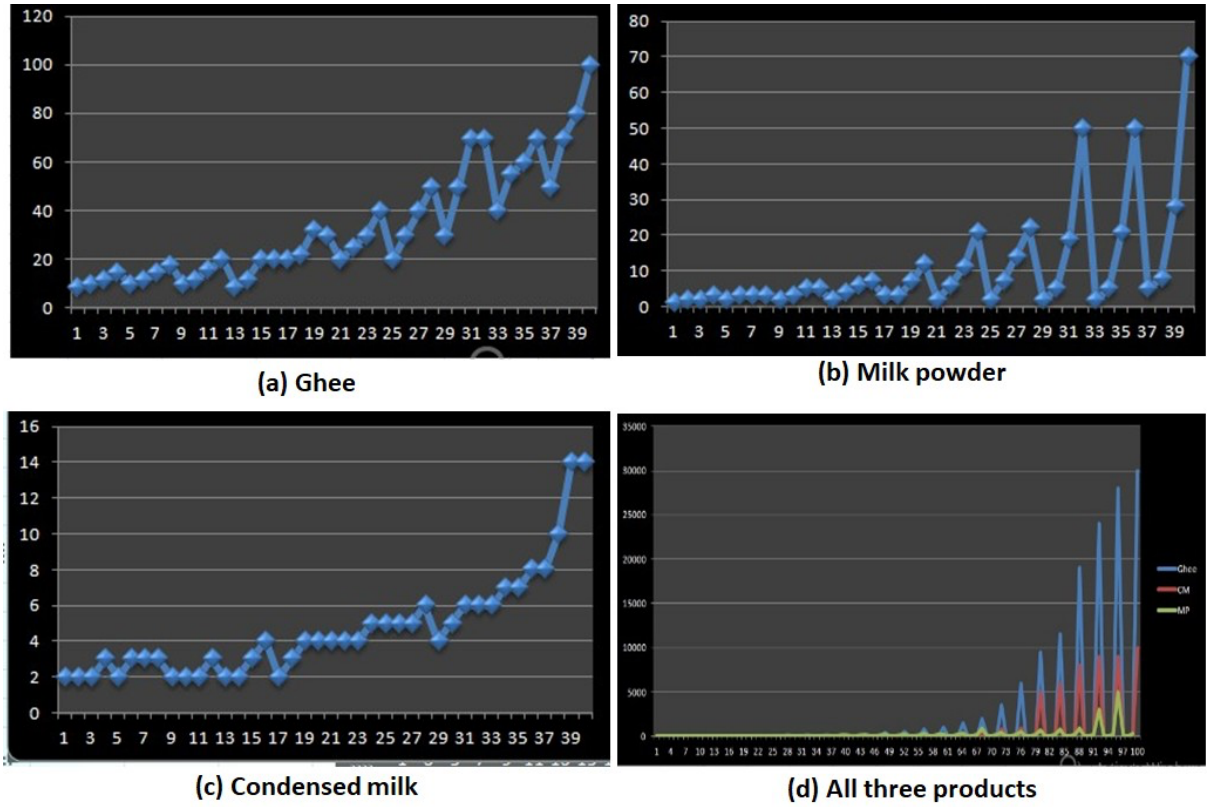
At the end of third phase of development, students collected data from experiments conducted in multiple iterations. The conversion ratios of all three products from milk is decided after analysis (see Table 1). The cross-sectional impact is exponentially high; participants were demanding more than what they require because they knew that the raw material supply is limited, and they will get the supplies proportionate to their demand.

Table 1: Product Conversion Ratios

Product	Units (KG)	Milk Requirement (litres)
Ghee	1	16
Milk Powder	1	8
Condensed Milk	1	2.5

At first, we conducted the experiment with single supply chains of Ghee, milk powder and condensed milk by adding a raw material (limited supply) to the chain. Then, the experiment was conducted with all the three chains simultaneously working with milk as their common raw material. The bullwhip graphs (Figure 3) suggest a significant rise in all the three supply chains from the one wherein they were functioning independently in the isolation. The conclusions from the simulation exercises are presented in the next section.

Figure 3: Bullwhip effect individually and for all three products



Conclusion

Students enthusiastically take part when the simulation is built up or applied in small segments. We have divided the presented simulation in three phases, and students realized the limitations of each previous phase. When we finally came up with the computerized version, they were clear with the calculations, worksheets, and analysis.

Students learnt career-oriented skills such as managing the supply and demand for the fast- moving consumer goods industry. Further, students gained industry and career insights, on price dynamics, time-management, order mechanism, inter-dependencies of retailer, supplier, distributor, manufacturer, timely intervention, and details of supply chain management. From an educator's point of view, this study represents a significant hands-on learning for the students, which would not have been possible using the standard lecture mode. The lab/studio environment, which allowed interaction as in real-world situation, added much value to their learning process. As instructors we learnt a lot as well. The key learning was designing student- centric project exercises of which the students take full ownership. Not only this increases participation, but beneath the excitement during the simulations, a subtle learning happened, which we believe is superior to any other mode or delivering education. We hope to further

enhance the simulation exercise every year by introducing new products, increasing the size of the markets (players), and making it more user

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