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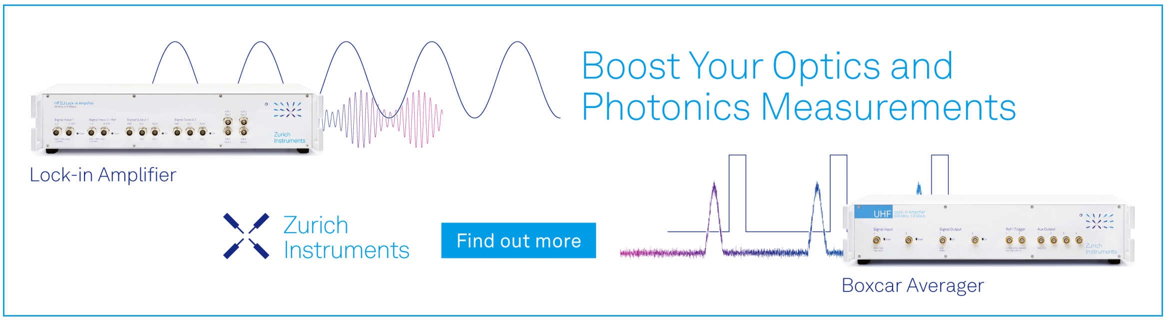

A New Simulation Game for Risk Pooling Learning Process

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Abstract. The effective learning process is an interesting research topic and one interesting learning process is simulation games. In this research, a simulation game about risk pooling using Anylogic is analyzed. In the game, students learn how to set minimum and maximum stock for factories, distributors, and retailers in centralized and decentralized systems, the game is played by 20 undergraduate students where half of them have learned supply chain have of them have not learned about it. The experiments give some interesting results where the game cannot show the benefit of a centralized system compared to the decentralized system, but the game can improve student decision making to set stock level since they can make a better decision on the fifth trial than the first trial.

INTRODUCTION

Learning method through simulation has been applied widely for undergraduate and postgraduate program. This learning method is one of the effective methods to make students understand the material in the class. Proserpiao and Gioia (2007) show that the learning process for the current generation is more effective using visuals, it should be interactive and focus on problem-solving. One type of learning method is using game simulation. A game simulation is done by mimicking real conditions and students will be asked to act as if they apply their knowledge in a real system. Simulation games are applied widely to teach in undergraduate and postgraduate programs and one popular game that has been applied especially in supply chain or logistic courses is Beer Game. Sarkar and Kumar (2016) found that simulation games help students to have more understanding of the basics of supply chain management and supply chain disruption. Beer game is an effective tool to study the concept if system thinking since it can be visualized clearly (Goodwin and Franklin, 1994). Pariafsai et al. (2016) found that virtual project-based simulation has high potential effectiveness as a learning tool. He applied virtual project-based simulation can improve his knowledge and skill in construction management. The simulation can train students can improve their skills in construction management students and they can learn the effect of small mistakes that risk finances and safety. Game simulation can improve students' decision-making skills for complex systems in operation management (Pasin and Giroux, 2011). Even though there is positive feedback for simulation game effectiveness as one of the learning methods, not many teaching materials can use simulation games as a teaching method and a new game simulation should be analyzed its effectiveness as a teaching method. Therefore, in this research, we develop a game simulation method and analyst its effectiveness. We develop a game simulation method for learning the risk-pooling concept.

The risk pooling conceptis a concept to centralize stock in one location instead of put stock in some location as a decentralized system. A risk- pooling system can be used to decrease inventory, The benefit of risk pooling compared to a decentralized system is increasing significantly when demand variability is increasing (Berman et.al.2011) and

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there are some interesting risk pooling research such as Nadeem (2016), Salimi, and Vahdani, (2018) and Oeser and Romani (2021). However not in every situation centralization is better than decentralization, therefore making correct decision making is very important. The simulation game is developed using Anylogic Software and the effectiveness of the game will be analyzed with an experiment using undergraduate student, Industrial Engineering Program, Petra Christian University. The first section of this paper introduces the gap in the research. The second section shows the simulation game and design experiment that will be conducted. Results and discussion will be shown in section three and section four gives the conclusion.

RESEARCH METHOD

The risk pooling simulation game is developed using Anylogic simulation software and the supply chain system consist factory, distributors, and retailers. The decentralized system is shown in Figure 1. Figure 1 shows that there is one factor that supplies products to three distributors and then the distributor delivers the item to each retailer. The centralized system is shown in Figure 2, where a stock of three distributors is centralized in one distributor. The game players have to decide the minimum and maximum stocks for the factory, distributor, and retailer with the objective to minimize each cost. The total cost is equal to the ordering cost and inventory cost where the ordering and the inventory cost can be set by the game administrator. The game administrator also can set the demand rate for every retailer, maximum factory production rate, and initial stock. The replenishment system at the factory, warehouse dan retailer is automatically generated when the stock level reaches minimum stock and order as much as the differences between maximum stock and current stock. By setting the different minimum levels and maximum levels for the factory, distributor, and retailer, and running the simulation that represented 200 days, the players will know the total cost for the factory, distributor, and retailer.

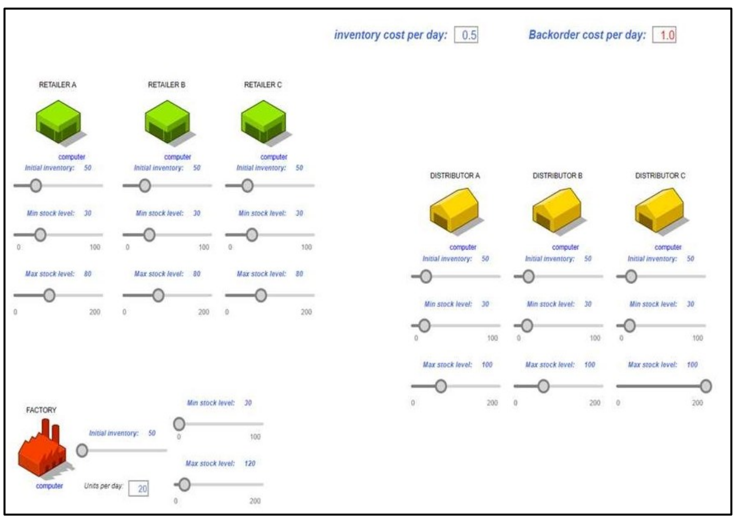

FIGURE 1. Decentralize system game.

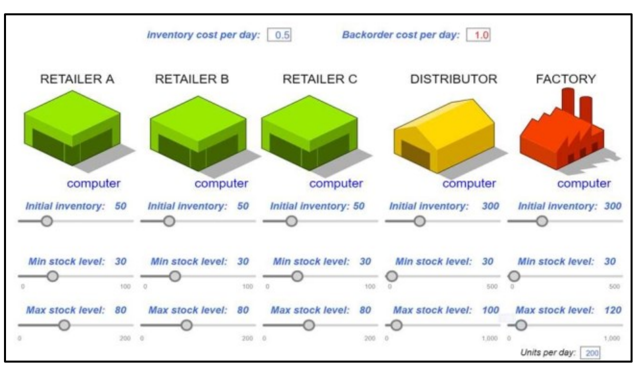

FIGURE 2. Centralized system game.

The experiments are conducted for undergraduate students Industrial Engineering program, at Petra Christian University. There are ten teams where five teams have already taken a supply chain management course (Team B) and know about risk pooling whereas five other teams never know about risk pooling, centralization, and decentralization supply chain (Team B). each team has two students, so they can discuss their strategy. Each team will play to manage the centralization and decentralization system. They will be chosen randomly which system he or they run the first time, centralized or decentralized system. Every player will run five times for every system. After they run the simulation game, they will be given some questions about the centralized and decentralized system. There are some hypotheses that will be proofed in this paper which are:

There is no significant difference of team A and team B total costs in a centralized system

There is no significant difference of team A and team B total costs in a decentralized system

There is a significant difference between decentralized and centralized system cost

There is a significant difference between the first trial and the fifth trial

RESULT AND DISCUSSION

The game result for each team for centralized and decentralized supply chain for five replications for each team and each strategy can be seen in Table 1 for the decentralized method and table 2 for the decentralized system. Where team 1 to 5 are the student that has been learned risk pooling and teams 6 to 10 are the students that have learned risk pooling.

TABLE 1. Centralized Simulation game costs.

Replication	Total cost									
	Team 1	**Team 2**	**Team 3**	**Team 4**	**Team 5**	**Team 6**	**Team 7**	**Team 8**	**Team 9**	**Team 10**
1	68607,5	81834	88111,5	88111,5	66465	73239	92876,5	88111,5	65209,5	55828
2	64630	85641	86146,5	80233	65266	93021,5	83692	78850	58662	54788
3	76580	82817	86146,5	73713,5	68496,5	82820,5	85100,5	80601,5	63215	56037,5
4	63746	84827	86146,5	70686,5	57995,5	74329,5	77951	59137,5	53983,5	56231,5
5	62900	73621	83630	66834	60257,5	59511	71527,5	63130	47261,5	47185,5

TABLE 2. Decentralized Simulation game costs.

Replication	Total cost									
	Team 1	**Team 2**	**Team 3**	**Team 4**	**Team 5**	**Team 6**	**Team 7**	**Team 8**	**Team 9**	**Team 10**
1	55828	61978	61978,5	61978,5	70913,5	75482	51651	59238	64684	67704
2	54788	65275	60620,5	68349,5	69188	45190	50504	89930	54742	50517,5
3	56037,5	70688	63692	60399,5	71756	45964	45865,5	64022,5	39972,5	42811,5
4	56231,5	75439	66377,5	56993	46849	47095	38010	59595,5	38244	37333
5	47185,5	60404	66844	56084,5	46819,5	47052	36663,5	46261	45890,5	38103,5

According to the results, we have to prove our hypothesis. In the first hypothesis, there is found that there are no total cost differences between the team that has learned risk pooling and a team that has not learned the supply chain. Detailed data analysis can be seen in Table 3. A different result is found for a decentralized system where there are significant differences between the total cost of team A and team B. Team A where student have learned about risk pooling and supply chain have better total cost than students who have not learned about risk pooling and supply chain, This is meant that the students that have learned about supply chain have a better strategy to set minimum and maximum stock and get better total cost than the student that has learned about the supply chain. This meant that the students who have learned about supply chains can implement their knowledge about inventory decisions in the game.

TABLE 3. Total cost differences for centralized.

Statistic				
Sample	**N**	**Mean**	**StDev**	**SE Mean**
Team B	5	69449	9390	4200

Team A	5	57723	10529	4709
		Paired t test		
Mean	**StDev**	**SE Mean**	**95% CI**	***P-Value***
11725	14485	6478	(-6260, 29711)	0,145

TABLE 4. Total cost differences for decentralized.

		Statistic		
Sample	N	Mean	StDev	SE Mean
Team B	5	60304	9550	4271
Team A	5	47294	4983	2228
		Paired t test		
Mean	StDev	SE Mean	95% CI	*P-Value*
17510	11676	5222	(3013, 32007)	0,028

The total cost comparison of a centralized and decentralized system is shown in Table 5 for students that have learned the supply chain and Table 6 for students that have not learned about the supply chain. The results show that there are no significant differences between centralized total cost and decentralized total cost for students that have learned the supply chain and students that have not learned the supply chain. Those results are not desired for the game simulation. Since theoretically where the supply chain only considers inventory and back-ordering cost, the centralized system should give a better result than the decentralized system since using a centralized system, the demand variation in distributors can be absorbed.

TABLE 5. Total cost differences for student have learned supply chain.

			Statistic	
Sample	N	Mean	StDev	SE Mean
Centralized	5	57723	10529	4709
Decentralized	5	47294	4983	2228
			Paired t test	
Mean	StDev	SE Mean	95% CI	*P-Value*
14929	12503	5591	(-595, 30453)	0,056

TABLE 6. Total cost differences for student have not learned supply chain.

			Statistic	
Sample	N	Mean	StDev	SE Mean
Centralized	5	69449	9390	4200
Decentralized	5	60304	9550	4271
			Paired t test	
Mean	StDev	SE Mean	95% CI	*P-Value*
9144	10077	4507	(-3368, 21657)	0,112

The last hypothesis is analyzed using a regression test and the results are shown in Tables 7-10. The results show similar conditions where there all slopes are negative. This is mean that there is a trend for students to have lower total costs as they try more. The total cost for the fifth trial is lower than the total cost of the first trial. Both students have learned or have not learned supply chain give the same results that they can learn to improve their decision where they play the game five times. The result also shows that the regression equation model is quite fit fits the data since the R square value are quite high, where the lowest R-squared score is 79.25% for a centralized system of the students who have not learned about the supply chain.

TABLE 7. Regression test for centralized system of student have not learned supply chain.

Equation: mean cost = 81555 - 2206 rep				
Coefficient				
Term	Coef	SE Coef	*T-Value*	*P-Value*
Constant	81555	1826	44,66	0,000
Slope	-2206	551	-4,01	0,028
S	R-sq	R-sq(adj)	R-sq(pred)	*P-Value*
1740,96	84,25%	79,01%	61,24%	0,028

TABLE 8. Regression test for decentralized system of student have not learned supply chain.

Equation: mean cost = 81555 - 2206 rep				
Coefficient				
Term	Coef	SE Coef	*T-Value*	*P-Value*
Constant	70599	1777	39,73	0,000
slope	-1831	536	-3,42	0,042
S	R-sq	R-sq(adj)	R-sq(pred)	*P-Value*
1694,30	79,56%	72,75%	44,55%	0,042

TABLE 9. Regression test for centralized system of student have learned supply chain.

Equation: mean cost = 82133 - 4414 rep				
Coefficient				
Term	Coef	SE Coef	*T-Value*	*P-Value*
Constant	82133	3562	23,06	0,000
slope	-4414	1074	-4,11	0,026
S	R-sq	R-sq(adj)	R-sq(pred)	*P-Value*
3396,39	84,91%	79,89%	50,64%	0,026

TABLE 10. Regression test for decentralized system of student have learned supply chain.

Equation: mean cost = 68112 - 5604 rep				
Coefficient				
Term	Coef	SE Coef	*T-Value*	*P-Value*
Constant	68112	3083	22,09	0,000
slope	-5604	930	-6,03	0,009
S	R-sq	R-sq(adj)	R-sq(pred)	*P-Value*

2939,63	92,37%	89,83%	75,29%	0,009

CONCLUSION

In this research, a simulation game about centralized and decentralized supply chain systems is developed. The supply chain system consists of one factory, three distributors dan three retailers. In a centralized system, three distributor stocks are centralized to one distributor. The game is built using Anylogic software. The game is tested on students that have learned and have not learned about the supply chain. The students play in a team where each team consists of two students. Every team plays both centralized and decentralized systems and they are assigned to play centralized or decentralized for the first game randomly. All teams are asked to set minimum and maximum stock to minimize total stock where the total stock consists of inventory holding cost and backorder cost.

The simulation game experiments show interesting results. Students who have learned supply chain significantly have better costs than students who have not learned supply chain for decentralized systems. However, in the decentralized system, the differences are not significant. All teams also have no differences in total costs for centralized and decentralized systems. This result is not expected since it does not show the benefit of a centralized system to reduce total costs. On the other side, the simulation game effectively increases the understanding of players to set better minimum and maximum stock levels since the total cost decrease as they try the game up to five times.

The experiment shows that the simulation game can improve the student decision-making process for determining minimum and maximum stock however it cannot show the benefit of a centralized system more than a decentralized system. Therefore, it is interesting to find factors that make students cannot use the benefit of a centralized system in the game for future research. The other future research can focus on the learning process of the game for postgraduate students and professionals.

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