Decision Making with LBA

Price War: Lotte Mart VS Emart

Minerva University

CS51: Formal Analyses

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Location-based inspiration

Our location is Seoul, South Korea, a market dominated by some of the most competitive monopolies. Emart and Lotte Mart are the few monopolies as Emart has 158 stores (Jobst, 2022), and Lotte Mart has 175 stores (Lotte Mart, 2021). Given the size of these corporations, they need to stay on top of price changes. This condition was particularly seen as I visited both the places thrice within a month and noticed a dramatic price change. Sometimes, the same cheaper products become less expensive or the same, but with offers like buy one get one free. I assumed that the product demand is not a big factor but instead the comparison of the sale of products with competitors. Therefore, I will be considering these two competitors in a price war setting as players. Based on Nash equilibrium and mixed strategies, these strategies will be analyzed to analyze payouts (outcomes). Additionally, the decision to keep the price the same or decrease them will be analyzed using a decision tree with maximax and maximin techniques. Given the limitation that most Korean finances are in the Korean language, multiple assumptions will be made based on experiences, other markets and hypothetical situations.

Decision trees and probabilities

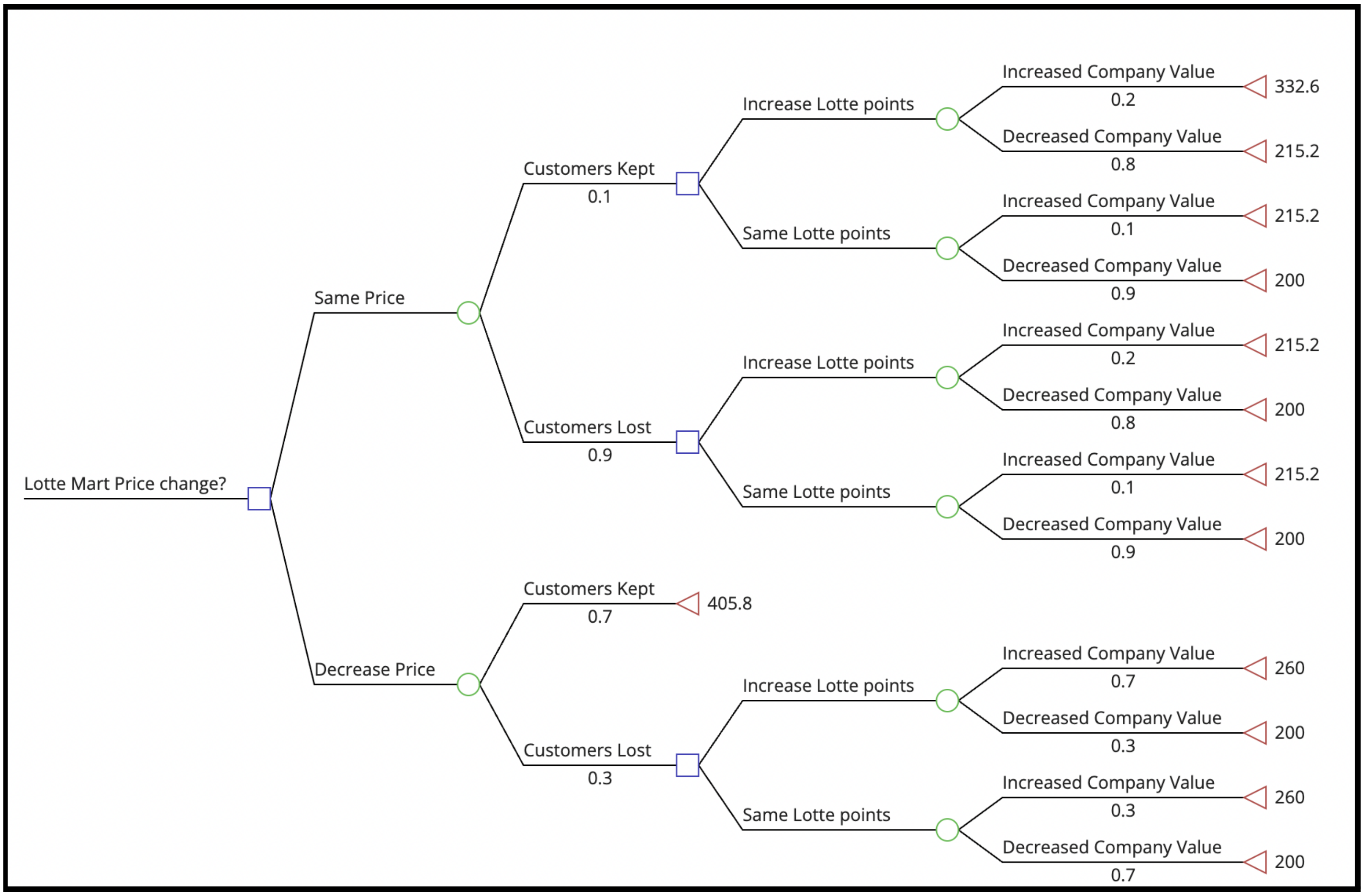

Fig.1 shows the decision tree for Lotte Mart price change based on keeping the price same or decreasing with an additional decision to increase the Lotte points gained or not based on customers kept or lost.

There are two main decision nodes (squares) of **the same price (SP)** and **decrease in price (DP)** with chance nodes (circles) being **customers kept (CK) or lost (CL)**, given the first decision node is the main tactic used by companies in price wars to keep up with their competitors. Lower probabilities are given to CK for SP as they did not adapt to the change in prices. Additionally, 0.3 probability is provided for CL as we assume the decision tree from the perspective of Lotte Mart, but it does not mean that Emart will sit quiet and would not change the price to compete, hence p(CL) > 0.1. Higher probabilities are given to chance nodes as a sign that the strategy will keep customers and increase the likelihood to win the war.

Second decision node is the change in **Lotte points** which is a subsequent strategy applied by Lotte Mart with price change. The points act as a reward that can be accumulated to get discounts in the future. Probabilities for SP and Lotte point change have a similar pattern based on how profitable each strategy depends on resources required and losses suffered alternating between 0.1 - 0.2 for increased value and 0.8 - 0.9 for decreased value. DP to Lotte points does the same but alternates between 0.3 and 0.7.

Final values are in billion KRW, with KRW 332.6 billion calculated via estimates made from Lotte Mart financial statements and **Appendix A** (정주원, 2022)**.** The change in price was calculated based on the simplification and generalization of the market as 22% increase in profits by reduction in price is observed (Dahan & Srinivasan, 2011). The change of 22% was added and subtracted when company value was increased or decreased. Finally, KRW 200 billion for the lowest fall and KRW 260 billion for DP with CL were assumed for simplification when odds of success are bleak.

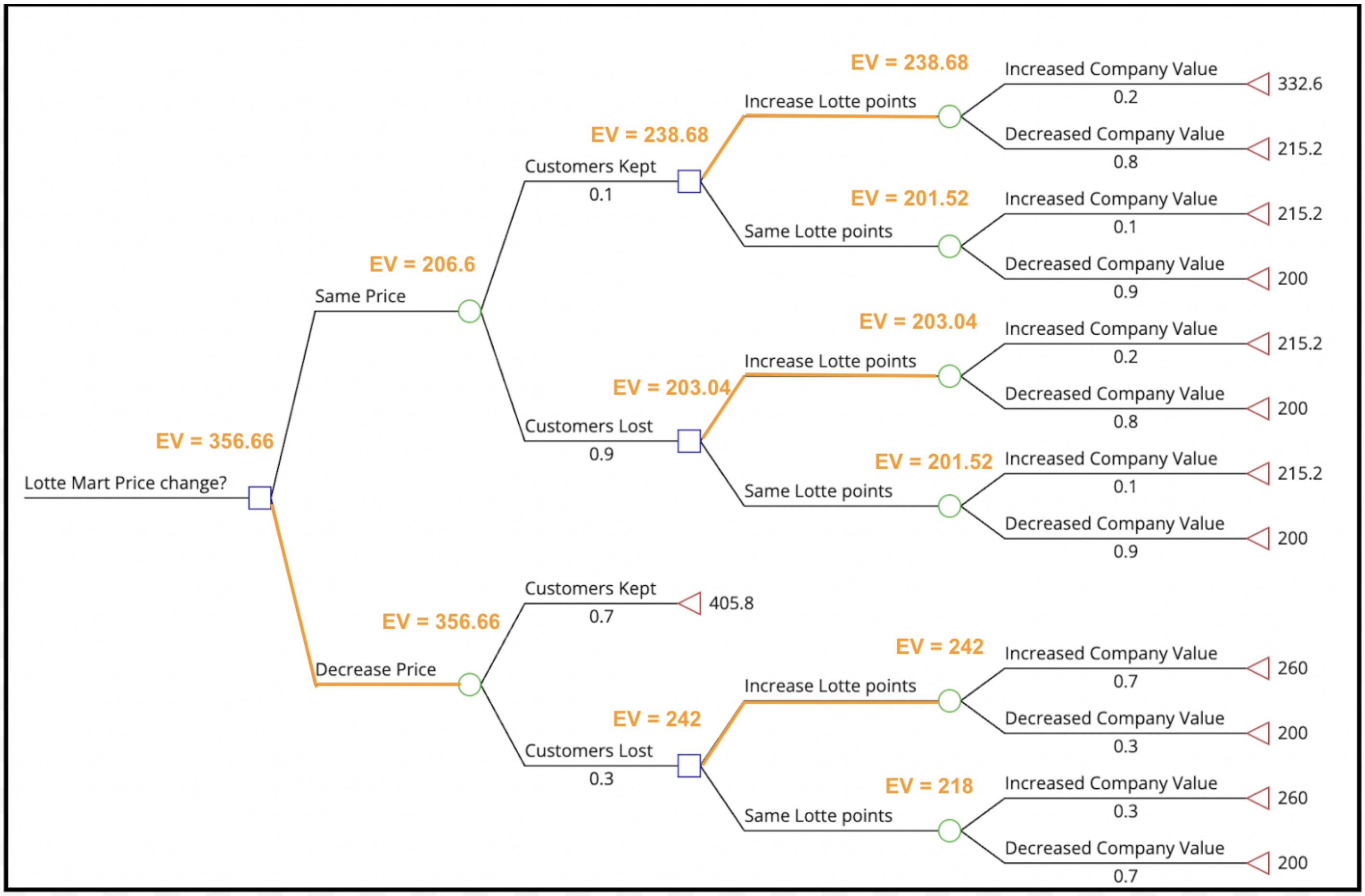

Fig. 2 shows the expected values of chance and decision nodes and the path to maximum utility. EV has utils as its unit.

Strategies were analyzed based on Expected Value, Maximax and Maximin. Expected value is calculated and a path is chosen which produces the maximum utility. It is the average of the possible outcomes weighted according to their probability. Fig. 2 shows all the expected values **(calculations shown in Appendix A).** Expected value for each was calculated by taking the product of the utilities and probabilities and summing them up for each chance node. For decision nodes, a comparison was made between the utilities of the two decision nodes as greater EV was chosen. Greater EV was chosen due to the intention of improving profits as terminal nodes (triangles) show the company value (net profit). Through iterative best EV selection we reached the final decision node (Lotte Mart Price change?). The higher EV (356.66 utils > 206.6 utils) hence, for EV strategy, it will be better if Lotte Mart reduces the prices and increases lotte points as seen by the selection of second decision node.

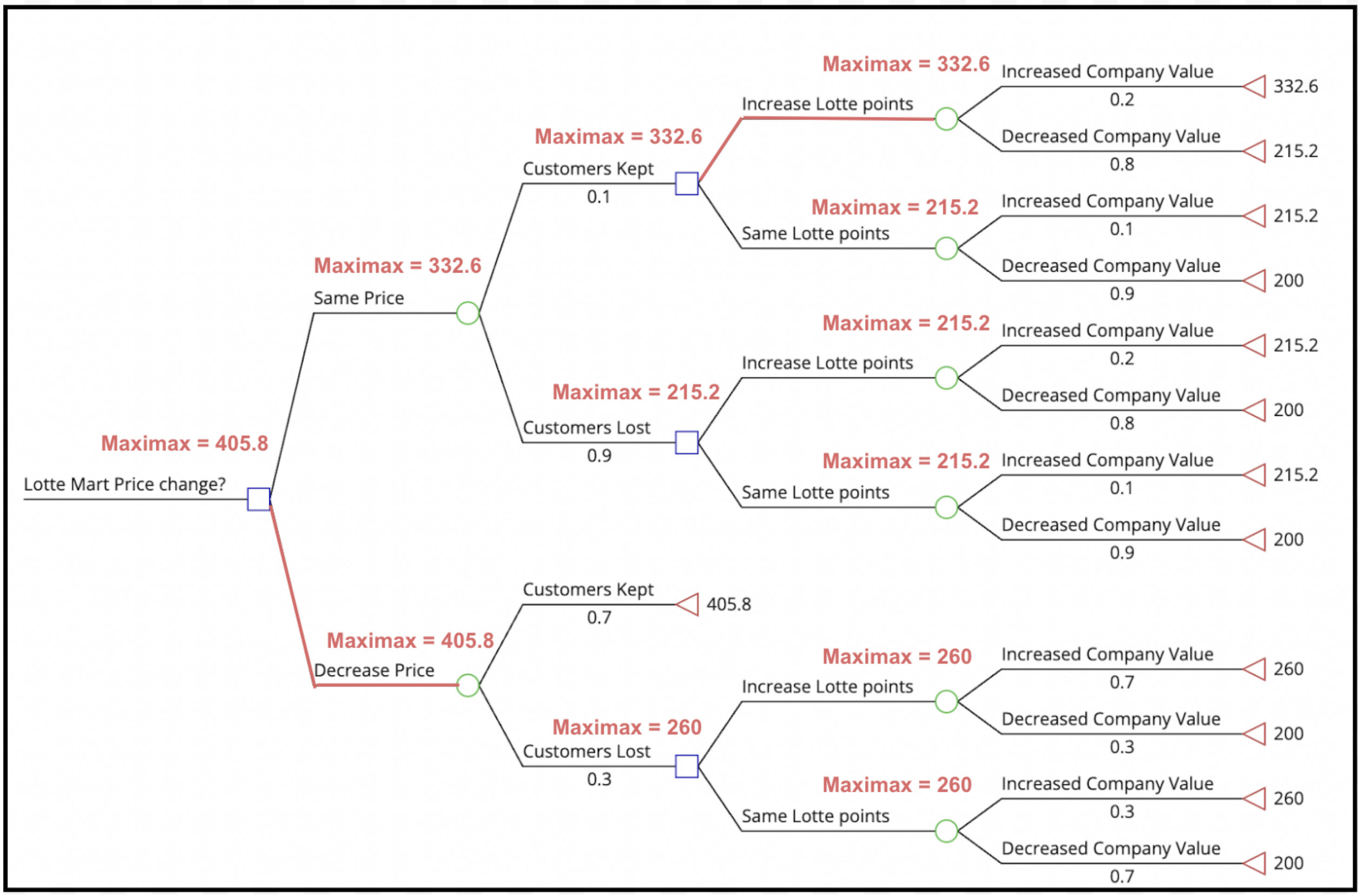

Fig. 3 shows the maximax values of chance and decision nodes and the path to maximum outcome-value.

Maximax **(Fig. 3)** is calculated by taking the highest-valued outcome as it is a maximization problem. Here only values are considered and not the probabilities, which leads to indifference at decision nodes of CL for both SP and DP.

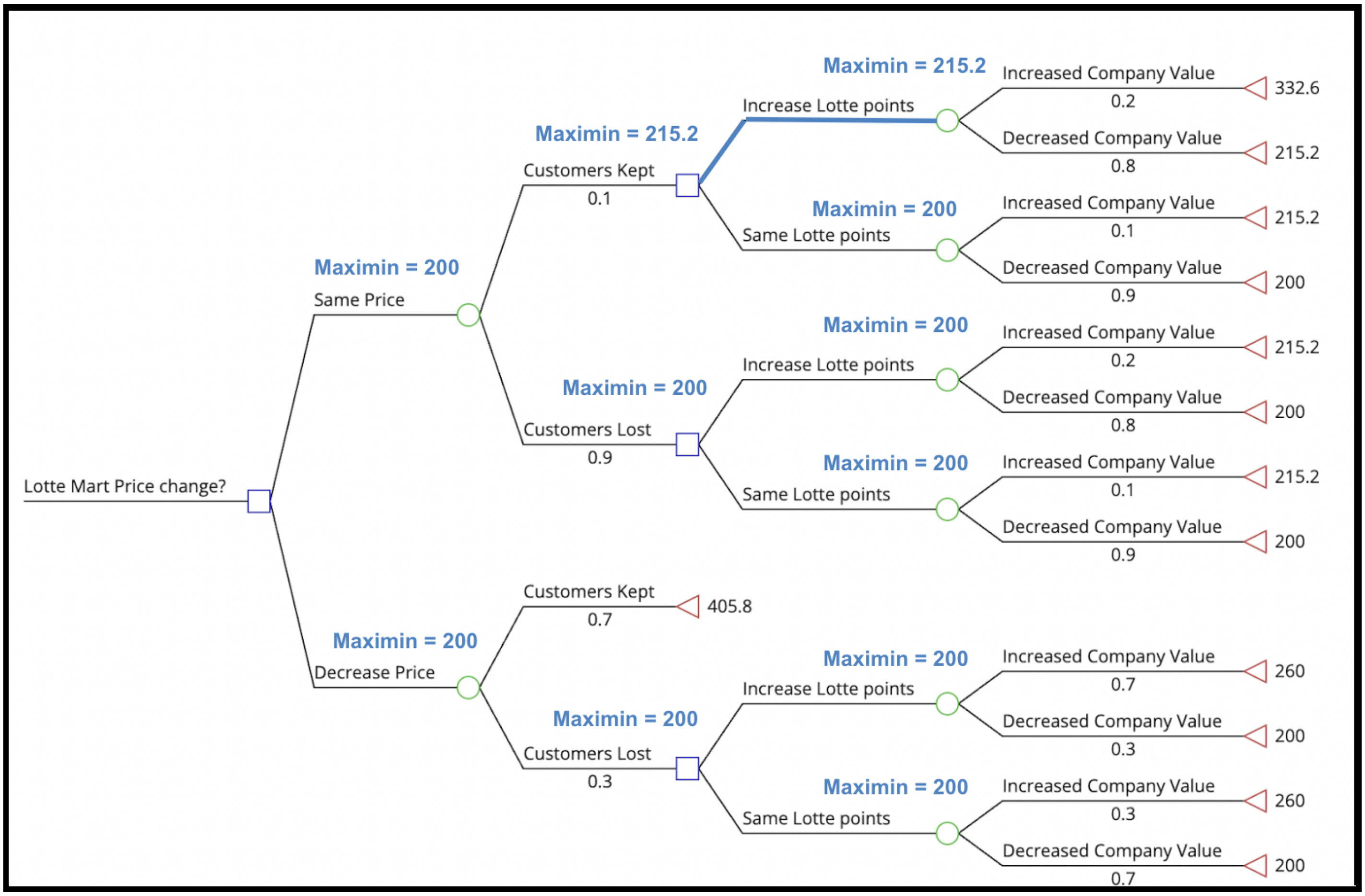

Fig. 4 shows there is no maximin strategy for this scenario due to the similar values on each chance node we cannot find a clear path hence via maximin strategy we will be indifferent between two strategies. Additionally, due to indifference the rollback cannot proceed from the first point of indifference but just for the purpose of visualization other maximin are shown otherwise for CLs it would not go any further.

Maximin **(Fig. 4)** is calculated by assessing whether we maximize or minimize our values. In this case, we are maximizing, so we will take the best minimum values, e.g., between KRW 332.6 billion and KRW 215.2 billion, we will choose 215.2 billion from terminal nodes to chance nodes. After this selection, we will proceed with rollback. Then from chance node to decision node, we will choose the best maximum value, e.g., KRW 215.2 billion rather than KRW 200 billion.

Comparing the three strategies, it is clear that EV is the best choice as it finds the path of maximum utility, leading to decreasing the price. Maximax leads to the same decision; however, due to CL showing indifferent decisions, it is an inferior strategy to EV in this case. Lastly, Maximin is overall indifferent due to similar outcome-values on nodes. Hence we cannot make clear decisions and ignore this strategy.

Hypothetically, imperfect information could exist when the information is not sufficient to make a confident decision about a scenario. Based on Coupang's new Rocket fresh door-to-door delivery services, it is surpassing other online stores by a significant margin (Hyun-woo, 2020). Coupang is planning to enter the grocery market due to its latest success in e-commerce. This new feature will make Lotte Mart and Kakao Mart's price war irrelevant and their businesses obsolete as their e-commerce sites: Lottery and SSG, cannot compete. This information is a source of imperfect information as the Coupang Rocket fresh feature is new, and they might not pivot immediately to the product market the current competitors hold. Still, this information provided new evidence for our prior to updating our posterior. Further updates can be made by monitoring the success of the current Rocket fresh maneuver.[1]

Although Coupang is not entering the current price war market immediately; however, their threat makes the price war between Emart and Lotte Mart shorter. With new evidence, we can assume that the more time they will spend in their price war, the more opportunities Coupang will get to enter the market. Hence, by limiting the number of times, they can change their prices and offer lucrative offers. Lastly, due to imperfect information about Coupang's Rocket fresh success, we can assume that the likelihood ratio will keep updating to reach a positive number, supporting the new posterior that Coupang will enter the market.[2]

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[1] **#probabilty:** I have identified relevant probabilities for different decisions and the likeliness of their outcomes in the decision tree with reasonable justification and reasoning. Conditional probabilities have been calculated by computing EVs for the tree rollback and compared with each other to find the best EV decision and the lack of use of probability in other strategies has been identified and justified. (footnote continued)Lastly, Bayesian statistics were used to explain how new information (imperfect) will be used to update the prior and to get a new posterior and the purpose of doing this.

[2] **#decisiontrees:** A clear decision tree has been made with 2 and more decision nodes with decision, chance and terminal nodes identified and values have been provided for terminal nodes with a strong justification and evidence, assumptions are mentioned. EV, Maximax and Minimax have been calculated with assessment and justification of which strategy is best for making the best decision in the above scenario. Bayesian statistics theory has been used via providing imperfect information and explaining the change in outcomes due to the new information.

Game theory

Emart			
Lotte Mart		Same	Decrease
	Same	0, 0	-2, 1
	Decrease	1, -2	1, 1

Fig. 5 shows the payoff matrix of a price war between Lotte Mart and Emart. The strategy is change of price with decisions as decrease in price or keeping the price same.

The price war includes two players: Lotte Mart and Emart, competitors in the groceries market. The game is symmetric with the assumption that both parties have equal resources. The main change they are applying includes a change in price for their products, as seen in **Fig. 1** and **Fig. 5.** The price change is based on either keeping the price the same and suffering loss if the other decreases or decreases price to match the competitor's price. The scenario is based on a real-life scenario where Emart reduced its prices for 500 products assuming the price drop is 10%; Lotte Mart reduced the price of its product by a similar percentage (Min-Ji, 2021). The strategies involved can be Lotte keeps it the same while Emart decreases and vice versa or both of them can adopt the SP strategy, which will end the war while DP strategy will continue the war. Hence, they both need to choose to keep the price the same to end the war.

Strategy Analysis

For payoff matrix analysis, we are only considering change in price not involvement of Lotte points or other extraneous variables. Upon analyzing the strategies, it can be concluded that there are two strictly dominant strategies. A strictly dominant strategy is when the actions of one player will produce greater payoff to one player no matter what are the actions of other players. The strictly dominant strategies are followed by (Lotte Mart, Emart):

1. LM's strategy of DP is strictly dominant over SP as (Same, Decrease) is (0,1) and (-2,1) in both cases; DP is strictly dominant for LM as it has greater payoff over the SP no matter what Emart does.
2. Emart's strategy of DP is strictly dominant over SP as (Same, Decrease) is (0,1) and (-2,1) in both cases, DP is strictly dominant for LM as it has greater payoff over the SP no matter what LM does.

		Emart	
Lotte Mart		Same	Decrease
	Same	0, 0	-2, 1*
	Decrease	1*, -2	1*, 1*

Fig. 6 shows the payoff matrix of a price war between Lotte Mart and Emart with best responses to find Nash equilibrium. * indicates a best response for that given payoff.

Nash Equilibrium

Seeing there are two dominant strategies and assuming rational people do not make strictly dominant strategies, we can proceed to find a Nash equilibrium. Nash equilibrium is a series of strategies that each player can implement, hence avoiding provision of incentives for the other player to switch their strategy. Nash equilibrium creates stability in the system and better predictability of outcomes. We can find Nash equilibrium via elimination of strictly dominated strategies via the best response method. Based on **Fig. 6**, we can see that the best response for both players is at (Decrease, Decrease). This response means that if both players decrease their prices, ignoring that they have limited resources and the process is iterative. We can then conclude that both LM and Emart will keep on making profit and improving Company Value, as shown in the decision tree, if they continue to decrease their prices and continue a price war. Additionally, this is pure Nash equilibrium as players only have one type of strategy change in price or not. Due to similar action, the players cannot randomize between different strategies; hence no mixed strategy exists.[3]

[3] **#gametheory:** Aspects of the game have been identified and explained with relevant and detailed evidence e.g. payoffs. players, strategies. A symmetric game is made with relevant strictly dominant strategies analyzed and explained to infer the actions that each player will take. A payoff matrix is made with the payoffs of each player and a best response method is utilized to eliminate strictly dominant strategies to find Nash equilibrium; pure strategy Nash equilibrium is identified and justified with detailed comparison from a mixed strategy Nash equilibrium.

Optional: Iterative Game

Given that both the players have limited resources and each player will counter the other's strategy with a price change, the game can have iterative decisions. In this context, each player needs to see the other player's response and based on their resources, proceed with their strategy and update their posterior with the new information of the competitor. This brings other variables into play: probability of one of the competitors choosing the same option (primarily) who started the price war, LM, by responding to Emart (Min-Ji, 2021) to end the war. Another is the number of times the other player (in this case, Emart) will keep responding with a DP to continue the war. The optimized strategy based on the assumption that war will end with (Same, Same) will give the player more funds to control the game's flow by utilizing a DP strategy. This will bankrupt the other competitor or force them to make a move that makes them choose SP. Although this is a risk-seeking strategy rationally, as both parties do not know each other's funds, so small iterative changes need to be made**.**

Optional Challenge: Alternative Payoff Matrix

Emart			
Lotte Mart		**Implement Discount Offers (IDO)** **1/3**	**Remove Discount Offers (RDO)** **2/3**
	Increase Lotte Points (ILP) **2/3**	**0, 0** **2/9**	**-1, 1** **4/9**

	Decrease Lotte Points. **(DLP)** **1/3**	**-1, 1** **1/9**	**-1, -1** **2/9**

Fig. 7 shows the mixed strategy implemented by including Lotte points change. Probabilities are shown for Mixed strategy payoffs with outcome probabilities.

Based on our decision trees, we can see that LM has other features: Lotte points. This feature can be included to create a payoff matrix based on profit (change in company value).

Fig. 7 depicts a mixed strategy game as now both players are alternating between two different strategies: Change in Lotte points and Discount offers are incentives like buy one get one free (Emart) e.g. Almond chocolate sticks of LM being sold at Emart for buy two get one free. Given that it is a mixed strategy probability of each player's strategies will be calculated as shown below.

$$EU_{IDO} = \sigma_{ILP}(0) + (1 - \sigma_{ILP})(1) = 1 - \sigma_{ILP}$$

$$EU_{RDO} = \sigma_{ILP}(1) + (1 - \sigma_{ILP})(-1) = 2\sigma_{ILP} - 1$$

$$EU_{IDO} = EU_{RDO}$$

$$1 - \sigma_{ILP} = 2\sigma_{ILP} - 1$$

$$2 = 3\sigma_{ILP}$$

$$\sigma_{ILP} = \frac{2}{3}$$

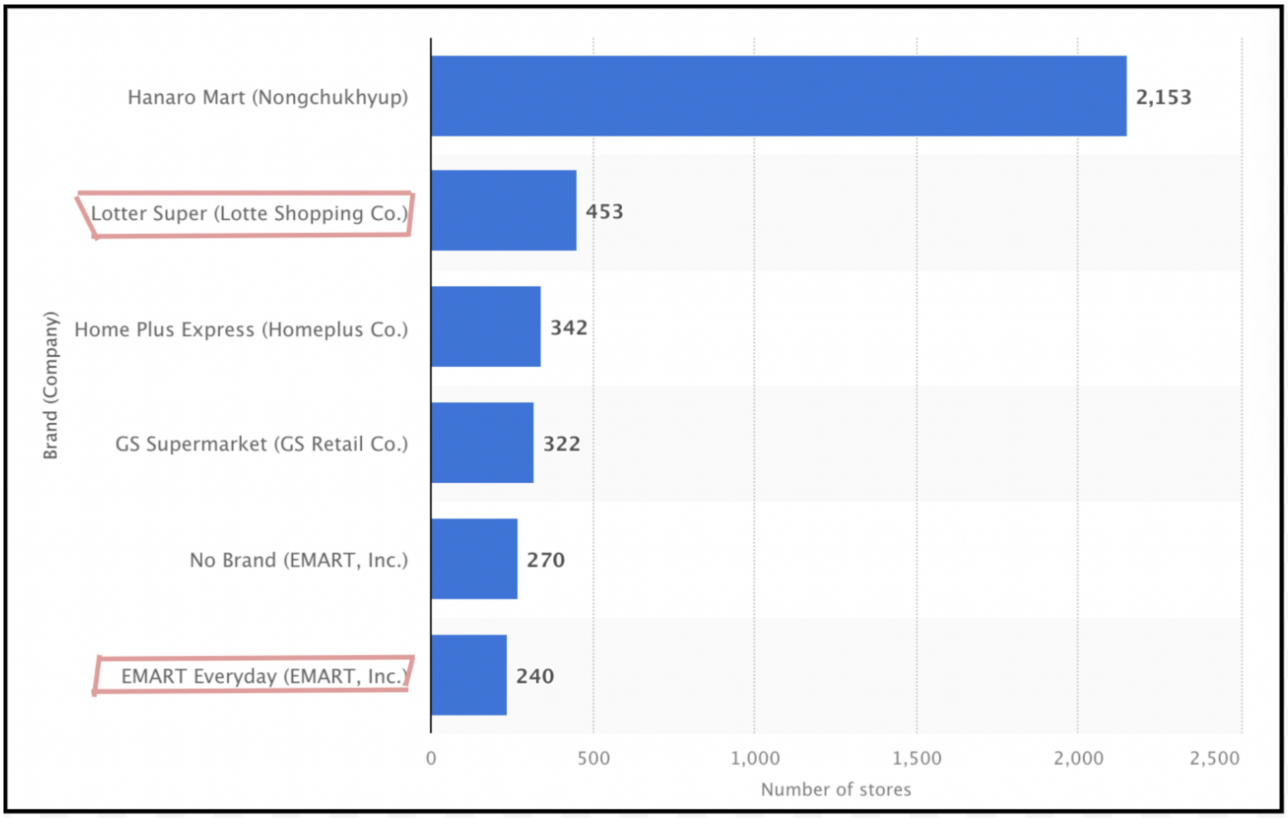
$$\sigma_{DLP} = \frac{1}{3}$$

The above values indicate that if LM plays ILP **23** of the time and DLP **13** of the time, Emart will be indifferent and expected utility would remain the same. We will then find the outcome of each by multiplying each probability by each other, as shown in **Fig. 7.** Finally, each outcome probability will be multiplied by the old payoff to find the mixed strategy Nash equilibrium payout. Therefore, LM should increase Lotte points while Emart should remove discount offers to prevent the other player from making an unpredictable move.

Utilities and biases

Loss aversion for Emart and Sunk costs for LM played considerable roles in their game theory. Emart showed loss aversion based on descriptive prospect theory, as it lowered its costs but saw Lotte Marts giving Lotte points which helped people get discounts on products. Emart has lower financial stability in the market than Lotte Mart based on the number of chains **(Fig. 8)** it owns and we can assume that more profit is earned with more chains. Additionally, it does not have such a system in place that delays the current lowering of price and distributes in the next quarter when customers accumulate enough points for discounts. Hence, according to normative prospect theory, it will not reduce its prices and will be loss averse. Emart will take a narrow framing approach. Emart is not financially stable; therefore, upon each iterative decision, they need to see whether this will cause immediate bankruptcy with a short time frame lenience.

Additionally, sunk costs for Lotte Mart will create a cognitive bias. It reduced prices and gave more Lotte points which means it has spent considerable resources to compete and outrun Emart. If Emart decides to lower its prices further, which is less likely but still can occur, Lotte Mart will do the same as losing now will mean a considerable loss and adverse effect on its reputation. This strategy will cause it to be more risk-seeking to win the war and take a broad-framing approach as it has invested massive resources into the price war. Winning will lead Emart to bankruptcy or give it a big hit that will jeopardize its business.[4]



[4] **#utility:** Rational behavior is assessed when addressing why a Nash equilibrium is needed as rational players not necessarily follow a strictly dominant strategy. Risk preferences and cognitive biases of each player have been identified, justified with evidence and utilized to explain their strategic behavior based on real evidence and descriptive or normative prospect theory. Lastly, narrow framing and broad framing have been utilized to further analyze the risk preferences and cognitive biases affecting players.

Fig. 8 shows the evidence that Lotte Mart is a bigger brand based on the number of stores it runs for groceries compared to Emart (Jobst, 2021). We are only considering Emart Everyday as No Brand is owned by child companies too (cleared by Korean Minervans).

Reflection

The results show that for the decision tree approach, EV will serve as the best source of strategic decision-making, giving the LM a decision to reduce prices for better utility. Maximax and Maximin cannot be used due to similar EVs leading to indifference in decision making upon rollback.

Game theory of the same scenario but accounting for Emart's decisions provided a dominant strategy for both players to utilize a DP approach over SP due to a greater payoff with DP strategy. Furthermore, a Nash equilibrium using the best response method was identified with both players playing a DP strategy to prevent the other from changing its decision. However, resources and time limitations accounted for the iterative process of addressing alternative strategies of ending price war after a certain gain. Lastly, a mixed strategy was shown with other strategies that can be implemented by both players concluding that LM should increase Lotte points. Simultaneously, Emart should remove discount offers to prevent the other player from making an unpredictable move.

WORD COUNT: 1589 words + 495 words for optionals [5]

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[5] **#professionalism:** I have maintained the world count rule, avoided grammatical and spelling errors, made the decision trees and payout matrixes with proper formatting, labeling and color distinction. I

References

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have used citations to cite my work and took precautions to avoid plagiarism. I have used all the guidelines from APA format, equations and code to better communicate the information.

Lotte Mart. (2021). Lotte. lotte.co.kr. Retrieved April 16, 2022, from https://www.lotte.co.kr/global/en/business/compDetail.do?compCd=L202#:~:text=Since%20then%2C%20it%20has%20been,is%20'Everyday%20NEW%20Store'.

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Appendix

Appendix A: Tree Diagram Values

1. Total Amount

$$\% \, Profit \; = \; Profit/Total \; Amount$$

$$\frac{35.3}{100} \; = \; \frac{117.4}{x}$$

$$x \; = \; \frac{117.4}{.353}$$

$$Total \; Amount \; = KRW \; 332.6 \; billion$$

2. Change in Prices

$$\% \, change \; in \; price \; = \; Change \; in \; price/Total \; Amount$$

$$\frac{22}{100} \; = \; \frac{x}{332.6}$$

$$x \; = \; 0.22 \; \times \; 332.6$$

$$Change \; in \; price \; = \; KRW \; 73.2 \; billion$$

3. Max Value (DP and CK)

$$Max \; Value \; (DP \; and \; CK) \; = \; KRW \; 332.6 \; billion \; + \; 73.2 \; billion \; = \; KRW \; 405.8 \; billion$$

4. Decreased Company Value

$$Decreased \; Company \; Value \; = \; KRW \; 332.6 \; billion \; - \; 73.2 \; billion \; = \; KRW \; 215.2.8 \; billion$$

5. Expected Values

```python
#For Same prices
ILP_1 = 0.2*332.6 + 0.8*215.2
SLP_1 = 0.1*215.2 + 0.9*200
if (ILP_1 > SLP_1):
  CK_1 = ILP_1
else:
  CK_1 = SLP_1

ILP_2 = 0.2*215.2 + 0.8*200
SLP_2 = 0.1*215.2 + 0.9*200

if (ILP_2 > SLP_2):
  CL_1 = ILP_2
else:
  CL_1 = SLP_2

SP = 0.1*CK_1 + 0.9*CL_1

print("EV of Increased Lotte Points =", ILP_1)
print("EV of Same Lotte Points =", SLP_1)
print("EV of Customers Kept =", CK_1)
print("EV of Increased Lotte Points =", ILP_2)
print("EV of Same Lotte Points =", SLP_2)
print("EV of Customers Lost =", CL_1)
print("EV of Same Price =", round(SP,2))
```

```
EV of Increased Lotte Points = 238.68
EV of Same Lotte Points = 201.52
EV of Customers Kept = 238.68
EV of Increased Lotte Points = 203.04
EV of Same Lotte Points = 201.52
EV of Customers Lost = 203.04
EV of Same Price = 206.6
```

```
#For Decreased prices
CK_2 = 405.8

ILP_3 = 0.7*260 + 0.3*200
SLP_3 = 0.3*260 + 0.7*200
if (ILP_3 > SLP_3):
  CL_2 = ILP_3
else:
  CL_2 = SLP_3

DP = 0.7*CK_2 + 0.3*CL_2

print("EV of Customers Kept =", CK_2)
print("EV of Increased Lotte Points =", ILP_3)
print("EV of Same Lotte Points =", SLP_3)
print("EV of Customers Lost =", CL_2)
print("EV of Decreased Price =", round(DP,2))
```

```
EV of Customers Kept = 405.8
EV of Increased Lotte Points = 242.0
EV of Same Lotte Points = 218.0
EV of Customers Lost = 242.0
EV of Decreased Price = 356.66
```