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MARKETING-SALES SIMULATION GAME

1 DECISIONS AND PAYOFFS

1.1 Company A Sales Department

Sales department negotiates the prices of Premium and Normal chips with retailers C and D, p_{AC}^{P}, p_{AD}^{P}, p_{AC}^{N}, and p_{AD}^{N} with $1.5 < p_{AC}^{P}, p_{AD}^{P} < 3$ and $0.85 < p_{AC}^{N}, p_{AD}^{N} < 1.2$.

It also negotiates quantities of Premium and Normal chips allocated to retailers C and D, q_{AC}^{P}, q_{AD}^{P}, q_{AC}^{N}, and q_{AD}^{N}.

Sales department maximizes total quantities sold, i.e., $q_{AC}^{P*} + q_{AD}^{P*} + q_{AC}^{N*} + q_{AD}^{N*} = q_{A}^{P*} + q_{A}^{N*}$

1.2 Company A Marketing Department

Marketing department decides how many units of Premium and Normal chips will be produced, i.e., q_{A}^{P} and q_{A}^{N}.

The total production capacity is $q_{A}^{P} + q_{A}^{N} = 150{,}000$.

Marketing department decides about investment in promotion, i.e., I_{A}^{P}, with $0 \leq I_{A}^{P} \leq 8000$.

Marketing department maximizes the average profit margin, i.e., $0.25[(0.9p_{AC}^{P} - c_{A}^{P}) + (0.9p_{AD}^{P} - c_{A}^{P}) + (0.9p_{AC}^{N} - c_{A}^{N}) + (0.9p_{AD}^{N} - c_{A}^{N})] - I_{A}^{P}/(q_{A}^{P*} + q_{A}^{N*})$

The cost of production is $c_{A}^{P} = 0.85$ and $c_{A}^{N} = 0.5$. Therefore, we have:

$$0.25[(0.9p_{AC}^{P} - 0.85\ ) + (0.9p_{AD}^{P} - 0.85\ ) + (0.9p_{AC}^{N} - 0.5) + (0.9p_{AD}^{N} - 0.5)] - I_{A}^{P}/(q_{A}^{P*} + q_{A}^{N*})$$

1.3 Company B Sales Department

Sales department negotiates the prices of Premium and Normal chips with retailers C and D, p_{BC}^{P}, p_{BD}^{P}, p_{BC}^{N}, and p_{BD}^{N}, with $1.5 < p_{BC}^{P}, p_{BD}^{P} < 3$ and $0.85 < p_{BC}^{N}, p_{BD}^{N} < 1.2$.

It also negotiates quantities of Premium and Normal chips allocated to retailers C and D, q_{BC}^{P}, q_{BD}^{P}, q_{BC}^{N}, and q_{BD}^{N}.

Sales department maximizes total sales, i.e., $q_{BC}^{P*} + q_{BD}^{P*} + q_{BC}^{N*} + q_{BD}^{N*} = q_{B}^{P*} + q_{B}^{N*}$

1.4 Company B Marketing Department

Marketing department decides how many units of Premium and Normal chips will be produced, i.e., q_B^P and q_B^N

The total production capacity is $q_B^P + q_B^N = 150{,}000$

Marketing department decides about investment in promotion, i.e., I_B^P, with $0 \leq I_B^P \leq 8000$

Marketing department maximizes the average profit margin, i.e., $0{,}25[(0{,}9p_{BC}^P - c_B^P) + (0{,}9p_{BD}^P - c_B^P) + (0{,}9p_{BC}^N - c_B^N) + (0{,}9p_{BD}^N - c_B^N)] - I_B^P/(q_B^{P*} + q_B^{N*})$

The cost of production is $c_B^P = 0.85$ and $c_B^N = 0.5$. Therefore, we have:

$0{,}25[(0{,}9p_{BC}^P - 0.85) + (0{,}9p_{BD}^P - 0.85) + (0{,}9p_{BC}^N - 0.5) + (0{,}9p_{BD}^N - 0.5)] - I_B^P/(q_B^{P*} + q_B^{N*})$

1.5 Retailer C

Retailer negotiates the prices of Premium and Normal chips with companies A and B, p_{BC}^P, p_{AC}^P, p_{BC}^N, and p_{AC}^N

Retailer negotiates quantities of Premium and Normal chips with companies A and B, q_{BC}^P, q_{AC}^P, q_{BC}^N, and q_{AC}^N

1.6 Retailer D

Retailer negotiates the prices of Premium and Normal chips with companies A and B, p_{BD}^P, p_{AD}^P, p_{BD}^N, and p_{AD}^N

Retailer negotiates quantities of Premium and Normal chips with companies A and B, q_{BC}^P, q_{AC}^P, q_{BC}^N, and q_{AC}^N

2. MARKETS

We assume that, consumers can “travel” between the retailers. We also assume that normal chips produced by one firm are substitutes for normal chips produced by another firm. However, premium chips and normal chips are not substitutes. That is, markets for normal chips and markets for premium chips are independent.

2.1 Market for Normal chips

2.1.1 Firm A, Retailer C

Demand (Firm A, Retailer C):

$$\hat{q}_{AC}^N = 50{,}000 - 45{,}000p_{AC}^N + 25{,}000\, p_{BC}^N + 2{,}000p_{AD}^N + 1{,}000p_{BD}^N$$

Equilibrium quantity (Firm A, Retailer C):

$$q_{AC}^{N*} = \hat{q}_{AC}^{N} \text{ if } 0 < \hat{q}_{AC}^{N} \leq q_{AC}^{N}$$

$$q_{AC}^{N*} = 0 \text{ if } \hat{q}_{AC}^{N} \leq q_{AC}^{N} \text{ and } \hat{q}_{AC}^{N} < 0$$

$$q_{AC}^{N*} = q_{AC}^{N} \text{ if } \hat{q}_{AC}^{N} > q_{AC}^{N}$$

<u>2.1.2 Firm B, Retailer C</u>

Demand (Firm B, Retailer C):

$$\hat{q}_{BC}^{N} = 50{,}000 - 45{,}000p_{BC}^{N} + 25{,}000\, p_{AC}^{N} + 2{,}000p_{BD}^{N} + 1{,}000p_{AD}^{N}$$

Equilibrium quantity (Firm B, Retailer C):

$$q_{BC}^{N*} = \hat{q}_{BC}^{N} \text{ if } 0 < \hat{q}_{BC}^{N} \leq q_{BC}^{N}$$

$$q_{BC}^{N*} = 0 \text{ if } \hat{q}_{BC}^{N} \leq q_{BC}^{N} \text{ and } \hat{q}_{BC}^{N} < 0$$

$$q_{BC}^{N*} = q_{BC}^{N} \text{ if } \hat{q}_{BC}^{N} > q_{BC}^{N}$$

<u>2.1.3 Firm A, Retailer D</u>

Demand (Firm A, Retailer D):

$$\hat{q}_{AD}^{N} = 50{,}000 - 45{,}000p_{AD}^{N} + 25{,}000\, p_{BD}^{N} + 2{,}000p_{AC}^{N} + 1{,}000p_{BC}^{N}$$

Equilibrium quantity (Firm A, Retailer D):

$$q_{AD}^{N*} = \hat{q}_{AD}^{N} \text{ if } 0 < \hat{q}_{AD}^{N} \leq q_{AD}^{N}$$

$$q_{AD}^{N*} = 0 \text{ if } \hat{q}_{AD}^{N} \leq q_{AD}^{N} \text{ and } \hat{q}_{AD}^{N} < 0$$

$$q_{AD}^{N*} = q_{AD}^{N} \text{ if } \hat{q}_{AD}^{N} > q_{AD}^{N}$$

<u>2.1.4 Firm B, Retailer D</u>

Demand (Firm B, Retailer D):

$$\hat{q}_{BD}^{N} = 50{,}000 - 45{,}000p_{BD}^{N} + 25{,}000\, p_{AD}^{N} + 2{,}000p_{BC}^{N} + 1{,}000p_{AC}^{N}$$

Equilibrium quantity (Firm B, Retailer D):

$$q_{BD}^{N*} = \hat{q}_{BD}^{N} \text{ if } 0 < \hat{q}_{BD}^{N} \leq q_{BD}^{N}$$

$$q_{BD}^{N*} = 0 \text{ if } \hat{q}_{BD}^{N} \leq q_{BD}^{N} \text{ and } \hat{q}_{BD}^{N} < 0$$

$$q_{BD}^{N*} = q_{BD}^{N} \text{ if } \hat{q}_{BD}^{N} > q_{BD}^{N}$$

2.2 Market for Premium chips

2.2.1 Firm A, Retailer C

Demand (Firm A, Retailer C):

$$\hat{q}_{AC}^{P} = 20{,}000 - 1{,}000p_{AC}^{P} + 100\, p_{BC}^{P} + 10p_{AD}^{P} + p_{BD}^{P} + (I_A^P - I_B^P)$$

Equilibrium quantity (Firm A, Retailer C):

$$q_{AC}^{P*} = \hat{q}_{AC}^{P} \text{ if } 0 < \hat{q}_{AC}^{P} \leq q_{AC}^{P}$$

$$q_{AC}^{P*} = 0 \text{ if } \hat{q}_{AC}^{P} \leq q_{AC}^{P} \text{ and } \hat{q}_{AC}^{P} < 0$$

$$q_{AC}^{P*} = q_{AC}^{P} \text{ if } \hat{q}_{AC}^{P} > q_{AC}^{P}$$

2.2.2 Firm B, Retailer C

Demand (Firm B, Retailer C):

$$\hat{q}_{BC}^{P} = 12{,}000 - 1{,}000p_{BC}^{P} + 100\, p_{AC}^{P} + 10p_{BD}^{P} + p_{AD}^{P} + (I_B^P - I_A^P)$$

Equilibrium quantity (Firm B, Retailer C):

$$q_{BC}^{P*} = \hat{q}_{BC}^{P} \text{ if } 0 < \hat{q}_{BC}^{P} \leq q_{BC}^{P}$$

$$q_{BC}^{P*} = 0 \text{ if } \hat{q}_{BC}^{P} \leq q_{BC}^{P} \text{ and } \hat{q}_{BC}^{P} < 0$$

$$q_{BC}^{P*} = q_{BC}^{P} \text{ if } \hat{q}_{BC}^{P} > q_{BC}^{P}$$

2.2.3 Firm A, Retailer D

Demand (Firm A, Retailer D):

$$\hat{q}_{AD}^{P} = 12{,}000 - 1{,}000p_{AD}^{P} + 100\, p_{BD}^{P} + 10p_{AC}^{P} + p_{BC}^{P} + (I_A^P - I_B^P)$$

Equilibrium quantity (Firm A, Retailer D):

$$q_{AD}^{P*} = \hat{q}_{AD}^{P} \text{ if } 0 < \hat{q}_{AD}^{P} \leq q_{AD}^{P}$$

$$q_{AD}^{P*} = 0 \text{ if } \hat{q}_{AD}^{P} \leq q_{AD}^{P} \text{ and } \hat{q}_{AD}^{P} < 0$$

$$q_{AD}^{P*} = q_{AD}^{P} \text{ if } \hat{q}_{AD}^{P} > q_{AD}^{P}$$

2.2.4 Firm B, Retailer D

Demand (Firm B, Retailer D):

$$\hat{q}_{BD}^{P} = 12{,}000 - 1{,}000p_{BD}^{P} + 100\, p_{AD}^{P} + 10p_{BC}^{P} + p_{AC}^{P} + (I_{B}^{P} - I_{A}^{P})$$

Equilibrium quantity (Firm B, Retailer D):

$$q_{BD}^{P*} = \hat{q}_{BD}^{P} \text{ if } 0 < \hat{q}_{BD}^{P} \leq q_{BD}^{P}$$

$$q_{BD}^{P*} = 0 \text{ if } \hat{q}_{BD}^{P} \leq q_{BD}^{P} \text{ and } \hat{q}_{BD}^{P} < 0$$

$$q_{BD}^{N*} = q_{BD}^{N} \text{ if } \hat{q}_{BD}^{N} > q_{BD}^{N}$$

3. PROFITS

Firms receive 90% of the revenue from selling chips, while retailers receive 10%. Firm A and B's profits are given by:

$$\pi_A = (0{,}9p_{AC}^{P}q_{AC}^{P*} - c_{A}^{P}q_{AC}^{P}) + (0{,}9p_{AD}^{P}q_{AD}^{P*} - c_{A}^{P}q_{AD}^{P}) + (0{,}9p_{AC}^{N}q_{AC}^{N*} - c_{A}^{N}q_{AC}^{N}) + (0{,}9p_{AD}^{N}q_{AD}^{N*} - c_{A}^{N}q_{AD}^{N}) - I_{A}^{P}$$

$$\pi_B = (0{,}9p_{BC}^{P}q_{BC}^{P*} - c_{B}^{P}q_{BC}^{P}) + (0{,}9p_{BD}^{P}q_{BD}^{P*} - c_{B}^{P}q_{BD}^{P}) + (0{,}9p_{BC}^{N}q_{BC}^{N*} - c_{B}^{N}q_{BC}^{N}) + (0{,}9p_{BD}^{N}q_{BD}^{N*} - c_{B}^{N}q_{BD}^{N}) - I_{B}^{P}$$

Since the markets for premium and normal chips are independent, we can solve the model for each market separately.

3.1 Normal chips

Profits from selling normal chips are:

$$\pi_A = (0{,}9p_{AC}^{N}q_{AC}^{N*} - c_{A}^{N}q_{AC}^{N}) + (0{,}9p_{AD}^{N}q_{AD}^{N*} - c_{A}^{N}q_{AD}^{N})$$

$$\pi_B = (0{,}9p_{BC}^{N}q_{BC}^{N*} - c_{B}^{N}q_{BC}^{N}) + (0{,}9p_{BD}^{N}q_{BD}^{N*} - c_{B}^{N}q_{BD}^{N})$$

Plugging for costs and assuming that firms do not overproduce:

$$\pi_A = (0{,}9p_{AC}^N - 0.5)q_{AC}^{N*} + (0{,}9p_{AD}^N - 0.5)q_{AD}^{N*}$$

$$\pi_B = (0{,}9p_{BC}^N - 0.5)q_{BC}^{N*} + (0{,}9p_{BD}^N - 0.5)q_{BD}^{N*}$$

Plugging for the demand functions:

$$\pi_A = (0{,}9p_{AC}^N - 0.5)(50{,}000 - 45{,}000p_{AC}^N + 25{,}000\, p_{BC}^N + 2{,}000p_{AD}^N + 1{,}000p_{BD}^N) + (0{,}9p_{AD}^N - 0.5)(50{,}000 - 45{,}000p_{AD}^N + 25{,}000\, p_{BD}^N + 2{,}000p_{AC}^N + 1{,}000p_{BC}^N)$$

$$\pi_B = (0{,}9p_{BC}^N - 0.5)(50{,}000 - 45{,}000p_{BC}^N + 25{,}000\, p_{AC}^N + 2{,}000p_{BD}^N + 1{,}000p_{AD}^N) + (0{,}9p_{BD}^N - 0.5)(50{,}000 - 45{,}000p_{BD}^N + 25{,}000\, p_{AD}^N + 2{,}000p_{BC}^N + 1{,}000p_{AC}^N)$$

Maximizing with respect to prices:

$$p_{AC}^{N*} = 0.821 + 0.278P_{BC}^N + 0.044p_{AD}^N + 0.011p_{BD}^N$$

$$p_{AD}^{N*} = 0.821 + 0.278P_{BD}^N + 0.044p_{AC}^N + 0.011p_{BC}^N$$

$$p_{BC}^{N*} = 0.821 + 0.278P_{AC}^N + 0.044p_{BD}^N + 0.011p_{AD}^N$$

$$p_{BD}^{N*} = 0.821 + 0.278P_{AD}^N + 0.044p_{BC}^N + 0.011p_{AC}^N$$

Solving for prices:

$$p_{AC}^{N*} = p_{AD}^{N*} = p_{BC}^{N*} = p_{BD}^{N*} = 1.231$$

Therefore, optimum quantities are:

$$q_{AC}^{N*} = q_{AD}^{N*} = q_{BC}^{N*} = q_{BD}^{N*} = 29{,}073$$

3.2 Premium chips

Profits from selling premium chips are:

$$\pi_A = (0{,}9p_{AC}^P q_{AC}^{P*} - c_A^P q_{AC}^P) + (0{,}9p_{AD}^P q_{AD}^{P*} - c_A^P q_{AD}^P) - I_A^P$$

$$\pi_B = (0{,}9p_{BC}^P q_{BC}^{P*} - c_B^P q_{BC}^P) + (0{,}9p_{BD}^P q_{BD}^{P*} - c_B^P q_{BD}^P) - I_B^P$$

Plugging for costs and assuming that firms do not overproduce:

$$\pi_A = (0{,}9p_{AC}^P - 0.85)q_{AC}^{P*} + (0{,}9p_{AD}^P - 0.85)q_{AD}^{P*} - I_A^P$$

$$\pi_B = (0{,}9p_{BC}^P - 0.85)q_{BC}^{P*} + (0{,}9p_{BD}^P - 0.85)q_{BD}^{P*} - I_B^P$$

Plugging for the demand functions:

$$\pi_A = (0{,}9p_{AC}^P - 0.85)(20{,}000 - 1{,}000p_{AC}^P + 100\,p_{BC}^P + 10p_{AD}^P + p_{BD}^P + (I_A^P - I_B^P)) + (0{,}9p_{AD}^P - 0.85)(12{,}000 - 1{,}000p_{AD}^P + 100\,p_{BD}^P + 10p_{AC}^P + p_{BC}^P + (I_A^P - I_B^P)) - I_A^P$$

$$\pi_B = (0{,}9p_{BC}^P - 0.85)(20{,}000 - 1{,}000p_{BC}^P + 100\,p_{AC}^P + 10p_{BD}^P + p_{AD}^P + (I_B^P - I_A^P)) + (0{,}9p_{BD}^P - 0.85)(12{,}000 - 1{,}000p_{BD}^P + 100\,p_{AD}^P + 10p_{BC}^P + p_{AC}^P + (I_B^P - I_A^P)) - I_B^P$$

Taking derivatives with respect to investments in promotion:

$$0.9(p_{AC}^P + p_{AD}^P) - 2.7 > 0$$

$$0.9(p_{BC}^P + p_{BD}^P) - 2.7 > 0$$

Since the lowest possible prices for premium chips are 1.5, these derivatives are always positive. Therefore, in the optimum, each firms chooses the highest possible investment in promotion, i.e.:

$$I_A^{P*} = 6{,}000$$

$$I_B^{P*} = 6{,}000$$

Maximizing with respect to prices:

$$p_{AC}^{P*} = 10.4675 + 0.05P_{BC}^P + 0.01p_{AD}^P + 0.0005p_{BD}^P + 0.0005(I_A^P - I_B^P)$$

$$p_{AD}^{P*} = 10.4675 + 0.05P_{BD}^P + 0.01p_{AC}^P + 0.0005p_{BC}^P + 0.0005(I_A^P - I_B^P)$$

$$p_{BC}^{P*} = 10.4675 + 0.05P_{AC}^P + 0.01p_{BD}^P + 0.0005p_{AD}^P + 0.0005(I_B^P - I_A^P)$$

$$p_{BD}^{P*} = 10.4675 + 0.05P_{AD}^P + 0.01p_{BC}^P + 0.0005p_{AC}^P + 0.0005(I_B^P - I_A^P)$$

Plugging optimal level of investments in promotion:

$$p_{AC}^{P*} = 10.4675 + 0.05P_{BC}^P + 0.01p_{AD}^P + 0.0005p_{BD}^P$$

$$p_{AD}^{P*} = 10.4675 + 0.05P_{BD}^P + 0.01p_{AC}^P + 0.0005p_{BC}^P$$

$$p_{BC}^{P*} = 10.4675 + 0.05P_{AC}^P + 0.01p_{BD}^P + 0.0005p_{AD}^P$$

$$p_{BD}^{P*} = 10.4675 + 0.05P_{AD}^P + 0.01p_{BC}^P + 0.0005p_{AC}^P$$

Solving for prices:

$$p_{AC}^{P*} = p_{AD}^{P*} = p_{BC}^{P*} = p_{BD}^{P*} = 11.1416$$

Therefore, optimum quantities are:

$$q_{AC}^{P*} = q_{AD}^{P*} = q_{BC}^{P*} = q_{BD}^{P*} = 2{,}095$$