Supply Optimization at MicroSystems, Inc.

Summary

The case that we decided to solve is based on being a supply chain analyst for Microsystems Inc and determining the optimal solution to how to distribute the purchase of 5200 units of a key component part between four suppliers while minimizing the total costs. Part of the 5200 units is a 700 unit safety stock that the company requested just to make sure they have some of the part on hand. Minimizing costs is of course one of the main objectives of any business but is especially key when it goes towards your fixed costs and is a monthly expense. Minimizing Microsystems Inc fixed costs are important to being a profitable business so this case is something that can really help the company.

Our group then used the data from the case that was provided to begin to formulate our linear programming model. We then went through a couple of versions of our solver model in excel to be able to get an optimal solution that fulfilled all of the constraints. The group then used a one-way sensitivity analysis to test the relationship between the minimum number of units that need to be purchased to satisfy demand and how it affects the total cost and average unit cost.

We think that our model can be viable for Microsystems Inc to implement into their current operations as the model we created can even be scaled up or modified if need be. Microsystems Inc can use our current model to fit its current needs while also changing the constraints if it wants to increase the amount of safety stock, the minimum number of units needed to satisfy the demand, the average on time delivery rate, or the amount the company wants to get from a certain supplier.

Introduction

Company

MicroSystems Inc. is a leading, innovative technology company that produces cutting edge, lifesaving medical devices. Due to the high demand of these first to market products, flagship products often sell out and have long lead times. The inability to effectively supply the products are directly impacting the company's competitive edge to maximize their sales before similar products are introduced by competitors. In preparation for annual budgeting and sales projections, the company has hired a consulting company to identify the key driver in the company's inability to maximize available supply and long lead times.

Problem

Upon conducting a review of Microsystems Inc's product offerings and the key components essential to it's production, it is clear that the production is heavily dependent on the availability of hardware components. Historical records indicate that there are four suppliers that the company purchased parts from**. Table 1** shows the four suppliers against three leading decision factors for purchasing the parts. These factors consist of cost per unit, on time delivery, and quality acceptance rate. These three factors are directly influencing purchase behaviors but adverse contributing to the long lead time and inability to meet demand.

Table 1: MicroSystems Inc. Suppliers

Suppliers	***Cost Per Unit***	***Quality Acceptance Rate***	***On-time Delivery Rate***
Supplier 1	$15.00	99%	95%
Supplier 2	$12.30	90%	85%
Supplier 3	$14.50	95%	90%
Supplier 4	$13.90	90%	94%

The consultants concluded their review and acknowledged that MicroSystems Inc's approach of utilizing multiple suppliers for their parts was a smart method of combatting a high dependency on just a single supplier however, it would recommend an intensive review of the following criteria; establishing a minimum average quality acceptance rate, a minimum on time delivery average rate, identifying a maximum average cost per unit, and lastly ordering no more than a specified percentage of their total product order from a single supplier will improve the efficiency of their ordering practices.

Proposed Solution

The company adopted this recommendation and organized a team to identify the criteria outlined in the recommendation and determined a quality minimum acceptance average rate of 94%, a minimum on time delivery average of 90%, an average unit cost of $14, and lastly purchasing no more than 50% of the supply from a single supplier. In its review it also determined that a minimum of 4,500 units are required but to better prepare for the spoilage of the units that fail quality testing and demand the actual order will consist of 5,200 units.

While MicroSystems Inc. was pleased with the criteria that they established, they still had to determine the cost implication of implementing the practice. They would have to identify how much this optimized purchasing strategy with cost. While an increase of previous years purchasing budget is evident in the additional units, the increased cost would have to be minimized to be ensure approval from budgeting. Therefore, before submitting their annual budget proposal, it was suggested that the criteria be modeled using the historical data from the suppliers.

Main Chapter

Data Collection

In identifying a solution to the inability to produce enough product to meet demand it was determined that key components were the primary reason for the lead times. Historical data for each supplier was then evaluated to determine what their product's quality acceptance rate average, on time delivery average rate, and the cost per unit. Establishing these baselines for each supplier enabled the respective MicroSystems Inc. teams the ability to identify what the overall average would need to be to better meet production demand.

Data Analysis

The overall average criteria of quality acceptance rate average, on time delivery average rate, and the cost per unit were identified in conjunction with other factors such as the total number of units to be ordered, as well as safeguarding from over dependency on a single supplier. Through identifying these criteria we were able to build them into a model as constraints. **Table 2** below outlines the data that was gathered and how it contributed to the overall average criteria identified by MicroSystems Inc. The red indicates where a target requirement is not met and for each or the suppliers there is an area that they fall short.

Table 2: Suppliers in Comparison to Target Criteria

Suppliers	***Supplier 1***	***Supplier 2***	***Supplier 3***	***Supplier 4***	***Target***
Quality Acceptance Rate	99%	90%	95%	90%	94%
On-time Delivery Rate	95%	85%	90%	94%	90%
Cost Per Unit	15.00	12.20	14.50	13.90	14.00
Total Number of Units to Order	TBD	TBD	TBD	TBD	4800

Through this analysis it is clear that no one supplier can fulfill the target criteria and therefore the focus should shift to two key takeaways, the first being the number of units to be ordered. In the past, the number of units ordered consisted of the total number of desired units to be produced. However, when factoring in the average acceptance rate, it is important to note that the final count is expected to be fall about 6% short. Knowing that we open ourselves to about 6% of failed parts, this loss should be factored into the total number of parts orders. Therefore, the number of total units can be adjusted from 4,500 to 5,200 units.

Secondly is mitigating too much dependency on a single supplier. This is especially essential in respective to on time delivery. Placing large orders with a supplier that has the tendency to have delayed delivery can be detrimental to production schedules as well as the company's ability to fulfill demand. Balancing the criteria on time delivery against a maximum unit per supplier ensures that product will remain to come in through other suppliers in the in the event of a delay for another supplier.

Requirement Gathering

Building the linear programming model took some trial and error, in order to get all of the constraints included and for the model itself to work properly. One of the challenges that the group faced was factoring the weighted averages for the quality acceptance rate and on time delivery rate. Those two constraints were important ones in our model because while minimizing costs the case stated that the quality acceptance rate and on time delivery rate still had to be above 94 and 90 percent respectively. The decision variables and the objective function were the easier parts of the model to formulate while we had to seek additional information about the constraints I mentioned earlier. We also added in the constraint to making sure that one supplier doesn't account for over 50% of one order. This was the process that got our group to the final model that we used to complete our case.

Optimization Model

This optimization case aims to minimize the procurement cost for MicroSystems by strategically determining the quantities to be ordered from four distinct suppliers. The decision variables for this optimization problem involve specifying the quantities to be procured from each supplier, denoted as follows.

Decision Variables	**Definition**
S_1	Number of Units from Supplier 1
S_2	Number of Units from Supplier 2
S_3	Number of Units from Supplier 3
S_4	Number of Units from Supplier 4

Additionally, key parameters are defined as other variables to characterize each supplier

Inputs	**Definition**	**Values**
QA_1, QA_2, QA_3, QA_4	Quality Acceptance Rate for each Supplier	0.99, 0.9, 0.95, 0.9
D_1, D_2, D_3, D_4	On Time Delivery Rate for each Supplier	0.95, 0.85, 0.9, 0.94
C_1, C_2, C_3, C_4	Cost per Unit for each Supplier	15, 12.3, 14.5, 13.9

Objective Function is to minimize the total cost for Microsystems by procuring the optimal number of units from each supplier.

$$\text{i.e., } Z = \text{Min}\,(S_1C_1+S_2C_2+S_3C_3+S_4C_4)$$

$$Z = \sum_{i=1}^{4} S_i \cdot C_i$$

Objective Function	Description
Minimize Costs =SUMPRODUCT(S_1:S_4, C_1:C_4)	To minimize costs for the monthly order, we are using solver to determine the optimal number of units from each of the four suppliers at their given cost per unit.

Constraints:

There are multiple constraints defined by Microsystem and it's supply chain management

Demand and Safety Stock Requirement:

The total number of units ordered (S_1+S_2+S_3+S_4)must be equal to or greater than 5200 to meet the demand and ensure a safety stock.

$$S_1+S_2+S_3+S_4 >= 5200$$

$$\sum_{i=1}^{4} S_i \geq 5200$$

Average Quality Acceptance Rate Constraint:

The average quality acceptance rate, calculated as the weighted average of each supplier's acceptance rate (S_i*QA_i), must be at least 94%. This ensures a high overall quality standard in the procured units.

$$(S_1 \cdot QA_1+S_2 \cdot QA_2+S_3 \cdot QA_3+S_4 \cdot QA_4)/(\ S_1+S_2+S_3+S_4) \geq 0.94$$

$$(S_1 \cdot QA_1+S_2 \cdot QA_2+S_3 \cdot QA_3+S_4 \cdot QA_4) >= 0.94\ (\ S_1+S_2+S_3+S_4)$$

{ To satisfy the constraints of linear model without errors}

$$\frac{\sum_{i=1}^{4} S_i \cdot QA_i}{\sum_{i=1}^{4} S_i} \geq 0.94$$

On-Time Delivery Average Constraint:

The average on-time delivery rate, calculated as the weighted average of each supplier's on-time delivery rate ($S_i D_i$), must be at least 90%. This ensures that the suppliers consistently deliver components on time.

$$(S_1 \cdot D_1 + S_2 \cdot D_2 + S_3 \cdot D_3 + S_4 \cdot D_4) / (S_1 + S_2 + S_3 + S_4) \geq 0.90$$

$$S_1 \cdot D_1 + S_2 \cdot D_2 + S_3 \cdot D_3 + S_4 \cdot D_4 \geq 0.90\,(S_1 + S_2 + S_3 + S_4)$$

{ To satisfy the constraints of linear model without errors}

$$\frac{\sum_{i=1}^{4} S_i \cdot D_i}{\sum_{i=1}^{4} S_i} \geq 0.90$$

Average Unit Cost Constraint:

The average unit cost, calculated as the weighted average of each supplier's cost per unit ($S_i \cdot C_i$), must be $14 or lower. This ensures cost-effectiveness in procurement.

$$(S_1 \cdot C_1 + S_2 \cdot C_2 + S_3 \cdot C_3 + S_4 \cdot C_4) / (S_1 + S_2 + S_3 + S_4) \leq 14$$

$$S_1 \cdot C_1 + S_2 \cdot C_2 + S_3 \cdot C_3 + S_4 \cdot C_4 \leq 14\,(S_1 + S_2 + S_3 + S_4)$$

{To satisfy the constraints of linear model without errors}

$$\frac{\sum_{i=1}^{4} S_i \cdot C_i}{\sum_{i=1}^{4} S_i} \leq 14$$

Supplier Distribution Constraint:

No single supplier (S_i) should provide more than 50% of the total purchase. This constraint ensures diversification of suppliers, reducing the risk associated with relying heavily on a single source.

$$S_1 \leq 0.5 \cdot (S_1 + S_2 + S_3 + S_4)$$

$$S_2 \leq 0.5 \cdot (S_1 + S_2 + S_3 + S_4)$$

$$S_3 \leq 0.5 \cdot (S_1 + S_2 + S_3 + S_4)$$

$$S_4 \leq 0.5 \cdot (S_1 + S_2 + S_3 + S_4)$$

$$S_i \leq 0.5 \cdot \sum_{i=1}^{4} S_i \quad \text{for } i = 1, 2, 3, 4$$

Non- Negativity Constraint:

This constraint ensures that the quantities ordered from each supplier must be greater than or equal to zero.

$$Si \geq 0 \text{ for } i=1,2,3,4$$

Constraint	Formula	Description
Minimum Units Required by Microsystems	Total Units >= 4500	Making sure that the minimum purchase requirement is met.
Manager Order Plan	Total Units = 5200	Meeting the requirement for the additional safety stock for Microsystems.
Average Quality Acceptance	=SUMPRODUCT(S_1:S_4, QA_1:QA_4)/Total Number of Units >= 0.94	Making sure that the quality acceptance rate is 94% or higher.
Average On-Time Delivery Rate	=SUMPRODUCT(S_1:S4, D_1:D_4)/Total Number of Units >= 0.9	Making sure that the on-time delivery rate is 90% or higher.
Average Unit Cost	=SUMPRODUCT(S_1:S_4, C_1:C_4)/Total Number of Units <= 14	To make sure the average unit cost is under $14.
Units from Suppliers 1, 2, 3, and 4	S_1 <= 2600 S_2 <= 2600 S_3 <= 2600 S_4 <= 2600	This makes sure that over 50% of the monthly order isn't coming from one supplier.

After formulating this model, we went on to use a solver analysis to find the optimal solution for this case.

Solution Results & Analysis

The problem description has been transformed into a practical Excel model, where we've organized the data at the top and highlighted key decision variables. To create the objective function, we formulated necessary formulas, considering both the cost and the quantity of units from each supplier. Constraints have been specified at the bottom of the sheet, divided into Left-Hand Side (LHS) and Right-Hand Side (RHS), with constraint values on the RHS and resultant values on the LHS, connected by comparison operators.

Minimize the Total Purchasing cost

	Decision Variables	Num of Units	Quality Acceptance Rate	On-time Delivery Rate	Cost per Unit, $
Supplier 1	S1=		0.99	0.95	15
Supplier 2	S2=		0.9	0.85	12.3
Supplier 3	S3=		0.95	0.9	14.5
Supplier 4	S4=		0.9	0.94	13.9
	Total Units	0			

Objective Function

Minimize Total Cost	$ -

Constraints

	LHS		RHS
Minimum Units Req by MicroSystems	0	>=	4200
Manager Order plan	0	=	5200
Avg Quality Acceptance	#DIV/0!	>=	#DIV/0!
Avg On-time delivery rate	#DIV/0!	>=	#DIV/0!
Avg Unit Cost	#DIV/0!	<=	#DIV/0!
Units from Supplier 1	0	<=	0
Units from Supplier 2	0	<=	0
Units from Supplier 3	0	<=	0
Units from Supplier 4	0	<=	0

Constraints Calculation

	LHS		RHS
Minimum Units Req by MicroSystems	0	>=	4200
Manager Order plan	0	=	5200
Avg Quality Acceptance	0	>=	0
Avg On-time delivery rate	0	>=	0
Avg Unit Cost	0	<=	0
Units from Supplier 1	0	<=	0
Units from Supplier 2	0	<=	0
Units from Supplier 3	0	<=	0
Units from Supplier 4	0	<=	0

Once the model was appropriately labeled, we utilized the Solver tool found in the Data tab. Cell references for the objective function were assigned, with the optimization goal set to minimize, in line with the aim of reducing costs. The cell numbers for decision variables were specified in the changing variable cells section. Constraints were added to the constraints box at the bottom of the model, reflecting the outlined constraints in the problem statement.

Simplex LP solving method is selected as the problem's objective function, which is the total cost to be minimized, and the constraints involving demand, quality acceptance rates, on-time delivery rates, cost limits, and supplier distribution, all exhibit linear relationships. The Simplex Method is well-suited for optimizing linear objective functions subject to linear constraints.

Minimize the Total Purchasing cost

	Decision Variables	Num of Units	Quality Acceptance Rate	On-time Delivery Rate	Cost per Unit, $
Supplier 1	S1=	2311	0.99	0.95	15
Supplier 2	S2=	2568	0.9	0.85	12.3
Supplier 3	S3=	0	0.95	0.9	14.5
Supplier 4	S4=	321	0.9	0.94	13.9
	Total Units	**5200**			

Objective Function

Minimize Total Cost	$ 70,713.58

Constraints

	LHS		RHS
Minimum Units Req by MicroSystems	5200	>=	4500
Manager Order plan	5200	=	5200
Avg Quality Acceptance	0.940	>=	0.94
Avg On-time delivery rate	0.900	>=	0.90
Avg Unit Cost	13.60	<=	14
Units from Supplier 1	2311	<=	2600
Units from Supplier 2	2568	<=	2600
Units from Supplier 3	0	<=	2600
Units from Supplier 4	321	<=	2600

Constraints Calculation

	LHS		RHS
Minimum Units Req by MicroSystems	5200	>=	4200
Manager Order plan	5200	=	5200
Avg Quality Acceptance	4888	>=	4888
Avg On-time delivery rate	4680	>=	4680
Avg Unit Cost	70713.6	<=	72800
Units from Supplier 1	2311.11	<=	2600
Units from Supplier 2	2567.9	<=	2600
Units from Supplier 3	0	<=	2600
Units from Supplier 4	320.988	<=	2600

Upon applying the Simplex Linear Programming method, an optimal solution was obtained, strategically minimizing costs for MicroSystems.

The optimal order quantity involved the acquisition of 2311 units from Supplier 1; 2568 units from Supplier 2, no units from Supplier 3, and 321 units from Supplier 4 (rounded off). The resultant cost for Microsystems was $70,713.58.

This optimal solution has followed all the rules that was set and satisfies all the constraints Specifically, the total units procured matched the constraint value of 5,200, the average quality rate equaled 0.94, the average delivery rate met the goal of 0.90, the average cost per unit remained below the constraint value of $14 making the average cost to $13.60, and the total units procured from each supplier stayed below half of the total orders.

After obtaining the optimal solution, it's recommended to check the sensitivity report, accessible within the same solver window. This report is specifically designed for the Simplex LP method and provides valuable insights that helps decision-making.

Reduced Cost: Reduced cost in Simplex LP sensitivity analysis indicates how much a decision variable's cost needs to be reduced for it to be included in the optimal solution.

Shadow Price: Shadow price reflects the change in the total cost for each additional unit in a constraint, helping understand the impact of changes in constraint values.

Allowable Increase: Allowable increase signifies the maximum amount by which a decision variable can increase without affecting the optimality of the solution.

Allowable Decrease: Allowable decrease indicates the maximum reduction allowed in a decision variable without changing the optimal solution.

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C4	S1= Num of Units	2311	0	15	1.43777778	0.922222222
C5	S2= Num of Units	2568	0	12.3	1.57804878	8.3
C6	S3= Num of Units	0	0.79876543	14.5	1E+30	0.798765432
C7	S4= Num of Units	321	0	13.9	0.83	1.6

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
G17	Manager Order plan LHS	5200	13.5987654	5200	1E+30	5200.0000
G18	Avg Quality Acceptance LHS	0.94	10.2469136	0	0.005	0.0355
G19	Avg On-time delivery rate LHS	0.9	17.7777778	0	117.361111	0.0006
G20	Avg Unit Cost LHS	13.6	0	0	1E+30	0.4012
G21	Units from Supplier 1 LHS	2311	0	0	1E+30	288.8889
G22	Units from Supplier 2 LHS	2568	0	0	1E+30	32.09876543
G23	Units from Supplier 3 LHS	0	0	0	1E+30	2600
G24	Units from Supplier 4 LHS	321	0	0	1E+30	2279.012346

From the above sensitivity analysis,

- For Suppliers 1 and 4, the optimal solution remains unchanged even if one more unit is included (Allowable Increase) or one unit is removed (Allowable Decrease). Similarly, for Supplier 2, an allowable increase of around 1 and an allowable decrease of approximately 8 can be considered without altering the objective function.

- Supplier 3, with no order quantities in the optimal solution, could be included if the cost is reduced by $0.79, adjusting from $14.5 to $13.71.
- Constraints reveal a shadow price of $13.59 for the manager's order plan, indicating a $13.59 increase in total cost for every unit increase in quantity. Additionally, for every 1% increase in average quality acceptance, there is a $10.24 rise in total cost, with a maximum allowable increase of 0.005 (from 0.940 to 0.945). The average on-time delivery rate is crucial, as a unit increase in this constraint results in a $17.7 rise in total cost.
- The most sensitive constraints are the average quality acceptance and on-time delivery rate, where enhancements significantly impact the objective function's value. In contrast, the manager's order plan and average unit cost constraints do not substantially influence the objective function within their allowable ranges.

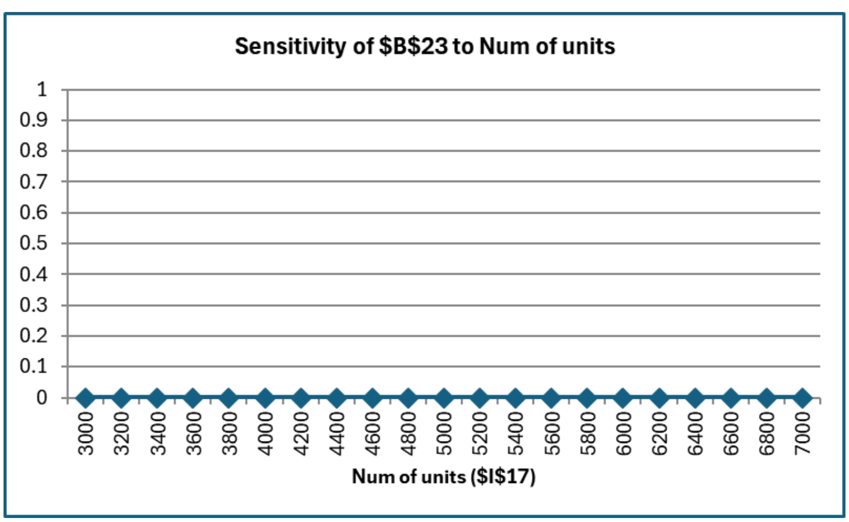
One Way Analysis

Utilizing one-way sensitivity analysis for the Right-Hand Side (RHS) of the constraint labeled "Manager Order Plan" in the model (cell I17), variations were examined with the number of units for order incrementing from 3000 to 7000 in steps of 200. The analysis involved evaluating the impact on decision variables and total cost.

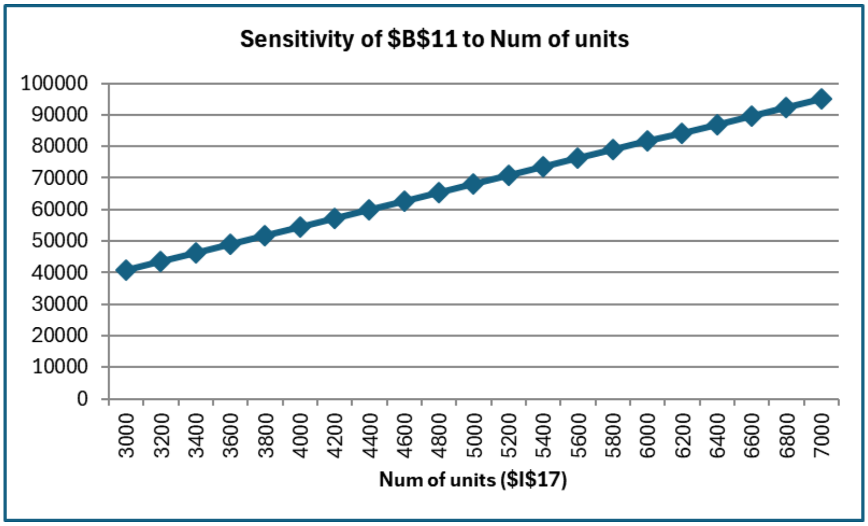
The results of the one-way sensitivity analysis indicate that the quantity of orders from Supplier 1 is positively sensitive to changes in the total order quantity; an increase in the total order quantity corresponds to an increase in the number of orders from Supplier 1. This sensitivity is also observed for Supplier 2 and Supplier 4, where the number of orders increases proportionally with the total order quantity, indicating sensitivity to this variation.

Num of units (cell I17) values along side, output cell(s) along top					
	B21	B22	B23	B24	B11
3000	1333	1481	0	185	$ 40,796.30
3200	1422	1580	0	198	$ 43,516.05
3400	1511	1679	0	210	$ 46,235.80
3600	1600	1778	0	222	$ 48,955.56
3800	1689	1877	0	235	$ 51,675.31
4000	1778	1975	0	247	$ 54,395.06
4200	1867	2074	0	259	$ 57,114.81
4400	1956	2173	0	272	$ 59,834.57
4600	2044	2272	0	284	$ 62,554.32
4800	2133	2370	0	296	$ 65,274.07
5000	2222	2469	0	309	$ 67,993.83
5200	2311	2568	0	321	$ 70,713.58
5400	2400	2667	0	333	$ 73,433.33
5600	2489	2765	0	346	$ 76,153.09
5800	2578	2864	0	358	$ 78,872.84
6000	2667	2963	0	370	$ 81,592.59
6200	2756	3062	0	383	$ 84,312.35
6400	2844	3160	0	395	$ 87,032.10
6600	2933	3259	0	407	$ 89,751.85
6800	3022	3358	0	420	$ 92,471.60
7000	3111	3457	0	432	$ 95,191.36
	Supplier 1	**Supplier 2**	**Supplier 3**	**Supplier 4**	**Total Cost**

In contrast, Supplier 3 exhibits insensitivity to variations in the total order quantity, as the number of orders remains consistent at 0 for any quantity of orders.



Moreover, the total cost for procuring components demonstrates sensitivity to variations in the order quantity, increasing as the order quantity rises. In summary, an overall trend is observed where an increase in orders results in a corresponding rise in the total procurement cost.



Two Way Analysis

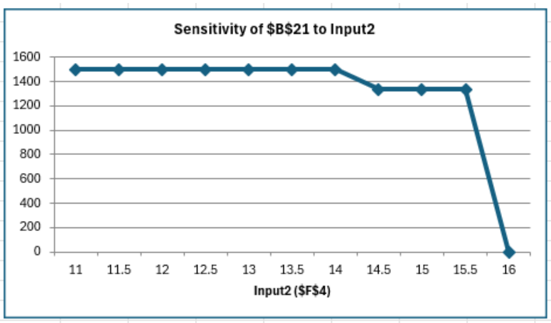
nput1 (cell I17) values along side, Input2 (cell F4) values along top, output cell in corner

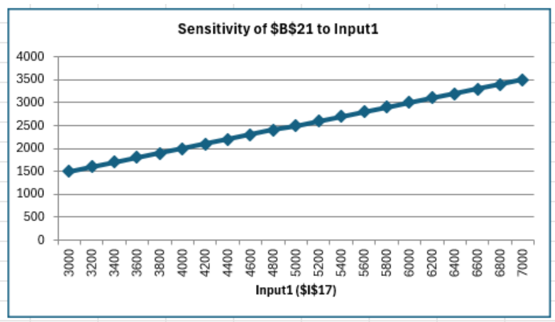
B21	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
3000	1500	1500	1500	1500	1500	1500	1500	1333	1333	1333	Not feasib
3200	1600	1600	1600	1600	1600	1600	1600	1422	1422	1422	Not feasible
3400	1700	1700	1700	1700	1700	1700	1700	1511	1511	1511	Not feasible
3600	1800	1800	1800	1800	1800	1800	1800	1600	1600	1600	Not feasible
3800	1900	1900	1900	1900	1900	1900	1900	1689	1689	1689	Not feasible
4000	2000	2000	2000	2000	2000	2000	2000	1778	1778	1778	Not feasible
4200	2100	2100	2100	2100	2100	2100	2100	1867	1867	1867	Not feasible
4400	2200	2200	2200	2200	2200	2200	2200	1956	1956	1956	Not feasible
4600	2300	2300	2300	2300	2300	2300	2300	2044	2044	2044	Not feasible
4800	2400	2400	2400	2400	2400	2400	2400	2133	2133	2133	Not feasible
5000	2500	2500	2500	2500	2500	2500	2500	2222	2222	2222	Not feasible
5200	2600	2600	2600	2600	2600	2600	2600	2311	2311	2311	Not feasible
5400	2700	2700	2700	2700	2700	2700	2700	2400	2400	2400	Not feasible
5600	2800	2800	2800	2800	2800	2800	2800	2489	2489	2489	Not feasible
5800	2900	2900	2900	2900	2900	2900	2900	2578	2578	2578	Not feasible
6000	3000	3000	3000	3000	3000	3000	3000	2667	2667	2667	Not feasible
6200	3100	3100	3100	3100	3100	3100	3100	2756	2756	2756	Not feasible
6400	3200	3200	3200	3200	3200	3200	3200	2844	2844	2844	Not feasible
6600	3300	3300	3300	3300	3300	3300	3300	2933	2933	2933	Not feasible
6800	3400	3400	3400	3400	3400	3400	3400	3022	3022	3022	Not feasible
7000	3500	3500	3500	3500	3500	3500	3500	3111	3111	3111	Not feasible

Two way sensitivity analysis with Cost by supplier 1(X-axis) and Order Quantity (Y-axis)

In the above two-way sensitivity analysis focusing on the number of orders from Supplier 1 (B21) concerning changes in the Cost per component from the same supplier (S1) and the total order quantity, we notice that the order quantity doesn't respond much to the cost per unit until it hits $14.5. Below this cost, Supplier 1's order quantity remains constant, no matter how many items we order, but it increases when the total order quantity rises.

If the cost ranges from $14.5 to $15.5, the order quantity decreases by nearly 200 units compared to the $11 to $14 cost range. However, as the total orders increase for MicroSystems, Supplier 1's order quantity goes up. But, if the cost reaches $16, considering components from Supplier 1 is not the best choice for the optimal solution, and it's not practical to include them.

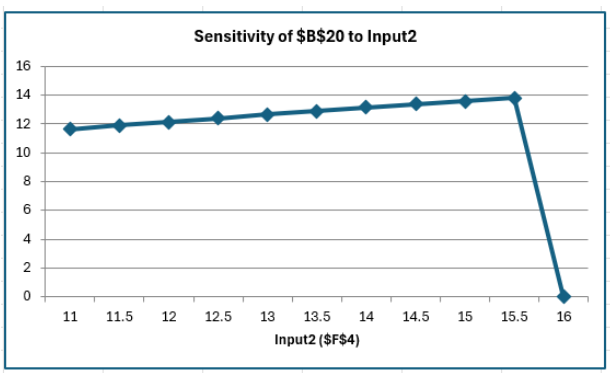


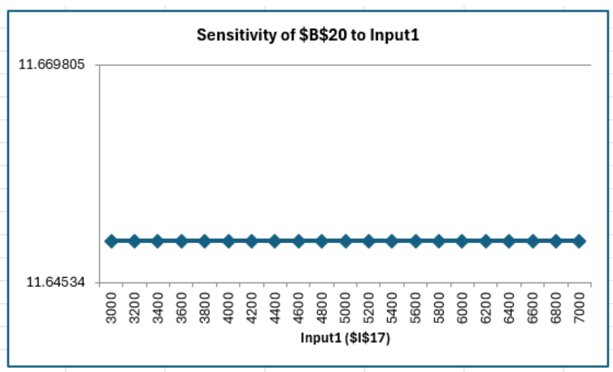


From the two-way sensitivity analysis concerning the Average price of the component, it is evident that the Average price remains unaffected by the total order quantity, maintaining consistency regardless of the number of orders from Microsystems. However, as we shift to the right, considering the Price of Supplier 1, it becomes apparent that the Average price is responsive to changes in the price set by Supplier 1.

B20	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
3000	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
3200	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
3400	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
3600	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
3800	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
4000	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
4200	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
4400	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
4600	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
4800	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
5000	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
5200	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
5400	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
5600	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
5800	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
6000	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
6200	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
6400	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
6600	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
6800	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible
7000	11.65	11.90	12.15	12.40	12.65	12.90	13.15	13.38	13.60	13.82	Not feasible

The Average price increases steadily until the cost set by Supplier 1 reaches $15.5. Beyond this threshold, it becomes impractical to include Supplier 1 in the optimal scenario and proceeding with Supplier 1 is not advisable. Nonetheless, if the price of Supplier 1 remains at or below $15.5, the Average price remains sensitive to changes in Supplier 1's pricing, regardless of the quantity of components ordered.





Conclusion

In our project our group used excel' s solver and SolverTable add-in to be able to find the optimal solution for minimizing Microsystems Inc costs for ordering a key component part every month. Our linear programming model helped achieve our goal of minimizing the cost of the order every month while maintaining a high-quality acceptance rate, high on time delivery rate, and keeping the cost per unit below 14 dollars.

The results of our solver/solver table model were that the cost of an order of 5200 units would at most cost $70,713.58 with 2,311 units being bought from supplier 1, 2,568 units from supplier 2, zero units from supplier 3, and 321 units from supplier 4. The average cost per unit is $13.59, the average quality acceptance rate is 94%, and the average on time delivery rate is at 90%. We also performed a one-way and two-way analysis to determine the sensitivity of constraints in relation to certain aspects of the model.

Our group thinks that this model can benefit Microsystems Inc by being able to continue to keep order costs for this part to a minimum while also being able to adapt to the quality standards set by the company or those of the suppliers. A limitation to this model is that adding a constraint where you have to purchase a certain percentage of units from all four suppliers could negatively affect the quality acceptance and on time delivery rates because you have to purchase units from a supplier with lower percentages in those categories which can both increase cost and those metrics. In terms of implementation, this model can be used before the order is sent through to summarize all of the factors together and make sure cost is still being minimized every period in this area.

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