



Bilkent University
Department of Industrial Engineering
IE 376 – Production Information Systems
Master Production Scheduling at Apple

In this case/game you will have a chance to use your skills in operations, particularly in master production scheduling considering inventory, stock-out, overtime and procurement costs. Ms. Irene Cook is the production planning manager at Apple located in Cupertino, California. Starting from the beginning of July until the end of September 2022, Ms. Cook decide how many 13-inch MacBooks should be produced on a weekly basis. In doing so, she considers sales trends, the time of the year, manufacturing capacity, available stock, overtime costs, inventory carrying costs, stock-out costs, and procurement costs. In this case/game, you will have a chance to make similar decisions in a simplified environment. You will have to deal with two products: 13" MacBook Air and 13" MacBook Pro.

The demand for MacBooks has a very seasonal pattern. The demand heavily depends on the time of the year. Sales are low initially in early July but rise rapidly as the school season gets closer. The demand later tapers off after the start of September. The demand in each year may be different from previous years depending on the economy in general, the state of the computer electronics industry and the competition. (See the HistoricalDemand worksheet in Apple.xlsx). You will play the game starting from the beginning of July. Week 1 corresponds to the first week of July. Your game finishes at the end of week 13 (the end of the financial quarter).

The 13" MacBooks (both Airs and Pros) are produced in a Foxconn manufacturing facility in Shenzhen, China. The only bottleneck operation in making the laptops is the assembly operation. Each MacBook Air requires 2.0 minutes of an assembly time attended by a single worker. For MacBook Pro, that time is 2.5 minutes per unit. There are currently 65 workers in the assembly line. Each worker is paid a fixed salary for which they work 45 hours per week (The salary is fixed even if a worker does not do assembly for the full 45 hours in a week). In addition, each worker can work up to 20 hours overtime in a week. Overtime is paid \$11.75 per hour for each employee. 5 new workers will complete their training and the workforce in assembly will increase to 70 at the beginning of week 6.

Each MacBook set needs one unit of M1 chip, Apple's recent microprocessor. These microprocessors are currently produced by Taiwan Semiconductor Manufacturing Company (TSMC) in Taiwan. The lead time for these chips are two weeks (Any order placed in week t will be received at the beginning of week $t+2$). Apple's current contract with TSMC allows Apple to order a maximum of 75,000 processors per week from the TSMC factory in Taiwan. Chips currently cost Apple \$78/unit, but this will drop to \$67/unit beginning with the 5th week of the quarter. If required, Apple can place an order from TSMC's factory in Nanjing, China with a negligible lead time (0 weeks), but this is outside of the contract and costs Apple \$85/unit (there is no price drop predicted for this factory). Apple may choose to carry inventory of M1s as well for future use. The inventory carrying costs are \$0.10/per unit per week.

Apple may carry inventory of MacBooks to meet future demand. Inventory holding cost is \$0.25/unit per week for MacBook Air and \$0.28/unit per week for MacBook Pro. Any inventory leftover at the end of 13 weeks (quarter) will cost \$10 for MacBook Air and \$13 for MacBook Pro as the company will offer new versions of these laptops and must sell the older versions at deep discounts. The company may also backorder demand. Backordering cost is \$0.50/unit per week for MacBook Air and \$0.58/unit per week for MacBook Pro. Any unsatisfied demand within the quarter will lead to a shortage cost of \$100 for MacBook Air and \$130 for MacBook Pro.

Prior to the Quarter

Ms. Cook has already made purchasing decisions for M1 chips from Taiwan and executed them for the two weeks prior to the start of July (week -1 and week 0). These purchase quantities are already recorded in the MPS worksheet in Apple.xlsx). Ms. Cook decided to purchase 85,000 units for each week (week -1 and week 0). Starting inventory of M1 chips at the beginning of July is 2,000 units.

The company works with frozen zone of 1 week. This means that the week 1 production decisions for MacBook Pros and MacBook Airs are already made at week 0 and cannot be changed at week 1. Production quantity for MacBook Pros is set to be 20000 for MacBook Pros and 38000 for MacBook Airs. The starting inventory at the beginning of week 1 is 1500 units for MacBook Pro and 1100 units for MacBook Air.

Responsibilities/Deliverables Prior to the Game

Studying the problem and its data, you are supposed to develop a master production schedule for periods 1-13. Your objective is obviously to minimize (expected) total costs that are composed of Inventory Carrying Costs (for MacBooks and M1s), Backorder Costs, Overtime Costs and Procurement costs.

In a small report (6-7 pages maximum), explain your scientific approach and calculations in coming up with the MPS. This is a case study with open-ended and possibly many alternative solution approaches, therefore you are allowed to use any type of tools and methodologies that you learnt in this course and other courses in the curriculum. You can use any software (as long as you can use the same software in online game session if necessary), but you need to be able to explain this properly in your report.

In addition to your approach for developing the MPS, you should also explain how you would respond to realization of demand as you proceed in the quarter. Would you want to change your MPS based on your observation of demand (the actual demand will be revealed at the beginning of each week)? How?

Your report should include your complete MPS for weeks 1-13. This should also include your procurement amounts for the chips. In addition, you should also provide a prediction of the total costs that you expect to see at the end of the horizon. **Your report is due on March 16, 2022 at 20:00 (moodle).**

Game in Class

We will play the master production scheduling game **March 17, 2022 at 18:30** (online through zoom). All students are required to be in class on that day and play the game. During the game, I will ask each group to determine its MPS for MacBook Pro and MacBook Air for the next week and M1 procurement amounts from Taiwan (slow supplier). Then I will reveal the demand information for the current period, and we will proceed to the next period. At this point, any extra requirement for M1s should be procured from Nanjing (fast supplier). For determining MPS in each period, groups will only have about 5 minutes. Therefore, all groups should come prepared and have an approach and tools to determine (or update) the MPS within that short period of time. At the beginning of each period, you need to be able to run your analysis for the remainder of the horizon and with the actual inventory/backorder information available for that period. Each group's MPS will be input to a spreadsheet and its actual costs will be calculated at the end of the game. I will inform you the progress of your group and other groups throughout the game.

Grading

70% of your grade in this case will depend on the report that you will submit prior to the game. 30% of your grade will depend on the actual cost of the MPS that you have during the game. We will also check for consistency of what you write in the report and what you did during the game. All group members are expected to contribute equally and fully. All members should attend the zoom session for class on March 17.