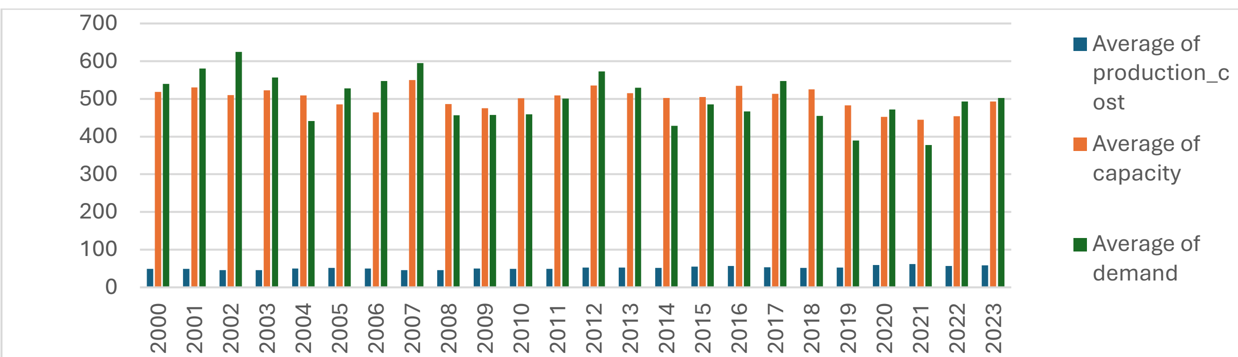
Module 03 – Production Modeling

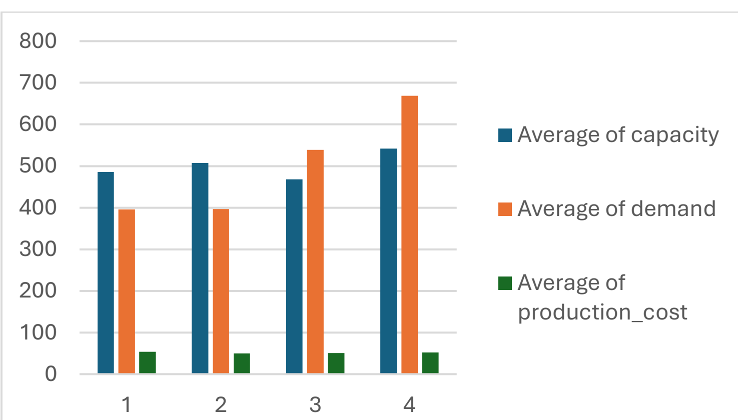
Exploratory Data Analysis

In this section, you should perform some data analysis on the data provided to you. Please format your findings in a visually pleasing way and please be sure to include these cuts:

- *Make a table of average demand, production capacity, and costs for each quarter, are there differences between quarters?*
- *Since we have temporal data (i.e. year and quarter), see if you can make a yearly and/or quarterly chart showing these metrics over time.*

Quarter	Average of demand	Average of Production	Average of capacity
1	396	54	486
2	397	50	507
3	539	51	468
4	669	52	542
Grand Total	**500.25**	**51.69**	**500.75**





Model Formulation

Write the formulation of the model into here prior to implementing it in your Excel model. Be explicit with the definition of the decision variables, objective function, and constraints

MIN: 54.00 P1 + 50.00 P2 + 50.60 P3 + 52.07 P4
+ 1.79(B0 + B1)/2 + 1.79(B1 + B2)/2
+ 1.79(B2 + B3)/2 + 1.79(B3 + B4)/2

Subject to:
0 ≤ P1 ≤ 546 } production level for quarter 1
0 ≤ P2 ≤ 526 } production level for quarter 2
0 ≤ P3 ≤ 576 } production level for quarter 3
0 ≤ P4 ≤ 505 } production level for quarter 4

Subject to:
40 ≤ B1 } safety-stock floor for Q 1
40 ≤ B2 } safety-stock floor for Q 2
54 ≤ B3 } safety-stock floor for Q 3
67 ≤ B4 } safety-stock floor for Q

200 + P1 – 396 – B1 = 0 } ending inventory for Q 1
B1 + P2 – 397 – B2 = 0 } ending inventory for Q 2
B2 + P3 – 539 – B3 = 0 } ending inventory for Q 3
B3 + P4 – 669 – B4 = 0 } ending inventory for Q 4

where:
B0 = 200 (beginning inventory)
B1 = 200 + P1 − 396
B2 = B1 + P2 − 397
B3 = B2 + P3 − 539
B4 = B3 + P4 – 669

Model Optimized for Cost Reduction
Implement your formulation into Excel and be sure to make it neat. This section should include:

- *A screenshot of your optimized final model (formatted nicely, of course)*
- *A text explanation of what your model is recommending*

	1	2	3	4
Beginning Inventory	200	350	479	516
Units Produced	546	526	576	505
Units Demanded	396.00	397	539	669
Ending Inventory	350	479	516	352
Maximum Production	546	526	576	505
Minimum Inventory	40	40	54	67
Average Inventory	275	415	498	434
Unit Production Cost	$54.00	$50.00	$50.60	$52.07
Unit Carrying Cost	$1.79	$1.79	$1.79	$1.79
Quarterly Production Cost	$29,484	$26,300	$29,146	$26,295
Quarterly Carrying Cost	$627	$857	$924	$630
Total Cost	$114,263			

Quarter	Average of demand	Average of Production Cost	Average of capacity
1	396	54	486
2	397	50	507
3	539	51	468
4	669	52	542
Grand Tota	500.25	51.69	500.75

Row Labels	Average of capacity	Average of demand	Production cost	Safety Stock
1	546	396	54.09 $	39.6
2	526	397	50.00 $	39.7
3	576	539	50.60 $	53.9
4	505	669	52.07 $	66.9

The cheapest way to hit next year's demand curve is to keep the line running at its full quarterly capacity every single period (546, 526, 576, 505 units). Because demand doesn't spike until Q4 (669 units), that means we deliberately over-produce in Q1-Q3 and let inventory pile up—from 200 units on hand in January to 516 units going into Q4. When the big Q4 rush hits, we draw that stock down to 352 units, which still leaves us well above the required safety-stock level (67 units).
Doing it this way trades a modest carrying cost ($3,038 total, or about $1.79 per unit per quarter) for much bigger savings on production: we avoid having to find expensive overtime or subcontracting capacity later, and we make most units in the cheaper $50-$51 cost quarters instead of the $54 one. All together, the plan covers all 2,001 units of demand, never drops below minimum inventory, and lands at an average cost of $51.69 per unit. Bottom line: total annual cost = $114,263, which is what the solver flagged as the lowest-cost feasible schedule given the capacity and safety-stock limits.

Model with Stipulation

Please copy the tab of your original model before continuing with the next part to avoid messing up your original solution. If we remove the production capacity constraint from the model & we removed the carrying cost, what do you think will happen? Try it out and see if it matches your expectation. Try to explain what is happening and talk a bit about fallbacks of models.

If we remove both the quarterly capacity limits and the 1.79 $/unit carrying charge, the solver takes the sheet in a totally different direction. Because inventory is now free and production isn't capped, the cheapest move is to run the line flat-out in the lowest-cost quarter (Q2 at $50/unit) and build virtually the entire year's demand there. The only work we'd still do in Q1 is the 396 units needed for that quarter's sales plus the 40-unit safety stock—about 436 units total at $54 each. Everything else roughly 1,765 units gets made in Q2 at $50 and then sits in the warehouse for the rest of the year. Inventory balloons past 2,000 units going into Q3, but because holding it no longer costs anything the model doesn't care. The math is simple: $54 × 436 ≈ $23.5 k for Q1 and $50 × 1,765 ≈ $88.3 k for Q2, with zero production or carrying cost in Q3 and Q4. Total annual cost drops to about $112 k, roughly a $2 k savings versus the $114,263 baseline but at the price of a huge production spike, mountains of idle capacity later in the year, and a warehouse packed to the rafters.