1. Solve the supply chain optimization problem.

Using the initial values provided, the optimal supply chain expense is $2,358.88. The volume shipped from each brewery to each packager is:

Brewer to Packager	P1	P2	P3	Total
B1	0	275	0	275
B2	29	0	121	150
B3	0	0	424	424
B4	100	0	0	100
Total	129	275	545	949

And volume from each packager to each customer is:

P → C	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	Tot.
P1	0	0	0	0	47	0	0	0	0	41	0	0	0	0	41	129
P2	48	0	0	0	0	0	64	93	0	0	0	0	0	70	0	275
P3	0	84	64	106	0	57	0	0	74	0	61	42	57	0	0	545
Total	48	84	64	106	47	57	64	93	74	41	61	42	57	70	41	949

2. Due to low demand, which breweries (if any) should be closed?

Per the Brewery to Packager table above, B2 and B4 are operating at minimum capacity. If demand remains low then these are the two breweries to consider closing.

If B2 is closed then the company reduces supply expense from $2,358.88 to $2,354.12, whereas if B4 is closed then the company reduces expense to $2,302.88. Closing B4 is the preferable choice.

The optimal solution with B4 closed still results in B2 operating at minimum capacity. However, closing both B2 and B4 results in higher supply expense than if both facilities are maintained ($2,388.84).

3. Due to low demand, should any of the packager facilities be closed?

Given the structure of the problem, closing any packaging facility would be value-destructive. However, the problem focuses only on the variable expense: it's possible that the fixed expense of running a plant that provides relatively low volume (e.g., P1) would drive to a different decision.

4. What happens if you increase demand?
The problem as outlined has an aggregate demand across all customers at 949 units. The binding constraint for the supply chain problem in total is Packager throughput, which is capped at 500 + 1500 + 2500 = 4500 units, which means the brewer can supply customers up to a demand multiplier of ~4.74x.

To get a sense of the edge case solution, I use a demand multiplier of 4.7x and round up fractional demand to the next unit, which results in a total demand of 4,465 units at an aggregate cost of $10,925.48. This cost is 4.74x the expense in the baseline setup, so there is a nearly linear extrapolation of expense as demand rises.

The brewer to packager table shows that in this edge case it would still make sense to consider eliminating B4. Doing so reduces the optimal expense to $10,883.48:

Brewer to Packager	**P1**	**P2**	**P3**	**Total**
B1	0	1465	0	1465
B2	400	0	0	400
B3	0	0	2500	2500
B4	100	0	0	100
Total	500	1465	2500	4465

In this high-demand scenario it does not make sense to close any Packagers since total packaging volume is the binding constraint.

5. What have you learned? How could you use constrained optimization in your work?

A key aspect of my job at a relatively vanilla retail bank is to a) understand how our overall balance sheet would change under base and idiosyncratic conditions; b) identify strategies to ensure key objectives - like capital and liquidity levels and risk exposures - are within internal and external policy limits. The strategies we have available to address the second half of that job responsibility is constrained by a variety of additional factors.

The structure of the optimization problem I deal with can be formulated as a transshipment problem. Decisions made in one area of the business / balance sheet can have impacts on downstream supply volumes and profitability measures, which then need to be appropriately consumed (with additional impact to profitability) to achieve risk management objectives.

That said, much of my work is focused on stochastic forecasting with probabilistic outcomes. As we get deeper into the course, I think the concepts will be increasingly relevant.

Note: some interim results were run by editing the inputs and rerunning the model. Not all outputs used above were saved as iterations of model execution.