

Understanding the Value of Large Time Windows for Scheduled Delivery Problems

Motivation

Online grocery business is growing fast around the world. A key component of the business is the time window design. Customers will choose a time window to receive their orders. The overlapping time window design used by Peapod.com suggest that there could be potential benefit from designing different type of time windows.

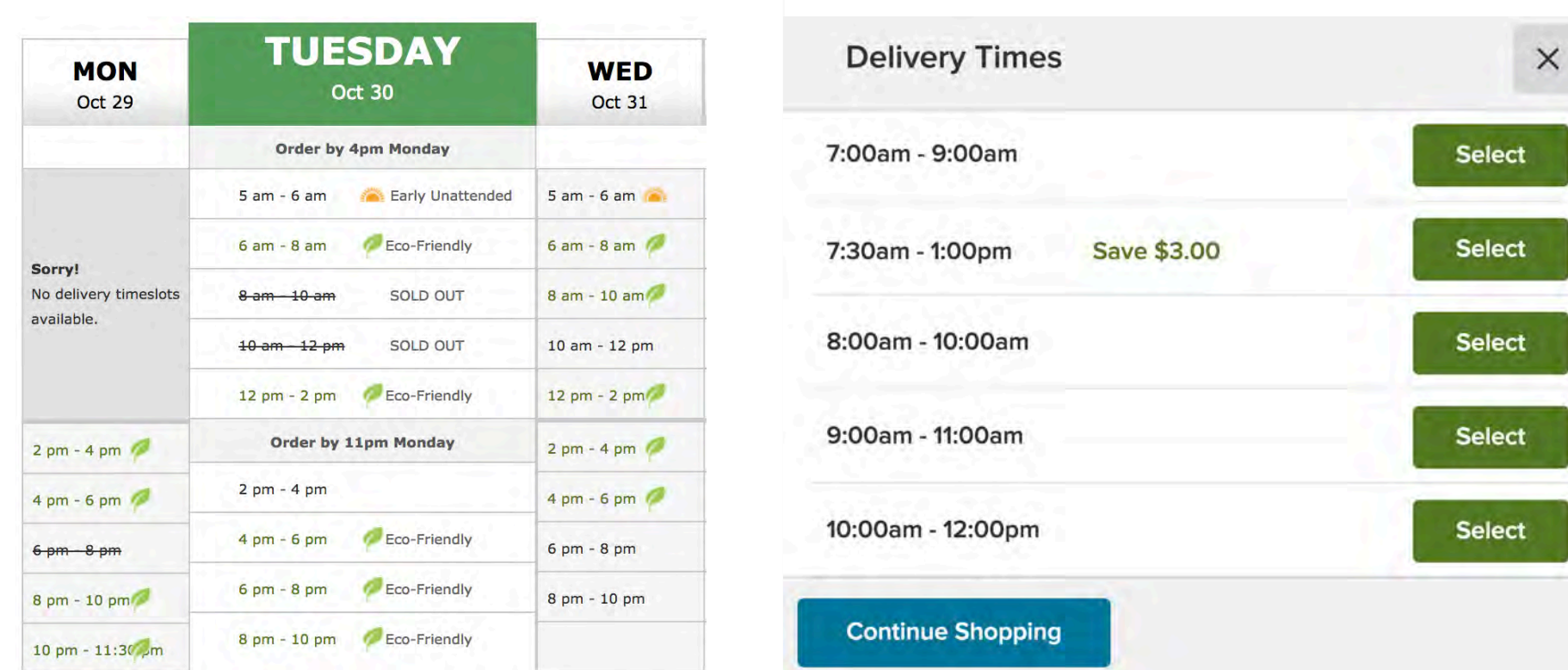
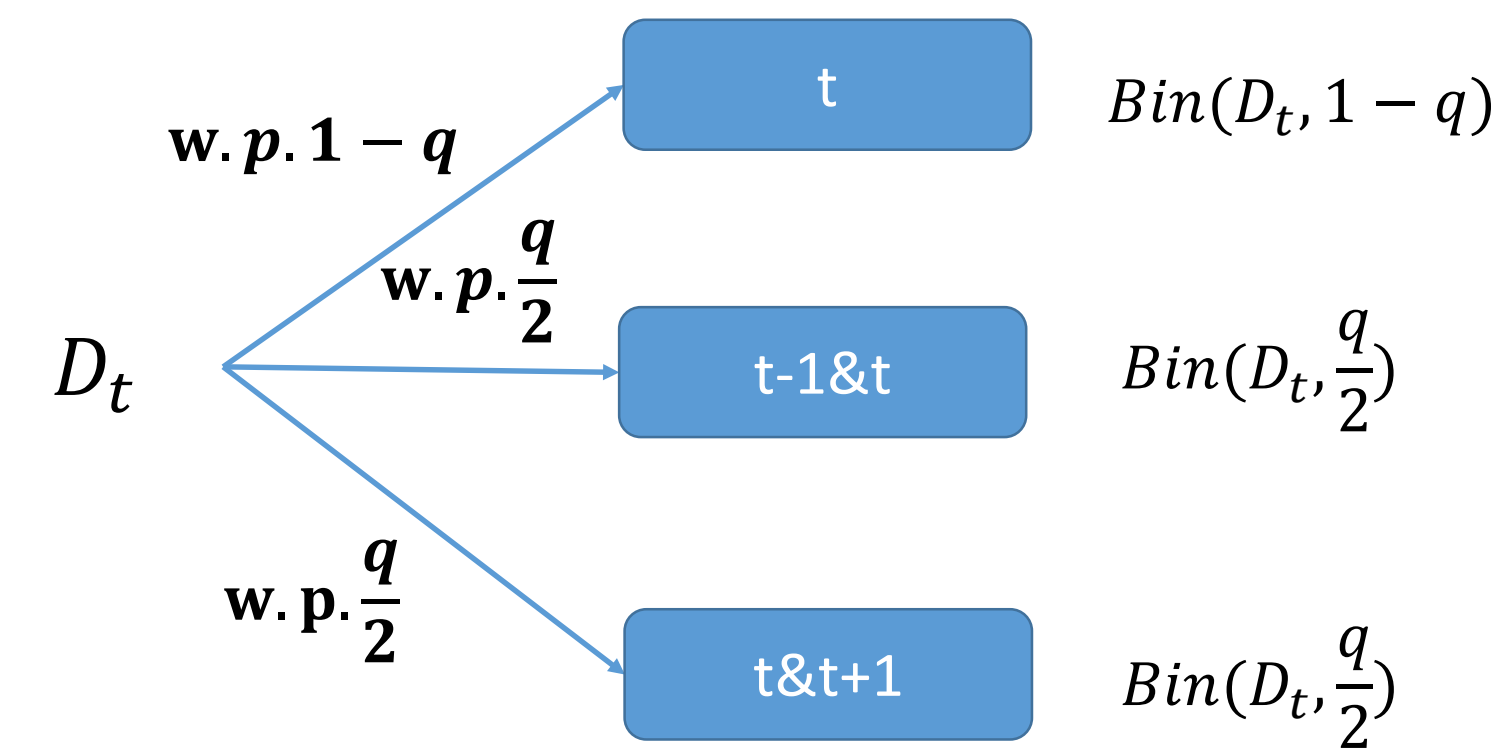


Figure 1. Example of time window design



Comparison with the Long Chain Design

Jordan and Graves (1995) observed that a *long chain design* often achieves almost the same performance as the fully flexible system. The benefit *increases* when adding each arc as the long chain is constructed (supermodularity). The largest benefit is always achieved when the chain is closed.

Experiments in Jordan and Graves (1995) uses the following parameters: $n=10$, $C = 100$, demands are i.i.d. truncated normal distribution with $\mu = 100$, $\sigma = 40$, $lb = 20$, $ub = 180$.

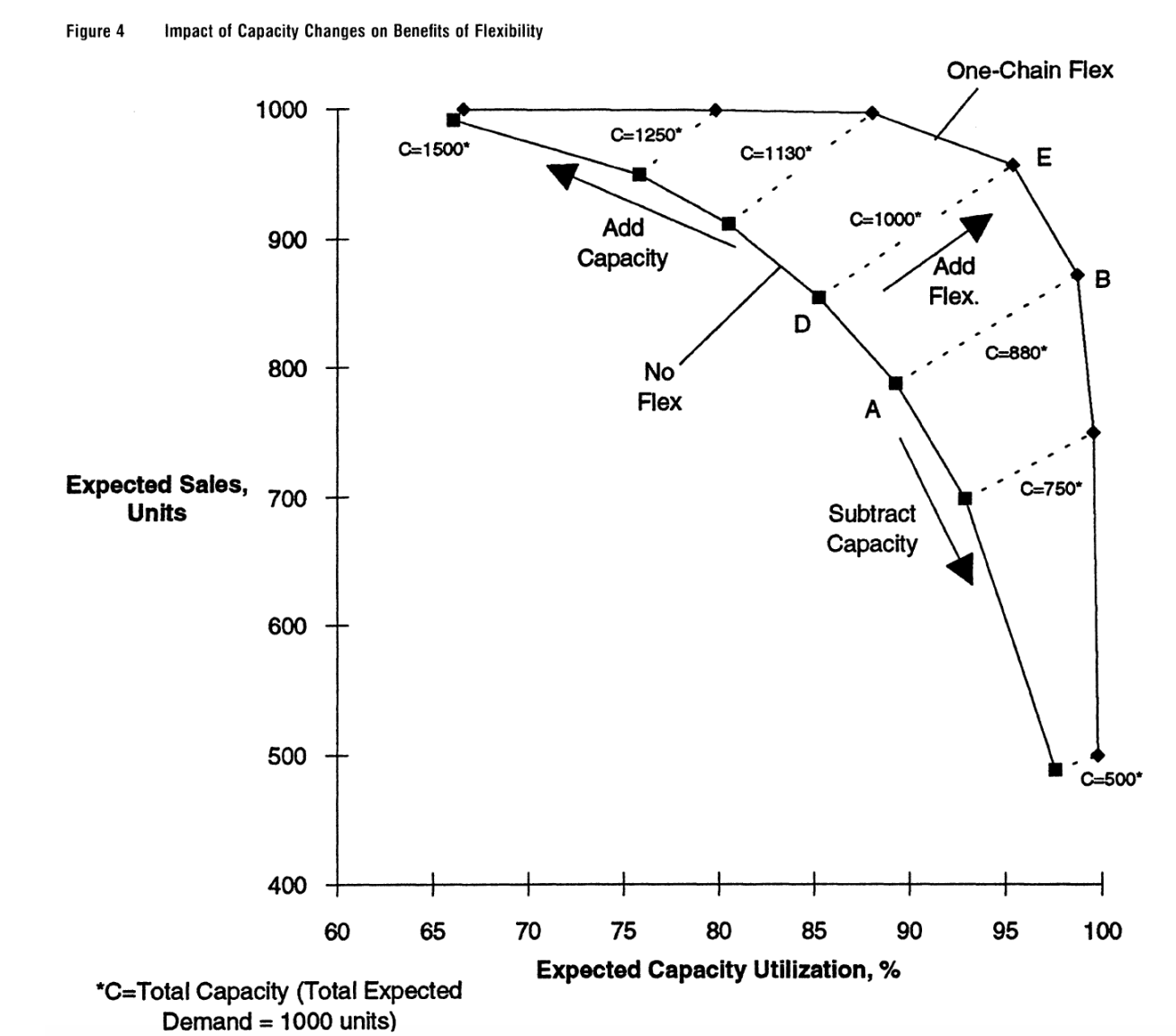
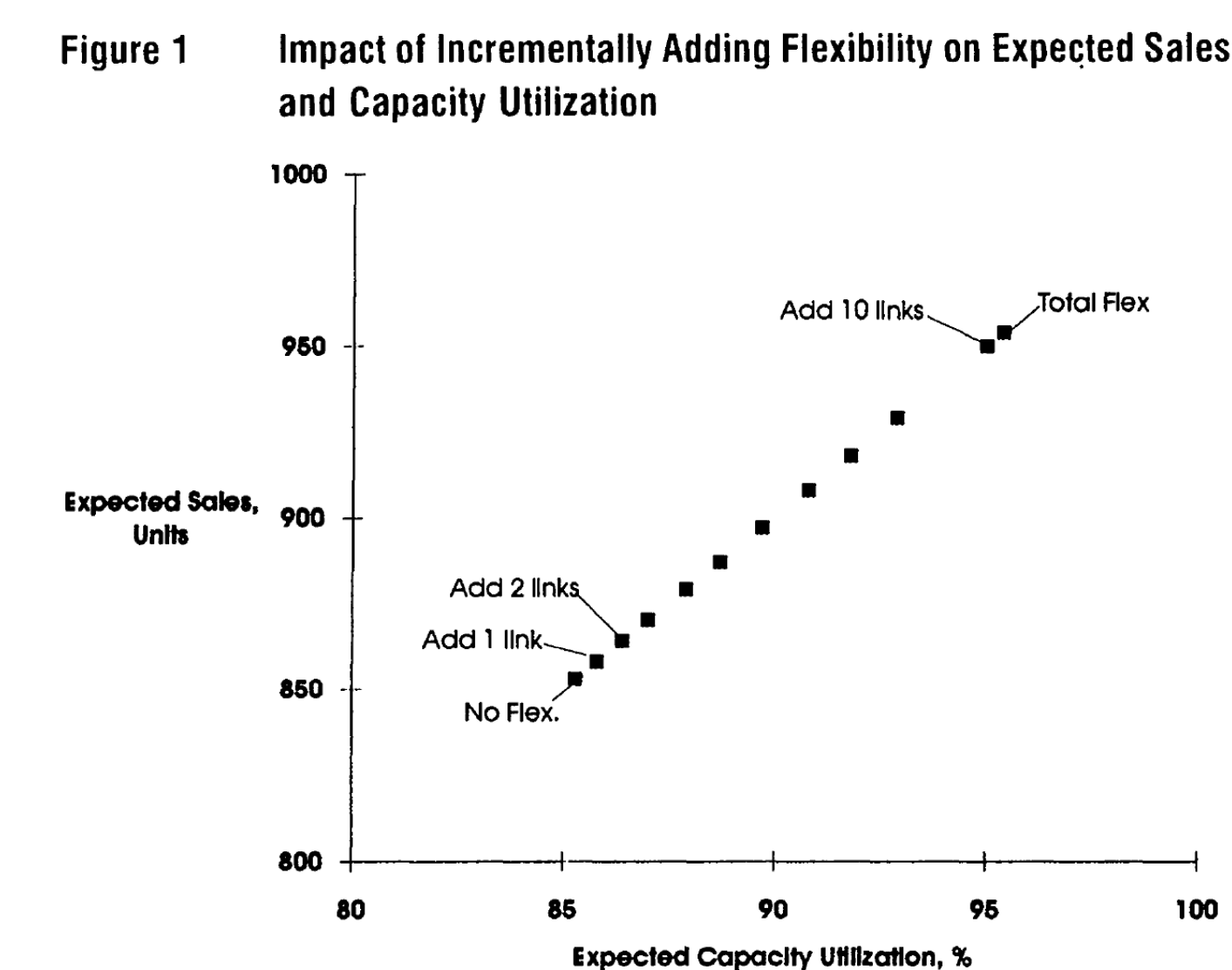


Figure 3. Results in Jordan and Graves (1995)

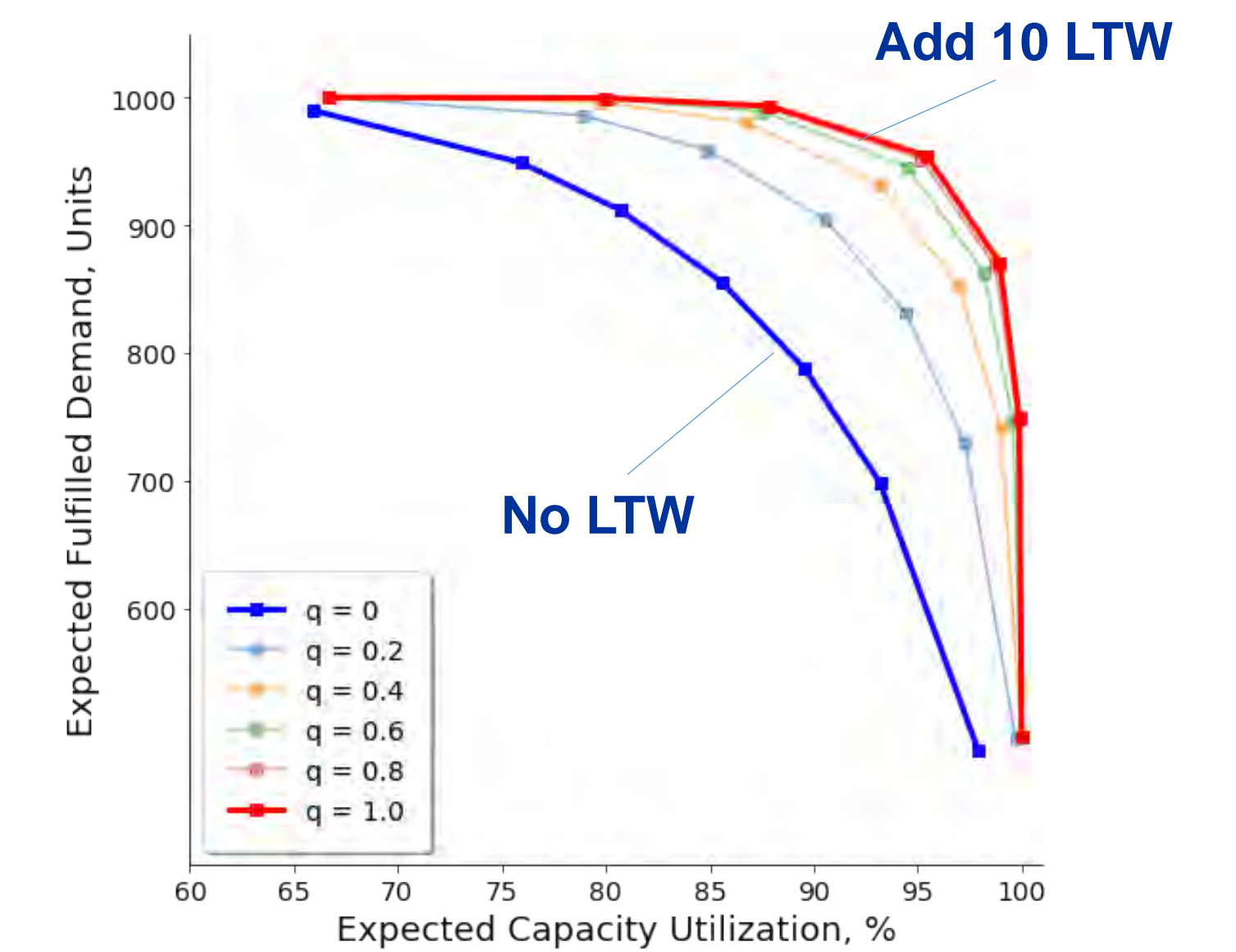
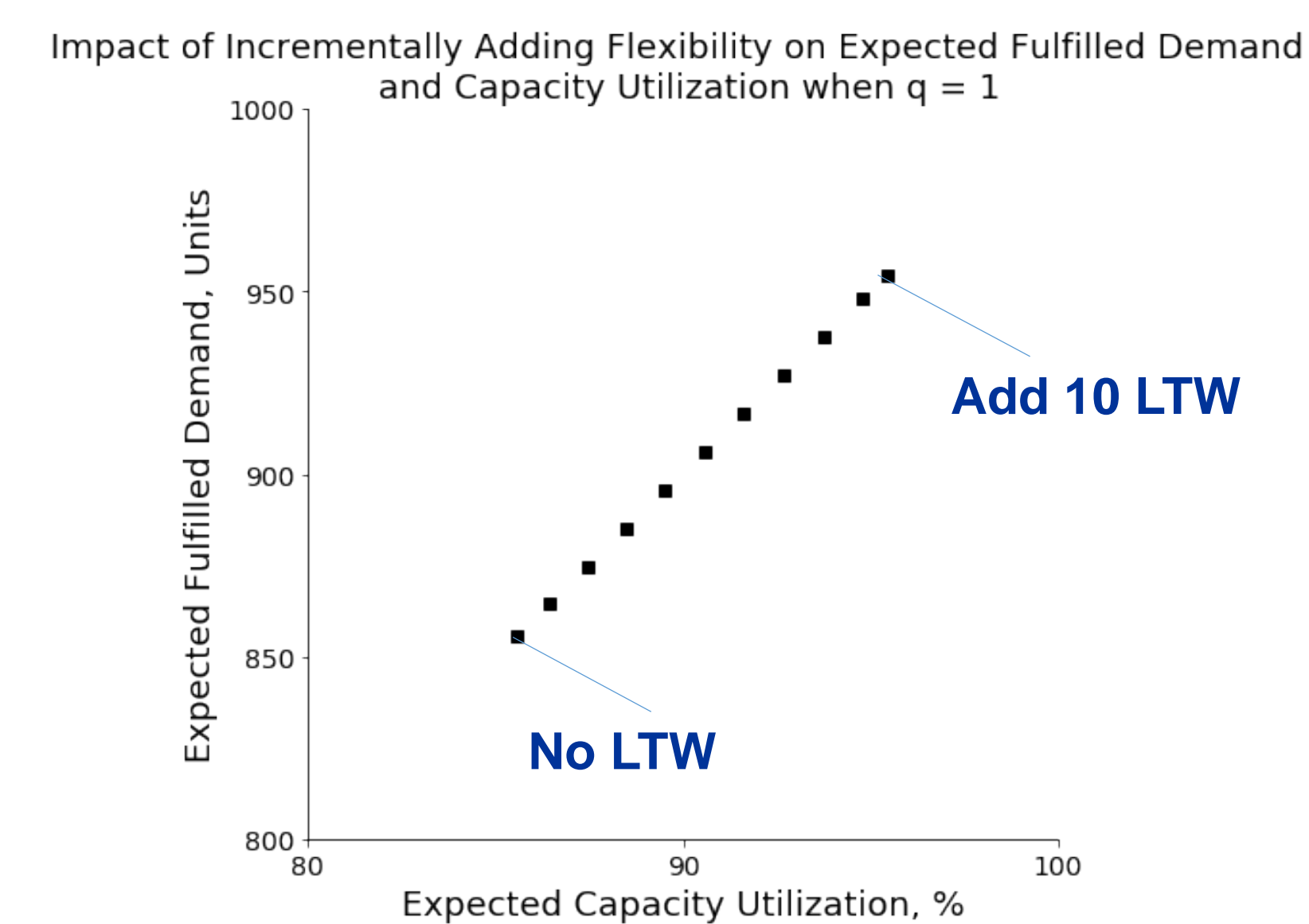


Figure 3. Results in the LTW design problem

Insights

In the LTW design, there is no increasing benefit when constructing the chain. Closing the chain yields the smallest benefit. Limited flexibility can provide almost as much benefit as full flexibility.

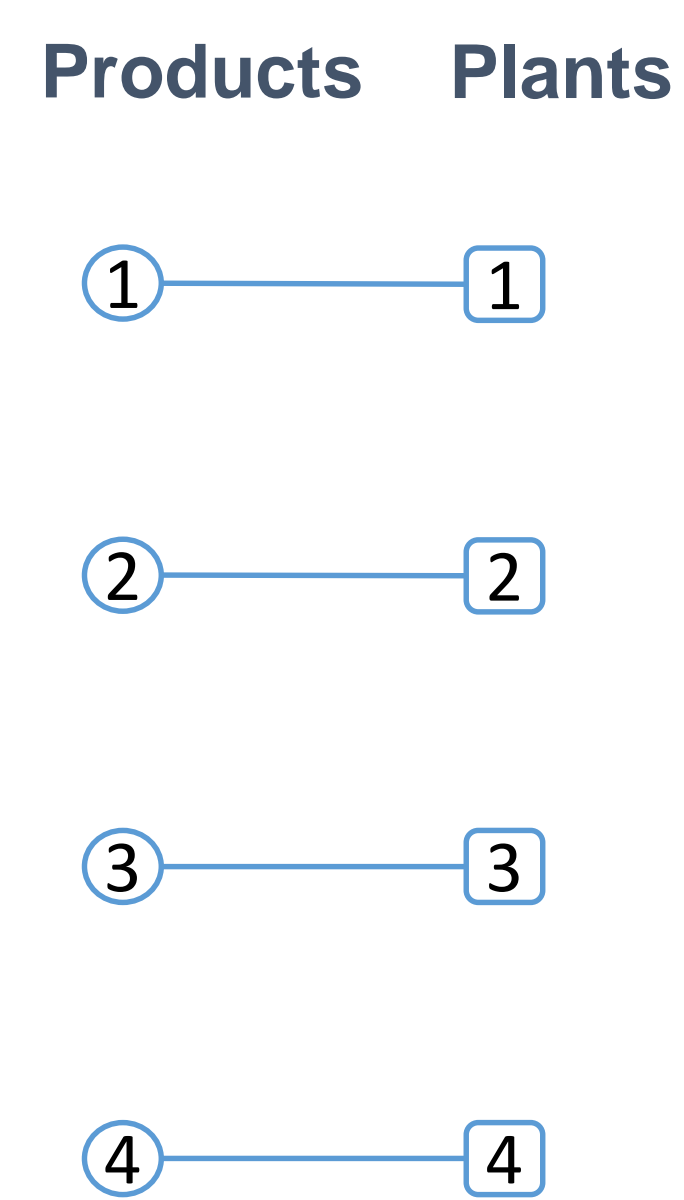
References

Jordan, William C., and Stephen C. Graves. "Principles on the benefits of manufacturing process flexibility." *Management Science* 41.4 (1995): 577-594.

Model

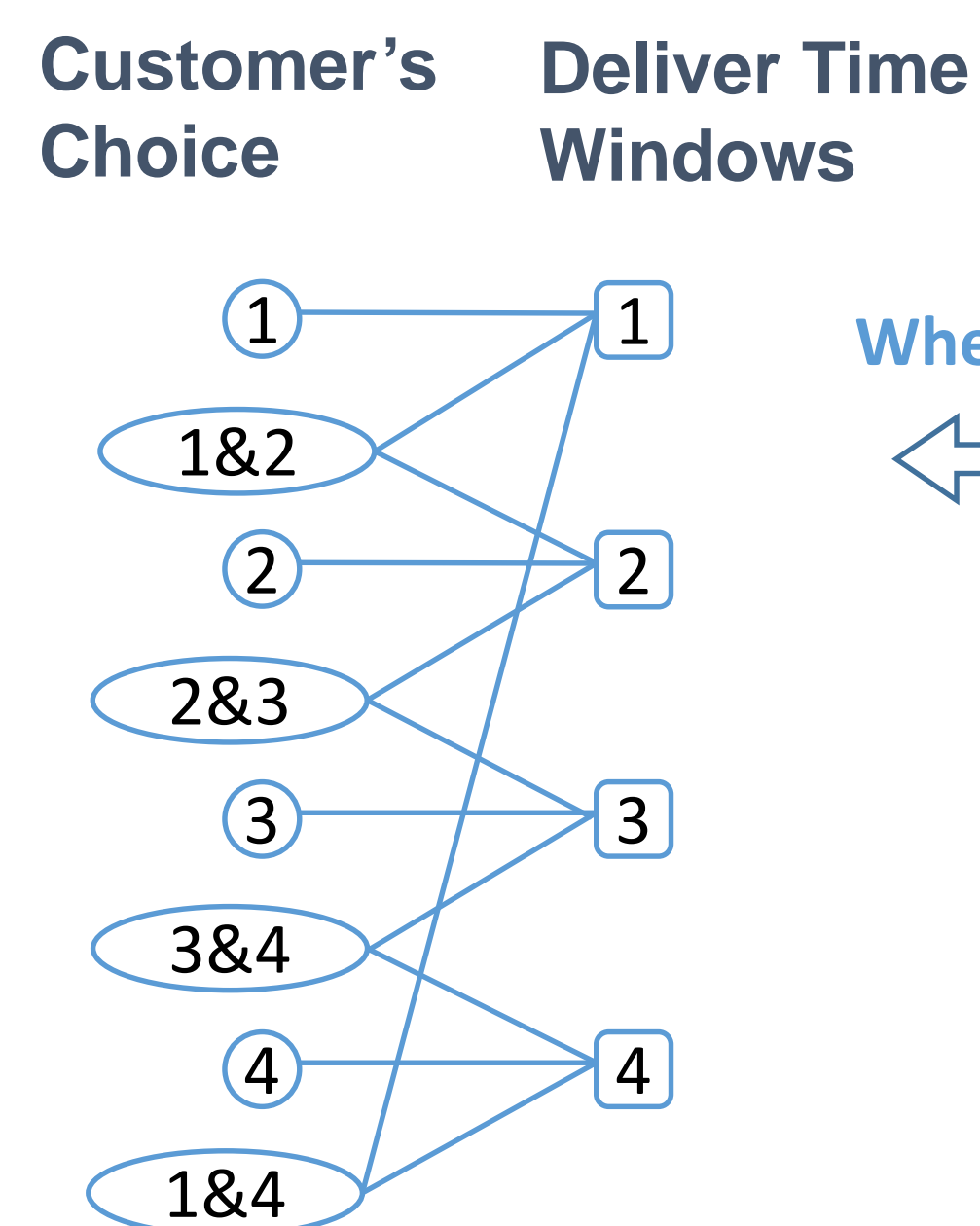
We assume there are n regular time windows in a day, each with delivery capacity C . The demands are i.i.d. random variables D_1, D_2, \dots, D_n . We offer large time windows 1&2, 2&3, ... $n-1$ & n and n &1. The probability of a customer being willing to extend to a LTW is q .

No Flex. System



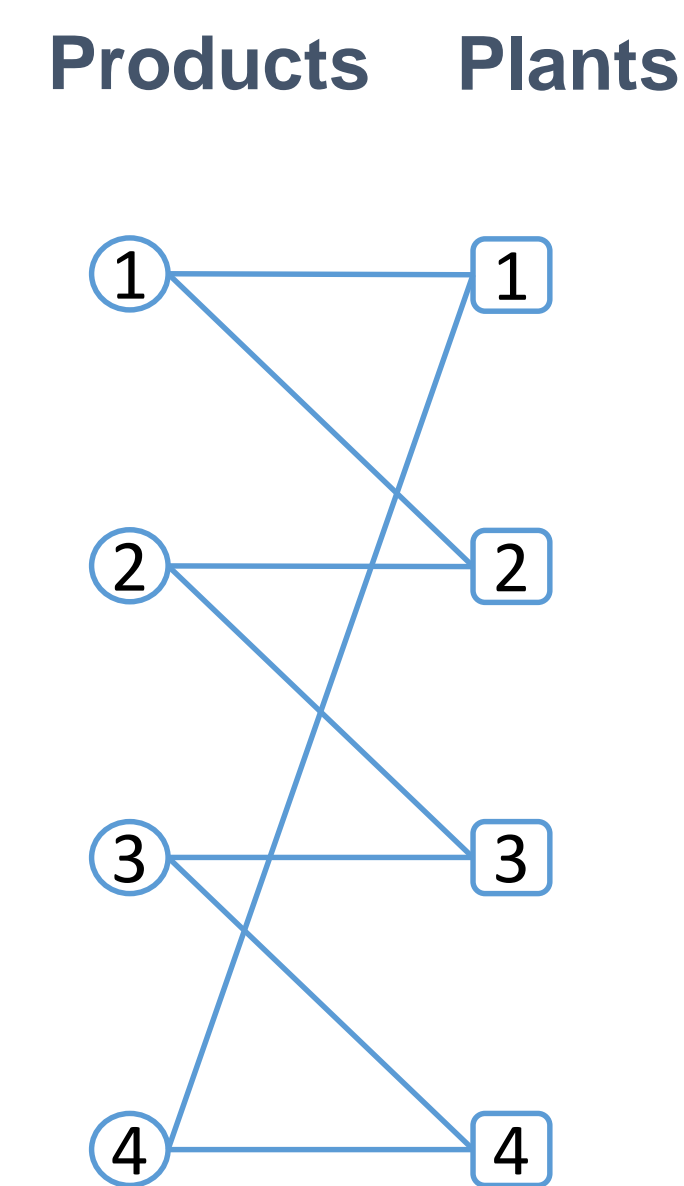
When $q = 0$

Flexible Delivery Windows



When $q = 1$

Long Chain Design



Max Flow

Figure 2. The Large Time Window design problem is equivalent to Process Flexibility Problem in two extreme cases