# Chapter 1: Value of Supply Chain Network Modeling

The objective for this chapter is to understand the definition of network design. You want the students to know what it is, know what data it requires, understand data accuracy versus precision, understand that it is driven by mathematical optimization, and understand that there are non-quantifiable factors to consider.

Class Topics for Chapter 1, “Value of Supply Chain Network Modeling” (1–3 hours of class time):

* Define the supply chain, network design problem, and cover examples. Some examples are provided, but you can pull from other network design cases and examples as well.
* Discuss the data needed to make such decisions (geographic data, transportation, warehouses, and plants).
* Discuss how optimization can solve these problems. We will formulate Mixed Integer Programs (MIP) later, but this could be a good place to spend some time on the topic. Here we discuss the main components of a MIP—the objective function, the constraints, the decision variables, and the data.
* Discussion on data accuracy and precision. The idea for the cartoon from the book came from something similar we saw a long time ago during a talk. The idea is not a new one, but the topic applies perfectly to network design.
* Discussion on the non-quantifiable aspects of the problem and to remind the class that business problems often involve other strategic issues.
* In-class exercise:
  + If you want to focus on optimization, this chapter could be a place to introduce the topic.
  + You can also spend time going into a network design case study (at a high level) to make sure students understand the concept.

Slide script and more detailed discussion points:

* **Slides 2–4.** In these slides, you define what a supply chain is and what network design is all about. We want to stress that we are talking about the physical supply chain (rather than how information or cash moves through a company).
  + This is a good place to provide some samples of what different supply chains may look like. You can see Chapter 12 for an overview of some generic types we outlined, but it is easy to come up with other examples.
  + If the class is new to the concept of the supply chain, it may be worth it to spend some time on this slide to help students understand a supply chain in general.
  + For more advanced students, it is helpful to make sure everyone has the same understanding of the supply chain.
  + In the text, we mention a rough statistic that 80% of the value of the supply chain is locked in with its design. A lot of people talk about this number in the field of “design for manufacturing” and apply it to supply chain design. It may be that there is more folklore than fact to this statement. After going to press, we found this working white paper from 1993: “Does Product Design Really Determine 80% of Manufacturing Cost” by Karl T. Ulrich and Scott A. Pearson (<http://dspace.mit.edu/bitstream/handle/1721.1/47202/doesproductdesig00ulri.pdf>). They cannot find evidence that this number is true. This could be an interesting discussion point. Also, the examples in the following slides provide information on the value of supply chain design that is specific.
  + Slide 4 is a good slide to discuss what network design means visually. You can say that network design helps figure out the best number and location of these warehouses (the black triangles).
* **Slides 3–15.** These slides complement the four examples in the book. Each of these slides has a blog entry up on NetworkDesignBook.com. Depending on your class, you can either quickly go through these (and use just the relevant ones) or take your time in going through one. They are interesting stories and help show the kinds of things companies use network design for. The slides are self-explanatory with additional references. But, here are some additional points:
  + **Mars and Wrigley**—You can introduce your students to CSCMP (www.cscmp.org, the Council of Supply Chain Management Professionals), a great supply chain organization with a variety of student chapters. You can talk about how just modeling the baseline saved $10M. We’ll cover this topic later, but you can say that just by thinking about the supply chain in a logical way and gathering all the data in one place allowed them to see savings that they would not have otherwise seen.
  + **Whirlpool and Maytag**—The article we link to from DCVelocity provides a nice discussion article. You could have the students read this and discuss it in class. They talk about how a merger looks from the point of view of people in the supply chain.
  + **MillerCoors**—This is a nice case to talk about big numbers—$750 million in savings, but also the fact that they report these numbers to the investment community (this shows the importance of these projects), and that once they finished one network optimization project, the quote suggests that they moved on to the next one.
  + **Home Depot**—Again, this shows the visibility that network design can get. Home Depot mentions the results of their network design in their letter to the shareholders. Also, this is a good retail example. The link to the SupplyChainDigest article can also be used in class discussion. Specifically, you can use this to talk about how Home Depot went from a strategy where they shipped from suppliers directly to stores to a strategy where they used warehouses. You can start to talk about the trade-offs between these two strategies and other industries where this happens (some products in the grocery are delivered directly from vendors).
  + **Global Chemical company**—This is from the book.
  + **Classic Case**—This shows a simple case and shows that this technology doesn’t have to be applied to complex supply chains.
  + **Pepsi**—This case shows network design being used to determine which product to make where. The case we reference on the slide provides you with more detail. IBM may have a similar case posted on [www.ibm.com](http://www.ibm.com). And, David Simchi-Levi at MIT has used this case and may have additional information in his book *Operations Rules*.
  + **Closed Loop**—This is interesting because it shows a closed loop supply chain. The lead in batteries is largely recycled, and you can model a supply chain that is a continuous loop.
  + **Sudzucker**—This provides a European example and where changing regulations changed the supply chain. Also, it could be interesting to use this to talk about the supply chain differences between the U.S. and Europe. In the case, it notes that Europe had many supply chains per country. This makes sense in many cases because of language, different markets, and so on. But, you may lose economies of scale.
  + **Toshiba**—This is an example of network design being used as part of a larger project. Interesting to bring up the point on the importance of quantifying different scenarios
  + **$55 million decision**—Again, a good case to use to remind students of the money involved in these types of decisions. You don’t want to put a $55 million warehouse in the wrong place.
  + **Other topics**—You can also talk about the example of the tablet and candy maker from the book. It can be a useful exercise to imagine what the supply chain looks like for a variety of companies. Without understanding different industries, this can be hard, but using your students experience and research, you should be able to come up with interesting examples.
* **Slide 16.** Here you can review the questions that network design can answer. Here is how you can use these questions:
  + Have the students figure out which of these questions were important to each of the cases presented earlier.
  + Pick a business that your students may know and see what questions would apply to that business.
  + If you are on a campus or in a city with your students, you might imagine some local business and think about a network design problem for that city—where should ambulances wait, where should UPS put drop boxes, and so on.
* **Slides 17–20.** These slides talk about the data that goes into these problems. Again, to add to the class discussion, you may want to tie this back to the cases. Other ideas for discussion include the following:
  + You could easily expand the data section to talk about transportation costs, taxes, or other elements of the data. We will talk about transportation and service levels later in the book.
  + For risk, you could talk about recent events and how they may have impacted the supply chain—things like the floods in SE Asia, the Tsunami in Japan, hurricanes, the Volcano that shut down Europe, and so on. You can mention that if you have single plant in this area, it may impact your entire business.
  + Have the students research how many warehouses a company like Walmart has or how many factories Nestle has. Many companies put their supply chain up on the web. This could be a nice way to talk about the data with some samples. You could use this to talk about the advantages and disadvantages to having warehouses or having multiple plants. The Home Depot case is a good case to discuss. Home Depot used to avoid warehouses and then changed strategies to have warehouses.
* **Slide 21.** Here we introduce optimization. In the next two chapters, we’ll go into this in more detail. But, for now, we want the students to understand that there is a mathematical way to solve these problems. We have experience with talking about the optimization in the categories of objective, constraints, and decision variables.
  + It helps to reinforce these concepts if you can talk about the cases and determine what the objective was, the constraints, and the decision variables. It can also be helpful to pick some other optimization problems for other fields or something your students can directly relate to.
* **Slide 22.** This section in the book is meant to help students realize that this is not an exact science. The cartoon reminds us that we need the right detail of analysis for the problem at hand. Network design is a business problem and not just a mathematical or engineering problem. There will be some (or a lot) of uncertainty with the data, and we should not confuse precision versus accuracy.
  + You could add to this section by doing some simple significant digit calculations (you can find plenty of material with a quick Google search).
  + You can also talk about the difficulty in predicting future demand or future oil prices (which lead to transportation costs).
* **Slides 23–25.** This section can be used to remind students that this is a business problem and there are non-quantifiable factors.
  + You might want to ask the students to give examples of companies taking action based on non-quantifiable information.

# Chapter 2: Intuition Building with Center of Gravity Models

This is a short chapter, and the class may be best with a hands-on exercise. The key point here is to introduce the idea of locating a facility by placing it in the center of customers. We also want students to realize that we are picking the best location from a list of candidate sites. The discussion on the physics center of gravity should explain why we are doing this—the physics center of gravity seems logical, but minimizes the wrong thing (and has other problems—it can pick strange places, it does not consider infrastructure, and so on).

Even though this problem is simple, it presents some interesting class discussion. For example, what is better—minimizing average distance or maximizing the percent of demand within a certain radius?

Class Topic for Chapter 2, “Intuition Building with Center of Gravity Models” (1–2 hours):

* Here we are starting with a simple model to show ***how*** these problems are solved. We introduce a fictional country called Logistica with different cities and determine a capital using simple distance calculations. You can use Logistica and other data sets to repeat this exercise in class to make sure students understand how to pick the best single point. (An interesting side is to make sure students understand why we pick from an existing list of cities rather than a weighted average of the latitude and longitude of the cities—and the different objectives of these approaches.)
* The Logistica spreadsheet is good to use for an in-class exercise.
* There is a spreadsheet that goes along with the sidebar. If your students have a strong math background, you can talk about why the physics center of gravity minimizes demand x distanced squared using calculus. If not, you can show the graph.

Slide script and more detailed discussion points:

* **Slide 2.** This slide shows our center of gravity intuition from everyday activities—a teeter totter and a waitress balancing a tray. This slide introduces how center of gravity translates to a logistics problem and why this is a good place to start for a book on network design.
  + You can tie this back to Chapter 1 by saying that the center of gravity problems are much easier than the cases we reviewed.
  + But, you can stress that the more complex cases were an extension of the center of gravity, not some unrelated problem.
* **Slides 3–7.** Cover the center of gravity based on principles that seem easy but will not scale when we move to more advanced network design.
  + Slide 4 is really the “eyeball” approach—pick a spot that looks good geographically. This may have some appeal, but is really just guessing.
  + Slides 5**–**7 talk about the physics center of gravity approach. This approach is more scientific. You want students to understand this approach, but come to the realization that this is a good approach in physics for balancing weight, but it is not good for locating a supply chain facility.
  + In these slides, you can use the sidebar spreadsheet to give the students a hands-on exercise.
* **Slides 8–9.** These wrap up by showing the practical center of gravity—picking a site from a candidate list. The candidate list happens to be our existing 25 cities. You should stress that in this case, we can simply enumerate all choices, but that this won’t be possible later.
  + You can use the Logistica spreadsheet to make this a hands-on exercise. To make it different from the book, you can change populations of the cities and see how the answers change.
  + You can also have the students pick points between cities to see how they do on key measures—there may be greenfield locations where we could build a capital.
  + This is a good place to have a discussion on the relative value of the different solutions.
  + Depending on how you assign homework, the homework questions also make for interesting discussion.

By the end of this chapter, the students should have good intuition on locating a single facility relative to demand points.