Now we go to chapter 13, which is aggregate planning. We want to plan for production. Plan for production to minimize our total cost. Then, of course, again, we start with a very simple model. Then gradually either in this course or throughout a carrier, we work out more complicated models, but here we discuss a simple model with a lot of simplification assumptions. In general, in any production or service enterprise, we do have 3 types of planning; Long range planning, which is indeed strategy planning, Intermediate planning, and short range planning. Long range planning usually goes for 3 to 5 years, but in general we can say any plan which is related to a period of greater than one year is called long range plan. Intermediate plans are related to 2 months to 12 month periods, and short range plans are related to monthly schedules, weekly schedules, daily schedules, and even hourly schedules.

In long range planning, which is related to periods of greater than one year we, for example, decide about expanding our capacity or reducing our capacity or merging with another company, or location of our plan for our distribution centers and layout of our operations either service operations or production operations. And by layout we mean physical arrangement, arrangement of physical entities like machines, like inventories like operators, how they are arranged within the manufacturing or service system such that the manufacturing or service system under consideration performs at the high quality short response time, a high flexibility, and, of course, low cost. Intermediate plans, which are the subject of this chapter, are related to man power planning, outsourcing, inventory management, back log management, hiring, and layoff. Inventory management means I produce now to sell it sometime later. I produce this week to sell it next week or two weeks from now. Back log management means I have a demand for this month, but I don’t have capacity. So, for example, I give some discount to my customers and I ask them to wait for production for about one week or one month or some period of time. So inventory satisfies the demand of future period based on production of a previous period while back log satisfies the demand of previous period using production of a future period. And finally we have short change plans or schedules during month of February who can go to vacation, who should be in operations, which machines should work, how many hours, and on what product. In this chapter we will be concerned about intermediate planning, and we will discuss two very basic models for intermediate plans.

Aggregate planning is a big picture to production planning. We don’t really go into details. We give big picture of how do we satisfy the demand. Aggregate planning is a production plan, a production plan to meet demand throughout the year. Aggregate planning is not concerned with individual products but it talks about a single product. It assumes that all products have been merged into a single product, and that single product is a prototype, a representer of all our products. It is an average product. When we say this average product, for example, needs 10 hours of labor, that means on average. One unit of our product needs 10 hours of labor. It is a prototype product, an aggregate product, which represents the average requirements of our individual products. It also shows the overall demand for all products and overall supply capacity of our production plans. So we melt all our product into a single product, and we represent our production plan in terms of that single product. Such a single product may not even exist, but it is a representater of an average product in our production system. So Ford Motors mirrors all its products in a single product and says this single product requires 24 hours assembly time. For example, this is not a Mustang. This is not an Explorer. This is not an Expedition. This is representative, a prototype of all products of Ford Motors.

For example, in a TV manufacturing plant, the aggregate planning does not go into all models and sizes. It only deals with the single representative aggregate TV. How much assembly time does this aggregate TV need? How much labor time does it aggregate TV need? How many machine hours does this aggregate TV need? And again such an aggregate TV maybe even does not exist in reality, but it is a representater of an average product. All models are lumped together and represent a single product, and that is why we call it aggregate planning. Aggregate planning.

Aggregate planning permits planners to develop intermediate range plans without being involved in too much details. Don’t forget defining which level of details is very important. Sometimes you go into a lot of detail, and then you forget the big picture. Here in intermediate planning we shouldn’t miss the big picture. We shouldn’t go to varied details of a machine over an individual such that we cannot see the other parts of the system. In aggregate planning, we are concerned with the quantity and also timing of demand. Demand is uneven throughout the year, so we don’t have a constant demand throughout the year. Demand is seasonal. In some periods it is low. In some periods it is high, and we should develop an economy called plan to satisfy this demand at minimum cost. Therefore, aggregate planning has two basic characteristics. An aggregate product, we have melted all products into a single product, a representative product. Uneven demand. Demand is not constant. Aggregate planning begins with forecast of demand for aggregate product or forecast of demand is interchangeable for one year. Then one year plan is prepared for each month. It includes the volume of output, working hours, overtime, outsourcing, inventories, back order or back logs, hiring, and layoffs. So aggregate planning tells us how to satisfy the demand. When to work. When to work in regular time. When also to work in overtime. When to outsource some of the jobs. When to produce inventory for later demand. When to say the demand wait for me for one month. I will produce for you next month. When to hire people, and when to layoff people. These are concepts. These are basic concepts of aggregate planning. So these are the pieces of information that I need. I need to know the demand. Demand for aggregate product, which is uneven thought the year. Then we need to know how much capacity is there. Usually there are 3 sources of capacity. Our production in regular time, our production in overtime, and also outsourcing. I like to know how much product can I produce in regular time? How much producing during overtime? And what is the outsourcing capacity? How much product could I outsource? Class one of information is related to demand + 2, is related to supply. Class 3 of information is related to our inventory cost and back log cost. Inventory tells us you can invent now and sell it later, but there is a cost involved, a carry over cost. Back log cost tell us if there is a demand for this week, but you don’t have capacity, regular capacity, nor overtime capacity, outsourcing capacity, and you have already allocated your regular capacity, your overtime capacity, and your outsourcing capacity to production, and still you are unable to satisfy the demand, then you say to some customers, I produce it next week, and I give it to you. Inventory has a cost. You should carry inventory from one period to another. Back log also has a cost, because the customer may tell you, no. I don’t wait. Okay. I will give you – for example, $10 for each period you wait. So if you wait for me to one period, for each unit of product I will give you $10 discount. If you wait for me to two periods for each unit of product I will give you $20 discount. So that is the third class of data, the third class of information. And then you need to know what is the hiring cost and what is our layoff cost. You want to satisfy the demand with minimum, and of course with the specific level of quality, response time, and flexibility.

So demand is not a straight lane. It is uneven. In this part of the year we have low demand. In this part we have high demand. The question is how to produce to meet the demand. How many employees? How much overtime? How much outsourcing? How much inventory? How much back orders? There are two extreme points of view in aggregate planning. One is level capacity says I really don’t care what is the demand. I produce at a capacity. I constantly produce at my capacity. If demand is low, I will add to inventory. If demand is high, I will use the inventory of previous periods, but my production would be a straight line.

Look, my friend, I will produce at this level. Okay. Over there, if demand is high, I will use this inventory that I have produced here. But chase demand says I will follow the demand. I will chase the demand. If demand goes low, I bring down my production. If demand goes up, I will increase my production. I just chase the demand. Level production is like this. Maintaining a steady rate of output while meeting variations in demand by a combination of options. So here we produce at a constant rate. When demand is low, our total production throughout the year is equal to the total demand. Demand – this is demand. Demand will go up. Here at the low pace then it will take off. Then it slows down again. But we produce at a constant rate. The maximum inventory that we carry on is here. Here we have the maximum inventory. And then gradually we consume all that inventory. At the end of the year what we have produced is equal to what the demand was.

If you want to show the maximum inventory here, look here. Demand is just very low. We are producing so this much inventory will be collected. Then at this point we are still using the same rate of production but demand is less than production, so we will add to inventory. We will add to inventory. Our maximum inventory will be at this point. At this point demand takes off. It’s rate becomes larger than production rate, and it consumes inventory. At this point what we have produced is equal to the total demand and then gradually demand slows down, and we still continue production with the same rate, and then finally they even each other.

So this is the maximum inventory demand. Chase demand is matching capacity to demand, production in each period is equal to the expected demand for that period. Now we will discuss general procedure for aggregate planning. Determine demand for each period for each month. Determine capacity for each period at regular time, overtime, and outsourcing. Identify company’s inventory policy. Isn’t company more in favor of chase the demand or it is more in favor of level capacity? Identify costs, costs of production regular time, cost of the production of overtime, cost of self contracting, cost of carrying inventory from one period to the next period, cost of back orders, and back orders we say cost of satisfying the demand of one period in one or more period later. It is the cost of good will, potential discount, back tracking, extra paperwork for that transaction. Back order cost is exactly the same as inventory cost as stated in terms of cost per unit per period. How much does it cost to satisfy the demand for one unit of product which its demand is this period from the production of next period? That is back orders cost or back log cost. Then we multiply that cost per unit to the total back order. We get total back order cost.

Let’s look at this problem. We have demand for 9 periods. Here I have not put 12 periods because if I had had 12 periods, I could not have shown the whole spread sheet, so demands for these months are given, and as you can see they are uneven. We have 10 full time employees. They can each produce 10 units per period at cost of $6 per unit. So we have 10 workers. Each can produce 20 units per period. 10 times 20 is 200, 200, 200, 200, 200, 200, 200, 200, 200. Total production capacity during these 9 months is 1,800. Total demand is 1,940. First total demand is greater than total supply in regular team, therefore, we definitely need to work in overtime or to outsource. Secondly demand here could go up up to 280, but here capacity is at most 200. Also here it can go down to 160 while the capacity is 200.

So if you have level capacity, we cannot satisfy the demand in regular time. So we should add some overtime over here, and then for example, we need 140 units more than our capacity in regular time. We will break down that 140 over 9 periods and produce at that level throughout the 9 periods. That is level capacity. If you want to chase the demand here, we produce 190. Here we produce 30 units in overtime, 60 units in overtime, 80 units in overtime, 10 units in overtime. We produce 170. We produce 160. 60 units overtime. We produce 180. That would be chase the demand. But we want to be somewhere in between. We want to know what is the production plan that minimizes total cost. In this problem we don’t have outsourcing. Our two sources are regular time and overtime. Regular time $6 per unit. Overtime $13 per unit. That is our production cost. But we also have inventory cost. If we carry one unit of product from this period to next period, it will cost us $5. If we keep demand of one unit of product in this period to satisfy it in the next period, that would cost us $10. Maximum overtime production capacity is 20 units per period. So at the best we can produce 220 here, 220 here, 220 here , 220 here, 220 here.

So if you want to solve this problem and find the best production plan, and we use a transportation model to do this. We assume production are origin, manufacturing plants, and months are retailers, demand sources.