Introduction to the Master Production Schedule (MPS)

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Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - the process of planning

Planning:
- Strategic:
  - Horizon: 2-5 years
  - Objectives: price, quality, service …
  - Planned item: the production level as a whole
  - Decisions: MTO, ATO, MTS policies …
  - Pace: year

- Aggregate:
  - Horizon: 1 year (6 – 18 months)
  - Objectives: to fulfil forecasted demand at the lowest cost, to avoid stock-out
  - Planned item: product families (groups, types)
  - Decisions: when production starts in each period, make or buy tactic …
  - Pace: month / week

- Operative:
  - Horizon: 1 week / day (shift)
  - Objectives: to effectively fulfil production orders
  - Planned item: each (single) part number
  - Decisions: when to produce, which workcentre, which sequence etc.
  - Pace: hour / real-time

The process is (still) inherently dominated by a hierarchic approach
Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - An overview of the process

When talking about MPS, only finished products are involved
Setting-up a MPS for the single-product case

- Two (alternative) approaches are available, i.e. level and chase
  - From the theoretical viewpoint
- These alternative plans represent the trade-off between stock holding costs and set-up costs
Setting-up a MPS for the single-product case

- A conceptual model
  - MPSs in the “A” zone are **infeasible**, since they do not meet demand
  - MPSs in the “B” zone are **ineffective**, since they are dominated by the leveled plan
  - **Real-life** MPSs are in the “C” zone; they are feasible and they represent a compromise between the two extremes (i.e. leveled and chase plan)
Introduction to the Master Production Schedule (MPS)

- MPS in practice
  - An example of a real-life MPS

During week 10 the plant is required to produce 165 units of product 15202

It does not look very fashionable …
Introduction to the Master Production Schedule (MPS)

- MPS in practice

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- Time buckets (e.g. weeks)

- Number of units (or lots) of product 15223 to be manufactured by B plant during week 5

Diagram:
- Time fence
- Week
- Product A
- Product B
- Product C
- Present
- Frozen
- Firm
- Full
- Open
MPS in practice

- Dealing with production capacity

An infeasible plan is converted into a feasible one through left-wise shifts of lots
  - At the expenses of both stock holding costs and (in case) set-up costs
Introduction to the Master Production Schedule (MPS)

- An example of (single-product) level vs. chase approach
  - The *theoretical* case (where no capacity constraints are present)

![Graph showing demand, cumulated demand, inventory levels, and feasible plans.]

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![Graph showing cumulated demand, cumulated level plan, and cumulated chase plan.]

- Area of feasible plans
- Area of infeasible plans
- Time

Cumulating the level plan ensures that the inventory level is continuous and smooth, whereas the chase plan adjusts inventory levels to exactly meet demand, leading to potential under- or overproduction depending on the capacity available.
Introduction to the Master Production Schedule (MPS)

- An example of (single-product) level vs. chase approach
  - The real-life case (where a capacity constraint of 32 units/month is present)

Both (level and chase) approaches are infeasible, so that a mixed approach (i.e. a compromise) is required.
Introduction to the Master Production Schedule (MPS)

- An example of (single-product) level vs. chase approach
  - The **real-life** case (where a capacity constraint of 32 units/month is present)

The mixed level based plan is made up from 2 pure level plans, with an intermediate set-up

### Demand

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<tr>
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### Cumulated Mixed Level-based

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Introduction to the Master Production Schedule (MPS)

- An example of (single-product) level vs. chase approach
  - The real-life case (where a capacity constraint of 32 units/month is present)

### Monthly Demand and Inventory Level

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### Introduction to the Master Production Schedule (MPS)

- An example of (single-product) level vs. chase approach
  - The **real-life** case: a resume

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Executive summary

- The process of planning is (still) inherently dominated by a hierarchic approach
- Two main approaches are available for MPS building, i.e. level and chase
  - Real life MPSs are a compromise between level and chase approach
Introduction to the Master Production Schedule (MPS)

- Practice

Company Alpha manufactures the sole product Beta, whose demand (in thousands) is reported in the table, starting from a raw material whose cost accounts for 2.5 Euros per piece; energy cost accounts for 0.5 Euros per piece. The maximum production capacity equals to 40,000 pieces per month (i.e. 1,000 pieces per shift) and the opportunity cost of holding inventory (including risk premium) accounts for 20% per year.

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Production process is plagued by an average 20% scrap rate, while during set-up (that occurs every time the throughput rate is changed) the scrap rate is 100%. Each set-up requires (on average) 1 shift and involves 2 operators (whose labor cost accounts for around 30,000 Euros per year each). At the beginning of September and January set-up is required to recover the plant from maintenance. Raw materials scrapped can be recycled by using a recovering machine whose yield is 40%, and which requires 1 operator (whose labor cost accounts for around 25,000 Euros per year).

You are required to prepare a chase plan and a level plan and to calculate:
- the overall cost and the inventory level at the end of each month (for either plan)
- the required initial inventory level that makes each plan feasible
Introduction to the Master Production Schedule (MPS)

- **Practice (short discussion)**
  - Available production capacity equals to 32,000 pieces per month, i.e. 40,000 x 0.8. Set-up cost equals to 2,000 Euros per setup, given by: 1,000 x (0.5 + 0.6 x 2.5), since during 1 entire shift the plant utilizes energy and produces 100% scraps, whose 60% is unrecoverable (so the cost of raw materials is “lost”). The (variable) production cost per each good piece is (2.5 x 0.2 x 0.4 + 0.5)/0.8 = 3.5 Euros per piece, since recycled scraps (i.e. 40% of 20% of the whole flow) can be used as if they were “new” raw materials.

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<td>20</td>
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<td>Inventory</td>
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<td>-48</td>
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<td>Chase plan</td>
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<td>10</td>
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<tr>
<td>Inventory</td>
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<td>8</td>
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</tbody>
</table>
Introduction to the Master Production Schedule (MPS)

- **Practice (short discussion, part II)**

The overall cost of the level plan equals to the stock holding cost, i.e. the product of the average inventory level (i.e. 28,167 pieces), the variable production cost per good piece (i.e. 3.5 Euros per piece) and the hurdle rate (20%): $3.5 \times 28,167 \times 0.2 = 19,717$ Euros per year.

The overall cost of the chase plan equals to the sum of the stock holding cost and the (differential) cost of 2 set-ups (2,000 Euros each). The average inventory level is 4,667 pieces, so stock holding cost accounts for: $3.5 \times 4,667 \times 0.2 = 3,267$ Euros per year and the overall cost equals to 7,267 Euros per year.

Notice that, since set-up is triggered by a change of the throughput rate, 2 differential set-ups take place (the former one in December, to “switch-off” the plant and the latter one in January, to switch it on); notice also that both set-ups that take place in August are not relevant (i.e. differential) according to the contribution approach.
Some deepening remarks
Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - When planning is needed?

  Notice that the subject is “planning” and NOT “forecasting”

- It depends on the way of responding to demand
  - Adopted by the considered production system

- i.e. it depends on the $P/D$ ratio, where
  - $P$ represents the total throughput time of the production system, i.e. how long the operation takes to:
    - Obtain (purchase) the resources
    - Produce (make, manufacture and/or assembly)
    - Deliver the product or service
  - $D$ represents the demand time, i.e. the total length of time customers have to wait between order issuing (i.e. asking for a product or service) and order receiving (i.e. obtaining what asked)
Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - When planning is needed

The lower the P / D ratio, the higher the need for planning

1. P / D = 1
   - Very high need for planning
   - (and reduced need for forecasting)

2. P / D >> 1
   - Reduced need for planning
   - (and very high need for forecasting)

Diagram:
- Purchase raw materials
- Manufacture subassemblies
- Assembly finished products
- Delivery to customers

Total throughput time (P)

D under MTS
D under ATO
D under MTO
D under PTO / ETO
Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - Some remarks about the risk
    - The **blind time** (also called **speculative time**) is the proportion of the total throughput time the producer carries out operational activities without (i.e. prior) having received a firm order (from a customer)

  - **Long** blind times, when combined with **poor** (final) customers’ demand forecasts, yield **high risk** of the producer
    - For this reason, the longer the blind time (i.e. the shorter the demand time), the higher the need for (reliable) forecasting
What does planning mean

- The concept of control

Significance of planning or control

<table>
<thead>
<tr>
<th>Area of planning</th>
<th>Area of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months / years</td>
<td>Hours / days</td>
</tr>
<tr>
<td>Days / weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Demand forecasts: aggregated
- Resources determination: financial
- Objectives: largely financial terms

- Demand forecasts: partially disaggregated
- Resources determination: contingencies
- Objectives: both financial and operations-related

- Demand forecasts: totally disaggregated
- Resources determination: deviation from plans
- Objectives: ad hoc operations-related
Introduction to the Master Production Schedule (MPS)

- What does planning mean
  - The concept of control
    - Has a twofold meaning:
      - Progress control
      - Workload control

Experimental results coming from a real-life job shop simulation

Below a relevant lower limit of the workload, the utilization rate (and so the ROI) is inadequate; however, beyond a relevant upper limit, additional workload leads lead time to increase, without any (significant) benefit in terms of utilization rate
Introduction to the Master Production Schedule (MPS)

- A planning dilemma:
  - is it worth to invest in production capacity?

- It depends on the confidence the production planners (managers) have in future demand matching the future capacity
  - E.g. if production planners are confident that (in the long term) demand will exceed current capacity, they are more tolerant of under-utilization (in the short term)

- A useful tool is the outlook ratio, estimated both for the long and short term

\[
\text{Outlook} = \frac{\text{forecast demand}}{\text{forecast capacity}}
\]
Introduction to the Master Production Schedule (MPS)

- A planning dilemma:
  - is it worth to invest in production capacity?

\[
Outlook = \frac{\text{forecast demand}}{\text{forecast capacity}}
\]

<table>
<thead>
<tr>
<th>Long-term outlook</th>
<th>Poor Outlook &lt; 1</th>
<th>Normal Outlook = 1</th>
<th>Good Outlook &gt; 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Outlook &lt; 1</td>
<td>Lay-off staff</td>
<td>Delay any action</td>
<td>Use overtime &amp; temporary staff</td>
</tr>
<tr>
<td>Normal Outlook = 1</td>
<td>Put up with idle time</td>
<td>Do nothing</td>
<td>Use overtime &amp; temporary staff</td>
</tr>
<tr>
<td>Good Outlook &gt; 1</td>
<td>Use idle time to build inventory</td>
<td>Use idle time to build inventory and recruit</td>
<td>Hire staff</td>
</tr>
</tbody>
</table>
Setting-up a (leveled) MPS for the two-product (single work-centre) case

Since $t_1$ to $t_2$ the plant manufactures product 2

Cumulative units

Demand (cumulative) product 1

Demand (cumulative) product 2
Executive summary

- Planning is a different concept from forecasting
  - The lower the P / D ratio, the higher the need for planning
  - The longer the blind time (= P–D) the higher the need for (reliable) forecasting
  - Long blind times combined with poor demand forecasts yield high risk of the producer
- To drive the investments in (additional) production capacity the outlook ratio (forecast demand / forecast capacity) is to be considered both in the short and long term