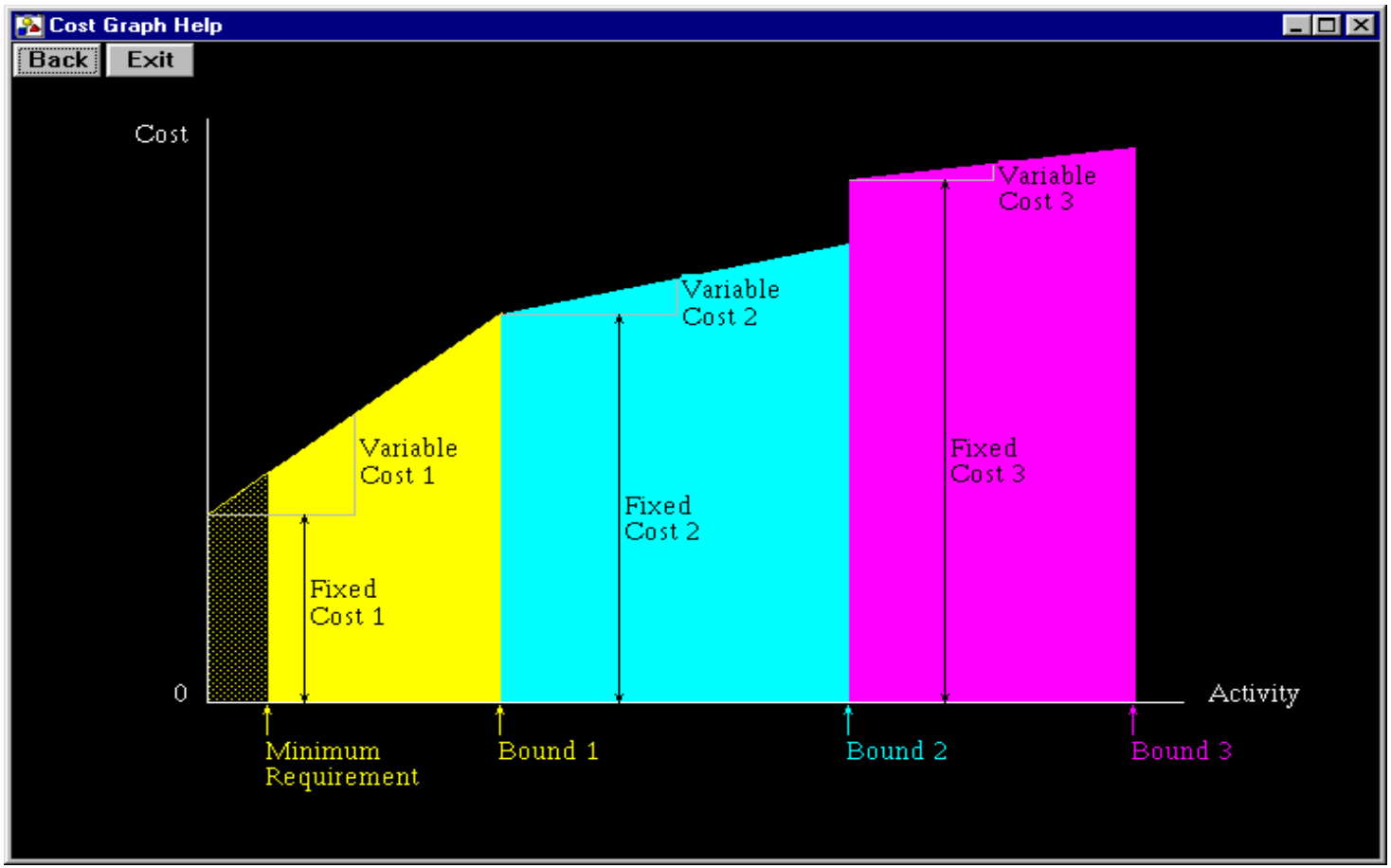
Supply Chain Normative Models
Necessarily Driver-Based

- Problem Statement: Find the least cost supply chain to fulfill a given, fixed demand. The solution includes:
  - Sites: physical locations
  - Missions: what activities are performed at the sites
  - Capacities: what are the volumes of each activity
- Relevant Definitions:
  - Cost function: mathematical expression of how a cost changes with changes in the level of an activity relating to that cost
  - Cost object: work unit (e.g., product, service, customer, function, organizational subdivision) for which cost data is desired
  - Cost driver: measure of activity that causes incurrence of cost in a cost object

Supply Chain Mixed Integer & Linear Programming (MILP) Models
Necessarily Driver-Based

- Model Structure
  - Since solution quantities within network are unknown, costs must be expressed as function of product volumes, i.e., cost functions
  - Cost functions are not continuous; they are linear, fixed, stepped or combination (see Fig. #1)
  - All costs (fixed/variable, indirect/common and direct) must be associated, directly, with one of the six types of cost objects
    - Products/services/projects, including raw material, WIP, and finished
      - created, directly, by activities
    - Activities/processes
      - create products
    - Facilities
      - contain activities at a geographic location
      - Include the costs for opening and closing

Fig. #1: Cost Function



Supply Chain Mixed Integer & Linear Programming Models
Normative and Necessarily Driver-Based

- Model Structure
  - All costs (fixed/variable, indirect/common and direct) must be associated, directly, with one of the six types of cost objects
    - Business sustaining/virtual facility
      - all other costs
    - Customers
      - consume finished products at a geographic location
    - Links
      - connect activities and facilities
  - The six cost objects are arranged in a cost “tree structure” (see Fig. #2)
  - Facilities and sustaining costs are placed in layers called echelons (see Fig. #3)
    - From raw material suppliers to customers

Fig. #2: Cost “tree structure”

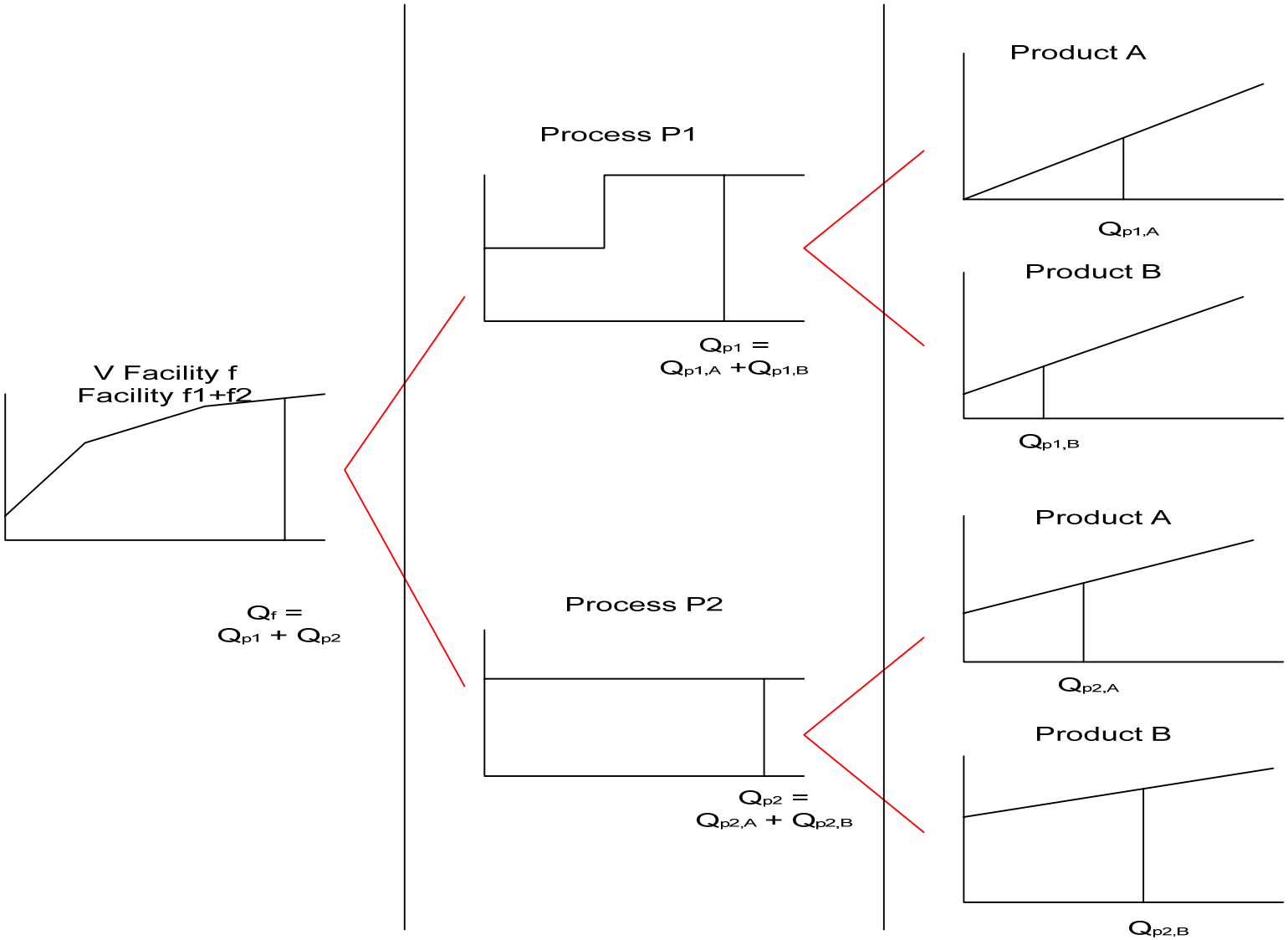
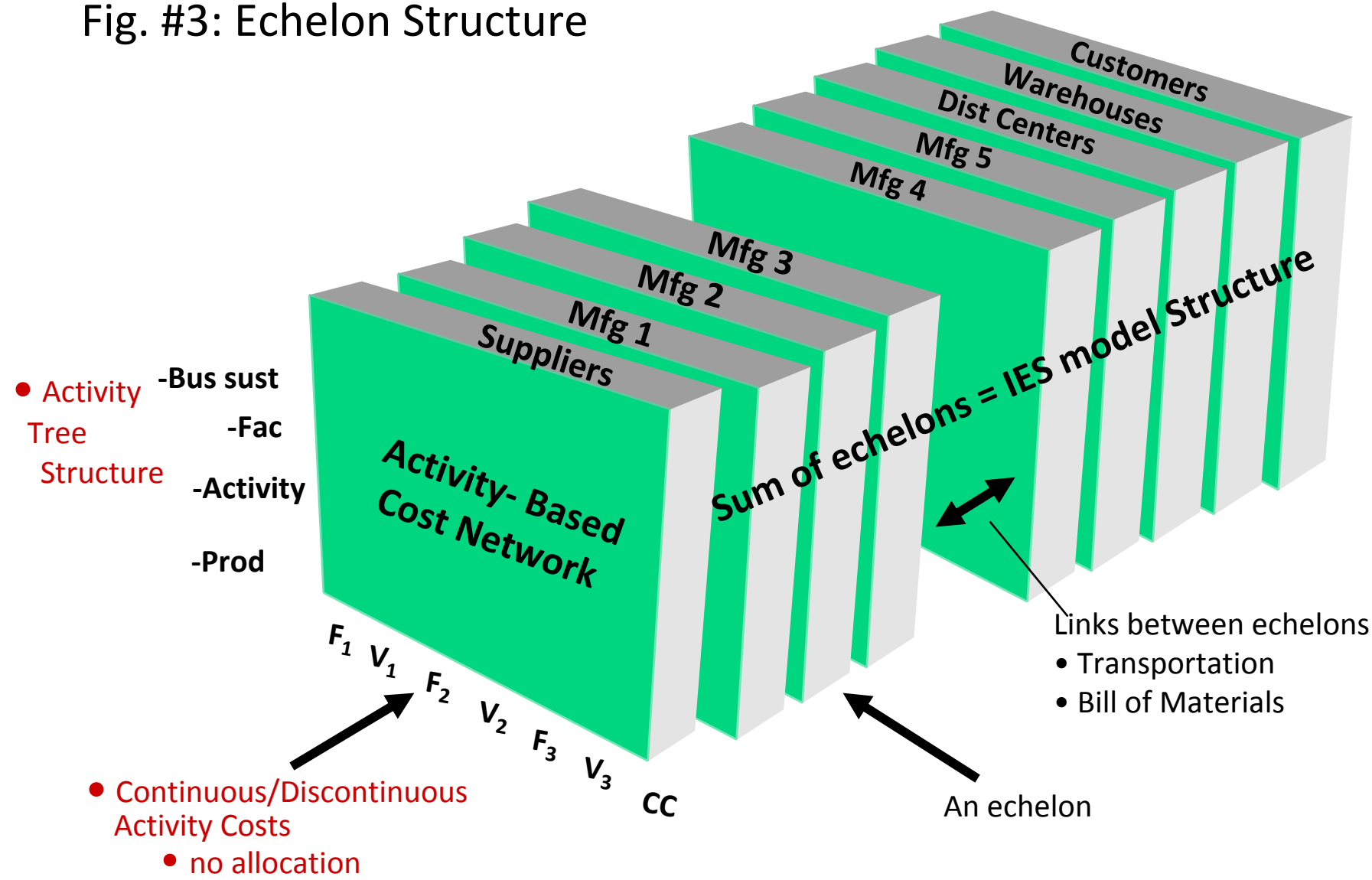


Fig. #3: Echelon Structure



Supply Chain MILP Models
Necessarily Driver-Based

- Model Structure
  - Since solution quantities are unknown; costs must be expressed as function of product volumes (i.e., cost functions; see #1)
  - Cost functions are linear, fixed, stepped or combination
  - All cost (viz, fixed/variable, indirect/common and direct) must be associated, directly, with one of the six types of cost objects
  - A variety of constraints can be included in the model (see #2)
    - Capacity is one of the most important
    - Frequently, placed on cost functions (see #1)
  - A variety of capacity solutions can be modeled, simultaneously (e.g., Inventory build ahead vs. more equipment vs. OT)

Fig. #4: Examples of Constraints

- Production and process rates
- Transit time vs. customer response time
- Order fill rates
- Losses
  - transportation
  - process
- Capacities (e.g., bound 3: see Fig #1)
- Facility utilization rate
- Maximum number of facilities
- Minimum activity quantity (see Fig. #1)
  - computed, forced in, forced out