There are two key phenomena that affect multiple-stage supply chains

- Floating bottlenecks

- Stage-spanning bottlenecks

Reference: Graves, Tomlin, "Process Flexibility in Supply Chains," 2003.

- # Floating bottlenecks

Stage 1

1
2
3

Stage 2

1
2
3
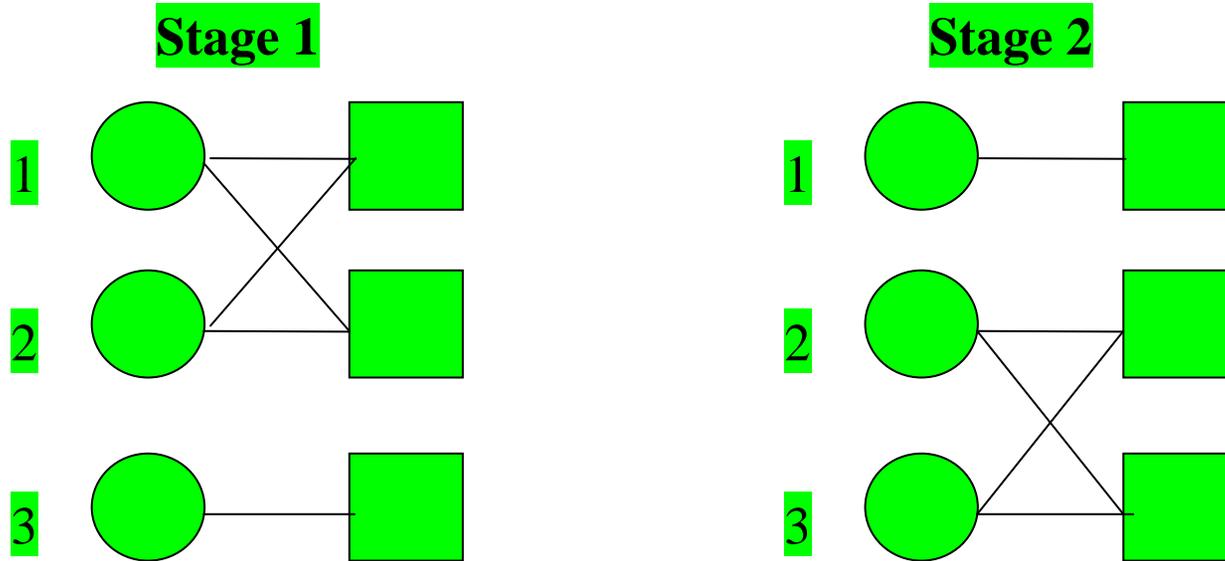
Scenario	Probability	Demand			Stage 1 Stand Alone Shortfall	Stage 2 Stand Alone Shortall	Supply Chain Shortfall
		Product 1	Product 2	Product 3			
1	0.5	100	50	150	50	0	50
2	0.5	150	50	100	0	50	50
				Expected Shortfall	25	25	50

The expected shortfall is larger than the maximum expected stand-alone stage shortfall as the bottleneck floats between stages

- Stage-spanning bottlenecks

Stage 1

1
2
3

Stage 2

1
2
3
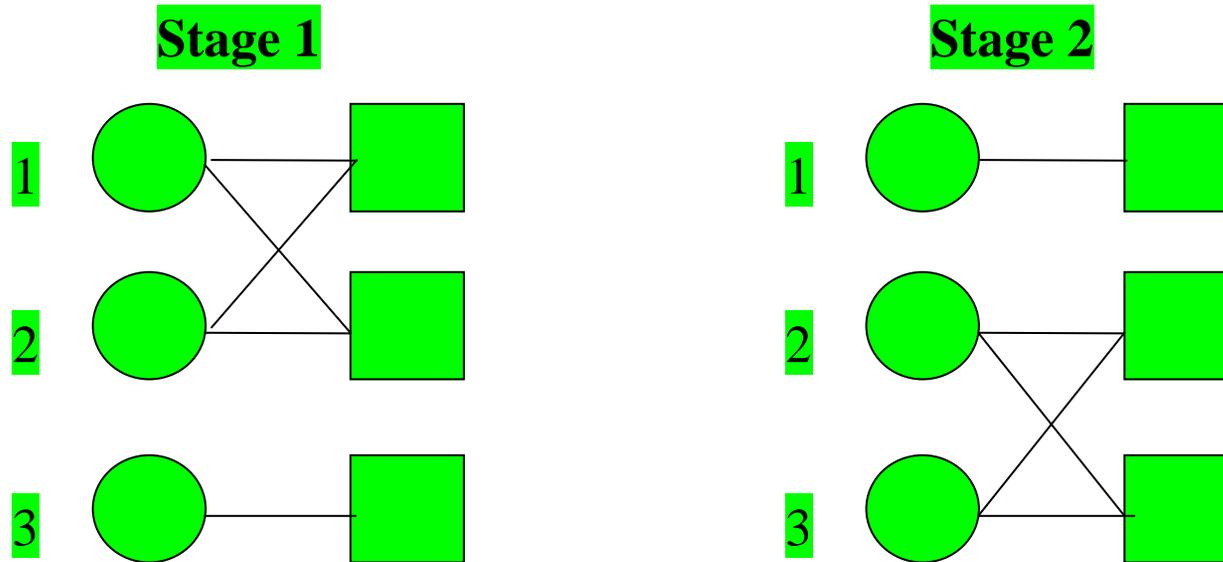
Demand			Stage 1 Stand Alone	Stage 2 Stand Alone	Supply Chain Shortfall
Product 1	Product 2	Product 3			
150	50	150	50	50	100

These two phenomena are called inefficiencies

Simulation shows that these inefficiencies can significantly affect a supply chain's performance

**Figure 8
Inefficiencies for Pairs Configuration**
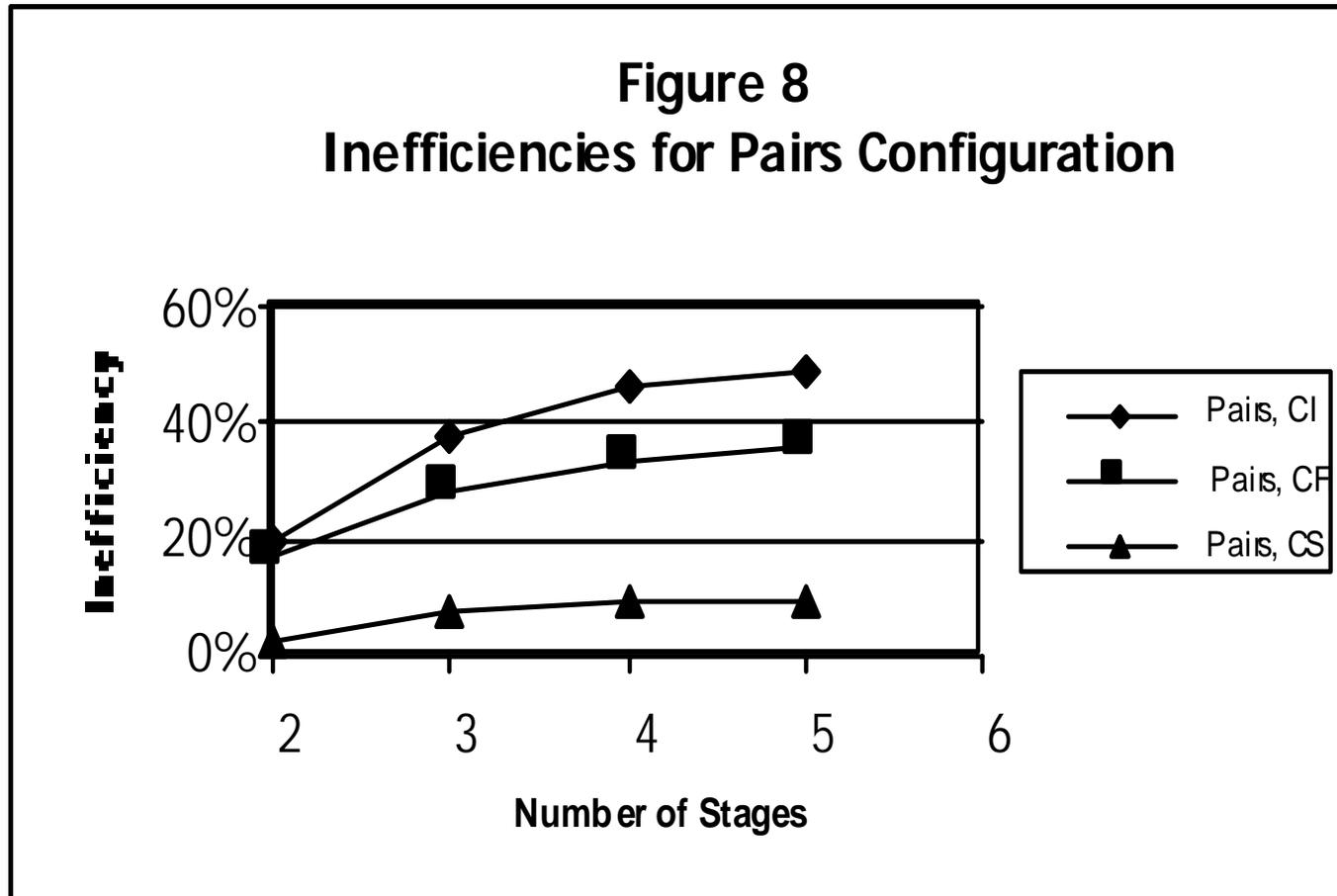
A pairs strategy performs much worse than a total flexibility strategy

Figure 10
Configuration Loss for Pairs Configuration
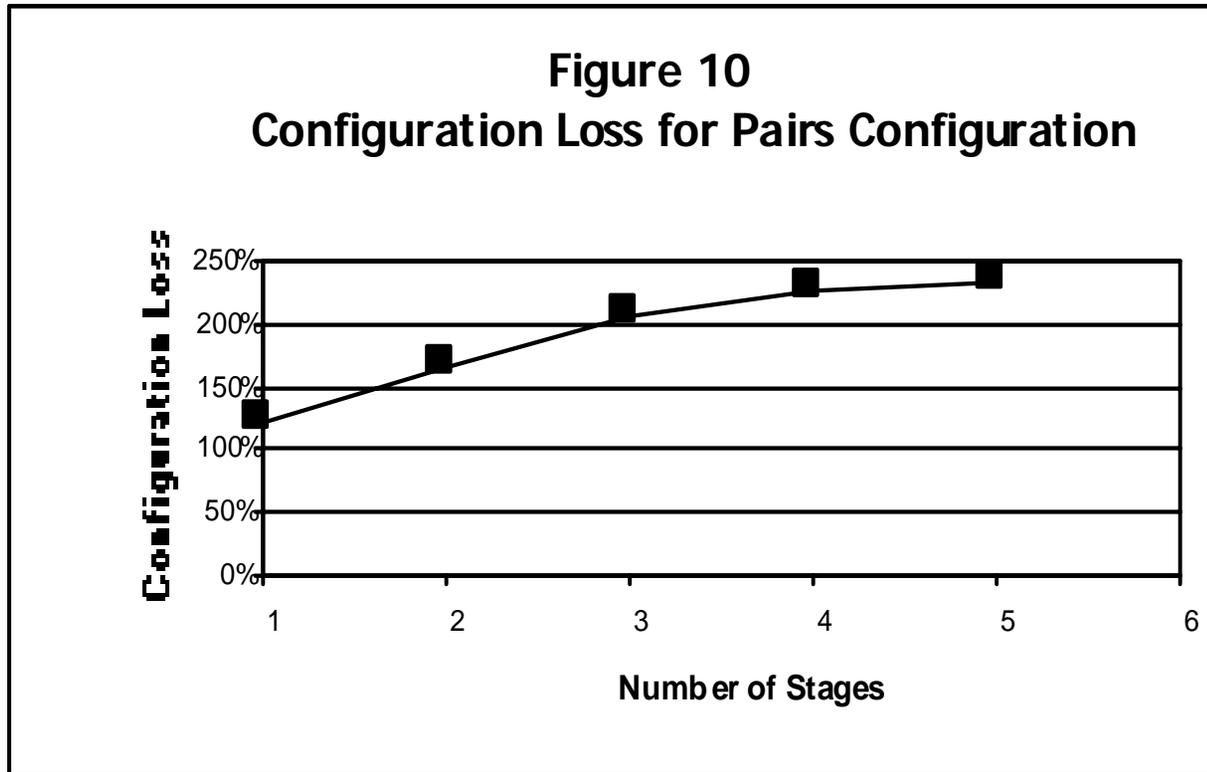
Chain configurations offer very good protection against the inefficiencies

Figure 11
Configuration Inefficiency For Chains
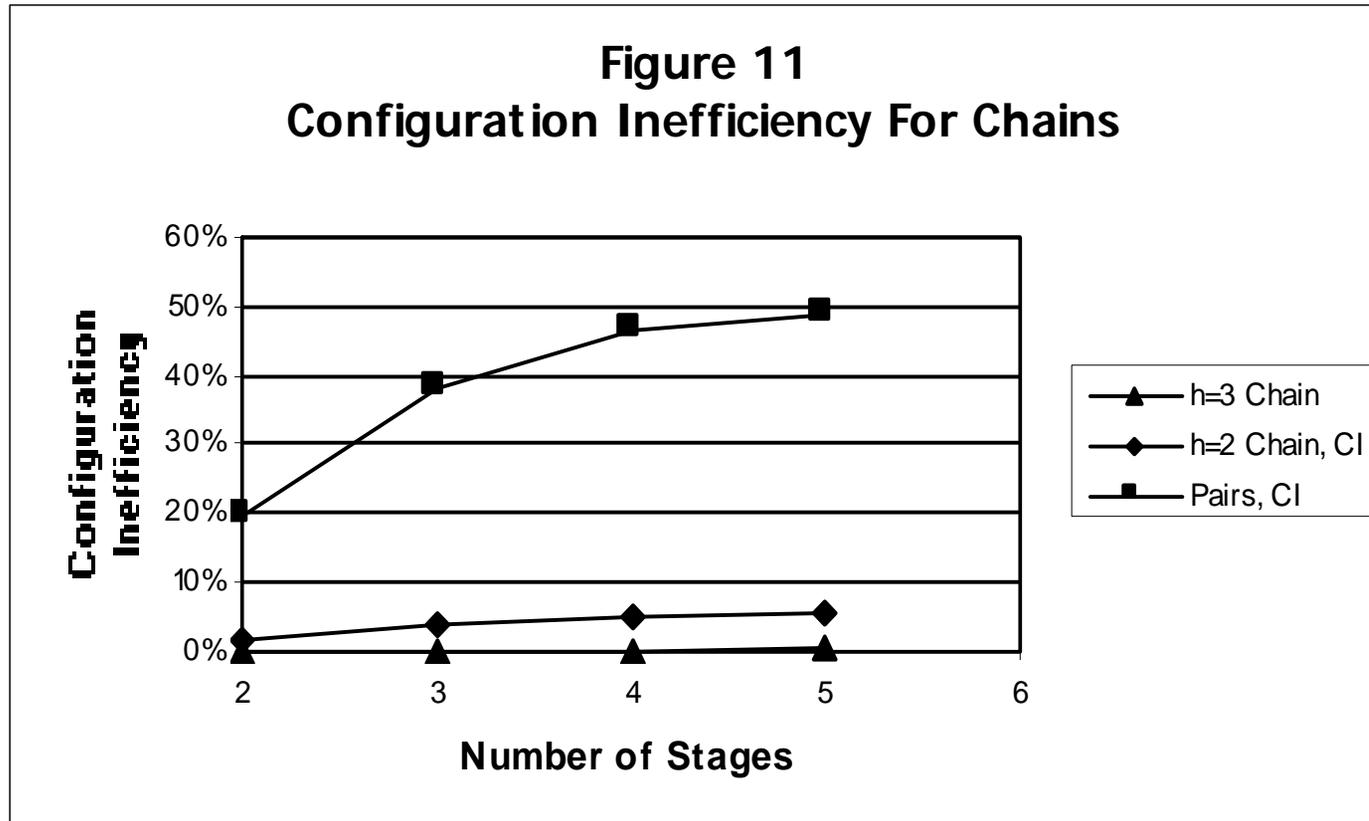
A chain strategy performs very well

Figure 13
Configuration Loss for Chain Configuration

A chain strategy performs very well

Figure 14
Configuration Loss for Chain Configuration

Configuration Loss vs Number of Stages
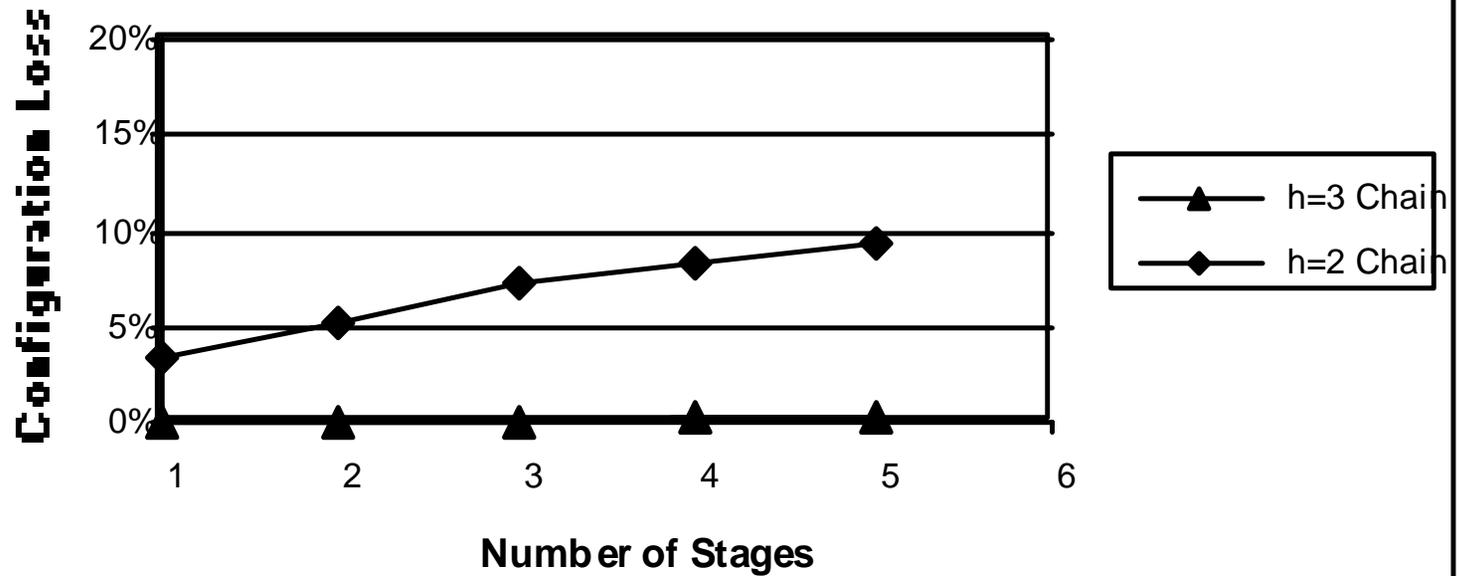
- h=3 Chain
- h=2 Chain
- Pairs
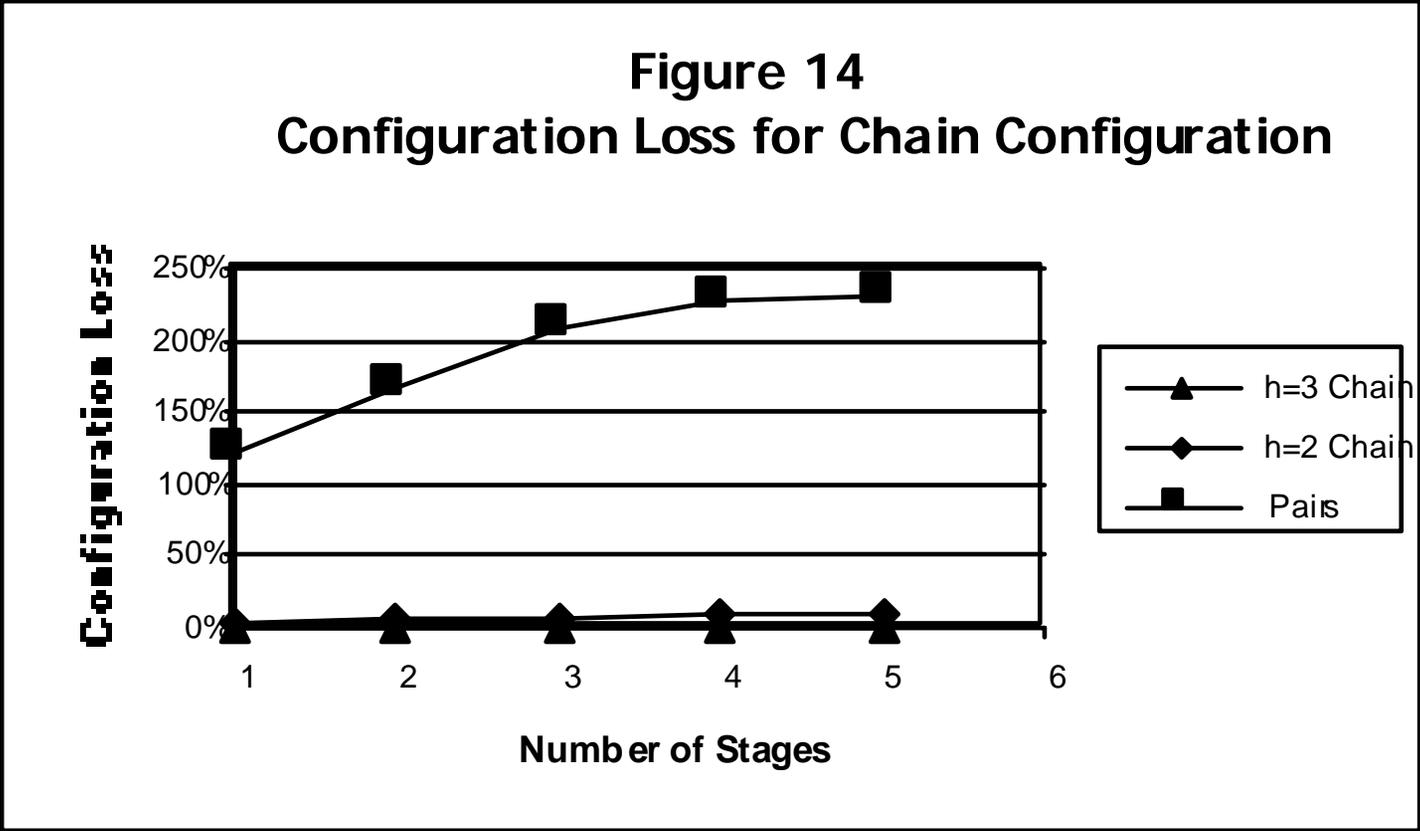
If the number of stages or the number of products is very large, then an *h*=3 chain strategy may be advisable

Figure 15
Configuration Loss for h=2 Strategy as the Number of Stages and Products Increase
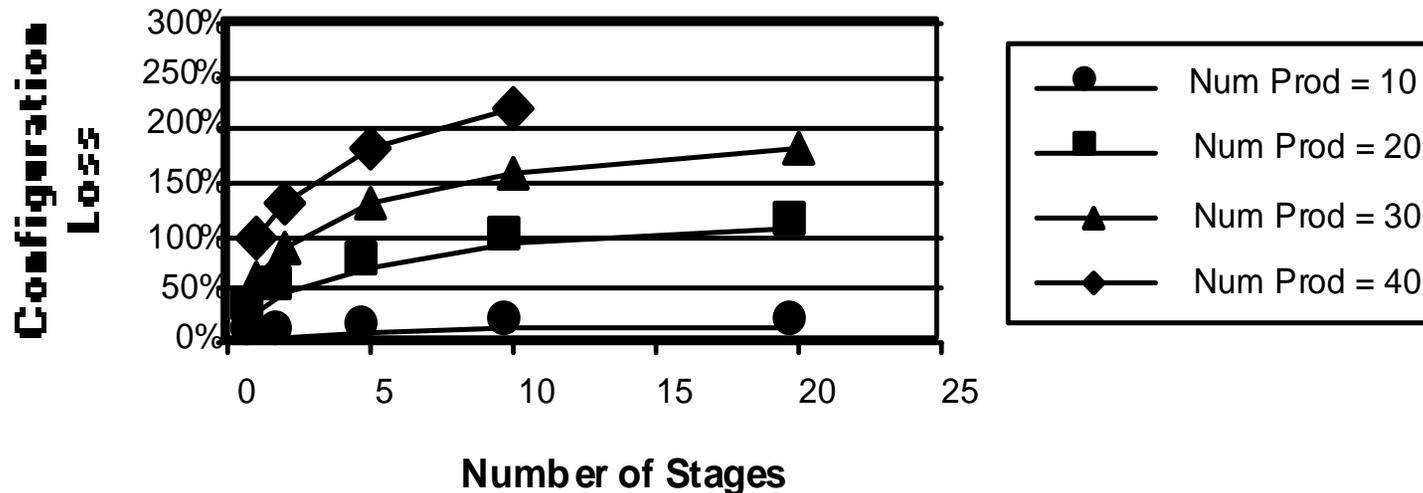
Flexibility guidelines for single-stage supply chains

- Try to create chains that encompass as many plants and products as possible (ideally all plants and products would be part of one single chain)
- Try to equalize the number of plants (measured in total units of capacity) to which each product in the chain is directly connected
- try to equalize the number of products (measured in total units of expected demand) to which each plant in the chain is directly connected.

Flexibility guidelines for multiple-stage supply chains

- The guidelines for single-stage supply chains should be followed to create a chain structure for each of the supply chain stages.

- In supply chains with a large number of products or stages, additional flexibility is advisable, especially for stages in which the capacity is not much greater than the expected demand.

- This extra layer of flexibility should again be added in accordance with the above guidelines to create another chain structure overlaying the initial chain structure.

The key findings

Multiple-stage supply chains suffer from two types of inefficiencies that affect performance

BUT

A similar strategy of using chain configurations still works very well