Chapter 6

Designing Global Supply Chain Networks

Learning Objectives

- Identify factors that need to be included in total cost when making global sourcing decisions.
- Define uncertainties that are particularly relevant when designing global supply chains.
- Explain different strategies that may be used to mitigate risk in global supply chains.
- Understand decision tree methodologies used to evaluate supply chain design decisions under uncertainty.

Impact of Globalization on Supply Chain Networks

- Opportunities to simultaneously grow revenues and decrease costs
- Accompanied by significant additional risk
- Difference between success and failure often ability to incorporate suitable risk mitigation into supply chain design
- Uncertainty of demand and price drives the value of building flexible production capacity

Impact of Globalization on Supply Chain Networks

Risk Factors	Percentage of Supply Chains Impacted
Natural disasters	35
Shortage of skilled resources	24
Geopolitical uncertainty	20
Terrorist infiltration of cargo	13
Volatility of fuel prices	37
Currency fluctuation	29
Port operations/custom delays	23
Customer/consumer preference shifts	23
Performance of supply chain partners	38
Logistics capacity/complexity	33
Forecasting/planning accuracy	30
Supplier planning/communication issues	27
Inflexible supply chain technology	21

Table 6-1

The Offshoring Decision: Total Cost

- Comparative advantage in global supply chains
- Quantify the benefits of offshore production along with the reasons
- Two reasons for offshoring failure
  - Focusing exclusively on unit cost rather than total cost
  - Ignoring critical risk factors

The Offshoring Decision: Total Cost

Performance Dimension	Activity Impacting Performance	Impact of Offshoring
Order communication	Order placement	More difficult communication
Supply chain visibility	Scheduling and expediting	Poorer visibility
Raw material costs	Sourcing of raw material	Could go either way depending on raw material sourcing
Unit cost	Production, quality (production and transportation)	Labor/fixed costs decrease; quality may suffer
Freight costs	Transportation modes and quantity	Higher freight costs
Taxes and tariffs	Border crossing	Could go either way
Supply lead time	Order communication, supplier production scheduling, production time, customs, transportation, receiving	Lead time increase results in poorer forecasts and higher inventories

Table 6-2

The Offshoring Decision: Total Cost

Performance Dimension	Activity Impacting Performance	Impact of Offshoring
On-time delivery/lead time uncertainty	Production, quality, customs, transportation, receiving	Poorer on-time delivery and increased uncertainty resulting in higher inventory and lower product availability
Minimum order quantity	Production, transportation	Larger minimum quantities increase inventory
Product returns	Quality	Increased returns likely
Inventories	Lead times, inventory in transit and production	Increase
Working capital	Inventories and financial reconciliation	Increase
Hidden costs	Order communication, invoicing errors, managing exchange rate risk	Higher hidden costs
Stock-outs	Ordering, production, transportation with poorer visibility	Increase

Table 6-2

The Offshoring Decision: Total Cost

- A global supply chain with offshoring increases the length and duration of information, product, and cash flows
- The complexity and cost of managing the supply chain can be significantly higher than anticipated
- Quantify factors and track them over time
- Big challenges with off shoring is increased risk and its potential impact on cost

The Offshoring Decision: Total Cost

- Key elements of total cost
  - Supplier price
  - Terms
  - Delivery costs
  - Inventory and warehousing
  - Cost of quality
  - Customer duties, value added-taxes, local tax incentives
  - Cost of risk, procurement staff, broker fees, infrastructure, and tooling and mold costs
  - Exchange rate trends and their impact on cost

Risk Management in Global Supply Chains

- Risks include supply disruption, supply delays, demand fluctuations, price fluctuations, and exchange-rate fluctuations

- Critical for global supply chains to be aware of the relevant risk factors and build in suitable mitigation strategies

Risk Management in Global Supply Chains

Category	Risk Drivers
Disruptions	Natural disaster, war, terrorism Labor disputes Supplier bankruptcy
Delays	High capacity utilization at supply source Inflexibility of supply source Poor quality or yield at supply source
Systems risk	Information infrastructure breakdown System integration or extent of systems being networked
Forecast risk	Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base Information distortion

Table 6-3

Risk Management in Global Supply Chains

Category	Risk Drivers
Intellectual property risk	Vertical integration of supply chain Global outsourcing and markets
Procurement risk	Exchange-rate risk Price of inputs Fraction purchased from a single source Industry-wide capacity utilization
Receivables risk	Number of customers Financial strength of customers
Inventory risk	Rate of product obsolescence Inventory holding cost Product value Demand and supply uncertainty
Capacity risk	Cost of capacity Capacity flexibility

Table 6-3

Risk Management in Global Supply Chains

- Good network design can play a significant role in mitigating supply chain risk
- Every mitigation strategy comes at a price and may increase other risks
- Global supply chains should generally use a combination of rigorously evaluated mitigation strategies along with financial strategies to hedge uncovered risks

Risk Management in Global Supply Chains

Risk Mitigation Strategy	Tailored Strategies
Increase capacity	Focus on low-cost, decentralized capacity for predictable demand. Build centralized capacity for unpredictable demand. Increase decentralization as cost of capacity drops.
Get redundant suppliers	More redundant supply for high-volume products, less redundancy for low-volume products. Centralize redundancy for low-volume products in a few flexible suppliers.
Increase responsiveness	Favor cost over responsiveness for commodity products. Favor responsiveness over cost for short–life cycle products.

Table 6-4

Risk Management in Global Supply Chains

Risk Mitigation Strategy	Tailored Strategies
Increase inventory	Decentralize inventory of predictable, lower value products. Centralize inventory of less predictable, higher value products.
Increase flexibility	Favor cost over flexibility for predictable, high-volume products. Favor flexibility for unpredictable, low-volume products. Centralize flexibility in a few locations if it is expensive.
Pool or aggregate demand	Increase aggregation as unpredictability grows.
Increase source capability	Prefer capability over cost for high-value, high-risk products. Favor cost over capability for low-value commodity products. Centralize high capability in flexible source if possible.

Table 6-4

Flexibility, Chaining, and Containment

- Three broad categories of flexibility
  - New product flexibility
    - Ability to introduce new products into the market at a rapid rate
  - Mix flexibility
    - Ability to produce a variety of products within a short period of time
  - Volume flexibility
    - Ability to operate profitably at different levels of output

Flexibility, Chaining, and Containment

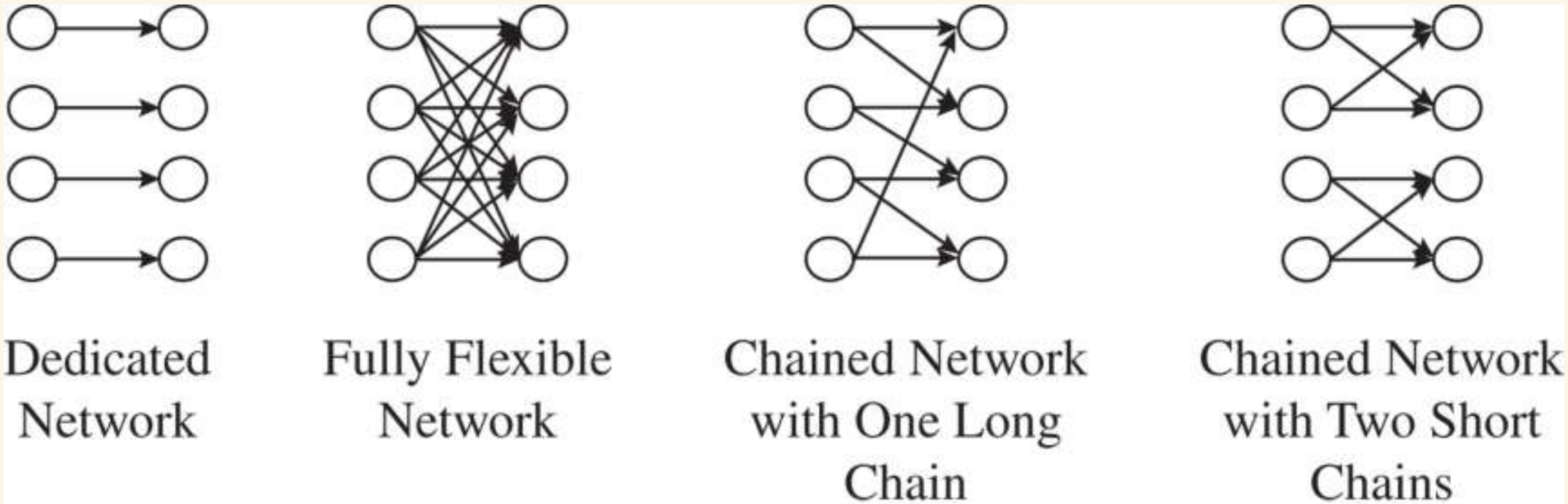

Figure 6-1

Flexibility, Chaining, and Containment

- As flexibility is increased, the marginal benefit derived from the increased flexibility decreases
  - With demand uncertainty, longer chains pool available capacity
  - Long chains may have higher fixed cost than multiple smaller chains
  - Coordination more difficult across with a single long chain
- Flexibility and chaining are effective when dealing with demand fluctuation but less effective when dealing with supply disruption

Discounted Cash Flow Analysis

- Supply chain decisions should be evaluated as a sequence of cash flows over time
- Discounted cash flow (DCF) analysis evaluates the present value of any stream of future cash flows and allows managers to compare different cash flow streams in terms of their financial value
- Based on the time value of money – a dollar today is worth more than a dollar tomorrow

Discounted Cash Flow Analysis

$$\text{Discount factor} = \frac{1}{1+k}$$

$$\text{NPV} = C_0 + \sum_{t=1}^{T} \left(\frac{1}{1+k} \right)^t C_t$$

where

$C_0, C_1, \ldots, C_T$ is stream of cash flows over T periods

NPV = net present value of this stream

k = rate of return

- Compare NPV of different supply chain design options
- The option with the highest NPV will provide the greatest financial return

Trips Logistics Example

- Demand = 100,000 units
- 1,000 sq. ft. of space for every 1,000 units of demand
- Revenue = $1.22 per unit of demand
- Sign a three-year lease or obtain warehousing space on the spot market?
- Three-year lease cost = $1 per sq. ft.
- Spot market cost = $1.20 per sq. ft.
- k = 0.1

Trips Logistics Example

Expected annual profit if warehouse space is obtained from the spot market	=	100,000 x $1.22 – 100,000 x $1.20
	=	$2,000

$$\text{NPV(No lease)} = C_0 + \frac{C_1}{1+k} + \frac{C_2}{(1+k)^2}$$

$$= 2,000 + \frac{2,000}{1.1} + \frac{2,000}{1.1^2} = \$5,471$$

Trips Logistics Example

Expected annual profit with three year lease = 100,000 x $1.22 – 100,000 x $1.00
= $22,000

$$NPV(\text{Lease}) = C_0 + \frac{C_1}{1+k} + \frac{C_2}{(1+k)^2}$$

$$= 22{,}000 + \frac{22{,}000}{1.1} + \frac{22{,}000}{1.1^2} = \$60{,}182$$

- NPV of signing lease is $60,182 – $5,471 = $54,711 higher than spot market

Using Decision Trees

- Many different decisions
  - Should the firm sign a long-term contract for warehousing space or get space from the spot market as needed?
  - What should the firm's mix of long-term and spot market be in the portfolio of transportation capacity?
  - How much capacity should various facilities have? What fraction of this capacity should be flexible?

Using Decision Trees

- During network design, managers need a methodology that allows them to estimate the uncertainty in demand and price forecast and incorporate this in the decision-making process

- Most important for network design decisions because they are hard to change in the short term

Basics of Decision Tree Analysis

- A *decision tree* is a graphic device used to evaluate decisions under uncertainty
  - Identify the number and duration of time periods that will be considered
  - Identify factors that will affect the value of the decision and are likely to fluctuate over the time periods
  - Evaluate decision using a decision tree

Decision Tree Methodology

- Identify the duration of each period (month, quarter, etc.) and the number of periods T over which the decision is to be evaluated
- Identify factors whose fluctuation will be considered
- Identify representations of uncertainty for each factor
- Identify the periodic discount rate k for each period
- Represent the decision tree with defined states in each period as well as the transition probabilities between states in successive periods
- Starting at period *T*, work back to Period 0, identifying the optimal decision and the expected cash flows at each step

Decision Tree – Trips Logistics

- Three warehouse lease options
  - Get all warehousing space from the spot market as needed
  - Sign a three-year lease for a fixed amount of warehouse space and get additional requirements from the spot market
  - Sign a flexible lease with a minimum charge that allows variable usage of warehouse space up to a limit with additional requirement from the spot market

Decision Tree – Trips Logistics

- 1000 sq. ft. of warehouse space needed for 1000 units of demand
- Current demand = 100,000 units per year
- Binomial uncertainty: Demand can go up by 20% with $p = 0.5$ or down by 20% with $1 - p = 0.5$
- Lease price = \$1.00 per sq. ft. per year
- Spot market price = \$1.20 per sq. ft. per year
- Spot prices can go up by 10% with $p = 0.5$ or down by 10% with $1 - p = 0.5$
- Revenue = \$1.22 per unit of demand
- $k = 0.1$

Decision Tree

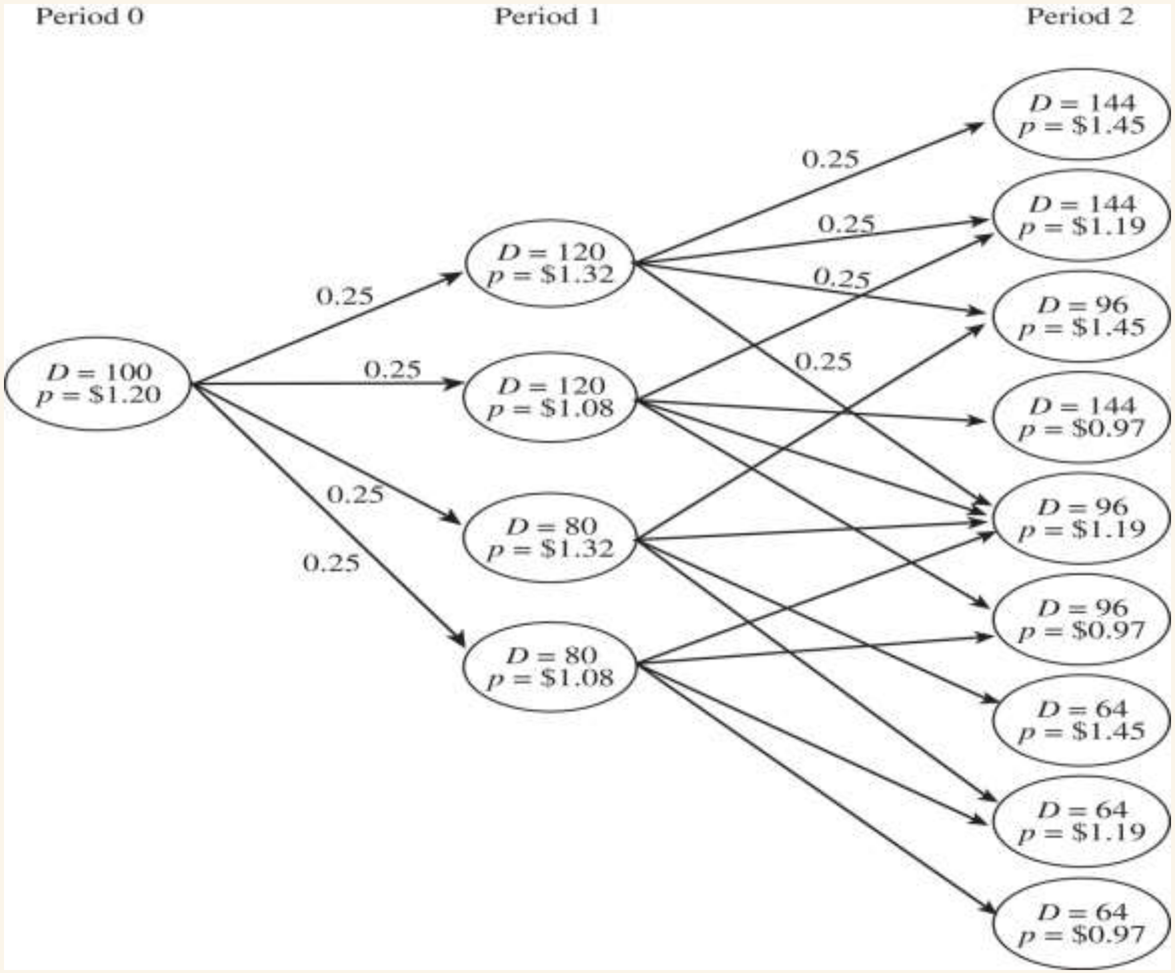

Figure 6-2

Decision Tree – Trips Logistics

- Analyze the option of not signing a lease and using the spot market
- Start with Period 2 and calculate the profit at each node

  For D = 144, p = \$1.45, in Period 2:

  $C(D = 144, p = 1.45,2) = 144{,}000 \times 1.45 = \$208{,}800$

  $P(D = 144, p = 1.45,2) = 144{,}000 \times 1.22 - C(D = 144, p = 1.45, 2) = 175{,}680 - 208{,}800 = -\$33{,}120$

Decision Tree – Trips Logistics

	Revenue	Cost $C(D =, p =, 2)$	Profit $P(D =, p =, 2)$
D = 144, p = 1.45	144,000 × 1.22	144,000 × 1.45	–$33,120
D = 144, p = 1.19	144,000 × 1.22	144,000 × 1.19	$4,320
D = 144, p = 0.97	144,000 × 1.22	144,000 × 0.97	$36,000
D = 96, p = 1.45	96,000 × 1.22	96,000 × 1.45	–$22,080
D = 96, p = 1.19	96,000 × 1.22	96,000 × 1.19	$2,880
D = 96, p = 0.97	96,000 × 1.22	96,000 × 0.97	$24,000
D = 64, p = 1.45	64,000 × 1.22	64,000 × 1.45	–$14,720
D = 64, p = 1.19	64,000 × 1.22	64,000 × 1.19	$1,920
D = 64, p = 0.97	64,000 × 1.22	64,000 × 0.97	$16,000

Table 6-5

Decision Tree – Trips Logistics

- Expected profit at each node in Period 1 is the profit during Period 1 plus the present value of the expected profit in Period 2
- Expected profit EP(*D* =, *p* =, 1) at a node is the expected profit over all four nodes in Period 2 that may result from this node
- PVEP(*D* =, *p* =, 1) is the present value of this expected profit and P(*D* =, *p* =, 1), and the total expected profit, is the sum of the profit in Period 1 and the present value of the expected profit in Period 2

Decision Tree – Trips Logistics

- From node $D = 120$, $p = \$1.32$ in Period 1, there are four possible states in Period 2
- Evaluate the expected profit in Period 2 over all four states possible from node $D = 120$, $p = \$1.32$ in Period 1 to be

$$
\begin{aligned}
EP(D = 120, p = 1.32,1) &= 0.2 \times [P(D = 144, p = 1.45,2) + \\
&\quad P(D = 144, p = 1.19,2) + P(D = 96, p = 1.45,2) + \\
&\quad P(D = 96, p = 1.19,2) \\
&= 0.25 \times [-33{,}120 + 4{,}320 - 22{,}080 + 2{,}880] \\
&= -\$12{,}000
\end{aligned}
$$

Decision Tree – Trips Logistics

- The present value of this expected value in Period 1 is
  PVEP(D = 120, p = 1.32,1)
  = EP(D = 120, p = 1.32,1) / (1 + k)
  = –$12,000 / (1.1)
  = –$10,909
- The total expected profit P(D = 120, p = 1.32,1) at node D = 120, p = 1.32 in Period 1 is the sum of the profit in Period 1 at this node, plus the present value of future expected profits possible from this node
  P(D = 120, p = 1.32,1) = 120,000 x 1.22 – 120,000 x 1.32 +
  PVEP(D = 120, p = 1.32,1)
  = –$12,000 – $10,909 = –$22,909

Decision Tree – Trips Logistics

- For Period 0, the total profit $P(D = 100, p = 120, 0)$ is the sum of the profit in Period 0 and the present value of the expected profit over the four nodes in Period 1

$EP(D = 100, p = 1.20, 0) = 0.25 \times [P(D = 120, p = 1.32, 1) +$
$P(D = 120, p = 1.08, 1) + P(D = 96, p = 1.32, 1) +$
$P(D = 96, p = 1.08, 1)]$
$= 0.25 \times [-22{,}909 + 32{,}073 - 15{,}273) + 21{,}382]$
$= \$3{,}818$

Decision Tree – Trips Logistics

$PVEP(D = 100, p = 1.20,1) = EP(D = 100, p = 1.20,0) / (1 + k)$

$= \$3,818 / (1.1) = \$3,471$

$P(D = 100, p = 1.20,0) = 100,000 \times 1.22 - 100,000 \times 1.20 + PVEP(D = 100, p = 1.20,0)$

$= \$2,000 + \$3,471 = \$5,471$

- Therefore, the expected NPV of not signing the lease and obtaining all warehouse space from the spot market is given by NPV(Spot Market) = $5,471

Decision Tree – Trips Logistics

- Fixed Lease Option

Node	$EP(D =, p =, 1)$	$P(D =, p =, 1) = D \times 1.22 - D \times p + EP(D =, p =, 1) / (1 + k)$
$D = 120, p = 1.32$	100,000 sq. ft.	–$22,909
$D = 120, p = 1.08$	100,000 sq. ft.	$32,073
$D = 80, p = 1.32$	100,000 sq. ft.	–$15,273
$D = 80, p = 1.08$	100,000 sq. ft.	$21,382

Table 6-6

Decision Tree – Trips Logistics

Node	Leased Space	Warehouse Space at Spot Price (*S*)	Profit *P*(*D* =, *p* =, 2) = *D* x 1.22 – (100,000 x 1 + *S* x *p*)
D = 144, *p* = 1.45	100,000 sq. ft.	44,000 sq. ft.	$11,880
D = 144, *p* = 1.19	100,000 sq. ft.	44,000 sq. ft.	$23,320
D = 144, *p* = 0.97	100,000 sq. ft.	44,000 sq. ft.	$33,000
D = 96, *p* = 1.45	100,000 sq. ft.	0 sq. ft.	$17,120
D = 96, *p* = 1.19	100,000 sq. ft.	0 sq. ft.	$17,120
D = 96, *p* = 0.97	100,000 sq. ft.	0 sq. ft.	$17,120
D = 64, *p* = 1.45	100,000 sq. ft.	0 sq. ft.	–$21,920
D = 64, *p* = 1.19	100,000 sq. ft.	0 sq. ft.	–$21,920
D = 64, *p* = 0.97	100,000 sq. ft.	0 sq. ft.	–$21,920

Table 6-7

Decision Tree – Trips Logistics

Node	$EP(D =, p =, 1)$	Warehouse Space at Spot Price (S)	$P(D =, p =, 1) = D \times 1.22 - (100{,}000 \times 1 + S \times p) + EP(D =, p =, 1)(1 + k)$
$D = 120, p = 1.32$	0.25 x [$P(D = 144, p = 1.45,2) + P(D = 144, p = 1.19,2) + P(D = 96, p = 1.45,2) + P(D = 96, p = 1.19,2)$] = 0.25 x (11,880 + 23,320 + 17,120 + 17,120) = $17,360	20,000	$35,782
$D = 120, p = 1.08$	0.25 x (23,320 + 33,000 + 17,120 + 17,120) = $22,640	20,000	$45,382
$D = 80, p = 1.32$	0.25 x (17,120 + 17,120 – 21,920 – 21,920) = –$2,400	0	–$4,582
$D = 80, p = 1.08$	0.25 x (17,120 + 17,120 – 21,920 – 21,920) = –$2,400	0	–$4,582

Table 6-8

Decision Tree – Trips Logistics

- Using the same approach for the lease option, NPV(Lease) = $38,364
- Recall that when uncertainty was ignored, the NPV for the lease option was $60,182
- However, the manager would probably still prefer to sign the three-year lease for 100,000 sq. ft. because this option has the higher expected profit

Decision Tree – Trips Logistics

- Flexible Lease Option

Node	Warehouse Space at $1 (*W*)	Warehouse Space at Spot Price (*S*)	Profit $P(D =, p =, 2) = D \times 1.22 - (W \times 1 + S \times p)$
D = 144, p = 1.45	100,000 sq. ft.	44,000 sq. ft.	$11,880
D = 144, p = 1.19	100,000 sq. ft.	44,000 sq. ft.	$23,320
D = 144, p = 0.97	100,000 sq. ft.	44,000 sq. ft.	$33,000
D = 96, p = 1.45	96,000 sq. ft.	0 sq. ft.	$21,120
D = 96, p = 1.19	96,000 sq. ft.	0 sq. ft.	$21,120
D = 96, p = 0.97	96,000 sq. ft.	0 sq. ft.	$21,120
D = 64, p = 1.45	64,000 sq. ft.	0 sq. ft.	$14,080
D = 64, p = 1.19	64,000 sq. ft.	0 sq. ft.	$14,080
D = 64, p = 0.97	64,000 sq. ft.	0 sq. ft.	$14,080

Table 6-9

Decision Tree – Trips Logistics

Node	$EP(D =, p =, 1)$	Warehouse Space at $1 ($W$)	Warehouse Space at Spot Price (S)	$P(D =, p =, 1) = D \times 1.22 - (W \times 1 + S \times p) + EP(D =, p = ,1)(1 + k)$
D = 120, p = 1.32	0.25 x (11,880 + 23,320 + 21,120 + 21,120) = $19,360	100,000	20,000	$37,600
D = 120, p = 1.08	0.25 x (23,320 + 33,000 + 21,120 + 21,120) = $24,640	100,000	20,000	$47,200
D = 80, p = 1.32	0.25 x (21,120 + 21,120 + 14,080 + 14,080) = $17,600	80,000	0	$33,600
D = 80, p = 1.08	0.25 x (21,920 + 21,920 + 14,080 + 14,080) = $17,600	80,000	0	$33,600

Table 6-10

Decision Tree – Trips Logistics

Option	Value
All warehouse space from the spot market	$5,471
Lease 100,000 sq. ft. for three years	$38,364
Flexible lease to use between 60,000 and 100,000 sq. ft.	$46,545

Table 6-11

Onshore or Offshore

- D-Solar demand in Europe = 100,000 panels per year
- Each panel sells for €70
- Annual demand may increase by 20 percent with probability 0.8 or decrease by 20 percent with probability 0.2
- Build a plant in Europe or China with a rated capacity of 120,000 panels

D-Solar Decision

European Plant		Chinese Plant	
Fixed Cost (euro)	**Variable Cost (euro)**	**Fixed Cost (yuan)**	**Variable Cost (yuan)**
1 million/year	40/panel	8 million/year	340/panel

Table 6-12

Period 1		Period 2	
Demand	**Exchange Rate**	**Demand**	**Exchange Rate**
112,000	8.64 yuan/euro	125,440	8.2944 yuan/euro

Table 6-13

D-Solar Decision

- European plant has greater volume flexibility
- Increase or decrease production between 60,000 to 150,000 panels
- Chinese plant has limited volume flexibility
- Can produce between 100,000 and 130,000 panels
- Chinese plant will have a variable cost for 100,000 panels and will lose sales if demand increases above 130,000 panels
- Yuan, currently 9 yuan/euro, expected to rise 10%, probability of 0.7 or drop 10%, probability of 0.3
- Sourcing decision over the next three years
- Discount rate $k = 0.1$

D-Solar Decision

Period 0 profits = 100,000 x 70 – 1,000,000 – 100,000 x 40 = €2,000,000

Period 1 profits = 112,000 x 70 – 1,000,000 – 112,000 x 40 = €2,360,000

Period 2 profits = 125,440 x 70 – 1,000,000 – 125,440 x 40 = €2,763,200

Expected profit from onshoring = 2,000,000 + 2,360,000/1.1 + 2,763,200/1.21
= €6,429,091

Period 0 profits = 100,000 x 70 – 8,000,000/9 – 100,000 x 340/9
= €2,333,333

Period 1 profits = 112,000 x 70 – 8,000,000/8.64 – 112,000 x 340/8.64
= €2,506,667

Period 2 profits = 125,440 x 70 – 8,000,000/7.9524 – 125,440 x 340/7.9524 = €2,674,319

Expected profit from off-shoring = 2,333,333 + 2,506,667/1.1 + 2,674,319/1.21
= €6,822,302

Decision Tree

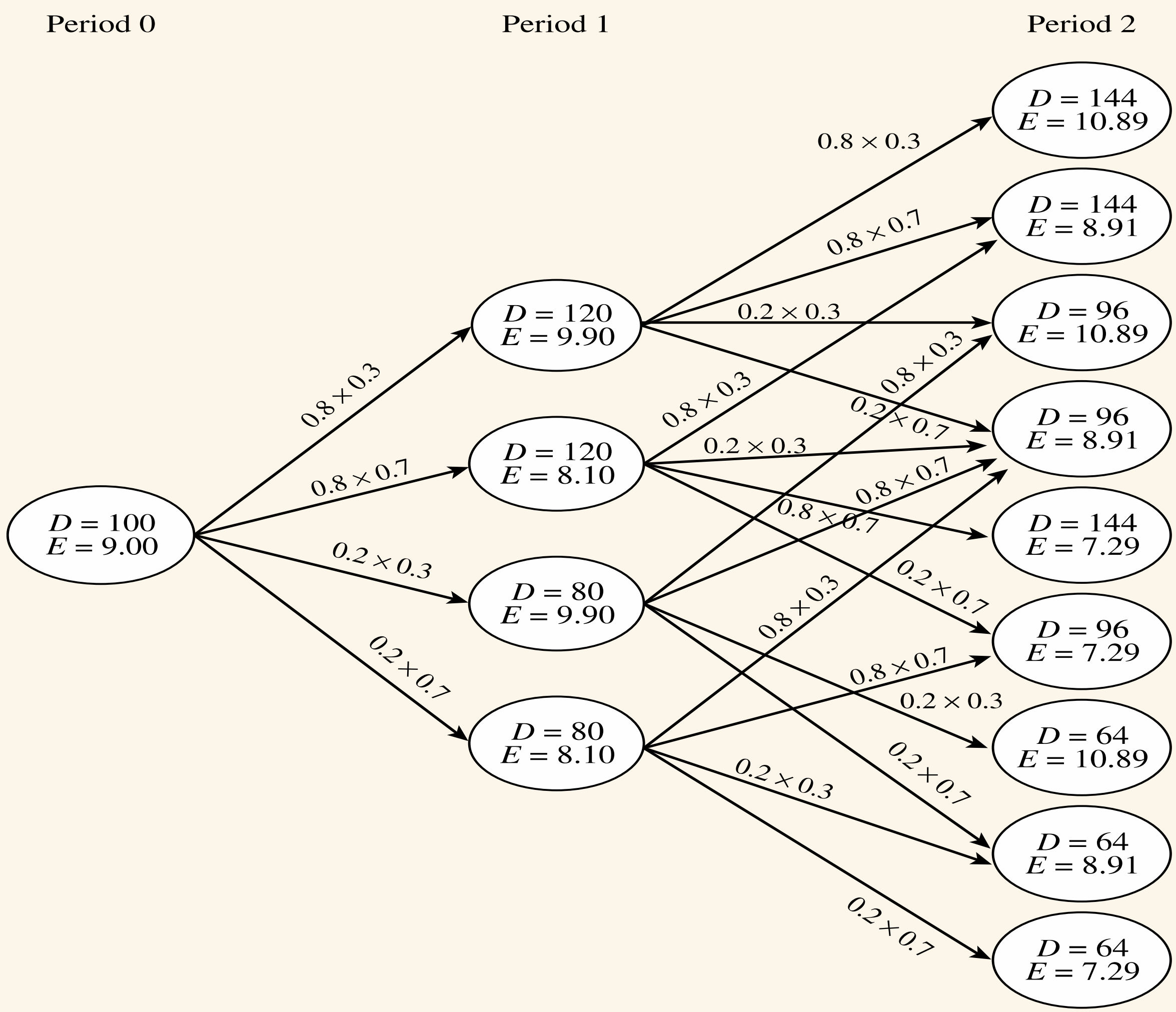

Figure 6-3

D-Solar Decision

- **Period 2 evaluation – onshore**

Revenue from the manufacture
and sale of 144,000 panels = 144,000 x 70
= €10,080,000

Fixed + variable cost
of onshore plant = 1,000,000 + 144,000 x 40
= €6,760,000

$P(D = 144, E = 10.89, 2)$ = 10,080,000 – 6,760,000
= €3,320,000

D-Solar Decision

D	*E*	Sales	Production Cost Quantity	Revenue (euro)	Cost (euro)	Profit (euro)
144	10.89	144,000	144,000	10,080,000	6,760,000	3,320,000
144	8.91	144,000	144,000	10,080,000	6,760,000	3,320,000
96	10.89	96,000	96,000	6,720,000	4,840,000	1,880,000
96	8.91	96,000	96,000	6,720,000	4,840,000	1,880,000
144	7.29	144,000	144,000	10,080,000	6,760,000	3,320,000
96	7.29	96,000	96,000	6,720,000	4,840,000	1,880,000
64	10.89	64,000	64,000	4,480,000	3,560,000	920,000
64	8.91	64,000	64,000	4,480,000	3,560,000	920,000
64	7.29	64,000	64,000	4,480,000	3,560,000	920,000

Table 6-14

D-Solar Decision

- **Period 1 evaluation – onshore**

$EP(D = 120, E = 9.90, 1) = 0.24 \times P(D = 144, E = 10.89, 2) +$
$0.56 \times P(D = 144, E = 8.91, 2) +$
$0.06 \times P(D = 96, E = 10.89, 2) +$
$0.14 \times P(D = 96, E = 8.91, 2)$
$= 0.24 \times 3{,}320{,}000 + 0.56 \times 3{,}320{,}000 +$
$0.06 \times 1{,}880{,}000 + 0.14 \times 1{,}880{,}000$
$= €3{,}032{,}000$

$PVEP(D = 120, E = 9.90,1) = EP(D = 120, E = 9.90,1)/(1 + k)$
$= 3{,}032{,}000/1.1 = €2{,}756{,}364$

D-Solar Decision

- **Period 1 evaluation – onshore**

  Revenue from manufacture and sale of 120,000 panels = 120,000 x 70 = €8,400,000

  Fixed + variable cost of onshore plant = 1,000,000 + 120,000 x 40 = €5,800,000

  $P(D = 120, E = 9.90, 1) = 8{,}400{,}000 - 5{,}800{,}000 + PVEP(D = 120, E = 9.90, 1)$
  $= 2{,}600{,}000 + 2{,}756{,}364$
  $=$ €5,356,364

D-Solar Decision

D	*E*	Sales	Production Cost Quantity	Revenue (euro)	Cost (euro)	Profit (euro)
120	9.90	120,000	120,000	8,400,000	5,800,000	5,356,364
120	8.10	120,000	120,000	8,400,000	5,800,000	5,356,364
80	9.90	80,000	80,000	5,600,000	4,200,000	2,934,545
80	8.10	80,000	80,000	5,600,000	4,200,000	2,934,545

Table 6-15

D-Solar Decision

- **Period 0 evaluation – onshore**

$$EP(D = 100, E = 9.00, 1) = 0.24 \times P(D = 120, E = 9.90, 1) + 0.56 \times P(D = 120, E = 8.10, 1) + 0.06 \times P(D = 80, E = 9.90, 1) + 0.14 \times P(D = 80, E = 8.10, 1)$$

$$= 0.24 \times 5{,}356{,}364 + 0.56 \times 5{,}5356{,}364 + 0.06 \times 2{,}934{,}545 + 0.14 \times 2{,}934{,}545$$

$$= €\ 4{,}872{,}000$$

$$PVEP(D = 100, E = 9.00,1) = EP(D = 100, E = 9.00,1)/(1 + k) = 4{,}872{,}000/1.1 = €4{,}429{,}091$$

D-Solar Decision

- **Period 0 evaluation – onshore**

  Revenue from manufacture and sale of 100,000 panels
  = 100,000 x 70 = €7,000,000

  Fixed + variable cost of onshore plant = 1,000,000 + 100,000 x 40
  = €5,000,000

  $P(D = 100, E = 9.00, 1)$ = 8,400,000 – 5,800,000 + $PVEP(D = 100, E = 9.00, 1)$
  = 2,000,000 + 4,429,091
  = €6,429,091

D-Solar Decision

- **Period 2 evaluation – offshore**

Revenue from the manufacture and sale of 130,000 panels
= 130,000 x 70
= €9,100,000

Fixed + variable cost of offshore plant
= 8,000,000 + 130,000 x 340
= 52,200,000 yuan

$P(D = 144, E = 10.89, 2)$ = 9,100,000 – 52,200,000/10.89
= €4,306,612

D-Solar Decision

D	*E*	Sales	Production Cost Quantity	Revenue (euro)	Cost (yuan)	Profit (euro)
144	10.89	130,000	130,000	9,100,000	52,200,000	4,306,612
144	8.91	130,000	130,000	9,100,000	52,200,000	3,241,414
96	10.89	96,000	100,000	6,720,000	42,000,000	2,863,251
96	8.91	96,000	100,000	6,720,000	42,000,000	2,006,195
144	7.29	130,000	130,000	9,100,000	52,200,000	1,939,506
96	7.29	96,000	100,000	6,720,000	42,000,000	958,683
64	10.89	64,000	100,000	4,480,000	42,000,000	623,251
64	8.91	64,000	100,000	4,480,000	42,000,000	–233,805
64	7.29	64,000	10,000	4,480,000	3,560,000	–1,281,317

Table 6-16

D-Solar Decision

- **Period 1 evaluation – offshore**

$$EP(D = 120, E = 9.90,1) = 0.24 \times P(D = 144, E = 10.89, 2) + 0.56 \times P(D = 144, E = 8.91, 2) + 0.06 \times P(D = 96, E = 10.89, 2) + 0.14 \times P(D = 96, E = 8.91, 2)$$

$$= 0.24 \times 4{,}306{,}612 + 0.56 \times 3{,}241{,}414 + 0.06 \times 2{,}863{,}251 + 0.14 \times 2{,}006{,}195$$

$$= €\ 3{,}301{,}441$$

$$PVEP(D = 120, E = 9.90,1) = EP(D = 120, E = 9.90,1)/(1 + k)$$

$$= 3{,}301{,}441/1.1 = €3{,}001{,}310$$

D-Solar Decision

- **Period 1 evaluation – offshore**

Revenue from manufacture and sale of 120,000 panels
= 120,000 x 70 = €8,400,000

Fixed + variable cost of offshore plant
= 8,000,000 + 120,000 x 340
= 48,800,000 yuan

$P(D = 120, E = 9.90, 1)$ = 8,400,000 – 48,800,000/9.90 + $PVEP(D = 120, E = 9.90, 1)$
= 3,470,707 + 3,001,310
= €6,472,017

D-Solar Decision

D	*E*	Sales	Production Cost Quantity	Revenue (euro)	Cost (yuan)	Expected Profit (euro)
120	9.90	120,000	120,000	8,400,000	48,800,000	6,472,017
120	8.10	120,000	120,000	8,400,000	48,800,000	4,301,354
80	9.90	80,000	100,000	5,600,000	42,000,000	3,007,859
80	8.10	80,000	100,000	5,600,000	42,000,000	1,164,757

Table 6-17

D-Solar Decision

- **Period 0 evaluation – offshore**

$$
\begin{aligned}
EP(D = 100, E = 9.00, 1) &= 0.24 \text{ x } P(D = 120, E = 9.90, 1) + \\
&\quad 0.56 \text{ x } P(D = 120, E = 8.10, 1) + \\
&\quad 0.06 \text{ x } P(D = 80, E = 9.90, 1) + \\
&\quad 0.14 \text{ x } P(D = 80, E = 8.10, 1) \\
&= 0.24 \text{ x } 6{,}472{,}017 + 0.56 \text{ x } 4{,}301{,}354 \\
&\quad + 0.06 \text{ x } 3{,}007{,}859 + 0.14 \text{ x } 1{,}164{,}757 \\
&= € \ 4{,}305{,}580
\end{aligned}
$$

$$
\begin{aligned}
PVEP(D = 100, E = 9.00,1) &= EP(D = 100, E = 9.00,1)/(1 + k) \\
&= 4{,}305{,}580/1.1 = €3{,}914{,}164
\end{aligned}
$$

D-Solar Decision

- **Period 0 evaluation – offshore**

Revenue from manufacture and sale of 100,000 panels
= 100,000 x 70 = €7,000,000

Fixed + variable cost of onshore plant
= 8,000,000 + 100,000 x 340
= €42,000,000 yuan

$P(D = 100, E = 9.00, 1)$ = 7,000,000 – 42,000,000/9.00 + $PVEP(D = 100, E = 9.00, 1)$
= 2,333,333 + 3,914,164
= €6,247,497

Decisions Under Uncertainty

- Combine strategic planning and financial planning during global network design
- Use multiple metrics to evaluate global supply chain networks
- Use financial analysis as an input to decision making, not as the decision-making process
- Use estimates along with sensitivity analysis

Summary of Learning Objectives

- Identify factors that need to be included in total cost when making global sourcing decisions
- Define uncertainties that are particularly relevant when designing global supply chains
- Explain different strategies that may be used to mitigate risk in global supply chains
- Understand decision tree methodologies used to evaluate supply chain design decisions under uncertainty