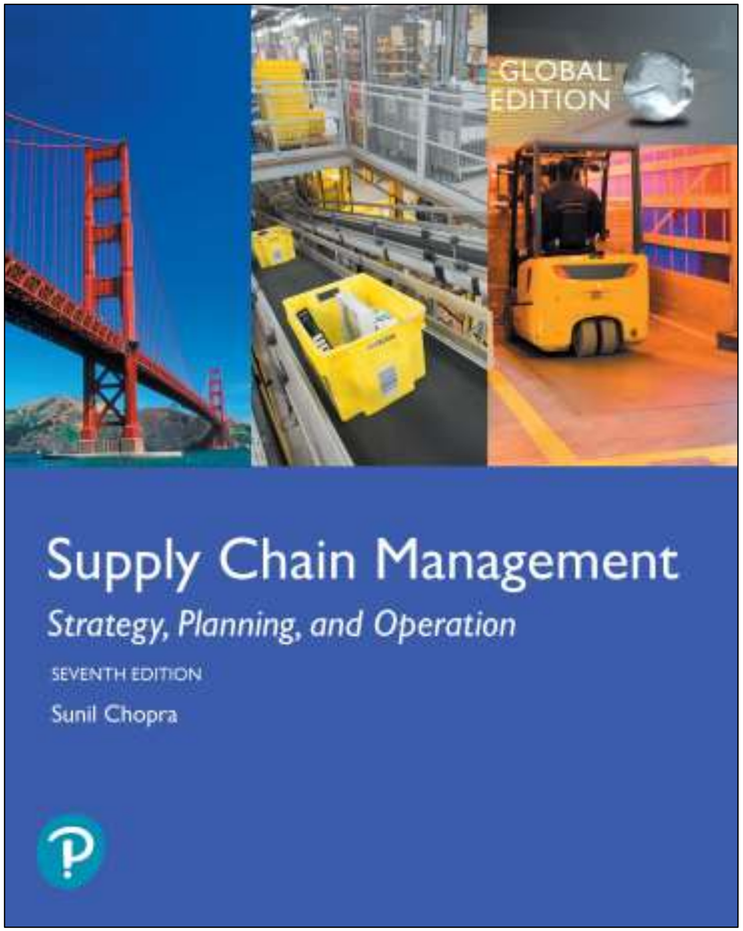
Supply Chain Management: Strategy, Planning, and Operation

Seventh Edition, Global Edition



Chapter 6

Designing Global Supply Chain Networks

Learning Objectives

6.1 Identify factors that need to be included in total cost when making global sourcing decisions.

6.2 Define relevant risks and explain different strategies that may be used to mitigate risk in global supply chains.

6.3 Understand decision tree methodologies used to evaluate supply chain design decisions under uncertainty.

6.4 Use decision tree methodologies to value flexibility and make onshoring/offshoring decisions under uncertainty.

Impact of Globalization on Supply Chain Networks (1 of 2)

- Opportunities to simultaneously increase revenues and decrease costs
- Accompanied by significant additional risk and uncertainty
- Difference between success and failure often the 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

Table 6-1 Results of Accenture Survey on Sources of Risk That Affect Global Supply Chain Performance

Risk Factors	Percentage of Supply Chains Affected
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

Importance of Total Cost (1 of 4)

- Comparative advantage in global supply chains
- Quantify the benefits of offshore production along with the reasons
- Two reasons offshoring fails

  1. Focusing exclusively on unit cost rather than total cost
  2. Ignoring critical risk factors

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 offshoring is increased risk and its potential impact on cost

Importance of Total Cost (2 of 4)

Table 6-2 Dimensions to Consider When Evaluating Total Cost from Offshoring

Performance Dimension	Activity Affecting 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

Pearson

Importance of Total Cost (3 of 4)

Table 6-2 [Continued]

Performance Dimension	Activity Affecting 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
Stockouts	Ordering, production, transportation with poorer visibility	Increase

Importance of Total Cost (4 of 4)

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

Summary of Learning Objective 1

It is critical that global sourcing decisions be made while accounting for total cost. Besides unit cost, total cost should include the impact of global sourcing on freight, inventories, lead time, quality, on-time delivery, minimum order quantity, working capital, and stock- outs. Other factors to be considered include the impact on supply chain visibility, order communication, invoicing errors, and the need for currency hedging. Offshoring typically lowers labor and fixed costs but increases risk, freight costs, and working capital.

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

Refer to “6.1 SC risk Management.pptx”

Using Decision Trees (1 of 2)

- Several 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 (2 of 2)

- Executives need a methodology that allows them to estimate global currency instability, unpredictable commodities costs, uncertainty about customer demand, political or social unrest in key markets, and potential changes in government regulations the uncertainty in demand and price forecast

Discounted Cash Flows

- 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 (1 of 3)

- 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 (2 of 3)

Expected annual profit if Warehousing space is obtained	=	(100,000 × \$1.22) − (100,000 × \$1.20)
from spot market	=	\$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 (3 of 3)

Expected annual profit with Three year lease	=	(100,000 × \$1.22) − (100,000 × \$1.00)
	=	\$22,000

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

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

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

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 (*T*)
  - Identify factors that will affect the value of the decision and are likely to fluctuate over the next *T* periods
  - Evaluate decision using a decision tree

Decision Tree Methodology

1. Identify the duration of each period (month, quarter, etc.) and the number of periods T over which the decision is to be evaluated
2. Identify factors whose fluctuation will be considered
3. Identify representations of uncertainty for each factor
4. Identify the periodic discount rate k for each period
5. Represent the decision tree with defined states in each period as well as the transition probabilities between states in successive periods
6. 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 (1 of 3)

- Three warehouse lease options
  1. Get all warehousing space from the spot market as needed
  2. Sign a three-year lease for a fixed amount of warehouse space and get additional requirements from the spot market
  3. 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 (2 of 3)

- 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 (1 of 2)

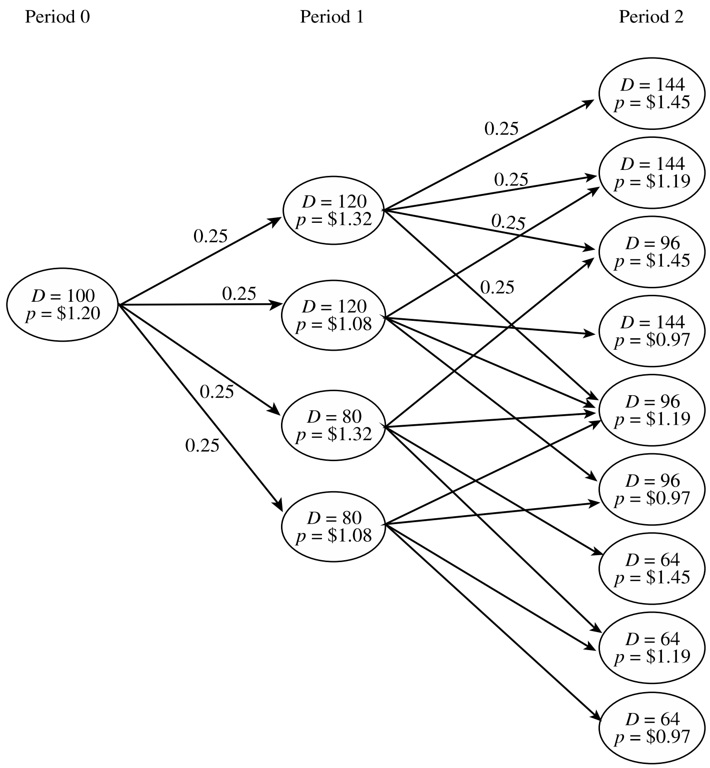


Figure 6-2 Decision Tree for Trips Logistics, Considering Demand and Price Fluctuation

Evaluating the Spot Market Option (1 of 9)

- 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:

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

$$= \$208{,}800$$

$$P(D = 144, p = 1.45,2) = 144{,}000 \times 1.22$$

$$- C(D = 144, p = 1.45, 2)$$

$$= 175{,}680 - 208{,}800$$

$$= -\$33{,}120$$

Evaluating the Spot Market Option (2 of 9)

Table 6-5 Period 2 Calculations for Spot Market Option

	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

Evaluating the Spot Market Option (3 of 9)

- 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

Evaluating the Spot Market Option

- 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

$$\begin{aligned}
EP(D = 120, p = 1.32,1) = 0.2 \times [&P(D = 144, p = 1.45,2) \\
&+ P(D = 144, p = 1.19,2) \\
&+ P(D = 96, p = 1.45,2) \\
&+ P(D = 96, p = 1.19,2)
\end{aligned}$$

$$= 0.25 \times [-33{,}120 + 4{,}320$$

$$- 22{,}080 + 2{,}880]$$

$$= -\$12{,}000$$

Evaluating the Spot Market Option (5 of 9)

- The present value of this expected value in Period 1 is

$$
\begin{aligned}
PVEP(D=120, p=1.32, 1) &= \frac{EP(D=120, p=1.32, 1)}{(1+k)} \\
&= \frac{-\$12{,}000}{(1.1)} \\
&= -\$10{,}909
\end{aligned}
$$

Evaluating the Spot Market Option

- 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

$$
\begin{aligned}
&P(D = 120, p = 1.32,1) = (120{,}000 \times 1.22) - (120{,}000 \times 1.32) \\
&+ PVEP(D = 120, p = 1.32,1) \\
&= -\$12{,}000 - \$10{,}909 = -\$22{,}909
\end{aligned}
$$

Evaluating the Spot Market Option (7 of 9)

Table 6-6 Period 1 Calculations for Spot Market Option

Node	$EP(D =, p =, 1)$	$P(D =, p =, 1) = D \times 1.22 - D \times p + \frac{EP(D =, p =, 1)}{(1+k)}$
$D = 120, p = 1.32$	−\$12,000	−\$22,909
$D = 120, p = 1.08$	\$16,000	\$32,073
$D = 80, p = 1.32$	−\$8,000	−\$15,273
$D = 80, p = 1.08$	\$11,000	\$21,382

Evaluating the Spot Market Option

- 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

$$
\begin{aligned}
EP(D = 100, p = 1.20{,}0) = 0.25 \times [&P(D = 120, p = 1.32{,}1) \\
&+ P(D = 120, p = 1.08{,}1) \\
&+ P(D = 96, p = 1.32{,}1) \\
&+ P(D = 96, p = 1.08{,}1)]
\end{aligned}
$$

$$
\begin{aligned}
&= 0.25 \times [-22{,}909 + 32{,}073 \\
&\quad - 15{,}273) + 21{,}382] \\
&= \$3{,}818
\end{aligned}
$$

Evaluating the Spot Market Option (9 of 9)

$$PVEP(D = 100, p = 1.20, 1) = \frac{EP(D = 100, p = 1.20, 0)}{(1 + k)}$$

$$= \frac{\$3,818}{(1.1)} = \$3,471$$

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

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

- 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

Evaluating the Fixed Lease Option

Table 6-7 Period 2 Profit Calculations at Trips Logistics for Fixed Lease Option

Node	Leased Space	Warehouse Space at Spot Price (S)	Profit $P(D =, p =, 2) = D \times 1.22 - (100{,}000 \times 1 + S \times p)$
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	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

Evaluating the Fixed Lease Option (2 of 5)

Table 6-8 Period 1 Profit Calculations at Trips Logistics for Fixed Lease Option

Node	*EP*(*D* =, *p* =, 1)	Warehouse Space at Spot Price (*S*)	*P*(*D* =, *p* =, 1) = *D* x 1.22−(100,000 x 1 + *S* x *p*) + *EP*(*D* =, *p* = ,1)(1 + *k*)
D = 120, *p* = 1.32	0.25 × [*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 × (11,880 + 23,320 + 17,120 + 17,120) = $17,360	20,000	$35,782
D = 120, *p* = 1.08	0.25 × (23,320 + 33,000 + 17,120 + 17,120) = $22,640	20,000	$45,382
D = 80, *p* = 1.32	0.25 × (17,120 + 17,120−21,920 − 21,920) = −$2,400	0	−$4,582
D = 80, *p* = 1.08	0.25 × (17,120 + 17,120 − 21,920 −21,920) = −$2,400	0	−$4,582

Evaluating the Fixed Lease Option (3 of 5)

- Using the same approach for the lease option, NPV (Lease) = \$38,364

$$EP(D = 100, p = 1.20,0) = 0.25 \times [P(D = 120, p = 1.32,1) + P(D = 120, p = 1.08,1) + P(D = 80, p = 1.32,1) + P(D = 80, p = 1.08,1)]$$

$$= 0.25 \times [35{,}782 + 45{,}382 - 4{,}582 - 4{,}582]$$

$$= \$18{,}000$$

Evaluating the Fixed Lease Option (4 of 5)

$$PVEP(D = 100, p = 1.20, 1) = \frac{EP(D = 100, p = 1.20, 1)}{(1 + k)}$$

$$= \frac{\$18{,}000}{(1.1)} = \$16{,}364$$

$$P(D = 100, p = 1.20, 0) = (100{,}000 \times 1.22) - (100{,}000 \times 1) + PVEP(D = 100, p = 1.20, 0)$$

$$= \$22{,}000 + \$16{,}364 = \$38{,}364$$

Evaluating the Fixed Lease Option (5 of 5)

- 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

Evaluating the Flexible Lease Option (1 of 2)

Table 6-9 Period 2 Profit Calculations at Trips Logistics with Flexible Lease Contract

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

Evaluating the Flexible Lease Option (2 of 2)

Table 6-10 Period 1 Profit Calculations at Trips Logistics with Flexible Lease Contract

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 × (11,880 + 23,320 + 21,120 + 21,120) = $19,360	100,000	20,000	$37,600
$D = 120$, $p = 1.08$	0.25 × (23,320 + 33,000 + 21,120 + 21,120) = $24,640	100,000	20,000	$47,200
$D = 80$, $p = 1.32$	0.25 × (21,120 + 21,120 + 14,080 + 14,080) = $17,600	80,000	0	$33,600
$D = 80$, $p = 1.08$	0.25 × (21,920 + 21,920 + 14,080 + 14,080) = $17,600	80,000	0	$33,600

Decision Tree – Trips Logistics (3 of 3)

Table 6-11 Comparison of Different Lease Options for 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

Summary of Learning Objective 3

Uncertainty in demand and economic factors should be included in the financial evaluation of supply chain design decisions. Decision trees can be used to evaluate supply chain decisions under uncertainty. Uncertainty along different dimensions over the evaluation period is represented as a tree with each node corresponding to a possible scenario. Starting at the last period of the evaluation interval, the decision tree analysis works back to Period 0, identifying the optimal decision and the expected cash flows at each step. The inclusion of uncertainty typically decreases the value of rigidity and increases the value of flexibility.

Onshore or Offshore

- The value of flexibility under uncertainty
  - 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 (1 of 21)

Table 6-12 Fixed and Variable Production Costs for D-Solar

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 6-13 Expected Future Demand and Exchange Rate

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

D-Solar Decision (2 of 21)

- 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 (3 of 21)

Period 0 profits = (100,000 × 70) – 1,000,000 − (100,000 × 40) = €2,000,000

Period 1 profits = (112,000 × 70) − 1,000,000 − (112,000 × 40) = €2,360,000

Period 2 profits = (125,440 × 70) − 1,000,000 − (125,440 × 40) = €2,763,200

$$\text{Expected profit from onshoring} = \frac{2{,}000{,}000 + 2{,}360{,}000}{1.1} + \frac{2{,}763{,}200}{1.21} = €6{,}429{,}091$$

D-Solar Decision (4 of 21)

$$\text{Period 0 profits} = (100{,}000 \times 70) - \left(\frac{8{,}000{,}000}{9}\right) - \left(\frac{100{,}000 \times 340}{9}\right) = €2{,}333{,}333$$

$$\text{Period 1 profits} = (112{,}000 \times 70) - \left(\frac{8{,}000{,}000}{8.64}\right) - \left(\frac{112{,}000 \times 340}{8.64}\right) = €2{,}506{,}667$$

$$\text{Period 2 profits} = (125{,}440 \times 70) - \left(\frac{8{,}000{,}000}{7.9524}\right) - \left(\frac{125{,}440 \times 340}{7.9524}\right) = €2{,}674{,}319$$

$$\text{Expected profit from off-shoring} = 2{,}333{,}333 + \frac{2{,}506{,}667}{1.1} + \frac{2{,}674{,}319}{1.21} = €6{,}822{,}302$$

Decision Tree (2 of 2)

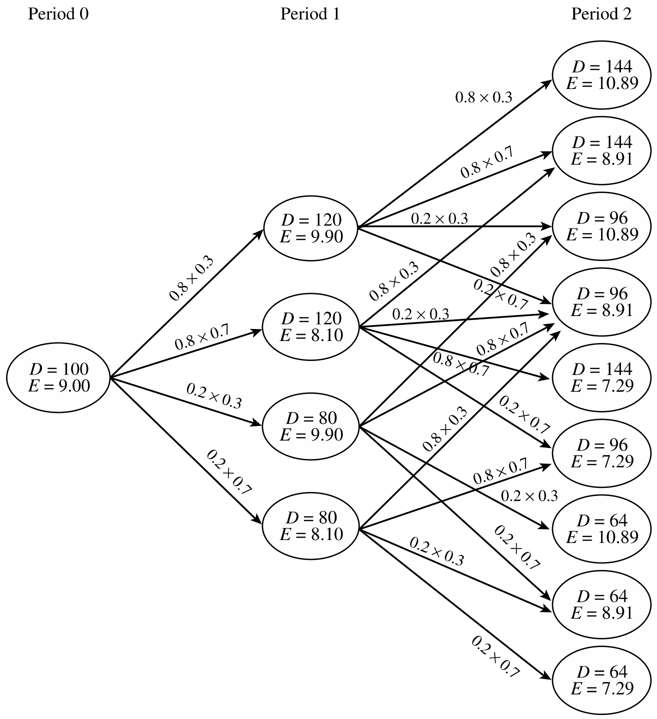


Figure 6-3 Decision Tree for D-Solar

D-Solar Decision (5 of 21)

- Period 2 evaluation – onshore

Revenue from the manufacture and sale of 144,000 panels

$$= 144{,}000 \times 70 = €10{,}080{,}000$$

Fixed + variable cost of onshore plant

$$= 1{,}000{,}000 + (144{,}000 \times 40)$$

$$= €6{,}760{,}000$$

$P(D = 144, E = 10.89{,}2)$

$$= 10{,}080{,}000 - 6{,}760{,}000$$

$$= €3{,}320{,}000$$

D-Solar Decision (6 of 21)

Table 6-14 Period 2 Profits for Onshore Option

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

D-Solar Decision (7 of 21)

- Period 1 evaluation – onshore

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

$$
= (0.24 \times 3{,}320{,}000) + (0.56 \times 3{,}320{,}000) + (0.06 \times 1{,}880{,}000)
$$

$$
+ (0.14 \times 1{,}880{,}000)
$$

$$
= €3{,}032{,}000
$$

D-Solar Decision (8 of 21)

$$PVEP(D = 120, E = 9.90, 1) = \frac{EP(D = 120, E = 9.90, 1)}{(1 + k)}$$

$$= \frac{3{,}032{,}000}{1.1} = €2{,}756{,}364$$

D-Solar Decision (9 of 21)

- Period 1 evaluation – onshore

Revenue from manufacture and sale of 120,000 panels

$$= 120{,}000 \times 70 = €8{,}400{,}000$$

Fixed + variable cost of onshore plant

$$= 1{,}000{,}000 + (120{,}000 \times 40)$$

$$= €5{,}800{,}000$$

$$P(D = 120, E = 9.90, 1) = 8{,}400{,}000 - 5{,}800{,}000$$

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

$$= 2{,}600{,}000 + 2{,}756{,}364$$

$$= €5{,}356{,}364$$

D-Solar Decision (10 of 21)

Table 6-15 Period 1 Profits for Onshore Option

D	*E*	Sales	Production Cost Quantity	Revenue (euro)	Cost (euro)	Expected 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

D-Solar Decision (11 of 21)

- Period 0 evaluation – onshore

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

$$= (0.24 \times 5{,}356{,}364) + (0.56 \times 5{,}5356{,}364)$$

$$+ (0.06 \times 2{,}934{,}545) + (0.14 \times 2{,}934{,}545)$$

$$= €\ 4{,}872{,}000$$

$$PVEP(D = 100, E = 9.00, 1) = \frac{EP(D = 100, E = 9.00, 1)}{(1+k)}$$

$$= \frac{4{,}872{,}000}{1.1} = €4{,}429{,}091$$

D-Solar Decision (12 of 21)

- Period 0 evaluation – onshore

Revenue from manufacture and sale of 100,000 panels

$$= 100{,}000 \times 70 = €7{,}000{,}000$$

Fixed + variable cost of onshore plant

$$= 1{,}000{,}000 + (100{,}000 \times 40)$$

$$= €5{,}000{,}000$$

$$P(D = 100, E = 9.00, 1) = 8{,}400{,}000 - 5{,}800{,}000$$

$$+ PVEP(D = 100, E = 9.00, 1)$$

$$= 2{,}000{,}000 + 4{,}429{,}091$$

$$= €6{,}429{,}091$$

D-Solar Decision (13 of 21)

- Period 2 evaluation – offshore

  Revenue from the manufacture and sale of 130,000 panels

  = 130,000 × 70

  = €9,100,000

  Fixed + variable cost of offshore plant

  = 8,000,000 + (130,000 × 340)

  = 52,200,000 yuan

$$P(D = 144, E = 10.89, 2) = 9{,}100{,}000 - \left(\frac{52{,}200{,}000}{10.89}\right)$$

$$= €4{,}306{,}612$$

Pearson

D-Solar Decision

Table 6-16 Period 2 Profits for Offshore Option

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

D-Solar Decision (15 of 21)

- Period 1 evaluation – offshore

$$
\begin{aligned}
EP(D = 120, E = 9.90, 1) &= 0.24 \times P(D = 144, E = 10.89, 2) \\
&\quad + 0.56 \times P(D = 144, E = 8.91, 2) \\
&\quad + 0.06 \times P(D = 96, E = 10.89, 2) \\
&\quad + 0.14 \times P(D = 96, E = 8.91, 2) \\
&= (0.24 \times 4{,}306{,}612) + (0.56 \times 3{,}241{,}414) \\
&\quad + (0.06 \times 2{,}863{,}251) + (0.14 \times 2{,}006{,}195) \\
&= € \ 3{,}301{,}441
\end{aligned}
$$

D-Solar Decision

$$PVEP(D = 120, E = 9.90,1) = \frac{EP(D = 120, E = 9.90,1)}{(1 + k)}$$

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

Pearson

D-Solar Decision (17 of 21)

- Period 1 evaluation – offshore

Revenue from manufacture and sale of 120,000 panels

= 120,000 × 70 = €8,400,000

Fixed + variable cost of offshore plant

= 8,000,000 + (120,000 × 340)

= 48,800,000 yuan

$$P(D=120, E=9.90, 1) = 8,400,000 - \left(\frac{48,800,000}{9.90}\right)$$

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

$$= 3,470,707 + 3,001,310$$

$$= €6,472,017$$

D-Solar Decision (18 of 21)

Table 6-17 Period 1 Profits for Offshore Option

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

D-Solar Decision (19 of 21)

- Period 0 evaluation – offshore

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

D-Solar Decision (20 of 21)

$$PVEP(D = 100, E = 9.00, 1) = \frac{EP\left(D = 100, E = 9.00, 1\right)}{\left(1 + k\right)}$$

$$= \frac{4,305,580}{1.1} = €3,914,164$$

D-Solar Decision (21 of 21)

- Period 0 evaluation – offshore

Revenue from manufacture and sale of 100,000 panels

= 100,000 × 70 = €7,000,000

Fixed + variable cost of onshore plant

= 8,000,000 + (100,000 × 340)

= €42,000,000 yuan

$$P(D = 100, E = 9.00,\ 1) = 7{,}000{,}000 - \left(\frac{42{,}000{,}000}{9.00}\right)$$

$$+ PVEP(D = 100, E = 9.00,\ 1)$$

$$= 2{,}333{,}333 + 3{,}914{,}164$$

$$= €6{,}247{,}497$$

Summary of Learning Objective 4

Relying solely on expected trends can lead to flawed decisions when designing global sup- ply chains under uncertainty. It is important to use an approach such as decision trees that accounts for future uncertainty. In the presence of uncertainty, flexibility can be valued as a real option using decision trees. Decision trees allow the valuation of different flexibility alternatives for each potential outcome of an uncertain future. This provides an accurate value of flexibility and other real options such as onshoring. In general, the value of real options such as flexibility and onshoring increases with an increase in uncertainty, while the value of inflexible choices decreases with an increase in uncertainty.