

Lecture 6: Short-run timber demand and supply

FOR 4684 Natural Resource Economics and Management

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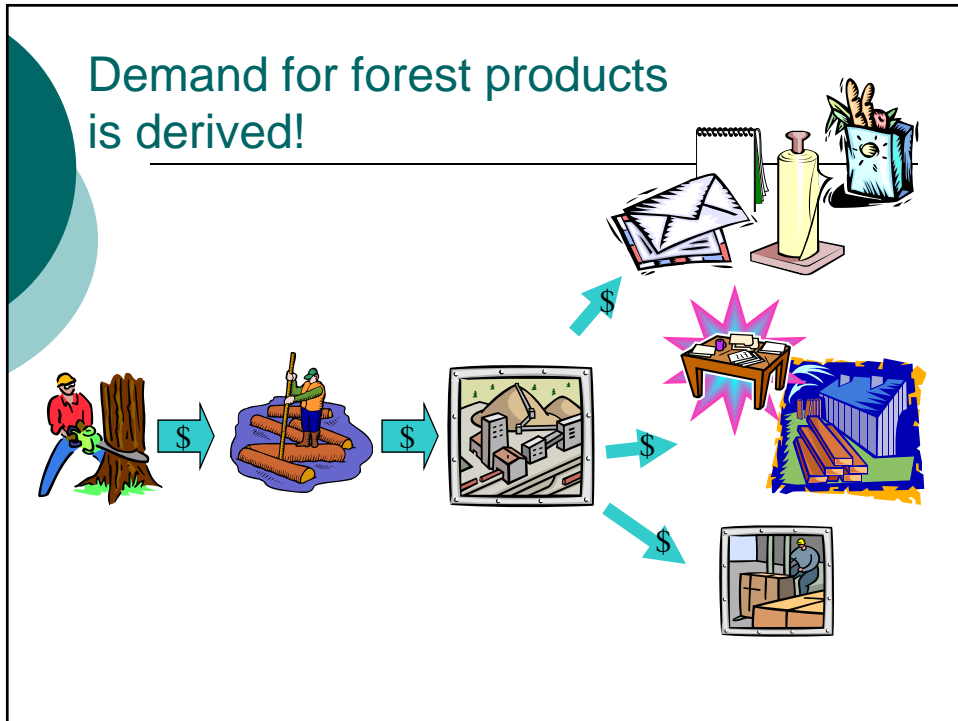


Short-run timber demand



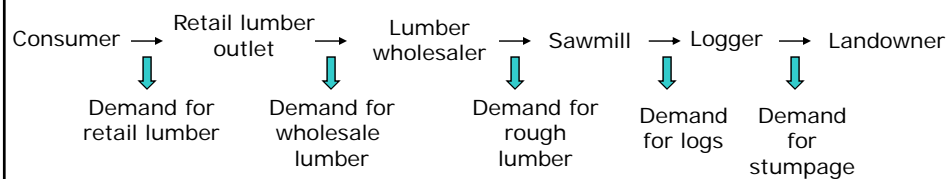
- “Short-run” demand is defined for:
 - A particular place or region
 - Over a specified time span
- Timber demand defines the stumpage quantities that would be purchased for harvesting at different prices.
- Downward sloping – higher stumpage prices would mean less timber harvested
- Short-run, so some parameters are fixed:
 - Number of purchasers (loggers, timber buyers)
 - Incomes and preferences
 - Only price and quantity of stumpage can vary

Demand for forest products is derived!



Derived demand from stumpage

- Consumers demand end products
 - Paper, lumber, plywood, poles, boxes
- Demand for stumpage is based on consumption of final products



Let's look at a simple model

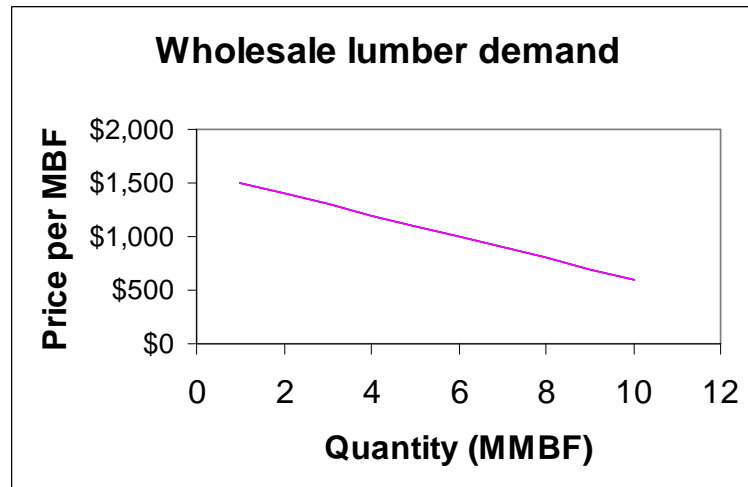
- Three market levels
 - Rough lumber (wholesale lumber)
 - Sawmills (log demand)
 - Stumpage (loggers work as agents for landowners)
- Wholesale lumber market is competitive
 - Mills are price takers – rough lumber price is fixed for all quantities
- All wood volumes will be in board feet and we will assume no overrun or underrun in conversion from board feet of lumber to board feet of logs.
- Handout 14 provides details of this example...

Wholesale lumber demand

- Our region has 7 wholesale buyers
- Demand schedule for each buyer is given in chart below:

Wholesale buyers of structural lumber								
	MBF purchased / year							Market
Price (\$/MBF)	Allied Plywood	A&P Suppliers	BuildCo.	Hilpp Brothers	EcoTimber	Dixie Lumber	SeArk Lumber	Demand
1500	100	400	500	0	0	0	0	1,000
1400	200	500	700	0	200	300	100	2,000
1300	300	600	900	200	300	400	300	3,000
1200	400	700	1,200	300	400	600	400	4,000
1100	500	800	1,300	400	500	800	700	5,000
1000	600	900	1,500	600	600	1,000	800	6,000
900	700	1,000	1,700	800	700	1,200	900	7,000
800	800	1,100	1,800	1,100	800	1,400	1,000	8,000
700	900	1,200	1,900	1,300	900	1,600	1,200	9,000
600	1,000	1,300	2,000	1,500	1,000	1,800	1,400	10,000

Graph of wholesale lumber demand



Conversion returns

- If the conversion costs to make lumber from logs is \$300 per MBF (milling costs)
 - $P_{Lu} - 300 = P_{Lo}$
- The costs to convert logs at sawmills from trees is \$200 per MBF (cut and haul costs)
 - $P_{Lo} - 200 = P_S$
- Since we have 100% conversion between logs and lumber
 - $Q_{Lu} = Q_{Lo} = Q_S$

Calculating the derived demand for logs and stumpage....

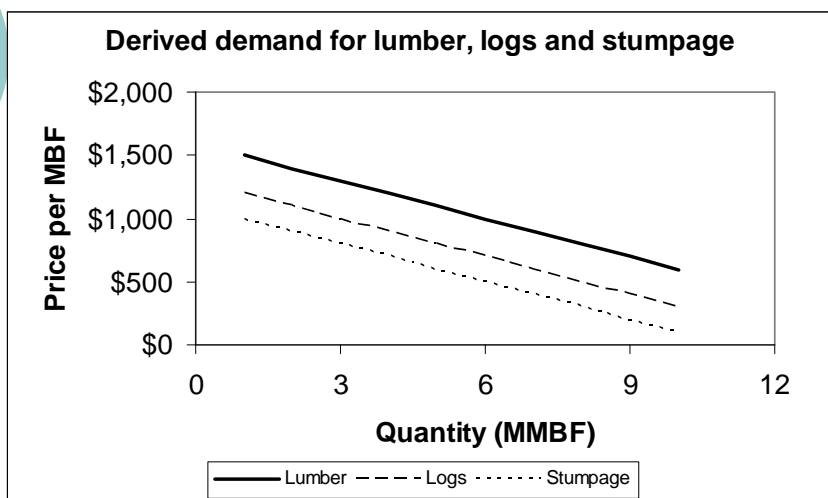
Transform	Cost (\$/MBF)					
Log - lumber	300					
Tree - log	200					
Wholesale lumber demand		Delivered log demand			Stumpage Demand	
Qty. (MMBF)	Price (\$/MBF)	Qty. (MMBF)	Price (\$/MBF)	Qty. (MMBF)	Price (\$/MBF)	
1	1500	1	1200	1	1000	
2	1400	2	1100	2	900	
3	1300	3	1000	3	800	
4	1200	4	900	4	700	
5	1100	5	800	5	600	
6	1000	6	700	6	500	
7	900	7	600	7	400	
8	800	8	500	8	300	
9	700	9	400	9	200	
10	600	10	300	10	100	

$$P_{Lu} - 300 = P_{Lo}$$

$$P_{Lo} - 200 = P_S$$

Note that no overrun/underrun means $Q_{Lu} = Q_{Lo} = Q_S$

Graphing the three demand curves...



A simple illustration of derived demand

- Lines would not necessarily be parallel – processing costs could change by quantity
- Volume and unit conversion changes often must be made
- Stumpage demand often a function of many final products:
 - Lumber, panels, paper
- Let's look at another way to derive demand...

An equation-based approach

- Based on an example from *Resource Economics for Foresters* (G. Robinson Gregory, 1987)
- Demand starts with end product
- Demand and supply curves for newsprint

$$P_n^d = 450 - 0.35Q_n$$

Demand price for newsprint (\$/ton)

Quantity of newsprint in hundreds of tons

Supply equations

Supply for newsprint

$$P_n^s = 100 + 0.14Q_n$$

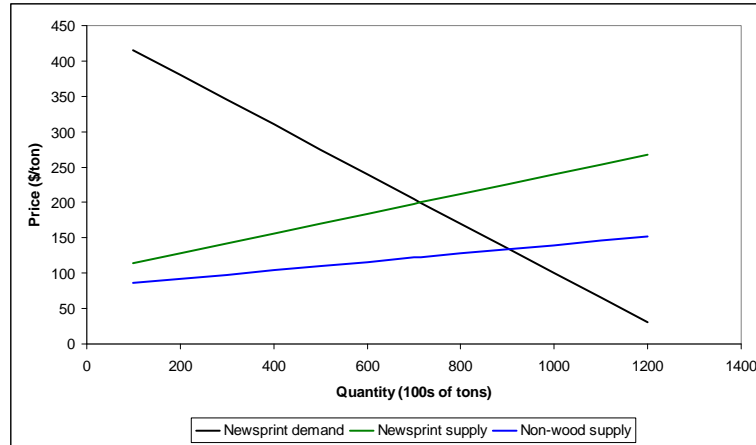
Supply price for all non-wood factors

$$P_o^s = 80 + 0.06Q_n$$

Supply and demand table

	Demand	Supply	Non-wood
Quantity	Price	Price	Supply price
100	415	114	86
200	380	128	92
300	345	142	98
400	310	156	104
500	275	170	110
600	240	184	116
700	205	198	122
715	199.75	200.1	122.9
800	170	212	128
900	135	226	134
1000	100	240	140
1100	65	254	146
1200	30	268	152

Supply and demand graphed



Derived demand

$$\text{Demand price for final product} - \text{Supply price for all non-wood factors} = \text{Demand price for timber}$$

Deriving demand for pulpwood

$$P_n^d = 450 - 0.35Q_n$$

$$-(P_o^s = 80 + 0.06Q_n)$$

$$P_{pwn}^d = 370 - 0.41Q_n$$

This is the demand for pulpwood, but the quantity is in tons of newsprint! We need demand for pulpwood in either cords or tons of pulpwood.

Conversion

- If we assume that 250 cords of pulpwood convert to 100 tons of newsprint
- This is the same as converting 670 tons of pulpwood to 100 tons of newsprint or a conversion of 6.7 to 1.
- The quantity (Q_n) is in 100's of tons, so it must be adjusted by a factor of 250.
- Price is already in \$/ton, so it must be adjusted only by 2.5

Conversion of equations

1. Convert to quantity of pulpwood (cords) rather than tons of newsprint.

$$P_{pwn}^d = 370 - \frac{0.41}{250} Q_n = P_{pwn}^d = 370 - 0.00164 Q_{cd}$$

2. Convert price in cords rather than tons of newsprint

$$\frac{P_{pwn}^d}{2.5} = \frac{370}{2.5} - \frac{0.00164 Q_{cd}}{2.5} = P_{pw}^d = 148 - 0.000656 Q_{cd}$$

This is the demand curve for pulpwood!

Interaction of supply and demand

Demand for pulpwood:

$$P_{pw}^d = 148 - 0.000656 Q_{cd}$$

If we are given a supply curve for pulpwood:

$$P_{pw}^s = 8 + 0.000128 Q_{cd}$$

We can solve 2 equations and 2 unknowns for the quantity and price of pulpwood per cord.

$$Q_{cd} = 178,571.43 \text{ cords}$$

$$P_{pw} = \$30.86 \text{ per cord}$$

Some thoughts about derived demand

- Derived demand will be more elastic when:
 - The factor being examined is more essential to the product,
 - The more inelastic the demand is for the final product,
 - The smaller the fraction of total cost that goes into the factor in question,
 - The more inelastic the supply curve of all other factors,
 - Used by firms with monopolistic power.

Two methods for deriving demand are essentially the same

1. Equation based

$$\begin{array}{r} \text{Demand} \\ \text{price for} \\ \text{final} \\ \text{product} \end{array} - \begin{array}{r} \text{Supply price} \\ \text{for all non-} \\ \text{wood} \\ \text{factors} \end{array} = \begin{array}{r} \text{Demand} \\ \text{price for} \\ \text{timber} \end{array}$$

2. Empirical conversions

- Adding demand schedules for sellers of a finished product to obtain a "market demand curve."
- Removing "non-wood" costs by subtracting costs of production (milling costs and cut and haul costs).



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SHORT-RUN TIMBER SUPPLY AND SUPPLY-DEMAND INTERACTION

Short-term timber supply

- Two ways to estimate
 - Stock supply – total standing inventory
 - Flow supply – harvested stumpage
- Timber supply is derived
 - Start from resource side (landowners)
 - Derived from individual sales with reservation prices
- Reservation price – the price at which a landowner will sell their timber.
- Handout 14

Individual suppliers in a region...

- Inventory of potential timber sellers in an area
- Volume and reservation price must be determined (can estimate empirically)

Individual Suppliers					
Tract	Owner	Total Acres for sale	Vol. / Acre (MBF)	Total Volume	Reservation Price
1	A	64	8	512	400
2	B	21	11	231	300
3	C	18	15	270	500
4	C	18	8	144	300
5	A	25	21	525	400
6	D	17	17	289	300
7	E	29	15	435	600
8	F	14	13	182	300
9	A	51	12	612	500
10	B	26	25	650	400
11	C	32	19	608	700
12	D	20	13	260	500
13	E	17	12	204	700
14	A	28	7	196	400
15	F	66	18	1188	700
16	F	78	11	858	500
17	D	44	17	748	800
18	C	19	10	190	600
19	E	14	11	154	300
20	F	55	15	825	600
21	G	61	13	793	400
22	A	26	7	182	600
23	C	14	18	252	800
24	D	18	18	324	400
25	E	23	16	368	600
		798	14	11000	

Individual suppliers in a region...

- Inventory of potential timber sellers in an area
- Volume and reservation price must be determined (can estimate empirically)
- Sorted by reservation price...

Sorted by reservation price					
Tract	Acres for sale	Vol. / Acre (MBF)	Total Volume	Reservation Price	Cumulative Volume
8	14	13	182	300	182
4	18	8	144	300	326
19	14	11	154	300	480
2	21	11	231	300	711
6	17	17	289	300	1000
14	28	7	196	400	1196
10	26	25	650	400	1846
21	61	13	793	400	2639
24	18	18	324	400	2963
1	64	8	512	400	3475
5	25	21	525	400	4000
9	51	12	612	500	4612
12	20	13	260	500	4872
16	78	11	858	500	5730
3	18	15	270	500	6000
18	19	10	190	600	6190
20	55	15	825	600	7015
22	26	7	182	600	7197
25	23	16	368	600	7565
7	29	15	435	600	8000
11	32	19	608	700	8608
13	17	12	204	700	8812
15	66	18	1188	700	10000
17	44	17	748	800	10748
23	14	18	252	800	11000
	798		11000		

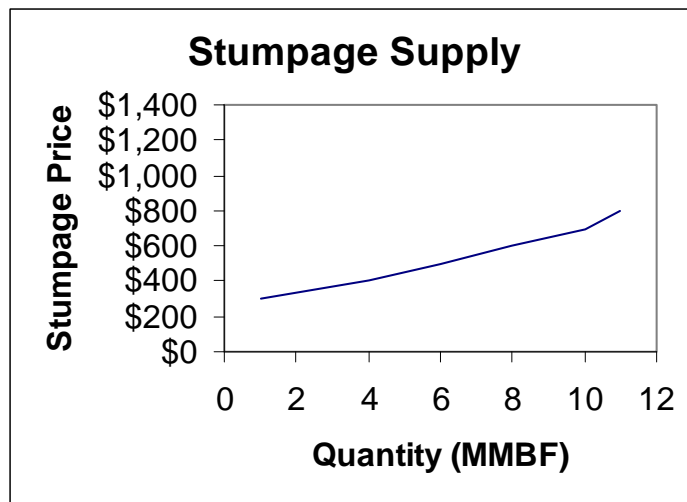
Supply table and equation

Sorted by resenation price

Tract	Acres for sale	Vol. / Acre (MBF)	Total Volume	Resenation Price	Cumulative Volume
8	14	13	182	300	182
4	18	8	144	300	326
19	14	11	154	300	480
2	21	11	231	300	711
6	17	17	289	300	1000
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12	20	13	260	500	4872
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18	19	10	190	600	6190
20	55	15	825	600	7015
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25	23	16	368	600	7565
7	29	15	435	600	8000
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15	66	18	1188	700	10000
17	44	17	748	800	10748
23	14	18	252	800	11000
	798		11000		

Price	Quantity
\$300	1,000
\$400	4,000
\$500	6,000
\$600	8,000
\$700	10,000
\$800	11,000

Graphing the supply equation....



Conversions (same as demand side)

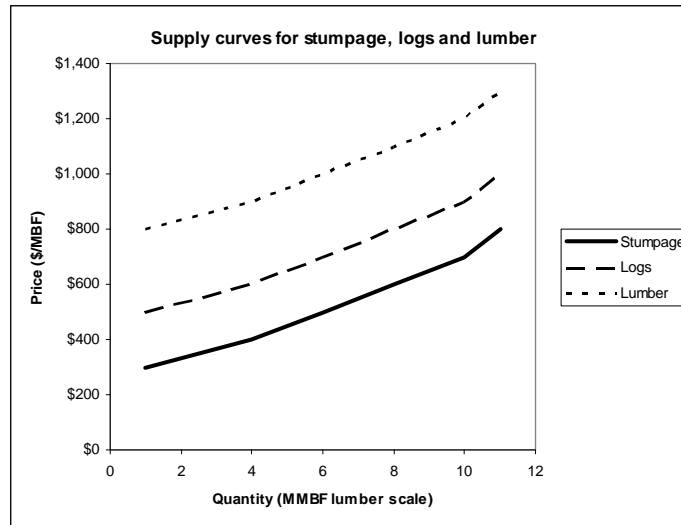
- If the conversion costs to make lumber from logs is \$300 per MBF (milling costs)
 - $P_{Lo} + 300 = P_{Lu}$
- The costs to convert logs at sawmills from trees is \$200 per MBF (cut and haul costs)
 - $P_S + 200 = P_{Lo}$
- Since we have 100% conversion between logs and lumber
 - $Q_{Lu} = Q_{Lo} = Q_S$

Creating derived supply of logs and lumber

Stumpage Supply		Log Supply		Lumber Supply	
Price (\$/MBF)	Quantity (MMBF)	Price (\$/MBF)	Quantity (MMBF)	Price (\$/MBF)	Quantity (MMBF)
300	1	500	1	800	1
400	4	600	4	900	4
500	6	700	6	1000	6
600	8	800	8	1100	8
700	10	900	10	1200	10
800	11	1000	11	1300	11

Note that no overrun/underrun means $Q_{Lu} = Q_{Lo} = Q_S$

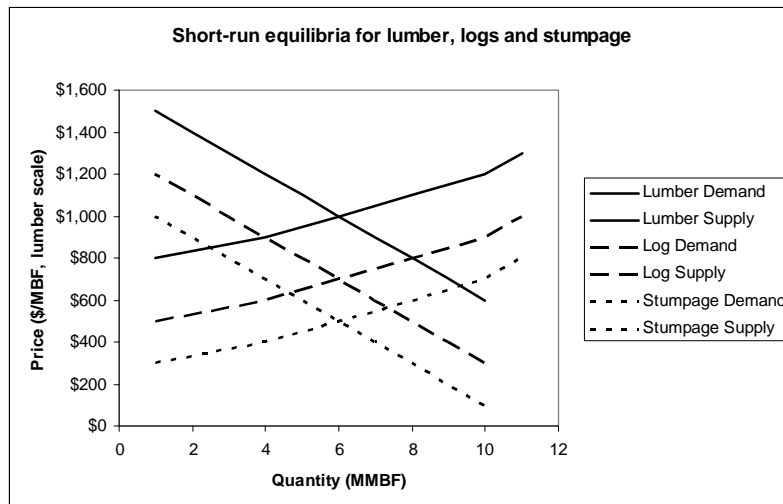
Supply curves for stumpage and logs and lumber (logs and lumber derived)



Supply and demand interaction

- We can now graph the short-run supply and demand graphs for lumber, logs, and stumpage and find the equilibrium points
- Differences in prices at equilibrium define the transformation costs from one product class to the next...

Short-run equilibrium



Revisiting the process of deriving short-run supply and demand – develop and use equations

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Deriving short-run timber supply

- Use data from HO-14
- Start with the timber sales in a region
- Non-wood costs:
 - Cut and haul \$200 / MBF
 - Milling \$300 / MBF
- 100% conversion returns between log and lumber scale

Tract	Owner	Total Acres for sale	Vol. / Acre (MBF)	Total Volume	Reservation Price
1	A	64	8	512	400
2	B	21	11	231	300
3	C	18	15	270	500
4	C	18	8	144	300
5	A	25	21	525	400
6	D	17	17	289	300
7	E	29	15	435	600
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23	C	14	18	252	800
24	D	18	18	324	400
25	E	23	16	368	600
		798		11000	

Steps in deriving timber supply

- Start with stumpage sales and reservation prices for all stands available for sale
- Sort all sales by reservation price
- For each level of reservation price, calculate cumulative volume that could be purchased at that price

Sorted by reservation price

Tract	Total Acres for sale	Vol. / Acre (MBF)	Total Volume	Reservation Price	Reservation Cumulative Volume
8	14	13	182	300	182
4	18	8	144	300	326
19	14	11	154	300	480
2	21	11	231	300	711
6	17	17	289	300	1000
14	28	7	196	400	1196
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3	18	15	270	500	6000
18	19	10	190	600	6190
20	55	15	825	600	7015
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25	23	16	368	600	7565
7	29	15	435	600	8000
11	32	19	608	700	8608
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15	66	18	1188	700	10000
17	44	17	748	800	10748
23	14	18	252	800	11000
	798		11000		

Now we have our supply curve

- At a price of \$300/MBF, landowners will provide 1 MMBF of timber for sale
- At a price of \$400/MBF, landowners will provide 4 MMBF for sale
- At \$500/MBF, 6 MMBF will be available for sale
- At \$600/MBF, 8 MMBF will be available for sale
- At \$700/MBF, 10 MMBF will be available for sale
- At \$800/MBF, 11 MMBF will be available for sale.

Stumpage Price (\$/MBF)	Supply Quantity (MMBF)
300	1
400	4
500	6
600	8
700	10
800	11

Regression results for stumpage supply

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.990610121							
R Square	0.981308411							
Adjusted R Square	0.976635514							
Standard Error	28.59645099							
Observations	6							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	171728.972	171729	210	0.000131841			
Residual	4	3271.028037	817.757					
Total	5	175000						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	222.8971963	25.4125709	8.771139	0.000932	152.3405882	293.453804	152.3405882	293.4538043
X Variable 1	49.06542056	3.385835688	14.49138	0.000132	39.66483364	58.4660075	39.66483364	58.46600748

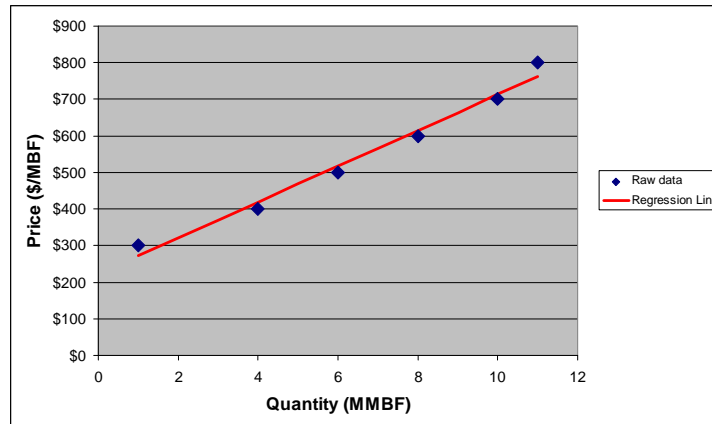
Price in \$/MBF

$$P_{tree}^s = 223 + 49Q_{tree}$$

Q in MMBF

Price	Quantity
272	1
321	2
370	3
419	4
468	5
517	6
566	7
615	8
664	9
713	10
762	11

Compare actual data to regression for timber supply



Now let's develop a regression equation for demand...

The raw data for demand from HO-14:

Wholesale lumber demand	
Qty. (MMBF)	Price (\$/MBF)
1	1500
2	1400
3	1300
4	1200
5	1100
6	1000
7	900
8	800
9	700
10	600

Now let's develop a regression equation for demand...

SUMMARY OUTPUT							
<i>Regression Statistics</i>							
Multiple R	1						
R Square	1						
Adjusted R Square	1						
Standard Error	0						
Observations	10						
<i>ANOVA</i>							
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>		
Regression	1	825000	825000	#NUM!	#NUM!		
Residual	8	0	0				
Total	9	825000					
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i> <i>Upper 95.0%</i>
Intercept	1600	0	65535	#NUM!	1600	1600	1600 1600
X Variable 1	-100	0	65535	#NUM!	-100	-100	-100 -100

Note that data are a straight line

$$P_{lumber}^d = 1600 - 100Q_{lumber}$$

We now have our equations for stumpage supply and lumber demand

$$P_{tree}^s = 223 + 49Q_{tree}$$

$$P_{lumber}^d = 1600 - 100Q_{lumber}$$

And we know our price of non-wood inputs (\$300 for milling and \$200 for cut and haul):

$$P_{nonwood}^s = 500$$

Two important relationships

1 Demand price for final product - Supply price for all non-wood factors = Demand price for stumpage

2 Supply price for final product = Supply price for all non-wood factors + Supply price for stumpage

Let's derive demand for stumpage

$$P_{lumber}^d = 1600 - 100Q_{lumber}$$
$$- (P_{nonwood}^s = 500)$$

$$P_{tree}^d = 1100 - 100Q_{tree}$$

Remember, $Q_{lumber} = Q_{log} = Q_{tree}$

Supply and demand equilibrium for stumpage

$$P_{tree}^d = 1100 - 100Q_{tree}$$

$$P_{tree}^s = 223 + 49Q_{tree}$$

Solving for price and quantity yields:

Quantity = 5.9 MMBF (or 5900 MBF)

Stumpage Price = \$510 / MBF

Now let's derive supply of lumber

$$P_{tree}^s = 223 + 49Q_{tree}$$

$$+ (P_{nonwood}^s = 500)$$

$$P_{lumber}^s = 723 + 49Q_{lumber}$$

Now, equilibrium for lumber can be determined

$$P_{lumber}^s = 723 + 49Q_{lumber}$$

$$P_{lumber}^d = 1600 - 100Q_{lumber}$$

Solving for price and quantity yields:

Quantity = 5.9 MMBF (or 5900 MBF)

Lumber Price = \$1010 / MBF

Some comments

- Regression equation data slightly different from tabular data
 - Quantities and prices just slightly different
 - Error term in regression equations

Product	Tabular data		Regression equations	
	Price (\$/MBF)	Quantity (MMBF)	Price (\$/MBF)	Quantity (MMBF)
Stumpage	\$500	6	\$510	5.9
Lumber	\$1000	6	\$1010	5.9



Next lecture...

Long-run timber demand
and supply...