3.3.5 → Insurance to value

→ overview → For many property insurance policies, such as homeowners insurance, the policy limit is set according to the item's value or its replacement cost, influencing the rate based on the chosen policy. Insurance to value (ITV) describes the relationship between the chosen insurance amount + the total value or replacement cost of the insured item. For instance, when an item is insured to full value, the insurance amount aligns with its total value or replacement cost.

→ This section explores the significance of ITV + the steps insurers might take to ensure that policies are adequately insured in alignment w/ the rates.

→ To help clarify the concept + issues associated w/ ITV, let's examine the example below.

→ You are given the following information on three homes.

- Home 1 is worth $200,000 and is insured for the full amount.
- Home 2 is worth $250,000 and is insured for the full amount.
- Home 3 is worth $250,000 and is insured for $200,000.
- Expected claim frequency for all homes is assumed to be 1%.
- Expected losses are uniformly distributed.

→ Based on the information above, the expected size of loss distributions of the three homes are as follows:

Loss Size ($000s)	Home 1		Home 2		Home 3	
	Loss Distribution	Average Reported Loss ($000s)	Loss Distribution	Average Reported Loss ($000s)	Loss Distribution	Average Reported Loss ($000s)
$0 < X \le 25$	12.5%	12.5	10%	12.5	10%	12.5
$25 < X \le 50$	12.5%	37.5	10%	37.5	10%	37.5
$50 < X \le 75$	12.5%	62.5	10%	62.5	10%	62.5
$75 < X \le 100$	12.5%	87.5	10%	87.5	10%	87.5
$100 < X \le 125$	12.5%	112.5	10%	112.5	10%	112.5
$125 < X \le 150$	12.5%	137.5	10%	137.5	10%	137.5
$150 < X \le 175$	12.5%	162.5	10%	162.5	10%	162.5
$175 < X \le 200$	12.5%	187.5	10%	187.5	10%	187.5
$200 < X \le 225$	-	-	10%	212.5	10%	200
$225 < X \le 250$	-	-	10%	237.5	10%	200
Total	100%	100	100%	125	100%	120

→ Since the expected losses are uniformly distributed, the average reported loss for each range is the midpoint of the range.

→ For home 1 + home 2, this applies to all ranges since both homes are fully insured. For example, for Home 1, the average reported loss in $000s for $0 \le X \le 25$ is $\frac{0+25}{2} = 12.5$.

→ For Home 3, the average reported loss is capped at 200,000, as the home is only insured for 200,000. This is why the average reported loss in $000s for Home 3 for $200 \le X \le 225$ + $225 \le X \le 250$ is 200.

→ The total average reported loss for each home, or the severity, is calculated as the sum of the product of the loss distribution + the average reported loss. The expected severity for each home is as follows:

Property	Expected Severity
Home 1	$100,000
Home 2	$125,000
Home 3	$120,000

→ The expected pure premium for each home can be calculated as the product of the expected frequency + the expected severity. Assuming no expenses or profit, the indicated rate per $1000 of amount of insurance can be calculated as the expected pure premium divided by the amount of insurance over $1000.

Property	Amount of Insurance	Expected Frequency	Expected Severity	Expected Pure Premium	Rate per $1,000 of Amount of Insurance
Home 1	$200,000	1%	$100,000	$1\% \times \$100{,}000 = \$1{,}000$	$\frac{\$1{,}000}{\$200{,}000/\$1{,}000} = \$5$
Home 2	$250,000	1%	$125,000	$1\% \times \$125{,}000 = \$1{,}250$	$\frac{\$1{,}250}{\$250{,}000/\$1{,}000} = \$5$
Home 3	$200,000	1%	$120,000	$1\% \times \$120{,}000 = \$1{,}200$	$\frac{\$1{,}200}{\$200{,}000/\$1{,}000} = \$6$

→ From the example, we can see that two issues arise when properties are not insured to their full value or replacement cost

→ 1) → The insurance payout will not be adequate to cover a total or near-total loss, leaving the insured unable to fully recover their pre-loss condition.

→ In the example above, Home 3 has a value of $250,000 but is only insured for $200,000. If it experiences a loss greater than $200,000, the insurance payout will be capped at $200,000, which does not cover the entire loss.

→ 2) → If the insurer bases the rate on the assumption that all homes are insured to their full value, the premium charged will not be sufficient to cover the expected loss on underinsured homes.

→ In the example above, assume the insurer charges a rate of $5 per $1000 insured for all three homes. Home 3, which is underinsured, will be charged inadequately because it has an indicated rate of $6 per $1000 insured. This leads to inequitable rates.

→ When properties are not insured to the same level, it leads to rate inequity. And if all homes are underinsured by the same percentage, the resulting premium may not be adequate to cover all losses, but it would be equitable. Over time, the insurer will raise the base rate so that the aggregate premium covers the expected aggregate losses. However, in this scenario, fully insured homes end up bearing part of the cost of the underinsured homes.

→ It is important to note that the issues of inequity + inadequacy of rates only exist if partial losses are possible. If all losses are total losses, the total premium collected will be adequate to cover all losses, + rates will be equitable, even if some homes are underinsured

→ Typically, most losses are partial rather than total. To ensure rates that are both equitable + adequate, insurers should charge rates based on the ITV level. Using our example above, if the insurer charges Home 1 + Home 2 a rate of $5 per $1000 of amount of insurance + Home 3 a rate of $6 per $1000 of amount of insurance, then the premium would have been equitable + adequate.

→ Varying rates based on ITV level

→ Note that Home 3, which is underinsured, has an indicated rate that is higher than the fully insured homes. In general, assuming partial losses are possible, the rate per amount of insurance decreases as the face value approaches the value of the insured property. The rate of this decrease varies based on the shape of the loss distribution:

→ In a right-skewed distribution, where small losses are more likely, the rate decreases at a decreasing rate as the ratio of the face value to the value of insured property increases

→ In a uniform distribution, where all losses are equally likely, the rate decreases at a constant rate as the ratio of the face value to the value of insured property increases

→ In a left-skewed distribution, where large losses are more likely, the rate decreases at an increasing rate as the policy face value increases.

→ Insurance to value initiatives

→ To encourage insurance to full value, insurers employ a feature known as guaranteed replacement cost (GRC). With GRC, the insurer would pay for the actual replacement cost of the home, even if it exceeds the policy limit, provided the property is insured to full value. However, a few large catastrophes in the 1990s led to replacement costs far exceeding the insured value, resulting in insurers paying out much more in losses than anticipated. This prompted many insurers to implement caps on replacement costs, such as 25% of the policy limit.

→ In recent years, the property insurance industry has adopted new methods to promote insurance coverage at full value. Insurers now employ more advanced property estimation tools, which were previously basic estimators that considered limited factors, such as square footage + room count, + adjusted values at renewal using broad geographic indices. Today's tools incorporate customized features of the home, such as granite countertops, hardwood floors, + the age of plumbing + electrical systems. These tools are also used to reassess insured value at renewal.

→ By increasing the amount of insurance on underinsured homes to align w/ the ITV level assumed in pricing, insurers can generate additional premium revenue w/o raising rates. Given that homeowners' loss distributions are generally right skewed (because smaller losses are more common), this added premium often outweighs the cost of additional losses. Homeowners also tend to accept the increased premium more readily when it results in greater coverage, rather than a rate increase.

→ Beyond estimation tools, the industry has improved its use of property inspections, indexation clauses, + insured education efforts. As w/ any significant operational change, actuaries must evaluate the impact of any ITV initiative on overall company performance.

→ Coinsurance clause

→ In addition to adjusting rates based on the ITV level, insurers have another tool at their disposal to achieve greater equity among risks: coinsurance. Coinsurance refers to two or more parties jointly covering a portion of the insured risk.

→ In property insurance, coinsurance is a policy provision where the insured agrees to maintain coverage at a specific ITV level (usually 80% or 90%). If the insured fails to meet this requirement, they may be subject to a penalty in the event of a claim, where insurance payout is reduced proportionally according to the degree of underinsurance.

→ Assume a required coinsurance percentage (c) + a policy is underinsured (ie $F < cV$). To determine the indemnity payment, we first need to calculate the apportionment ratio (a), which is the ratio of the coverage amount (or face value, F) to the coinsurance requirement (cV).

$$\boxed{a = \min\left(\frac{F}{cV}, 1\right) = \begin{cases} \frac{F}{cV}, & F < cV \\ 1, & F \ge cV \end{cases}}$$

→ Then, the indemnity payment (I) is the (100a)% of the loss (L), capped at face value

$$\boxed{I = \min(aL, F) = \begin{cases} aL, & L < cV \\ F, & L \ge cV \end{cases}}$$

→ There will be a coinsurance penalty (e) when the policy is underinsured (ie $F < cV$) + experiences a partial loss less than the coinsurance requirement (i.e. $L < cV$)

$$\boxed{e = \min(L, F) - I = \begin{cases} (1-a)L, & L \le F < cV \\ F - aL, & F \le L < cV \\ 0, & \text{otherwise} \end{cases}}$$

→ Notes → The situation above does not account for deductibles. If the policy includes a deductible, D, we calculate a + I in the same way, with L representing the amount of loss before the deductible. In this case, I is the indemnity payment before the

→ Example →

A home is valued at $500,000. The insured purchases a policy with a face value of $300,000 despite a coinsurance requirement of 80%. Assume there is no deductible.

Calculate the indemnity payment and coinsurance penalty for each of the following:

1. A $200,000 loss
2. A $300,000 loss
3. A $350,000 loss
4. A $450,000 loss

→ 1) The coinsurance requirement is

$$cV = 80\% * \$500{,}000 = \$400{,}000$$

Since the face value, F, is only $300,000, the insured fails to meet the coinsurance requirement. In this case, the apportionment ratio will be less than 1.

$$a = \min\left(\frac{F}{cV}, 1\right) = \min\left(\frac{\$300{,}000}{\$400{,}000}, 1\right) = 0.75$$

The indemnity payment is:

$$I = \min(aL, F) = \min(0.75 * \$200{,}000, \$300{,}000) = \min(\$150{,}000, \$300{,}000) = \$150{,}000$$

For this property, there will be a coinsurance penalty as long as the loss is less than the coinsurance requirement b/c the face amount is less than the coinsurance requirement. The amount of penalty for a loss of $200,000 is:

$$e = \min(L, F) - I = \min(\$200{,}000, \$300{,}000) - \$150{,}000 = \$50{,}000$$

→ (2) $a = 0.75$

$I = \min(0.75 * \$300{,}000, \$300{,}000) = \$225{,}000$

$e = \min(\$300{,}000, \$300{,}000) - \$225{,}000 = \$75{,}000$

There is a coinsurance penalty since the loss of $300,000 is less than the coinsurance requirement of $400,000.

→ (3) $a = 0.75$

$I = \min(0.75 * \$350{,}000, \$300{,}000) = \$262{,}500$

$e = \min(\$350{,}000, \$300{,}000) - \$262{,}500 = \$37{,}500$

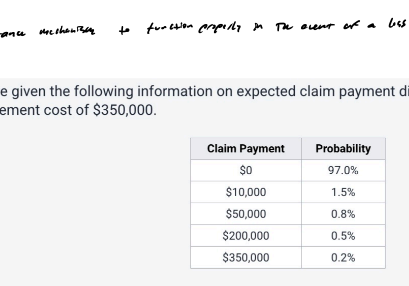
There is a coinsurance penalty since the loss of $350,000 is less than the coinsurance requirement of $400,000.

→ (4) $a = 0.75$

$I = \min(0.75 * \$450{,}000, \$300{,}000) = \$300{,}000$

$e = \min(\$450{,}000, \$300{,}000) = \$0$

→ From the example, we can see that the penalty goes up + then down as the loss amount increases. The chart below shows the magnitude of the coinsurance penalty for all loss values between $0 + the value of the home, which is $500,000.



→ The diagram above shows that the dollar coinsurance penalty increases linearly between $0 + the face value, where the penalty is the largest. It then decreases for loss sizes between the face amount + the coinsurance requirement. For losses greater than the coinsurance requirement, there is no coinsurance penalty, but the insured faces a shortfall as the payment doesn't fully cover the entire loss.

→ For the coinsurance mechanism to function properly in the event of a loss, it's essential to establish

→ Example →

You are given the following information on expected claim payment distribution for properties with a replacement cost of $350,000.

Claim Payment	Probability
$0	97.0%
$10,000	1.5%
$50,000	0.8%
$200,000	0.5%
$350,000	0.2%

- Assume no expenses or profit.

(a) Assuming all homeowners purchase full coverage, calculate the pure premium per $1,000 of insurance.

(b) Demonstrate with an example that the use of a fixed rate per $1,000 of insurance is inequitable if a subset of the insured group purchases only partial coverage.

(c) Describe two insurer initiatives that would reduce the inequity from part (b) above, including an explanation of how the inequity would be reduced.

→ a) The pure premium represents the expected claim payment. To calculate it, sum the product of each claim payment + its corresponding probability from the given table.

$$\text{Pure Premium} = (\$0 * 97\%) + (\$10{,}000 * 1.5\%) + (\$50{,}000 * 0.8\%) + (\$200{,}000 * 0.5\%) + (\$350{,}000 * 0.2\%) = \$2250$$

Then divide this sum by the face value of the policy, in thousands. Since the homeowners are fully covered, the face value is equal to the replacement cost of $350,000. The pure premium per $1000 of insurance is:

$$\frac{\$2{,}250}{\$350{,}000/\$1000} = \$6.43$$

→ b) For example, assume an insured purchases a policy w/ a face value of $250,000. Then the pure premium would be:

$$\text{Pure Premium} = (\$0 * 97\%) + (\$10{,}000 * 1.5\%) + (\$50{,}000 * 0.8\%) + (\$200{,}000 * 0.5\%) + (\$250{,}000 * 0.2\%) = \$2050$$

The pure premium per $1000 of insurance is:

$$\frac{\$2050}{\$250{,}000/\$1000} = \$8.20$$

Notice the pure premium when the property is underinsured is greater than the pure premium when the property is fully insured. If the insurer assumes all properties are fully insured + charges all risks the same rate of $6.43 per $1000 of insurance, then they would be undercharging the underinsured properties.

→ c) To reduce the inequity in premium charged, the insurer can charge each risk based on the level of insurance to value. For example, instead of charging all properties $6.43 per $1000 of insurance, the insurer can apply this rate to fully insured properties, while those insured for $250,000 could be charged a rate of $8.20 per $1000. This adjustment ensures that premium aligns w/ expected losses.

Another way to rate equity is to use a coinsurance clause. With this policy provision, any properties that are underinsured may be subject to a coinsurance penalty where the insurance payout is reduced proportionally by the level of underinsurance. This would create equity as properties that are paying lower premium for smaller coverage would receive lower indemnity payments.

→ Assignment

→ Q1) Given the following information on an individual property policy, answer the questions below. Show all work.

- The property value is $200,000.
- Assume no deductible applies.
- The frequency of non-zero loss is 10%.
- The severity of loss distribution is as follows:
  - 70% at 10% of value
  - 20% at 50% of value
  - 8% at 80% of value
  - 2% at 90% of value
- Permissible loss ratio is 65%.

(a) *(2 points)* The insured purchases a policy insuring the property to 80% of value. Determine the premium charged for the policy.

(b) *(1 point)* The insured instead purchases a policy insuring the property to 70% of value. Assuming the same rate per $100 of insured value as in part (a) above, determine the expected loss ratio for this policy.

(c) *(1 point)* Assume the insurer incorporates a coinsurance clause into the policy with a coinsurance requirement of 80%. The insured continues to insure the property to 70% of value. What is the expected loss ratio for this policy? Briefly explain your answer.

→

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1															
2			Property value, F =	$200,000											
3															
4			Probability of non-zero loss =	10.0%											
5															
6				=1-E4											
7			=B11*$E$2	=$E$4*C11	=MIN($D10,F$8*$E$2)										
8				Insured %	80%	70%									
9	% of value	Probability | Loss	Severity	Probability	Loss capped at F	Loss capped at F									
10			$0	90.0%	$0	$0			Pure premium (insured @ 80% of F) =	$5,000	=SUMPRODUCT($E$10:$E$14,$F$10:$F$14)				
11	10.0%	70.0%	$20,000	7.0%	$20,000	$20,000									
12	50.0%	20.0%	$100,000	2.0%	$100,000	$100,000			Premium = PP / PLR =	$7,692.31	=K10/$E$17				
13	80.0%	8.0%	$160,000	0.8%	$160,000	$140,000									
14	90.0%	2.0%	$180,000	0.2%	$160,000	$140,000									
15			Total	100.0%					Premium per $100 of insurance =	$4.81	=K12/($E$2*$F$8/100)				
16															
17			PLR =	65%					Pure premium (insured @ 70% of F) =	$4,800	=SUMPRODUCT($E$10:$E$14,$G$10:$G$14)				
18															
19									Premium (assuming same rate per $100 as above) =	$6,730.77	=K15*E2*G8/100				
20															
21									Premium per $100 of insurance =	$4.81	=K19/($E$2*$G$8/100)				
22															
23									Expected loss ratio = Exp Loss / Premium =	71.31%	=K17/K19				
24															
25			Coinsurance, c =	80%					Coinsurance amount, cV =	$160,000	=E25*E2				
26															
27									F =	$140,000	=E2*G8				
28															
29									apportionment %, a =	87.5%	=MIN(K27/K25,1)				
30															
31									Pure premium (insured @ 70% of F & coinsurance) =	$4,375.00	=(E10*G10+E11*G11+E12*G12)*K29+E13*G13+E14*G14				
32															
33									* Expected loss ratio (coinsurance) = Exp Loss / Premium =	65%	=K31/K19				
34															
35		* The coinusrance clause adjusts the expected losses to align with the PLR used to determine the premium, resulting in an expected loss ratio equal to the PLR													
36															

→ Q2) You are given the following information:

- Home is valued at $350,000.
- Coinsurance requirement = 80% of the property value
- Face value of policy = $275,000

(a) *(0.5 points)* Calculate the coinsurance apportionment ratio.

(b) *(0.5 points)* Calculate the maximum coinsurance penalty possible.

(c) *(0.5 points)* Calculate the coinsurance penalty for a $300,000 loss.

	K	L	M	N	O	P	Q	R	S	T	U
39											
40				V =	$350,000			apportionment ratio, a =		98.21%	=O42/(O40*O41)
41				c =	80%			Indemnity payment, I =		$270,089	=MIN(T40*O44,O42)
42				F =	$275,000			max coinsurance penalty (occures @ F), e =		$4,910.71	=MIN(O44,O42)-T41
43											
44	Hypothetical loss (for max coinsurance penalty), L =				$275,000	=O42		Indemnity payment, I =		$275,000	=MIN(T40*O46,O42)
45								coinsurance penalty, e =		$0	=MIN(O46,O42)-T44
46				Loss, L =	$300,000						

→ Q3) Given the following:

- Property is valued at $500,000.
- Coinsurance requirement is 88% of the property value.
- Policy face value is $300,000.

Graph and label the coinsurance penalty function.

→

	X	Y	Z	AA	AB	AC	AD
47							
48	V =	$500,000			apportionament ratio, a =	68.2%	=MIN(Y50/(Y48*Y49),1)
49	c =	88%					
50	F =	$300,000		Loss, L	Indemnity payment, I	Coinsurance penalty, e	
51				$0	$0	$0	
52				$50,000	$34,091	$15,909	
53				$100,000	$68,182	$31,818	
54				$150,000	$102,273	$47,727	
55				$200,000	$136,364	$63,636	
56				$250,000	$170,455	$79,545	
57				$300,000	$204,545	$95,455	
58				$350,000	$238,636	$61,364	
59				$400,000	$272,727	$27,273	
60				$450,000	$300,000	$0	
61				$500,000	$300,000	$0	
62					=MIN($AC$48*AA61,$Y$50)	=MIN(AA61,$Y$50)-AB61	
63