

The Economics of Transportation Safety


Ian Savage



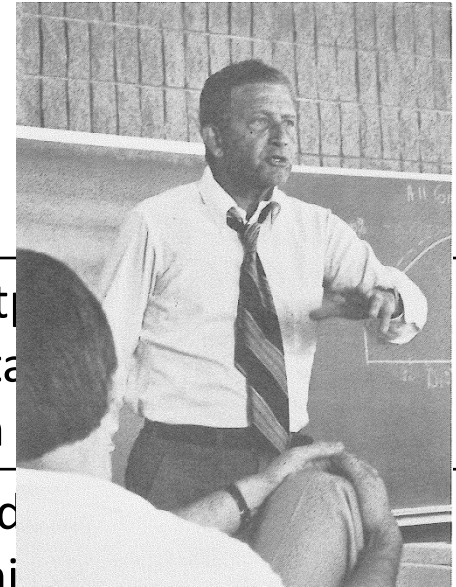
Leon N. Moses 1924-2013

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1980s		Deregulation and safety
1990s		HazMat transportation Truck safety
2000s	Retires, 2005	

"The risks of bodily harm are not unreasonable when consumers understand that risks exist, can appraise their probability and severity, know how to cope with them and voluntarily accept them to get benefits that could not be obtained in less risky ways"

Corwin D. Edwards


National Commission on Product Safety

Final Report (1970)

Part 1

What are the risks?

Clean up your language

 ~~Accidents~~ Crashes

Incidents

Magnitude of the risk

- Transportation related fatalities are 1 in every 56 deaths in the United States (average over period 2000-2009)
- But are 38% of all “unintentional injury deaths”
- Equivalent to the sum of the 2nd and 3rd most prevalent causes (falls and poisonings)
- Over the 2000-09 decade annual average fatalities were 43,239

43,239
Average Annual Total
2000-2009



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Average Annual Total
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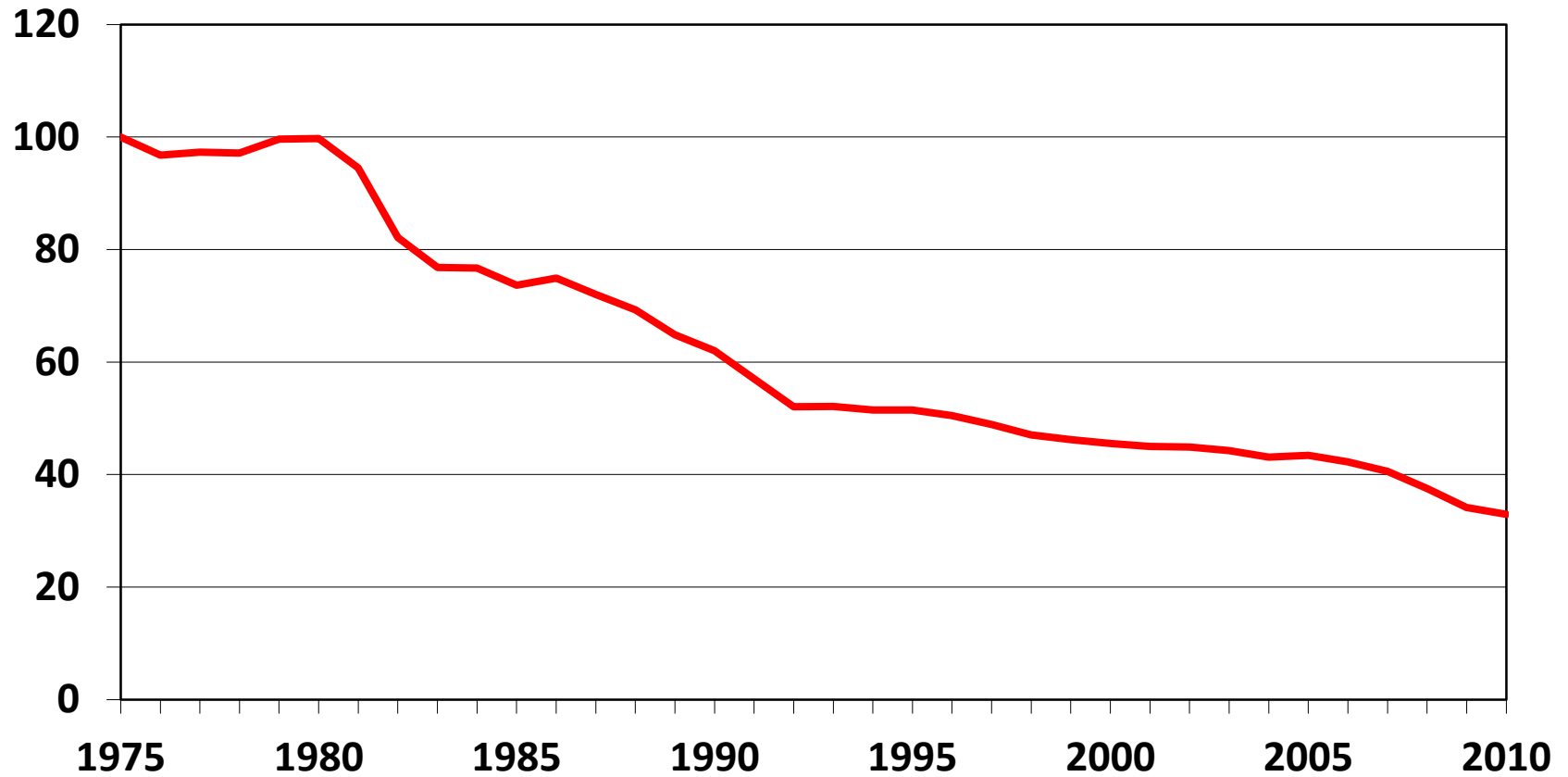
36,927 (85.4%)
Private transportation
only

6,312 (14.6%)
Commercial
transportation

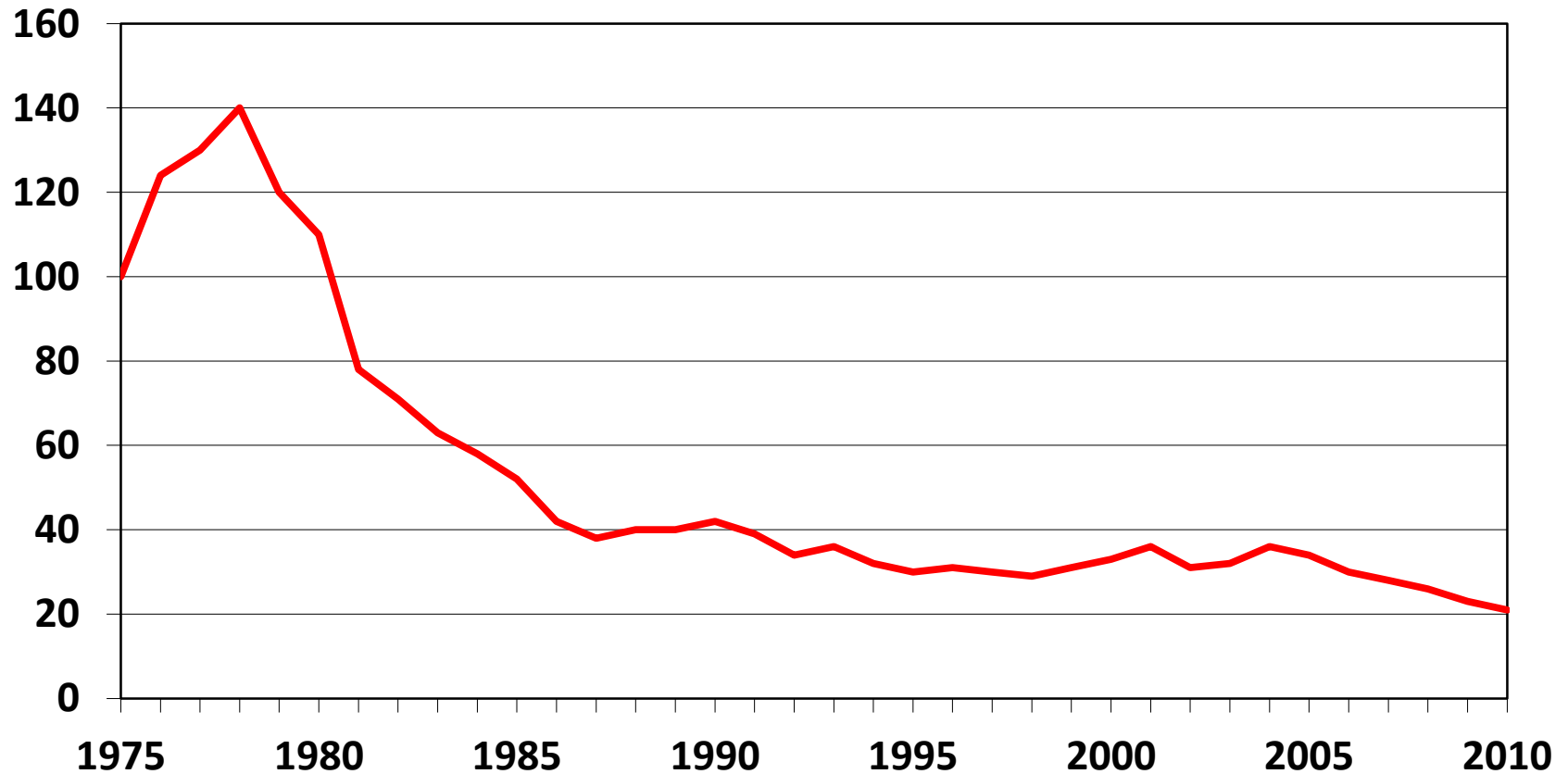
Passenger fatalities per billion passenger miles 2000-09

Riding a motorcycle	212.57
Driving or passenger in car and light truck	7.28
Passenger on a local ferry boat	3.17
Passenger on commuter rail and Amtrak	0.43
Passenger on urban mass transit rail	0.24
Passenger on a bus (holding more than 10 passengers – transit, intercity, school, charter)	0.11
Passenger on commercial aviation	0.07

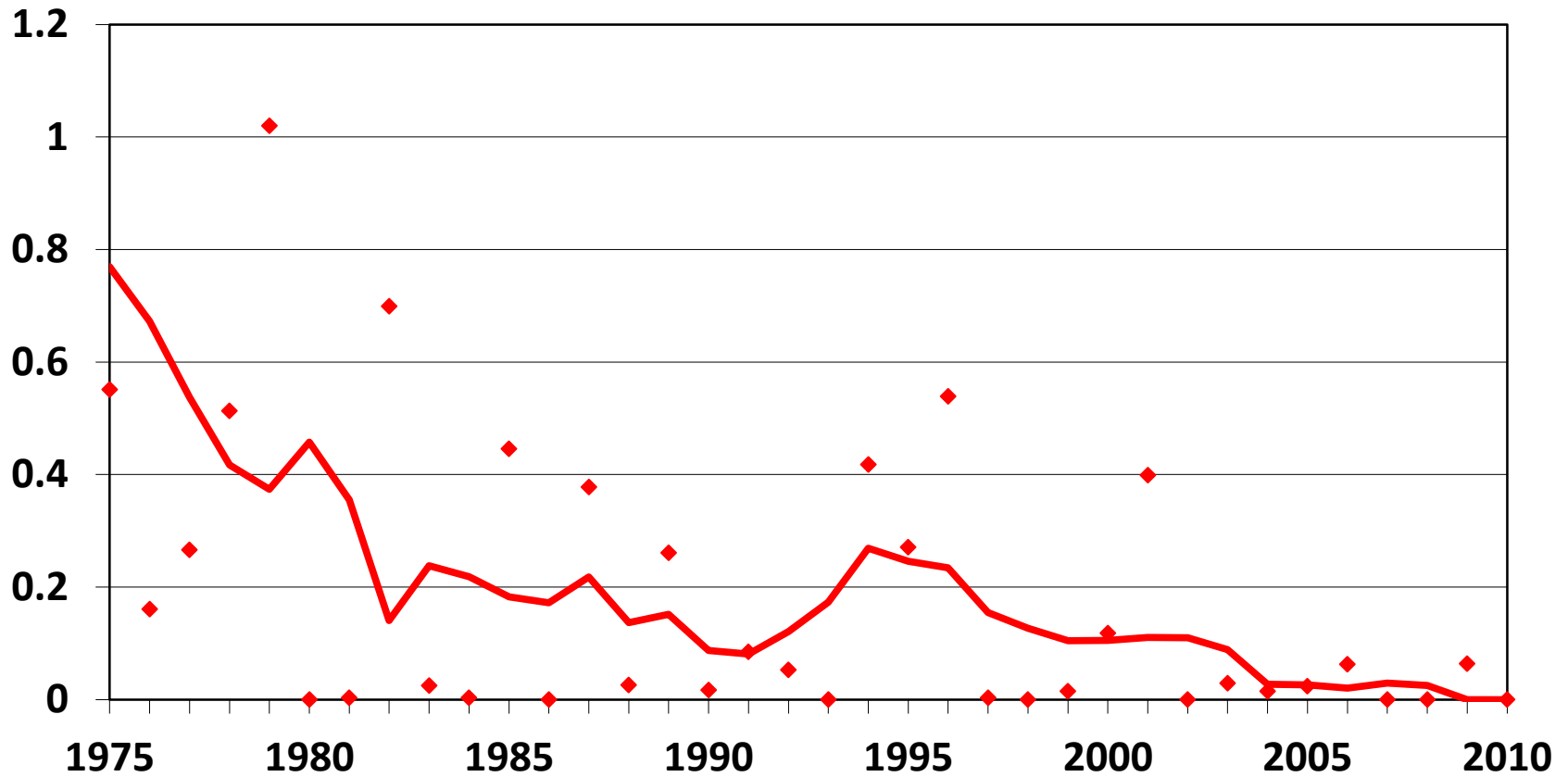
Highway fatalities per vehicle mile (index with 1975=100)



Railroad collisions and derailments per train mile (index with 1975=100)



Commercial aviation passenger fatalities per million enplanements (with 5yr m.a.)

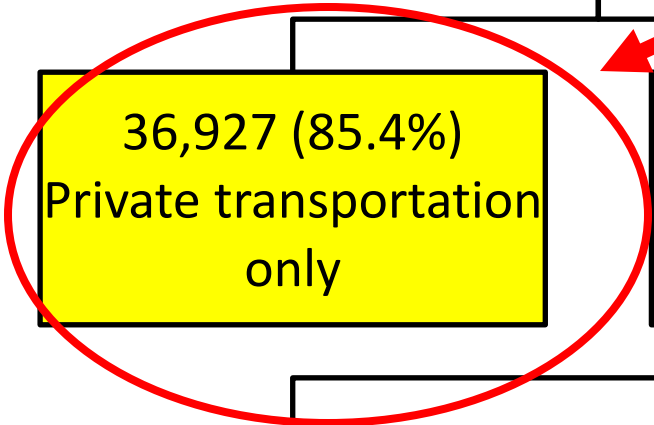


Economists have limited comparative advantage in analyzing these crashes

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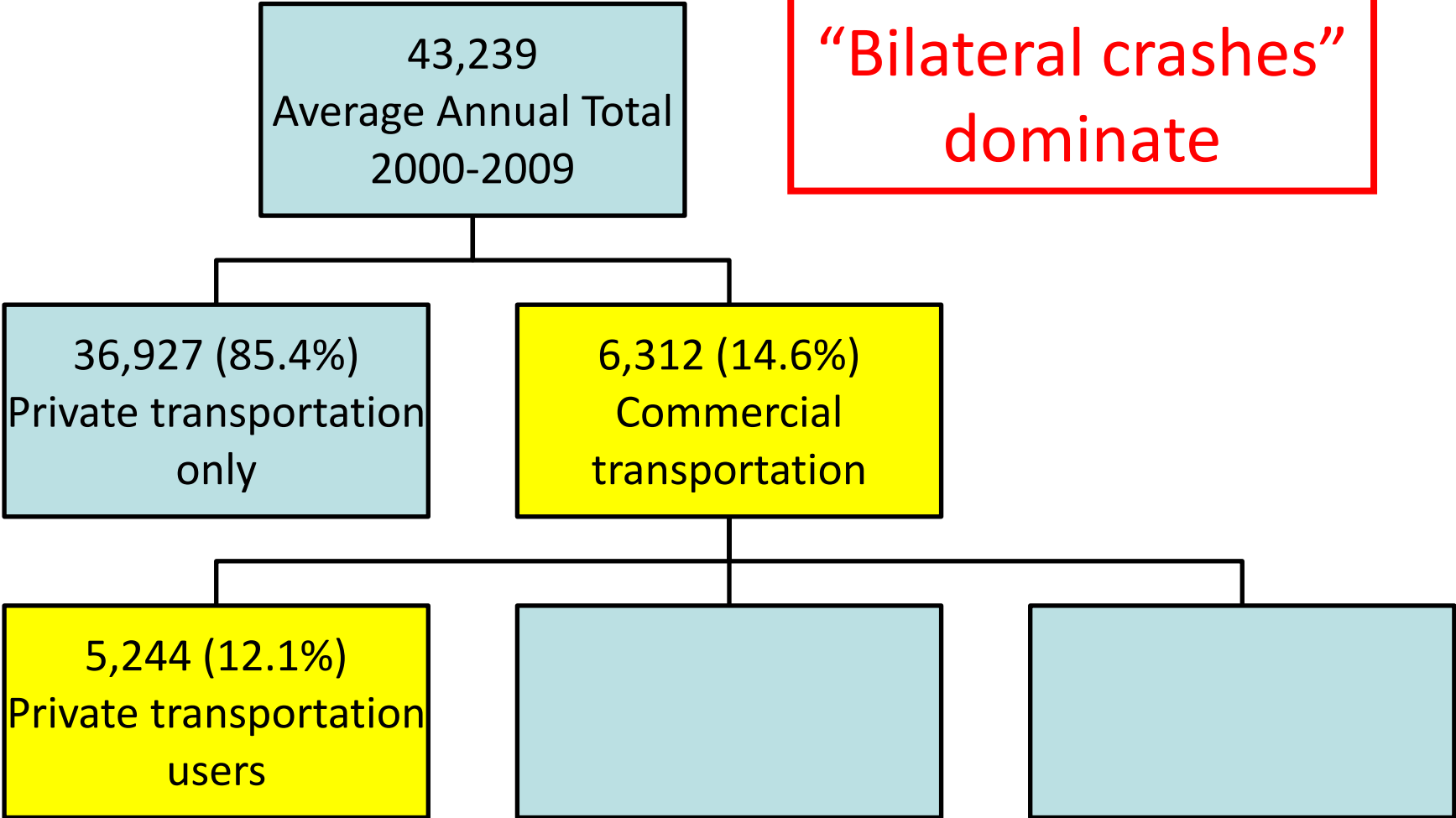
1. 55% of occupant-fatalities in single-vehicle crashes
2. 30% of occupant-fatalities are passengers
3. 10% of fatalities are motorcyclists
4. Third of fatal crashes involve alcohol
5. Elevated risk for men in general (3 X), and those under the age of 24 (2 X)
6. Human frailties such as inattention, cognitive overload and poor judgment abound

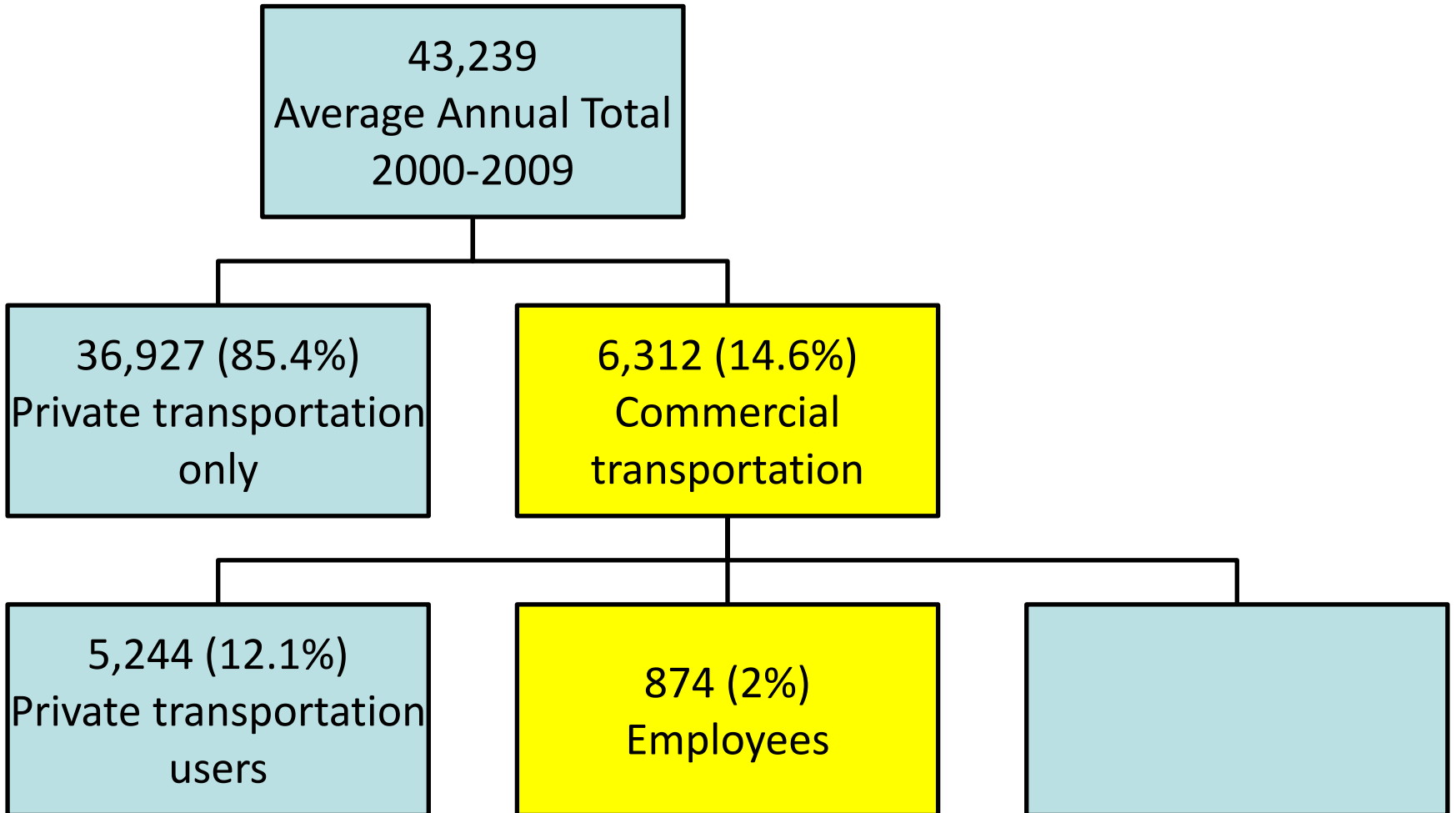
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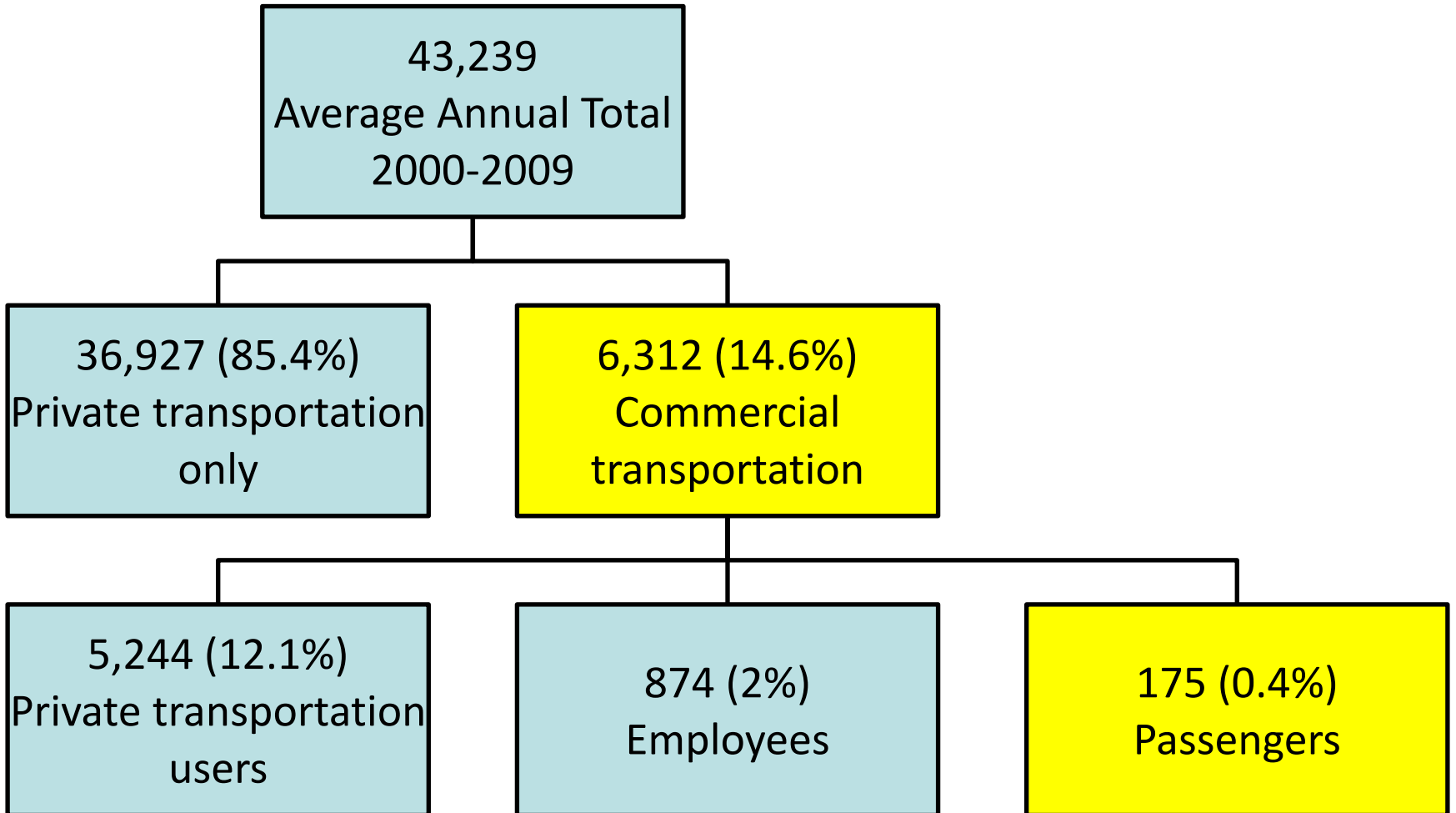
“Externalities” and
“Bilateral crashes”
dominate





Rates per 1,000 Employees 2009

	Fatality	Non-fatal Injury
Fishing	8.81	15
<i>Agriculture</i>	0.76	53
Taxi and limousine	0.62	37
Truck transportation	0.29	57
Water transportation	0.24	33
<i>Construction</i>	0.12	47
Pipeline transportation	0.10	15
Rail transportation	0.06	23
Air transportation	0.06	71
<i>Utilities</i>	0.03	31
Bus transportation	0.03	33-48
<i>Manufacturing</i>	0.03	50



Part 2

How much safety?, or
How safe is “safe enough”?

\$ per trip



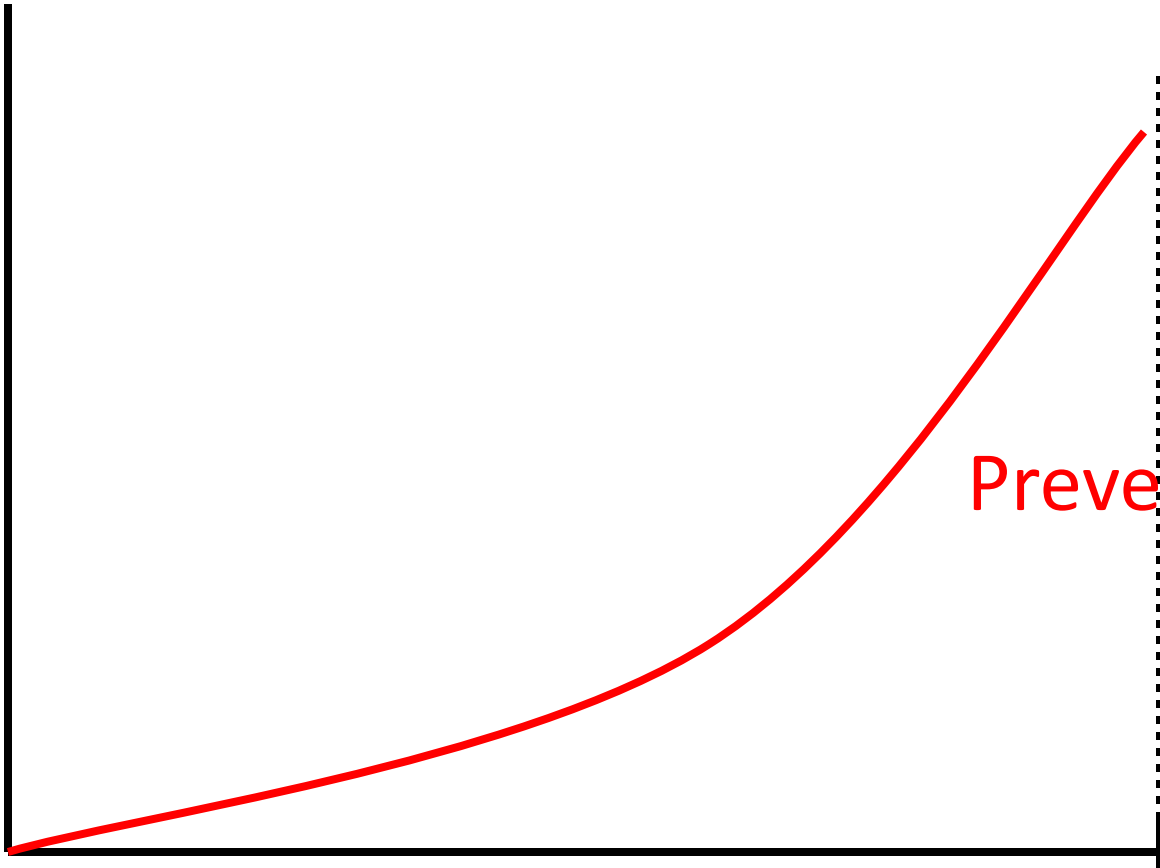
No safety

Perfect safety

“crash certain to occur”

“crash will never occur”

\$ per trip



Prevention cost

No safety

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Air New Zealand Flight 901, November 28, 1979



Chief Inspector of air accidents blamed the pilots

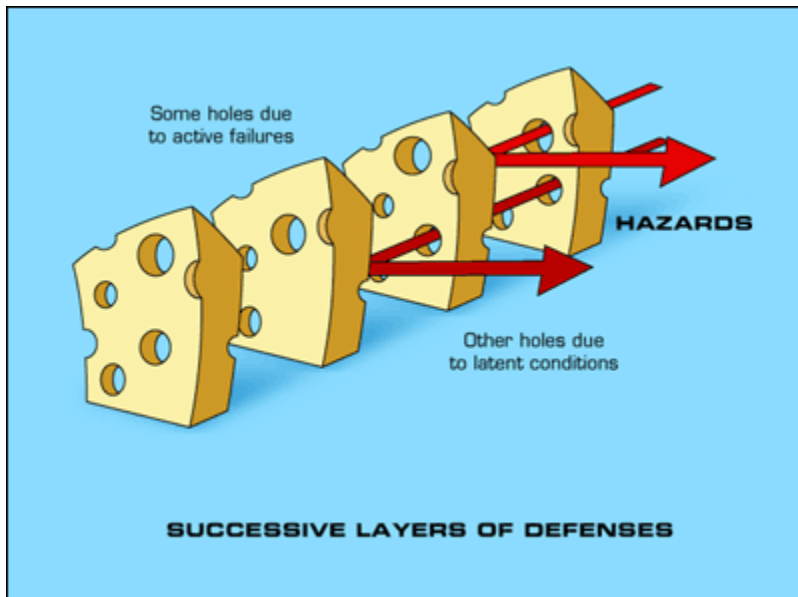


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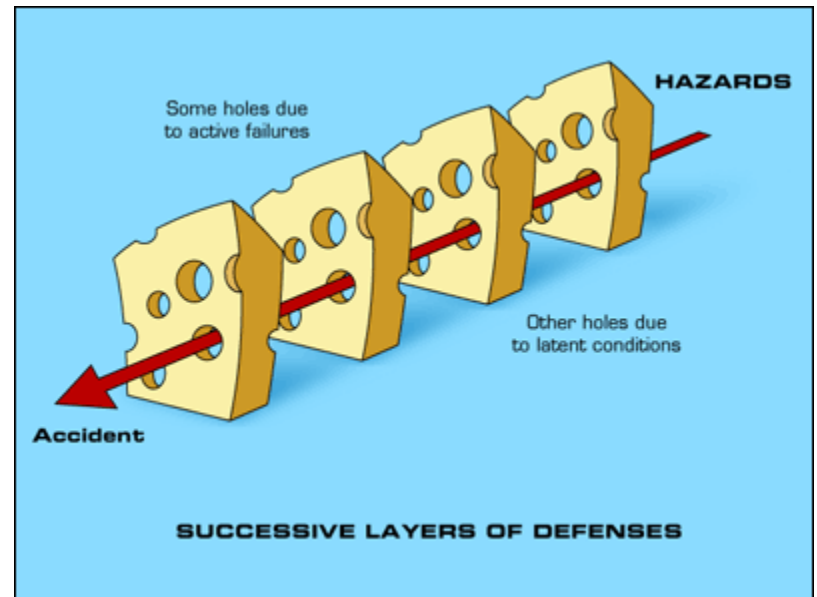
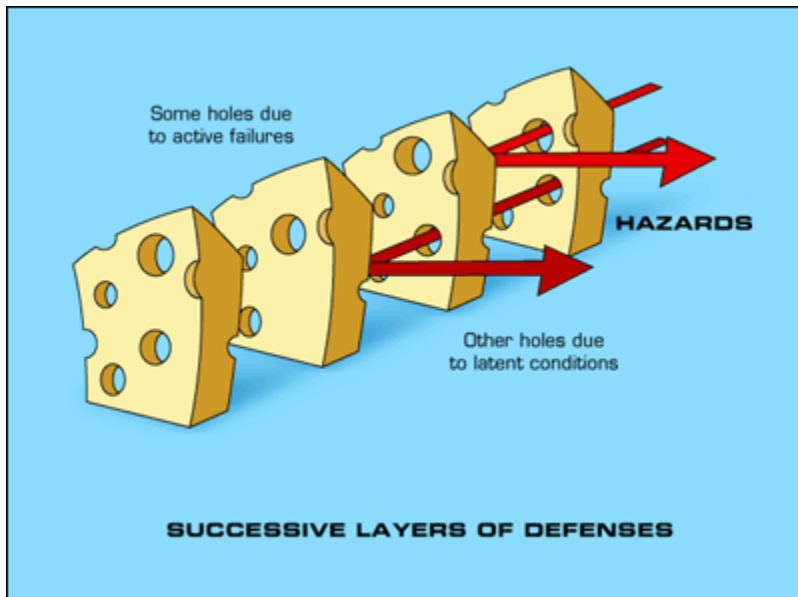
Royal Commission of Inquiry by Justice Peter Mahon accusing Air NZ management of a cover-up and conspiracy and "an orchestrated litany of lies"

James T. Reason



- Professor of Psychology, University of Manchester
- Daniel Maurino, James Reason, Neil Johnson and Rob Lee *Beyond Aviation Human Factors: Safety in High Technology Systems* (Ashgate, 1995)

“Swiss cheese theory”



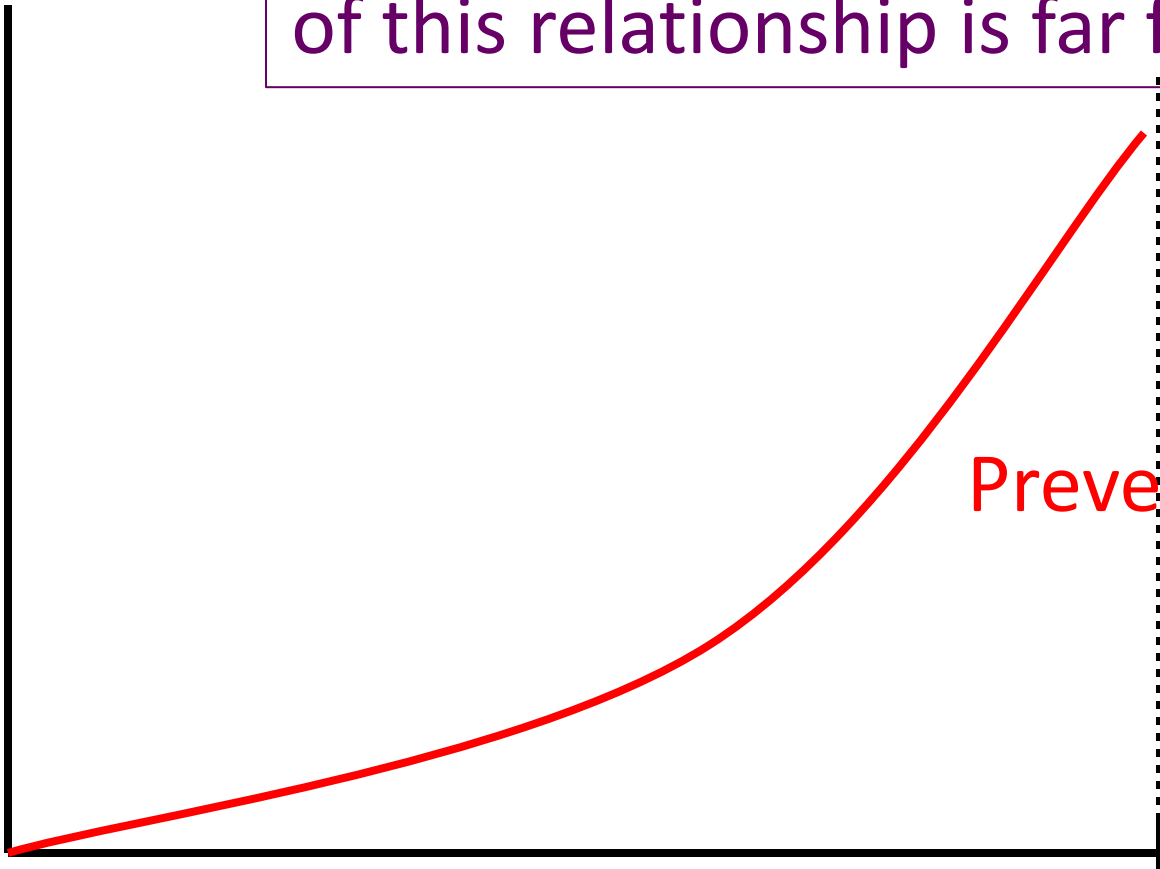
\$ per trip

Suggests to me that the nature of this relationship is far from clear

Prevention cost

No safety
"crash certain to occur"

Perfect safety
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\$ per trip

Crash costs
& legal
payments

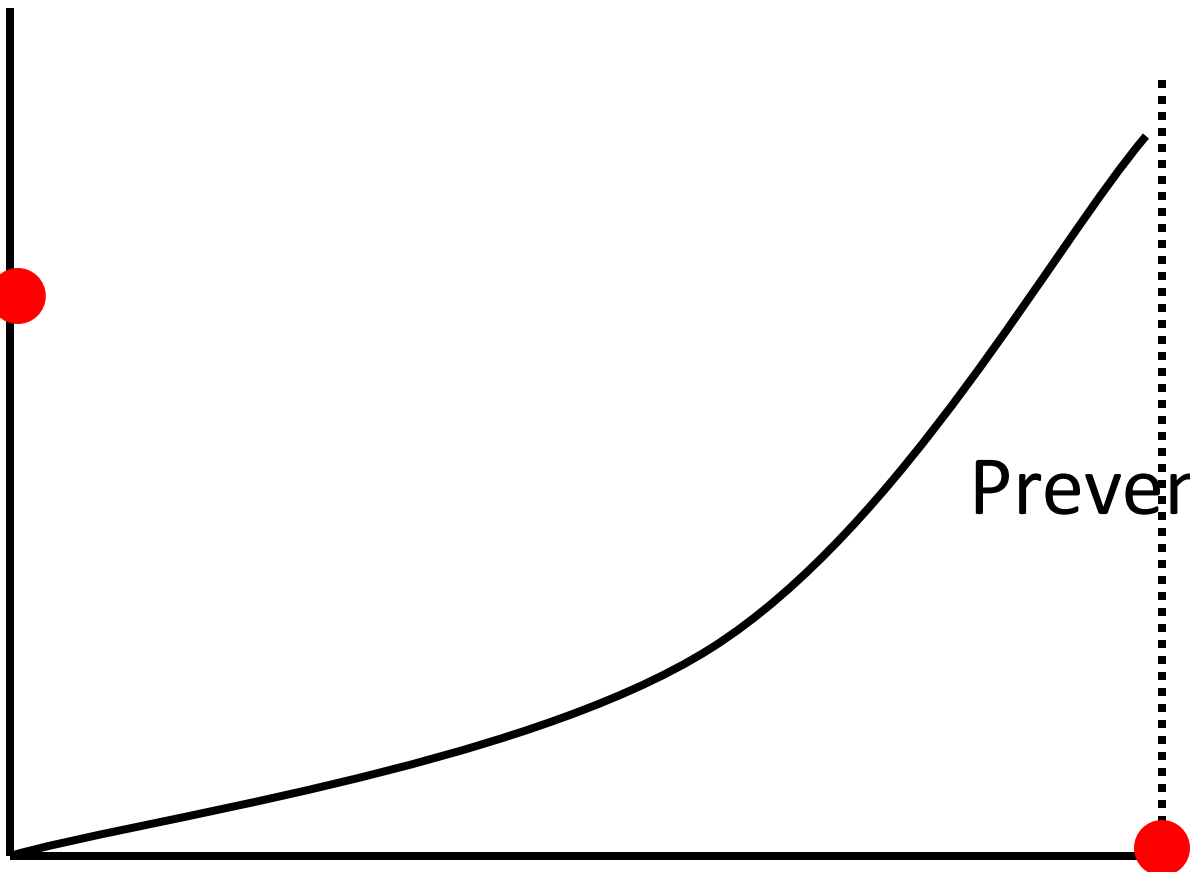
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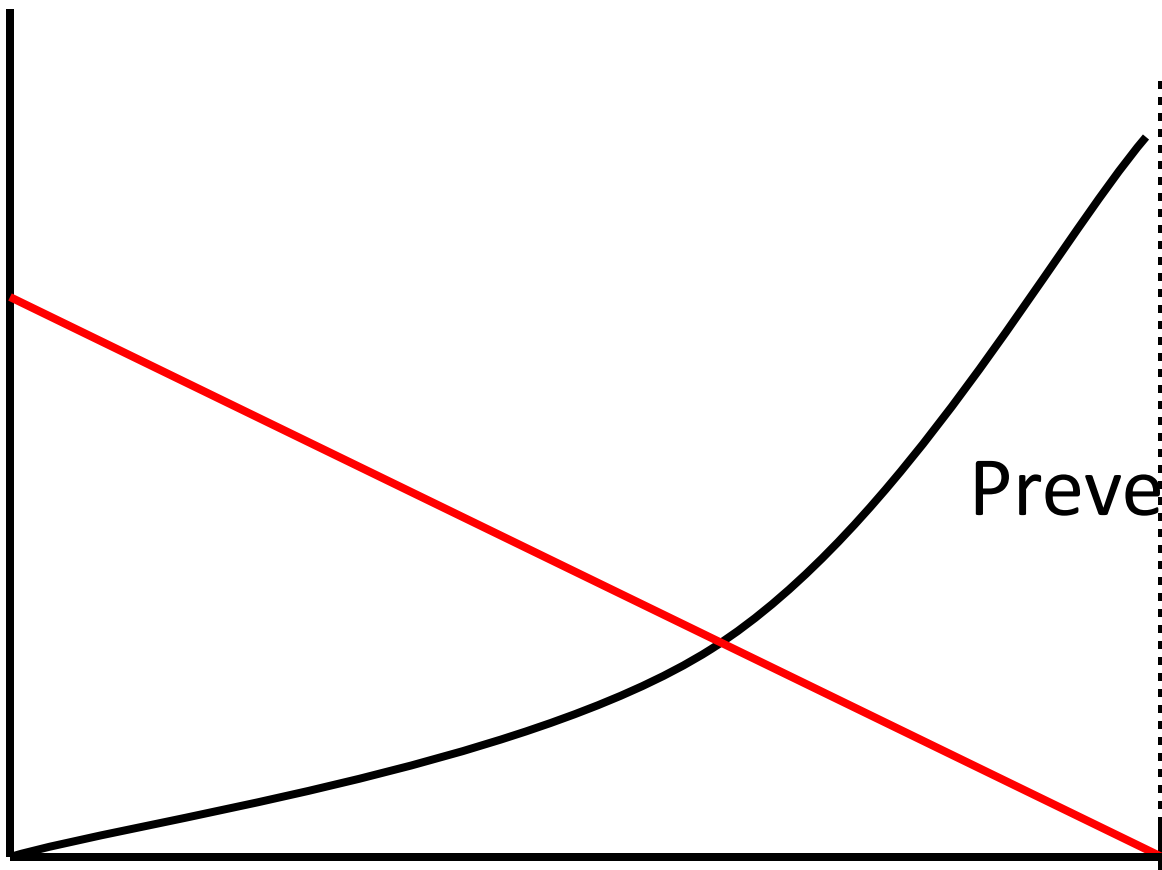
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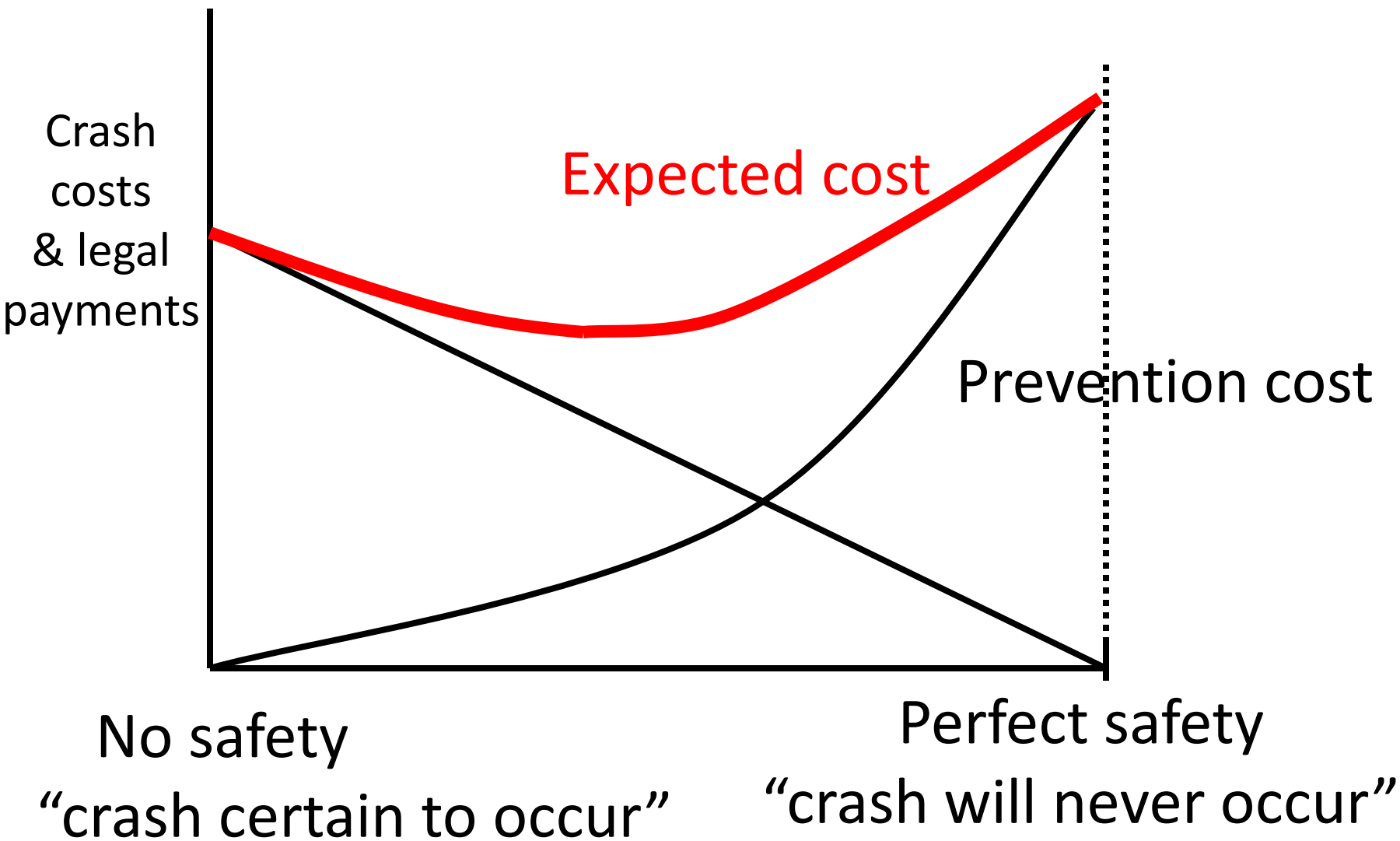
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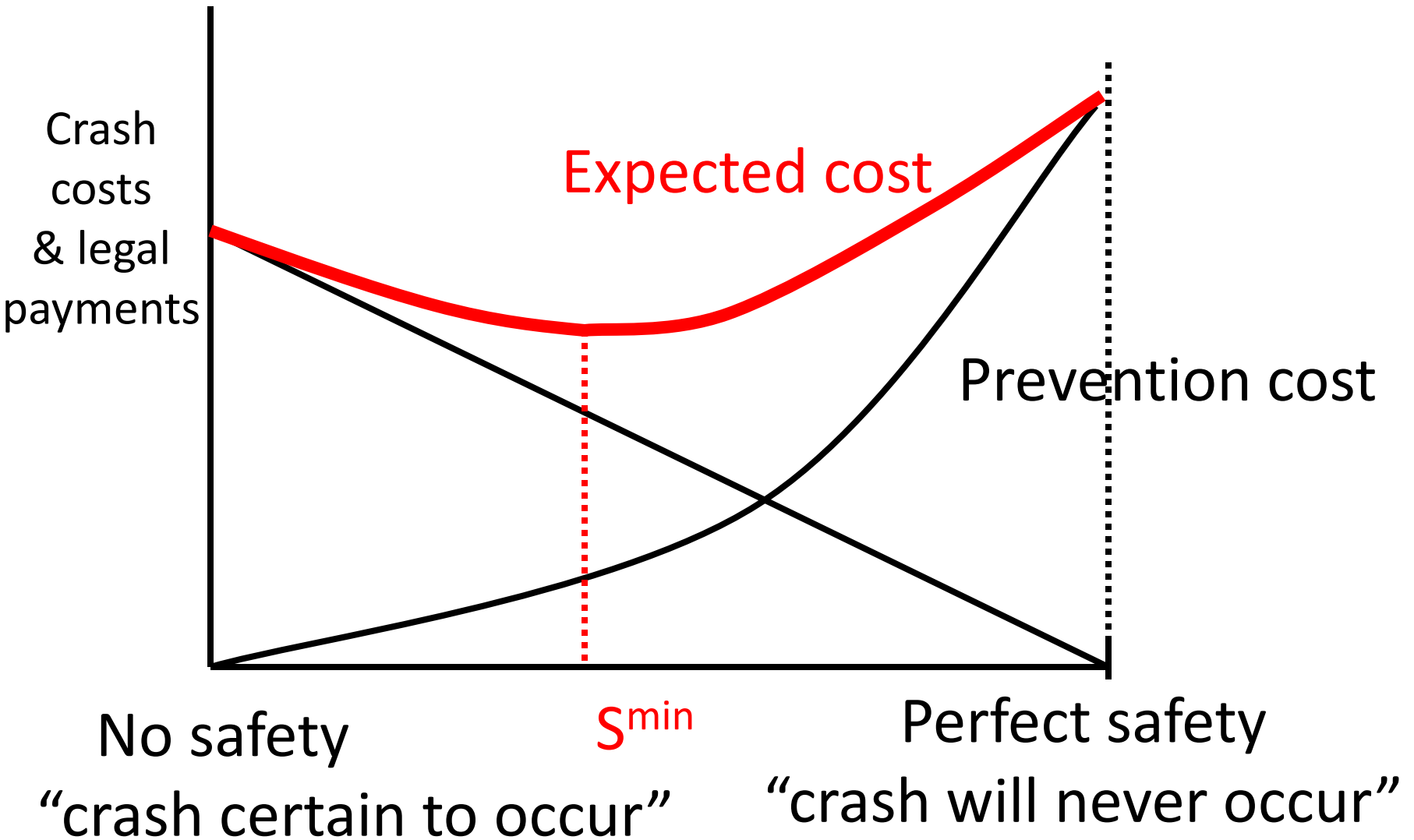
“crash will never occur”

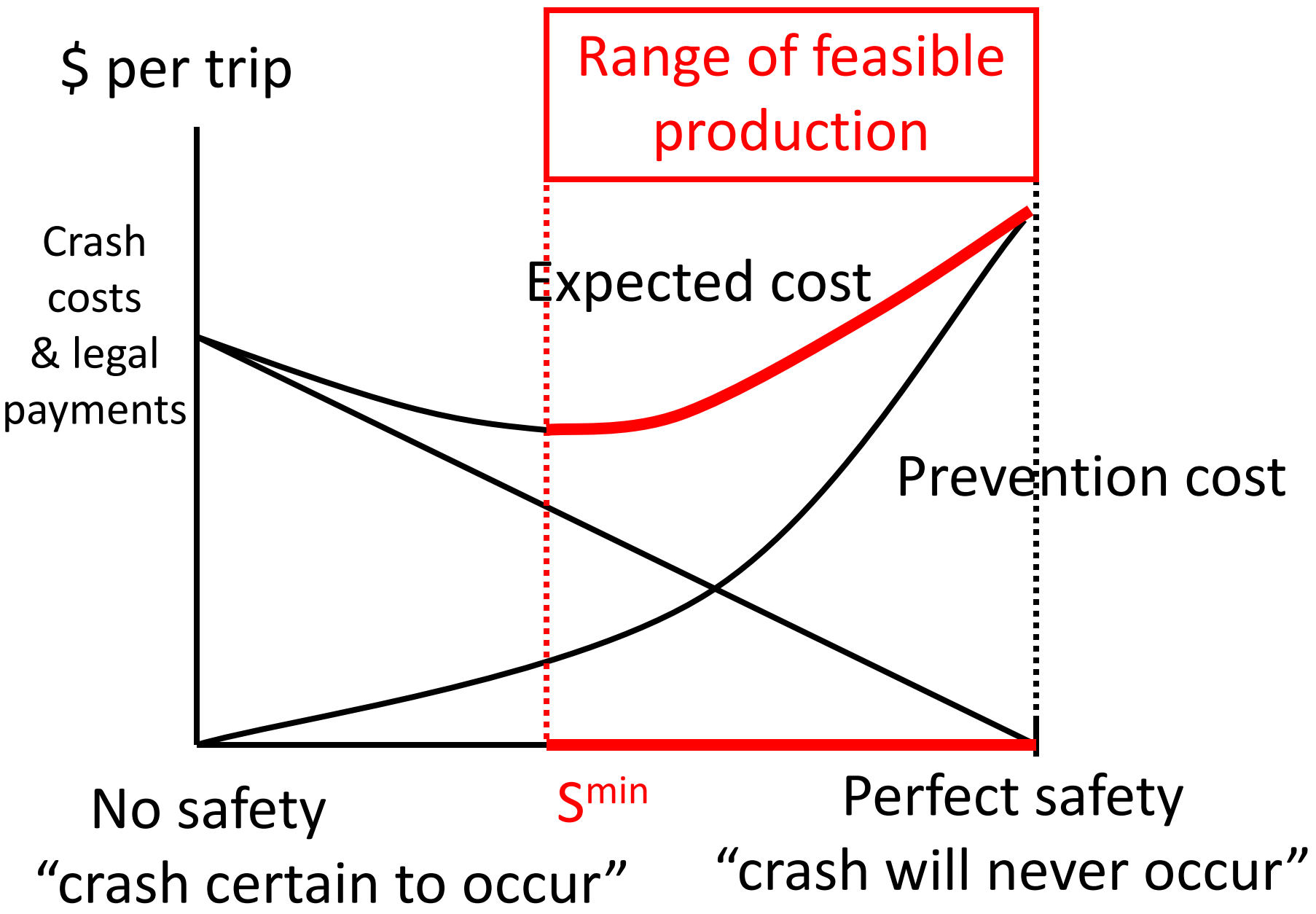


\$ per trip



\$ per trip





Benchmark model of consumers

- Many consumers
- Each buys at most one unit of travel per period of time
- Net value of non-safety attributes of transportation relative to next best consumption option varies across consumers (gives a downward sloping demand curve and a buy / don't buy decision)

Consumers' valuation of safety

- S = safety probability where $0 \leq S \leq 1$
 - 0 = crash certain to occur
 - 1 = crash will never occur

Consumers' valuation of safety

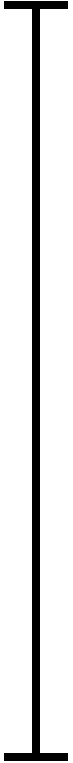
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Consumers' valuation of safety

- S = safety probability where $0 \leq S \leq 1$
 - 0 = crash certain to occur
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- $\theta_i S$ = value of safety attribute by consumer i
- $\theta_i > 0$ – everyone agrees more safety is better than less safety
- But some consumers value it more than others

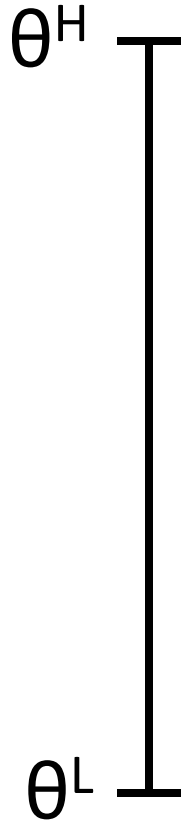
Valuation (θ_i)

θ^H



θ^L

Valuation (θ_i)

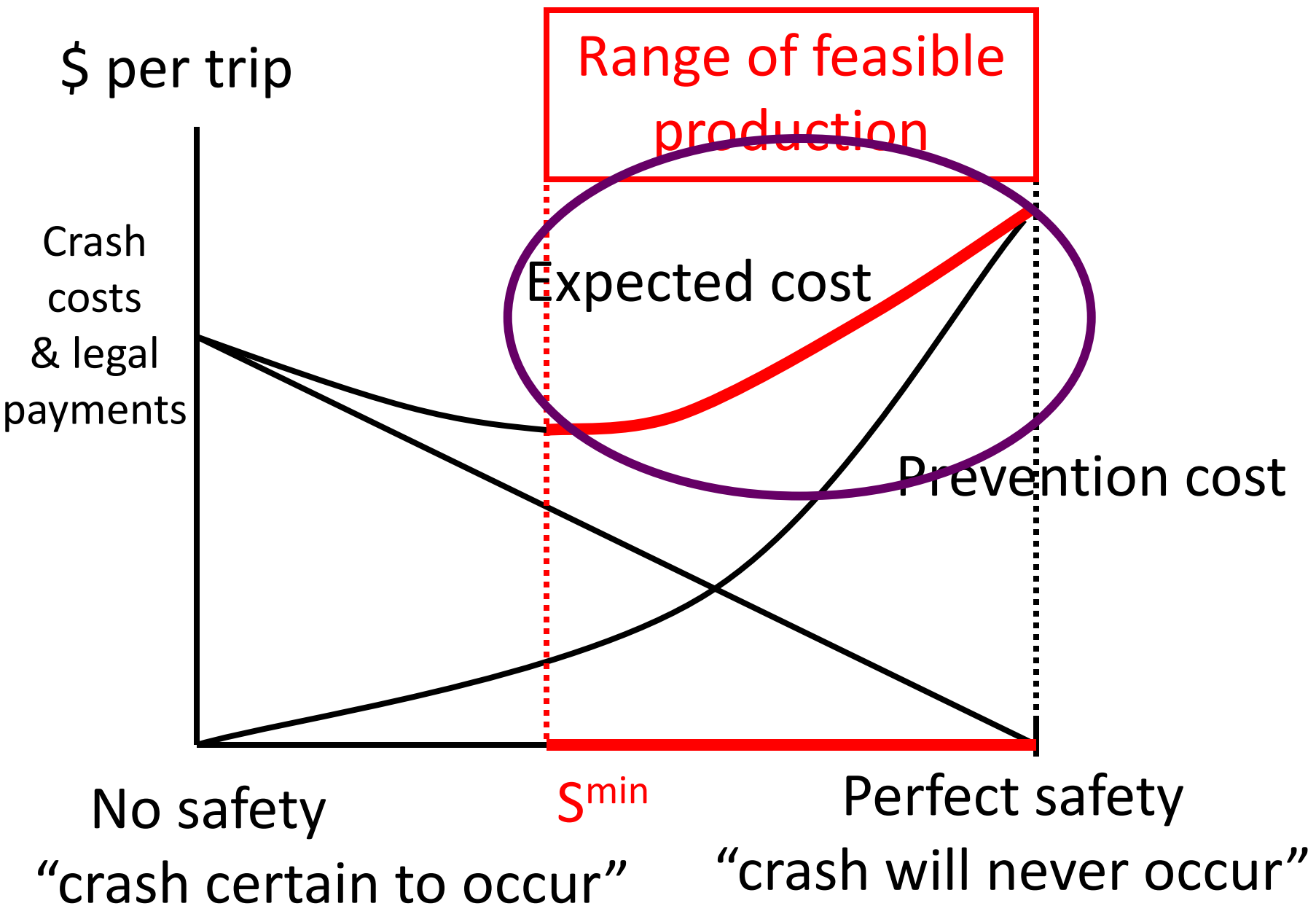


We don't know the range or distribution of θ_i

- For passengers (excepting some measure of central tendency – Value of a Statistical Life)
- Or for freight

Benchmark model

- Obtain a marginal cost of safety



\$ per trip

Crash costs & legal payments

Range of feasible production

Expected cost

Prevention cost

No safety

s_{min}

Perfect safety

“crash certain to occur”

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\$



S_{min}

Safety

Perfect safety

“crash will never occur”

\$



MC(S)

S^{min}

Safety

Perfect safety

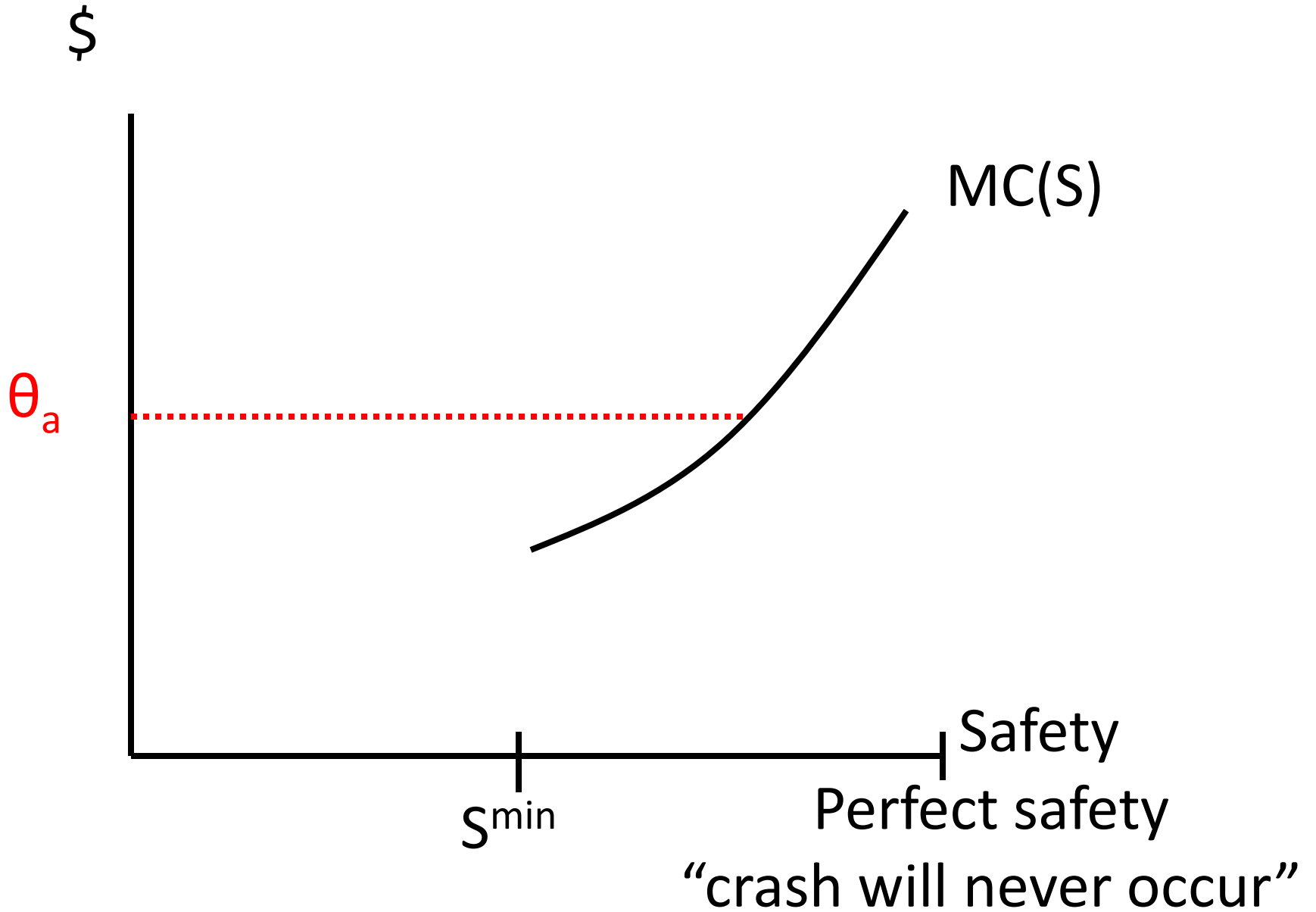
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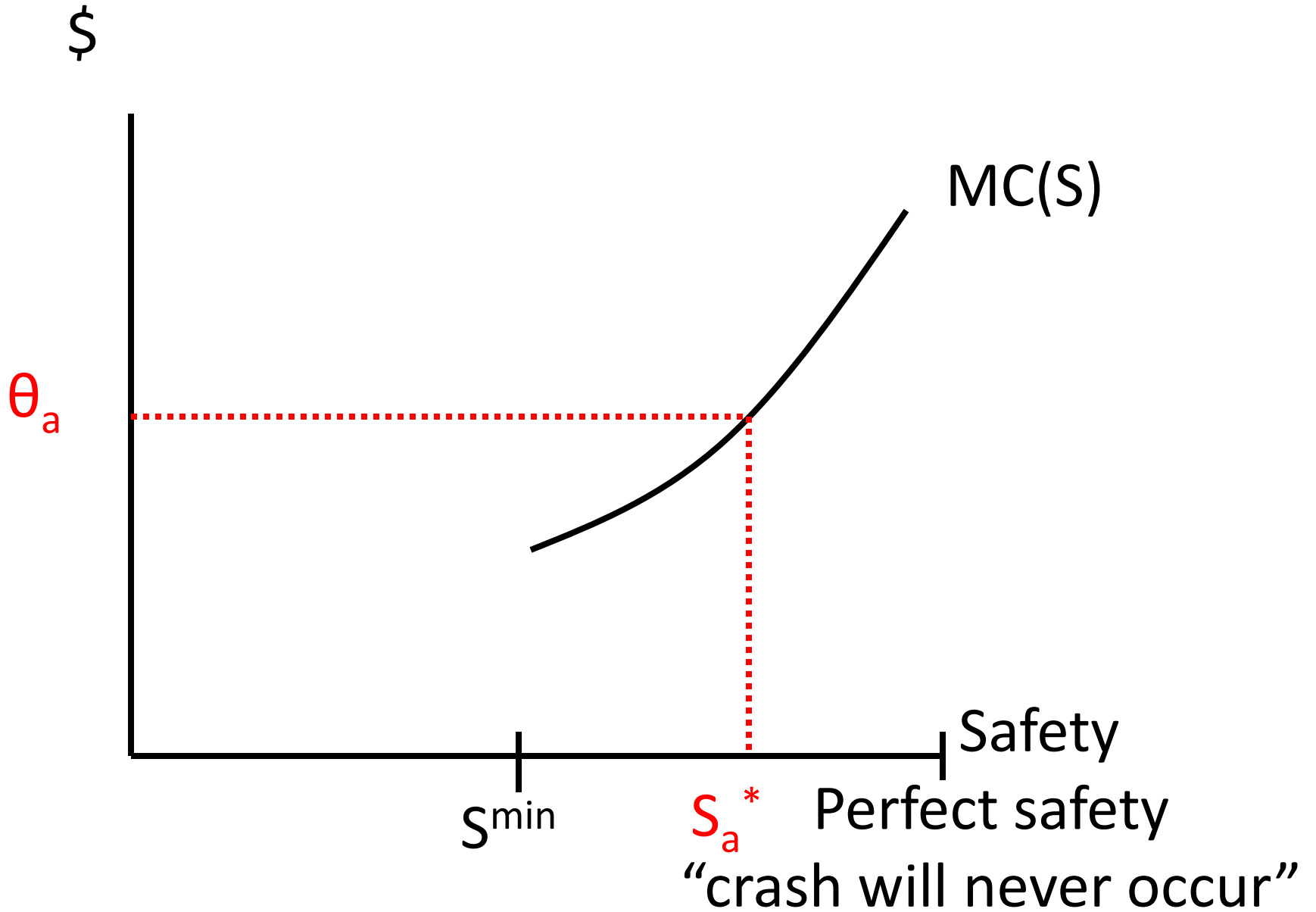
Benchmark model

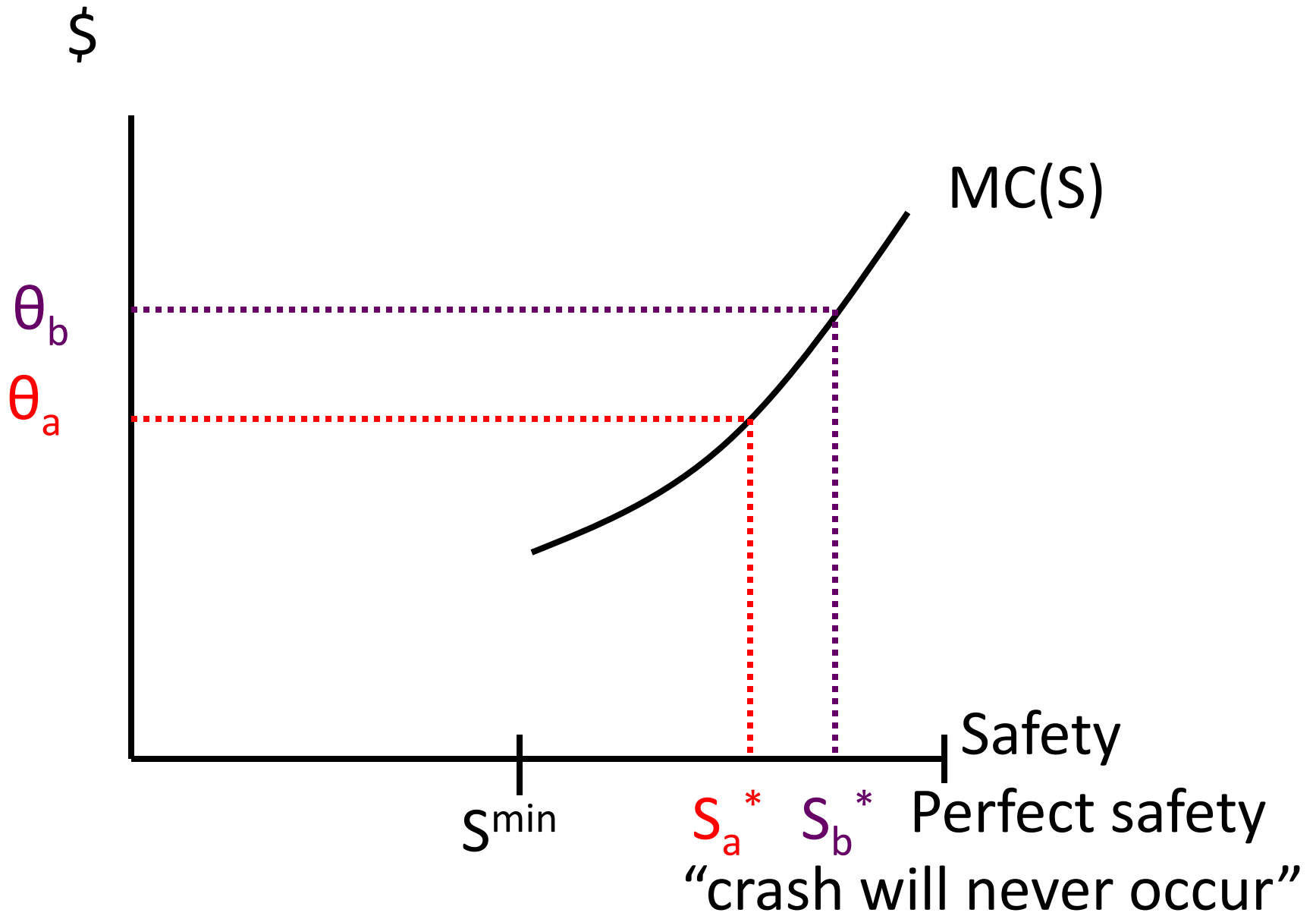
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- Benchmark model has price competed downward to marginal cost

Benchmark model

- Obtain a marginal cost of safety
- Benchmark model has price competed downward to marginal cost
- Consumers will purchase more safety until their θ_i just equals the “marginal price” of the increment of safety

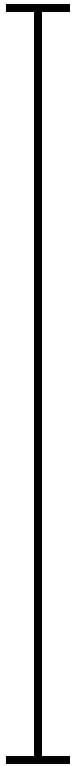






Valuation (θ_i)

θ^H



θ^L

Safety (S)



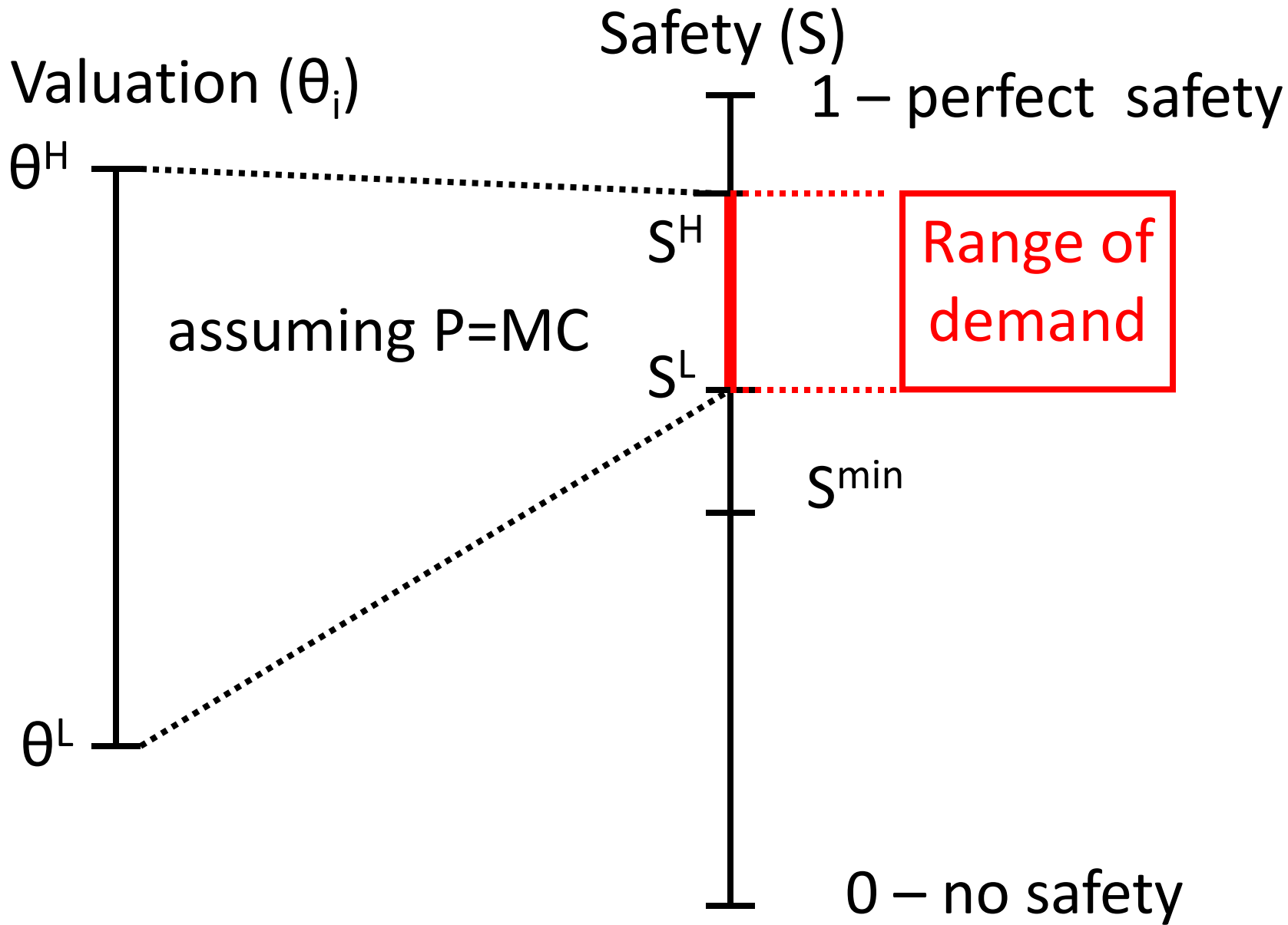
1 – perfect safety



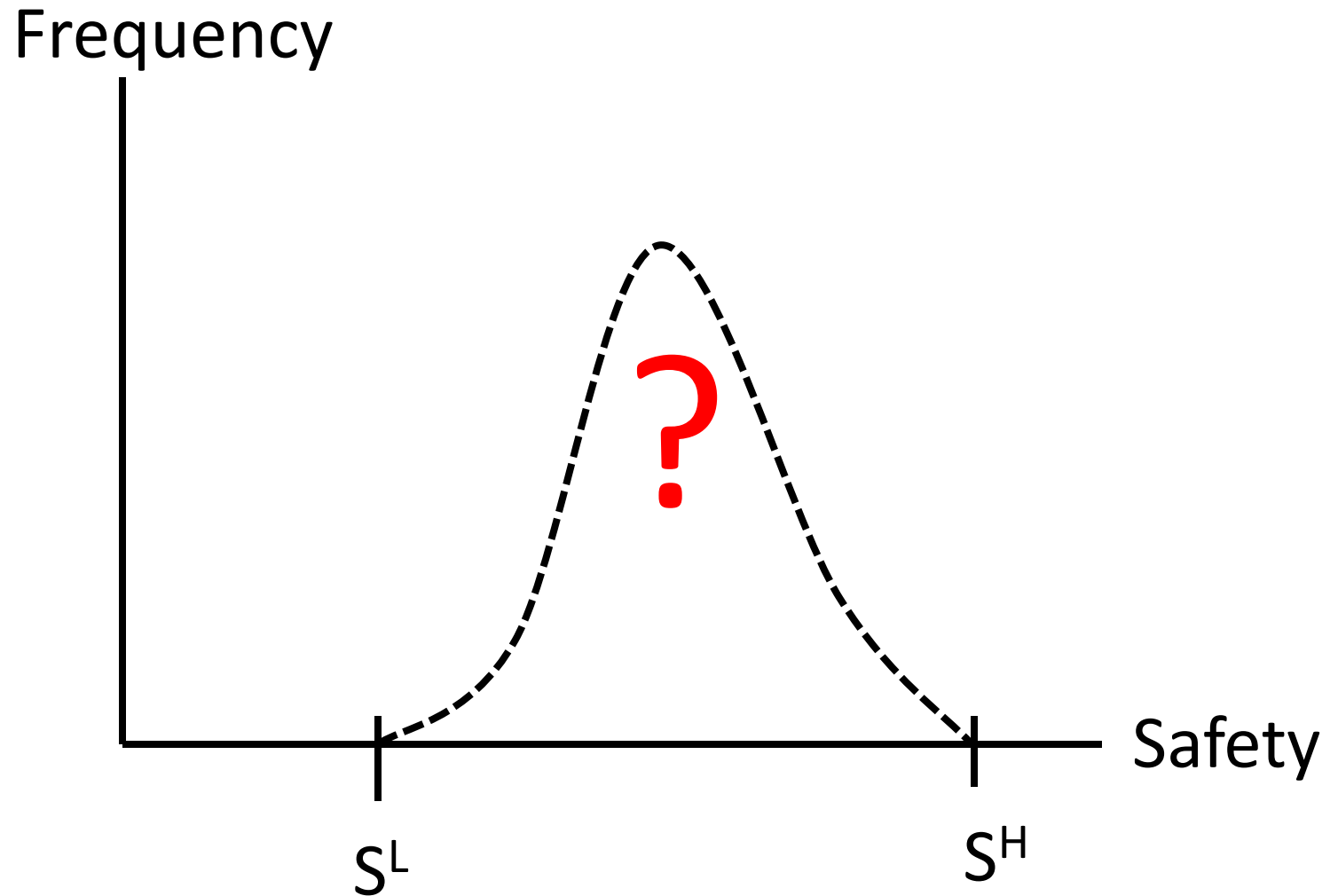
S^{\min}



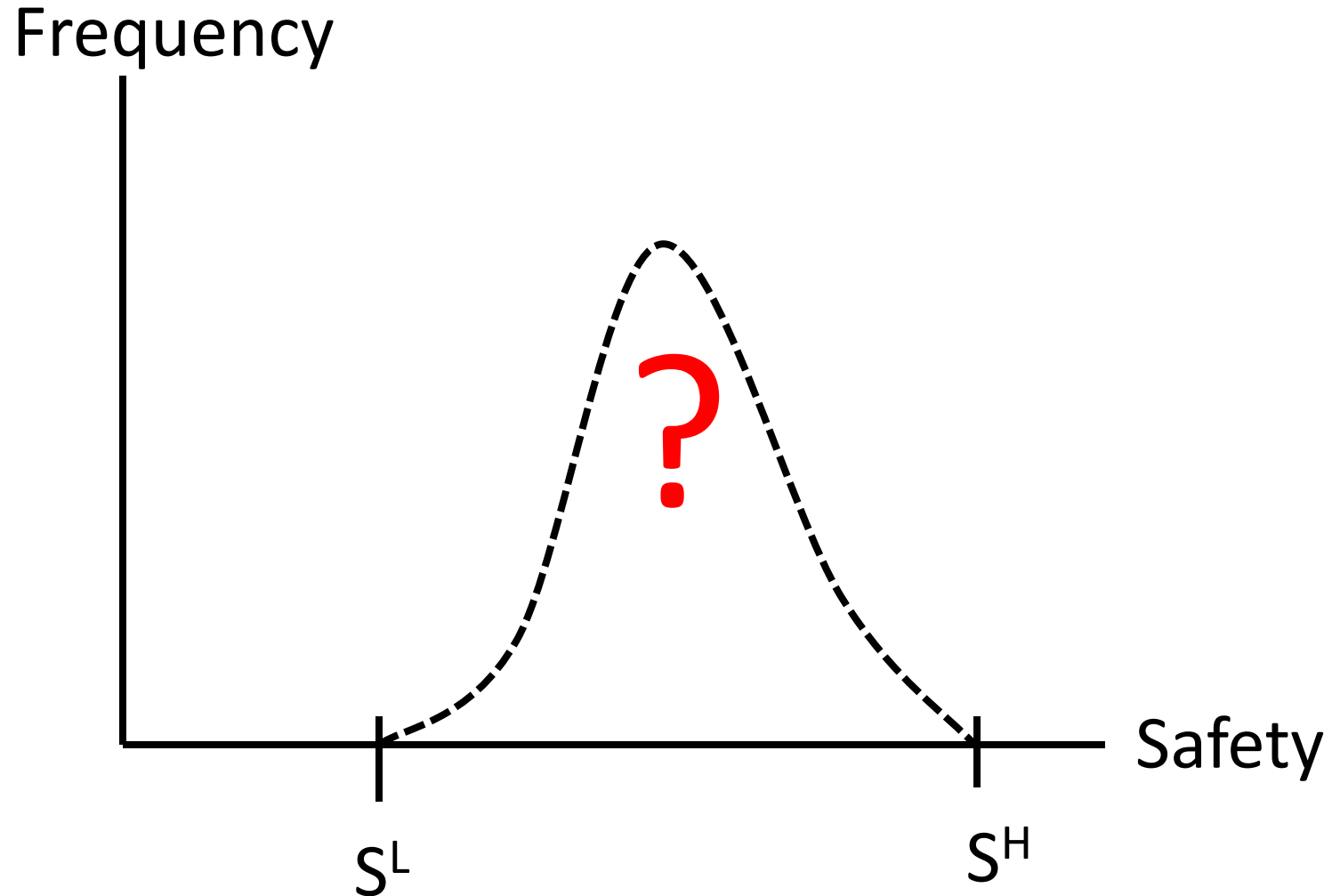
0 – no safety



Distribution of consumers

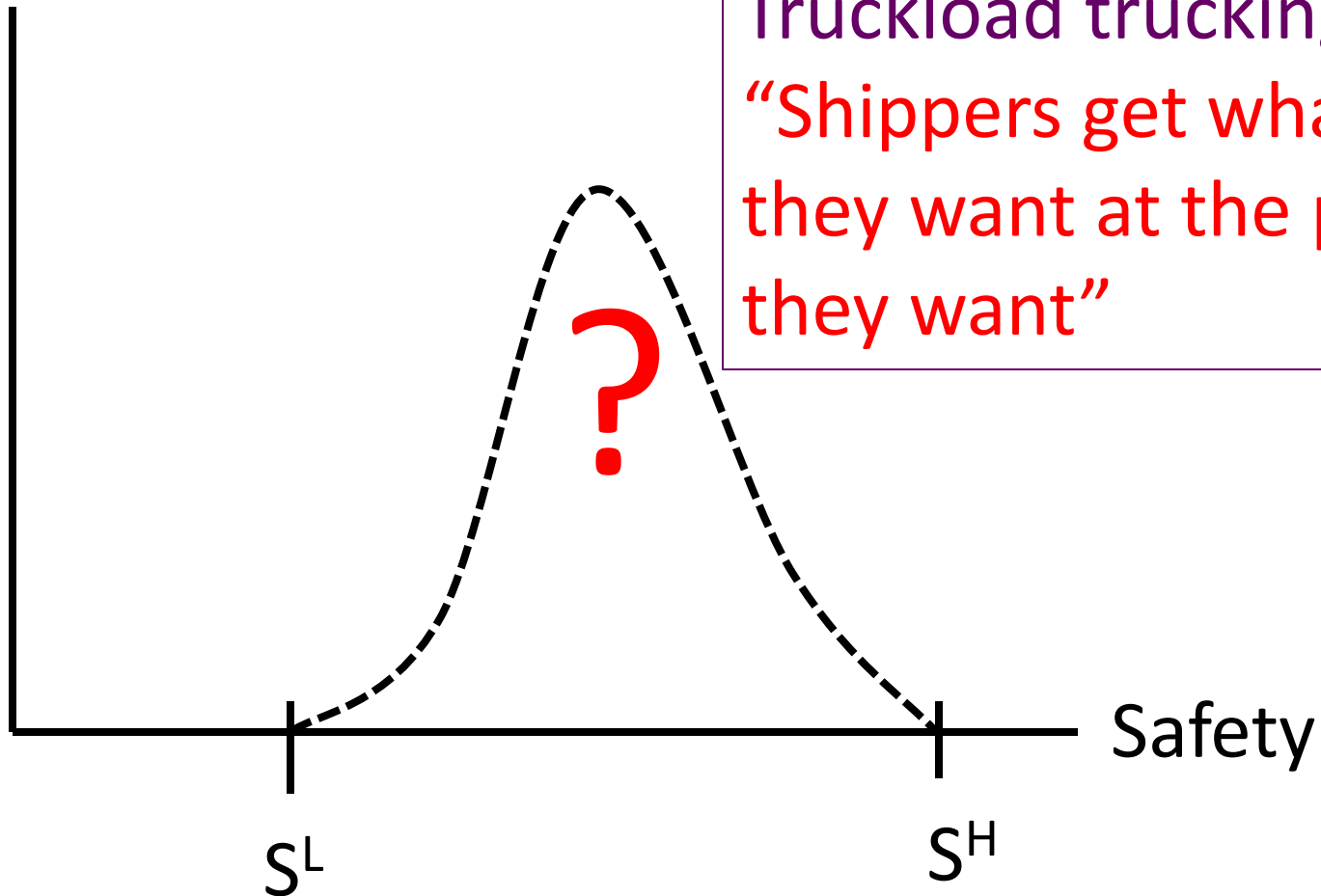


In a functioning competitive market carriers position themselves to satisfy consumer tastes



In a functioning competitive market carriers position themselves to satisfy consumer tastes

Frequency



Truckload trucking:
"Shippers get what
they want at the price
they want"

Imperfect competition

- In many modes “economies of density” limit the number of competitors

Imperfect competition

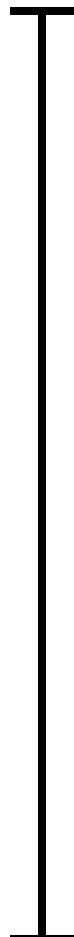
- In many modes “economies of density” limit the number of competitors
- “Lumpy” supply means that many passengers and also shippers with varied tastes have to share the same vehicle/train/plane/ship

Imperfect competition

- In many modes “economies of density” limit the number of competitors
- “Lumpy” supply means that many passengers and also shippers with varied tastes have to share the same vehicle/train/plane/ship
- Implies limited safety choices – “one size fits all”

Valuation (θ_i)

θ^H



θ^L

Valuation (θ_i)

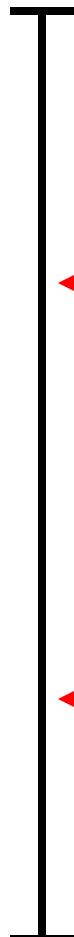
θ^H

safety differentiation
to blunt price
competition

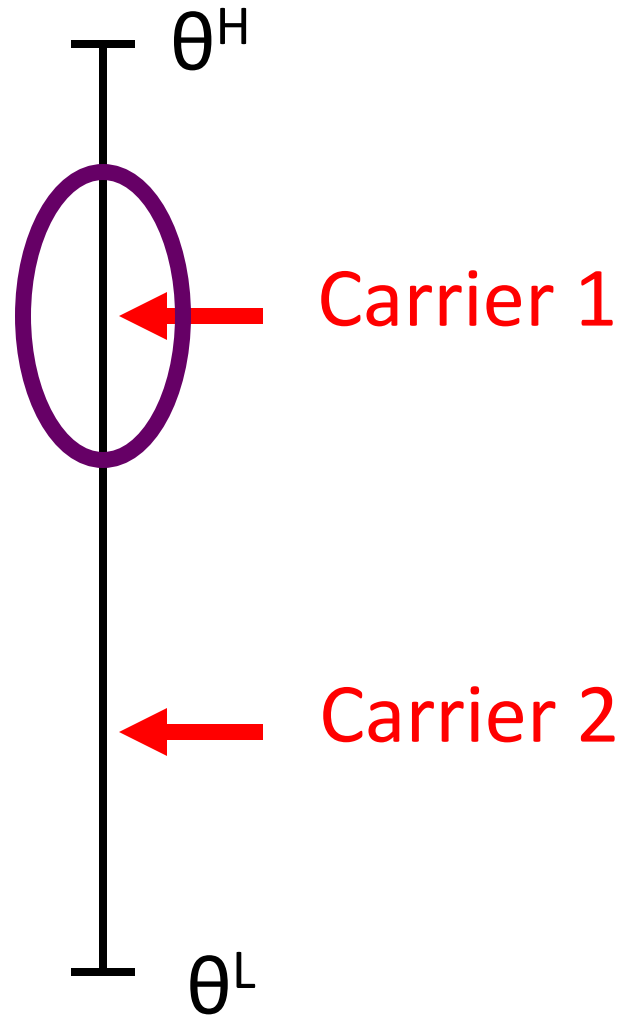
← Carrier 1
(higher safety
& higher price)

← Carrier 2

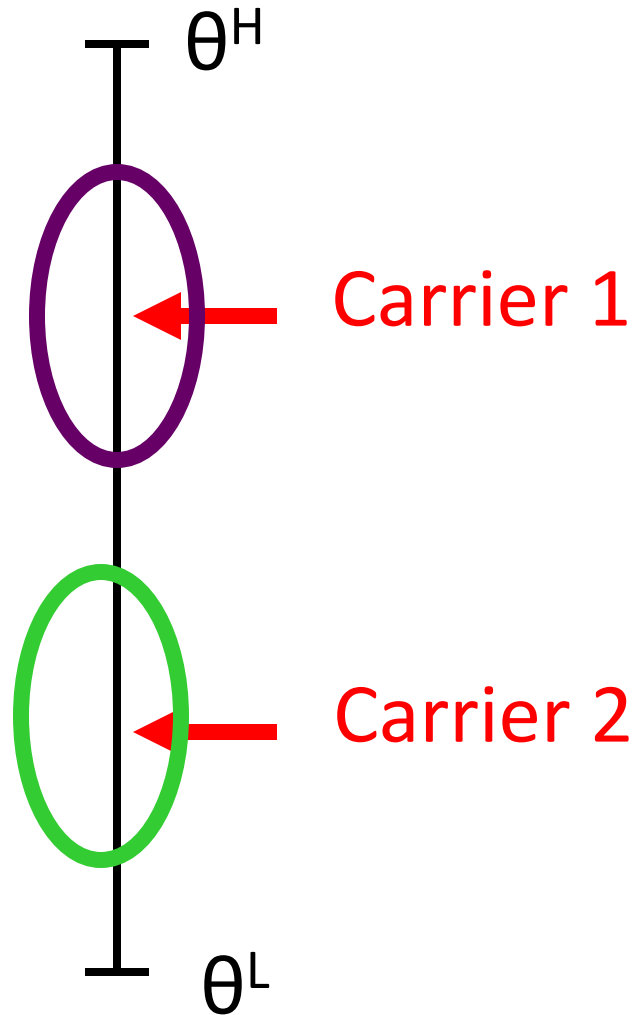
θ^L



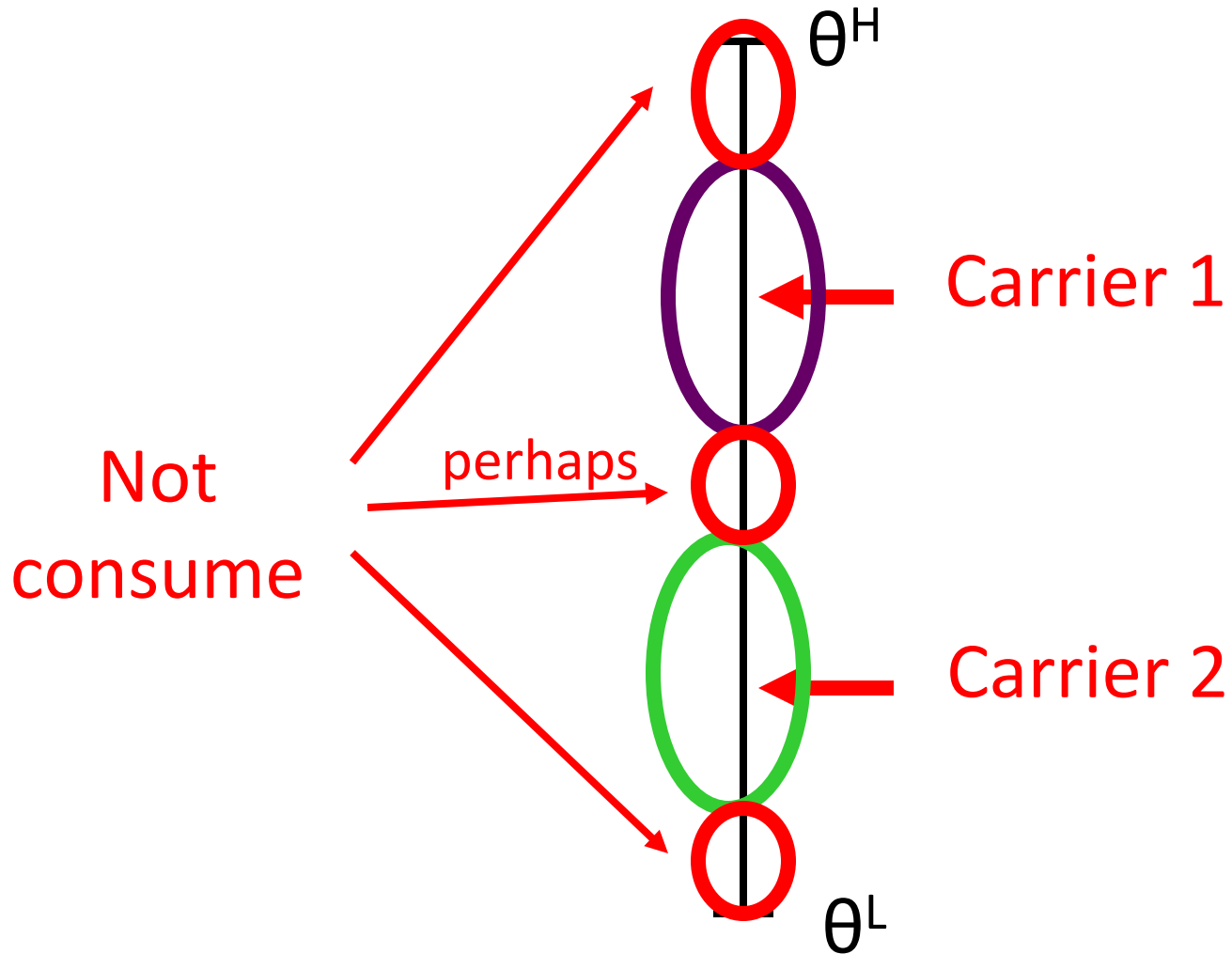
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Implications

- Consumers may rationally choose less than perfect safety

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Implications

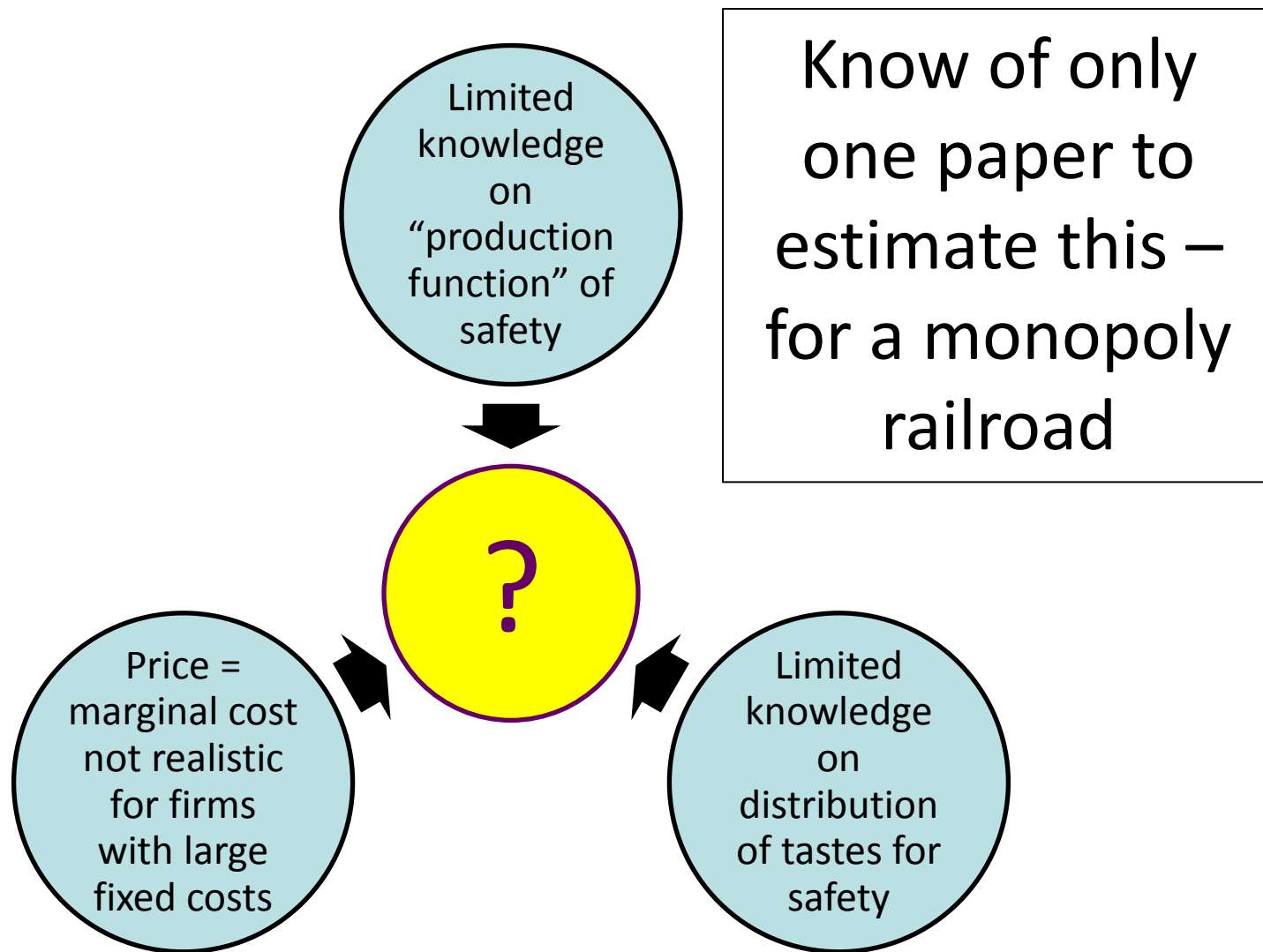
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Implications

- Consumers may rationally choose less than perfect safety
- Higher-safety and lower-safety options may optimally co-exist
- Diversity of safety offerings may be a sign that the market works not a sign of market failure
- Lower safety offerings reflect lower taste for safety by some shippers and passengers

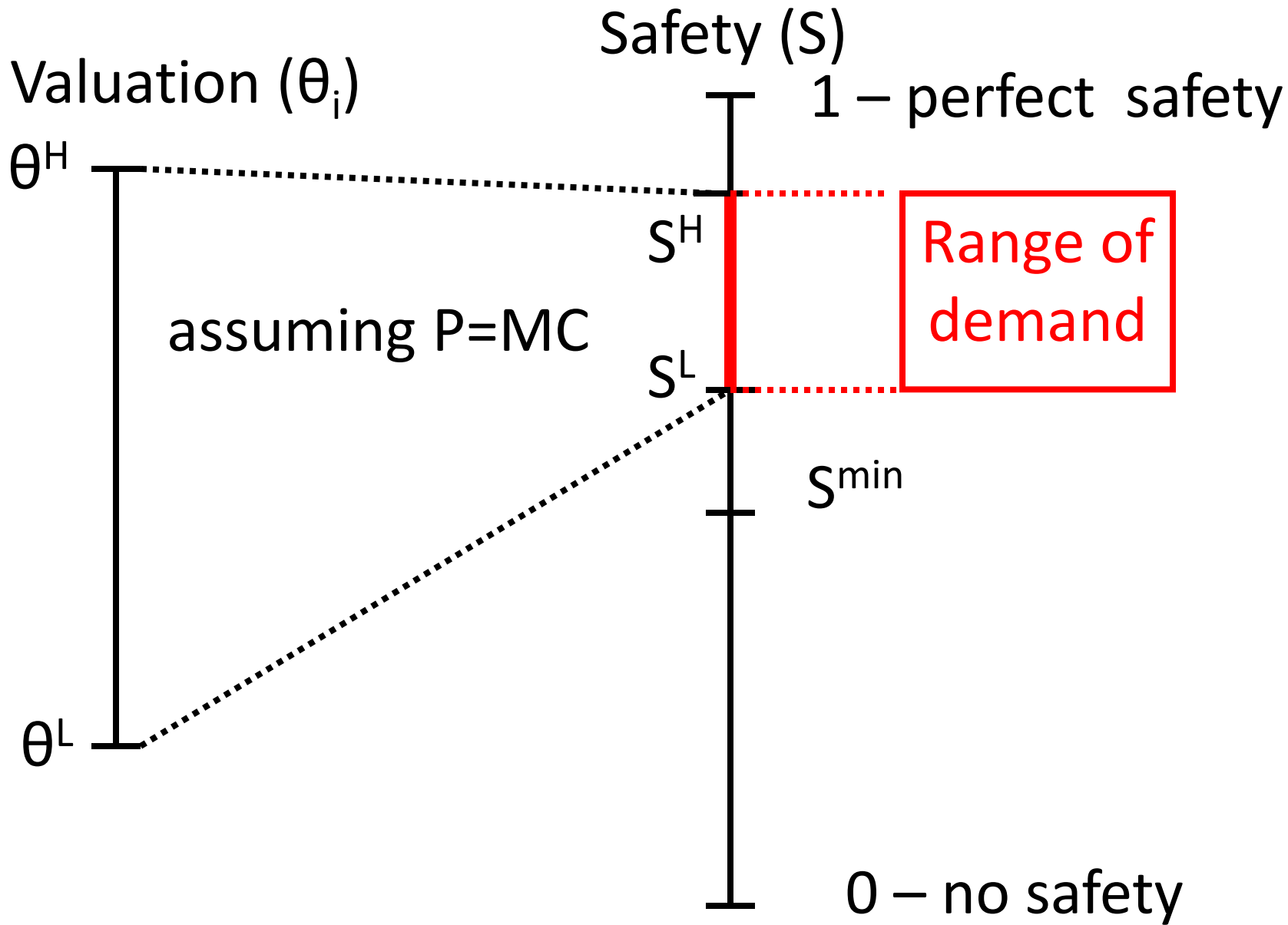
How much safety?

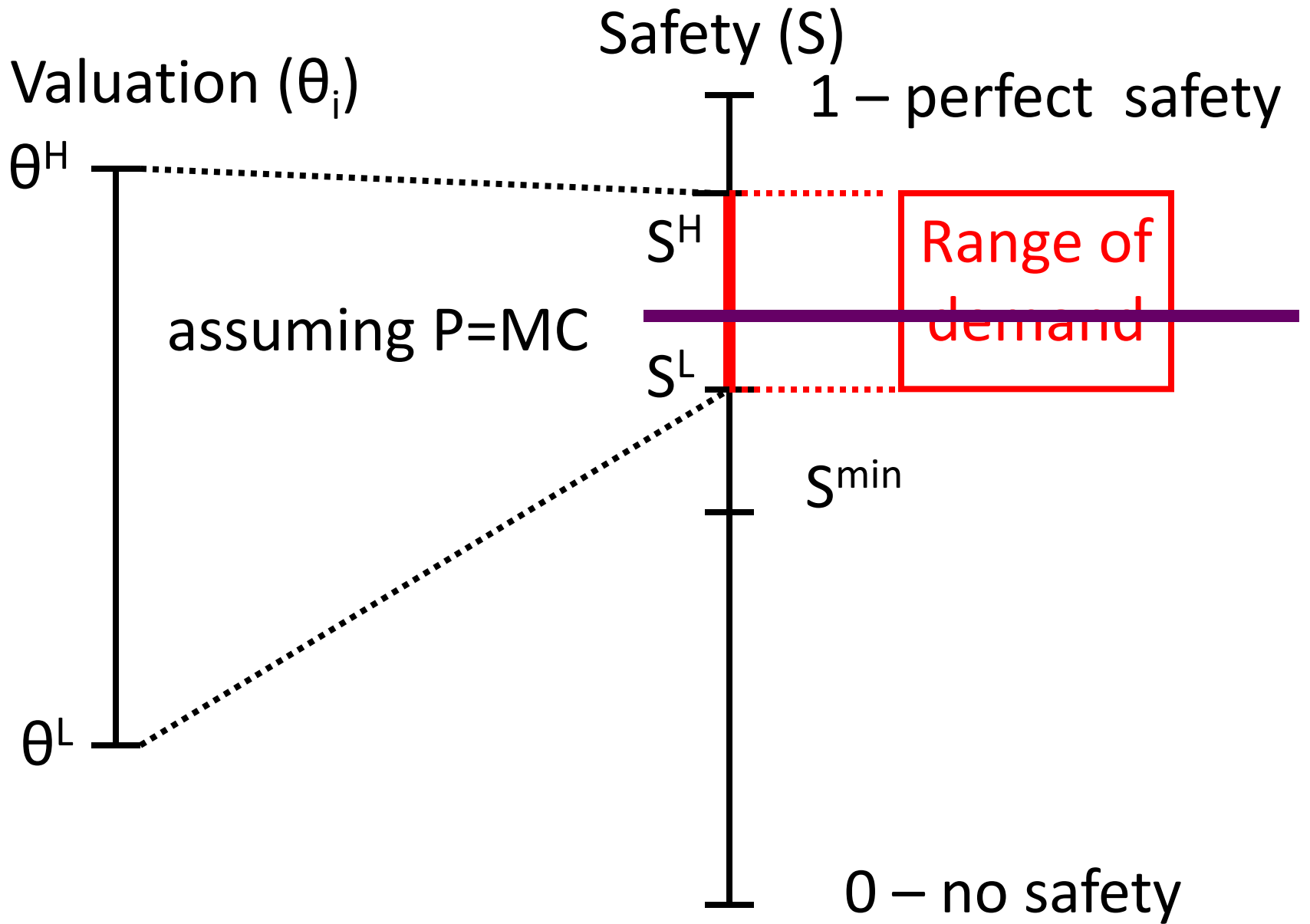
How much safety? - who knows!

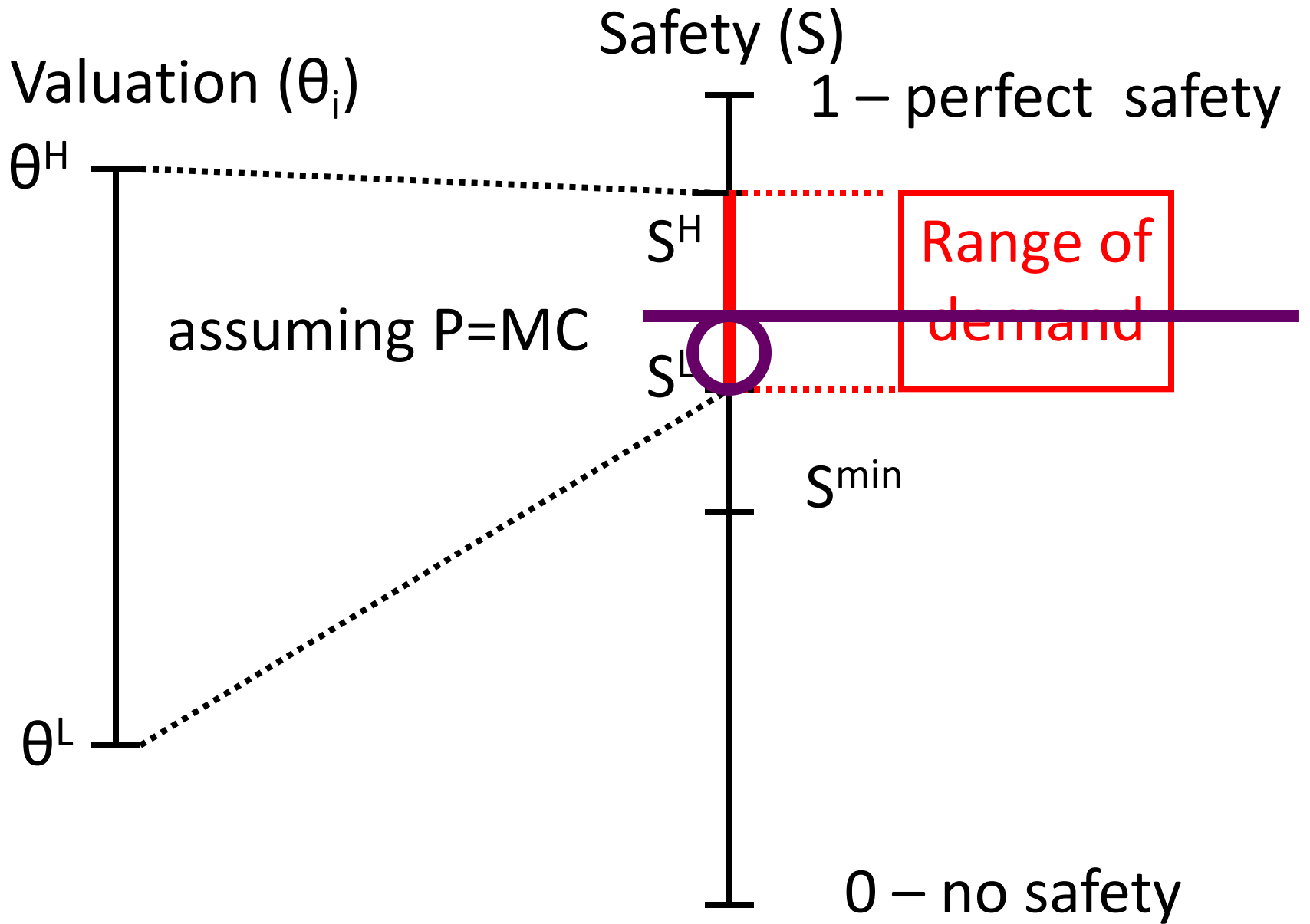


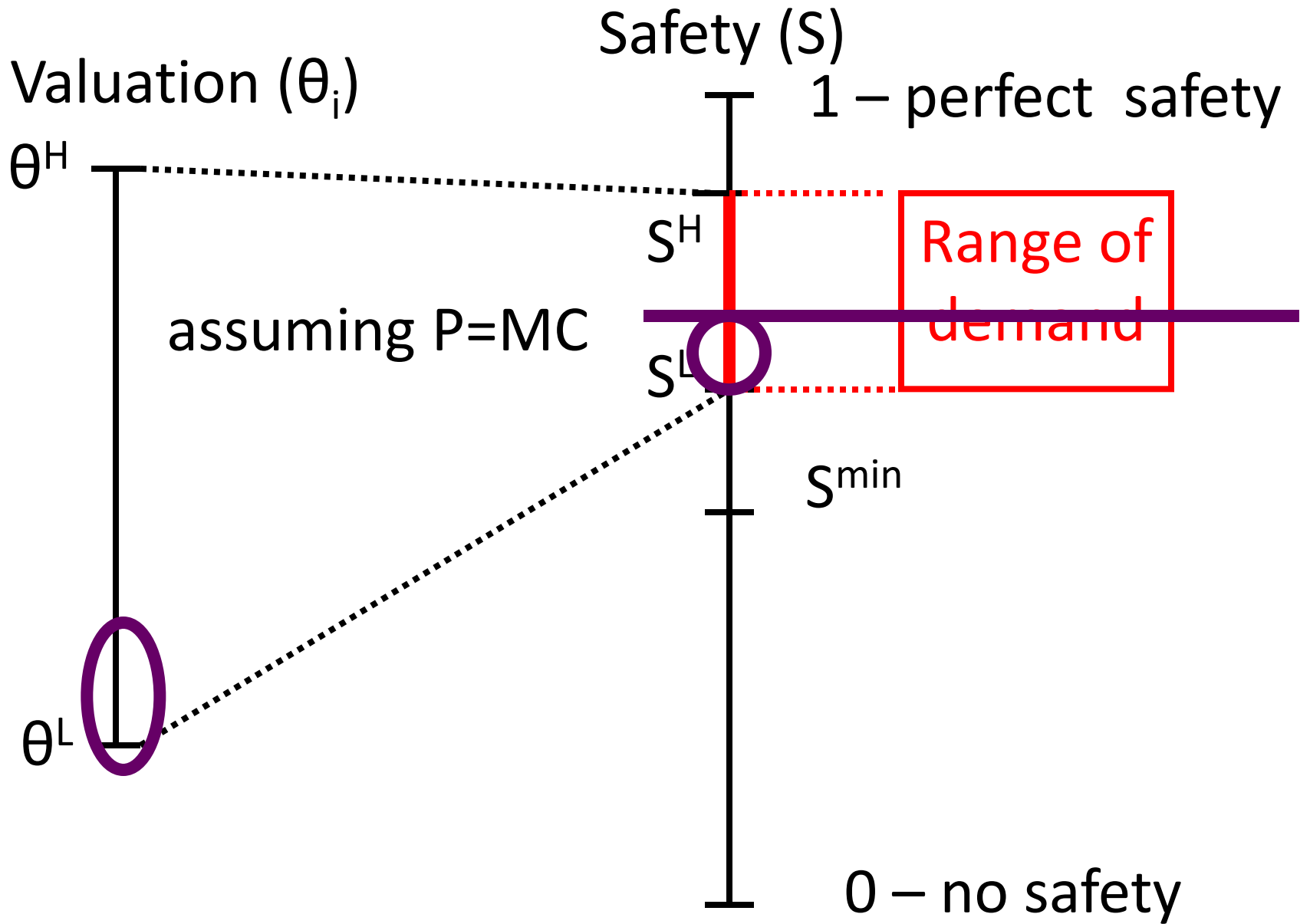
Part 3

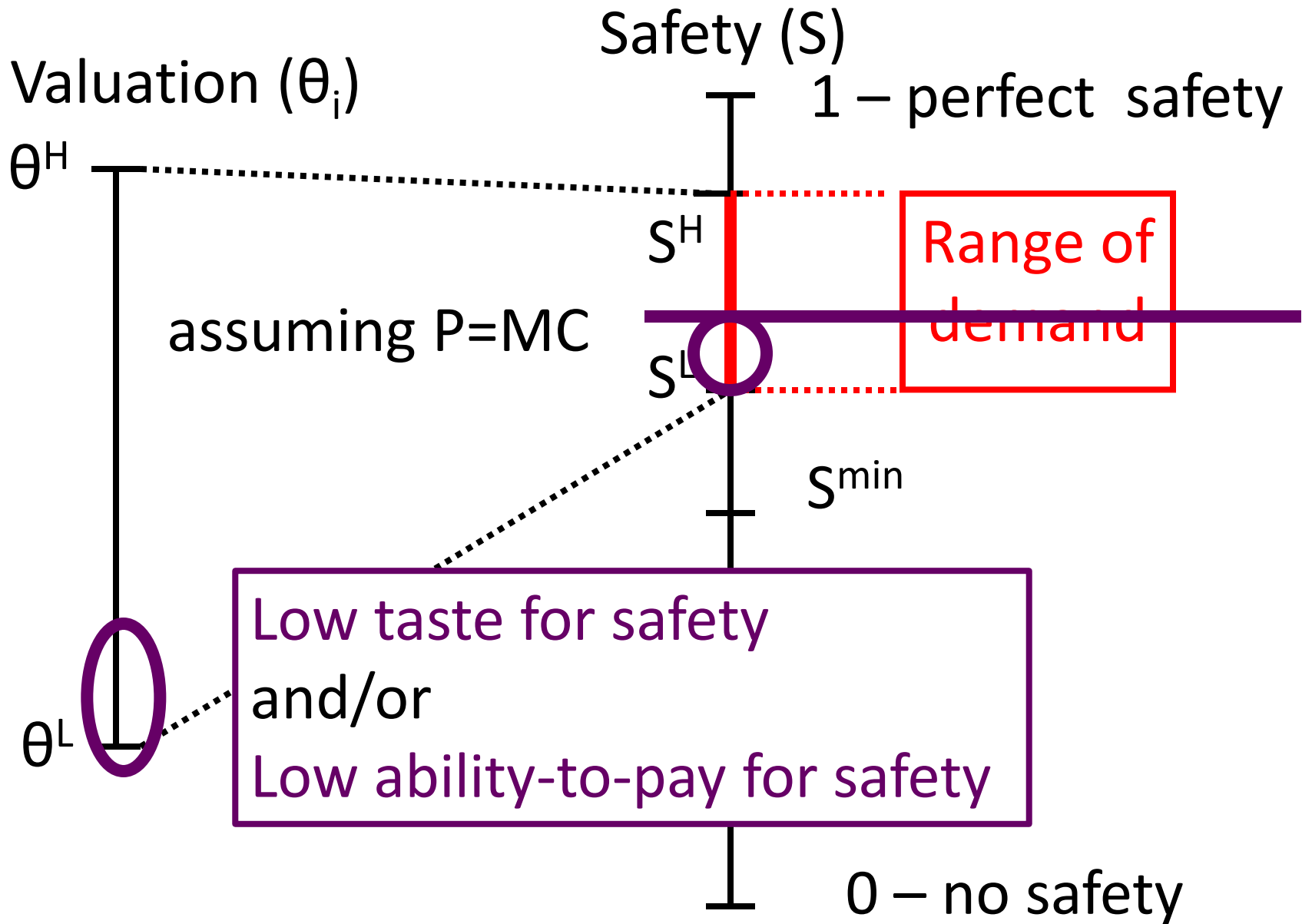
“Intolerable risk”











Part 4

Deviations from the
(unknown) optimal level(s)

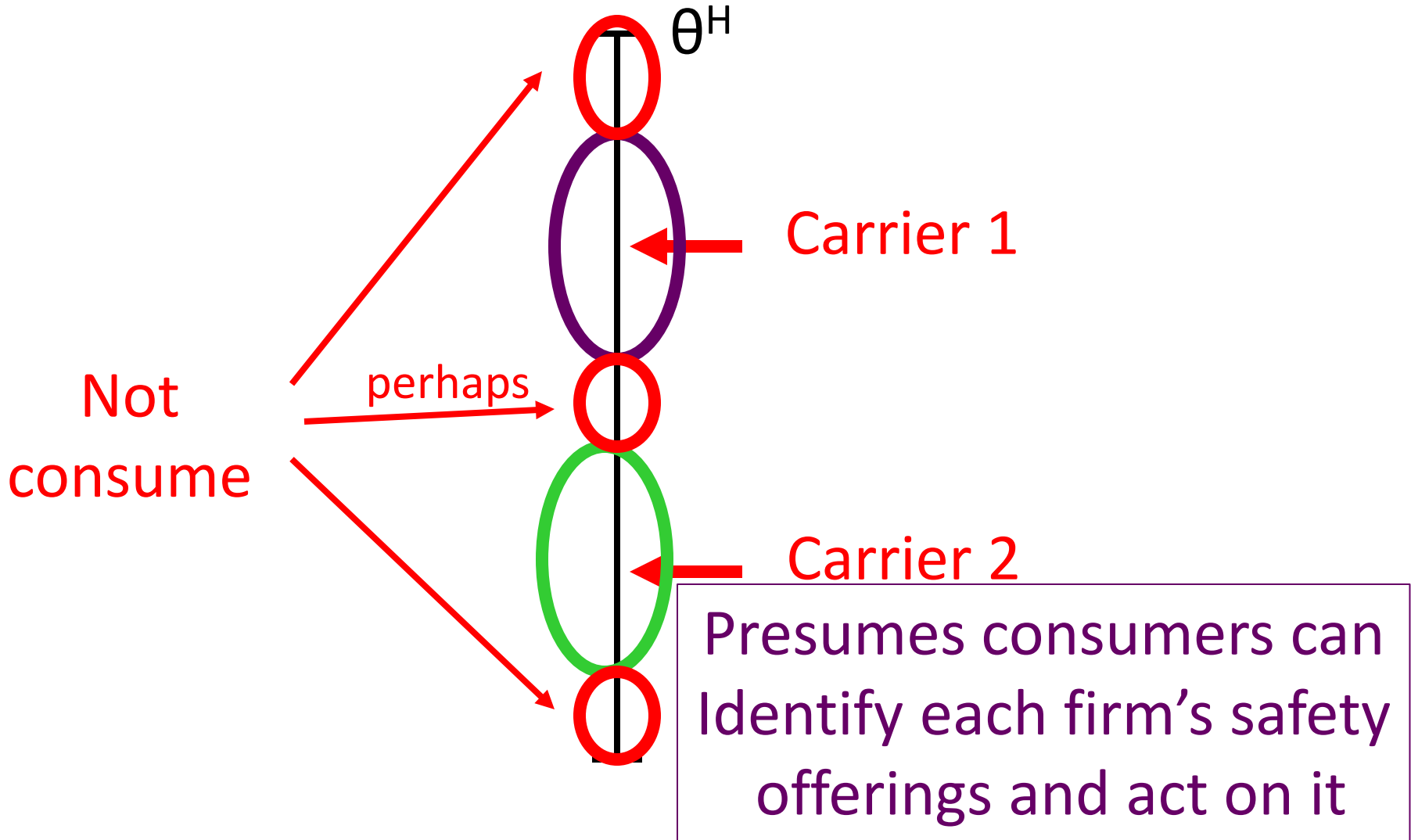
Assumptions for ideal marketplace

- Many carriers and $P=MC$

Assumptions for ideal marketplace

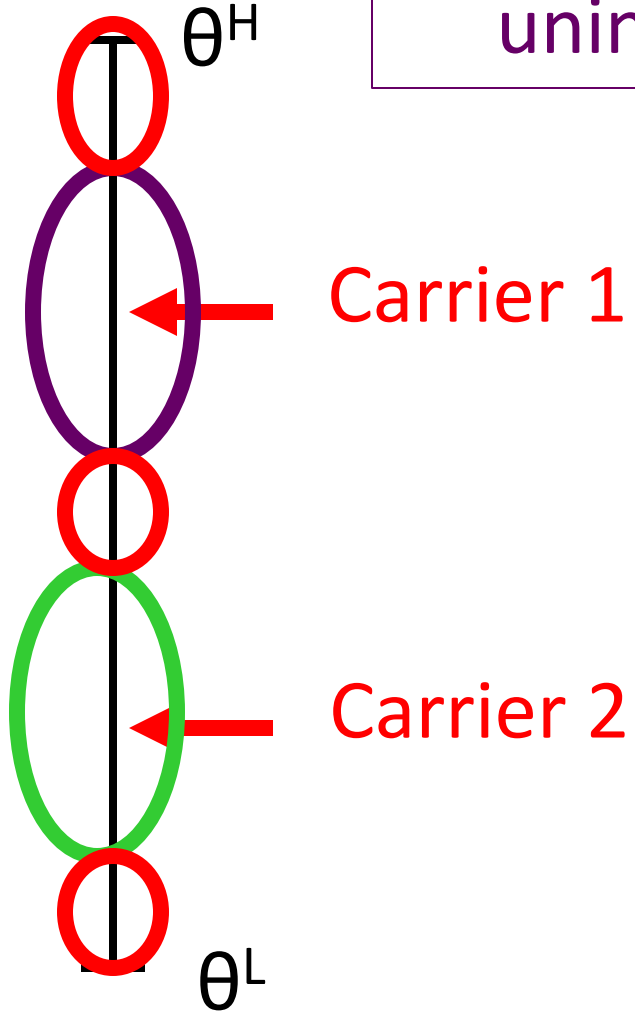
- Many carriers and $P=MC$
- Consumers are fully informed
- Consumers can make rational choices

Valuation (θ_i)



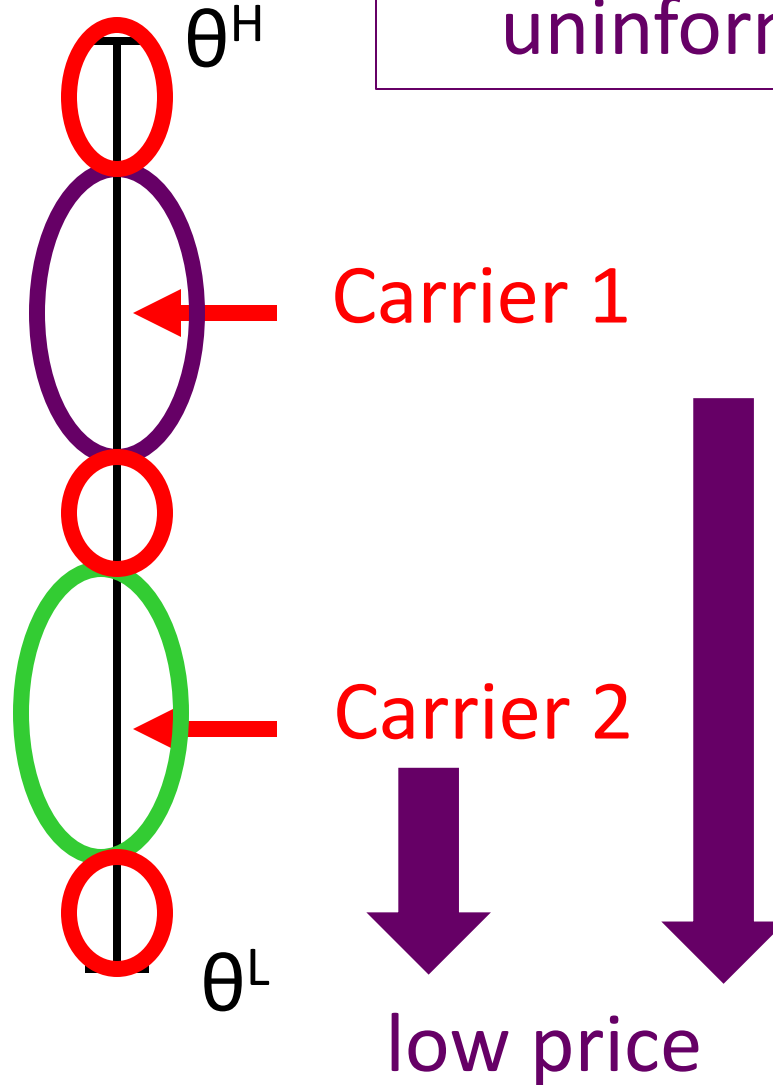
What if consumers were totally uninformed?

Valuation (θ_i)



Valuation (θ_i)

What if consumers were totally uninformed?



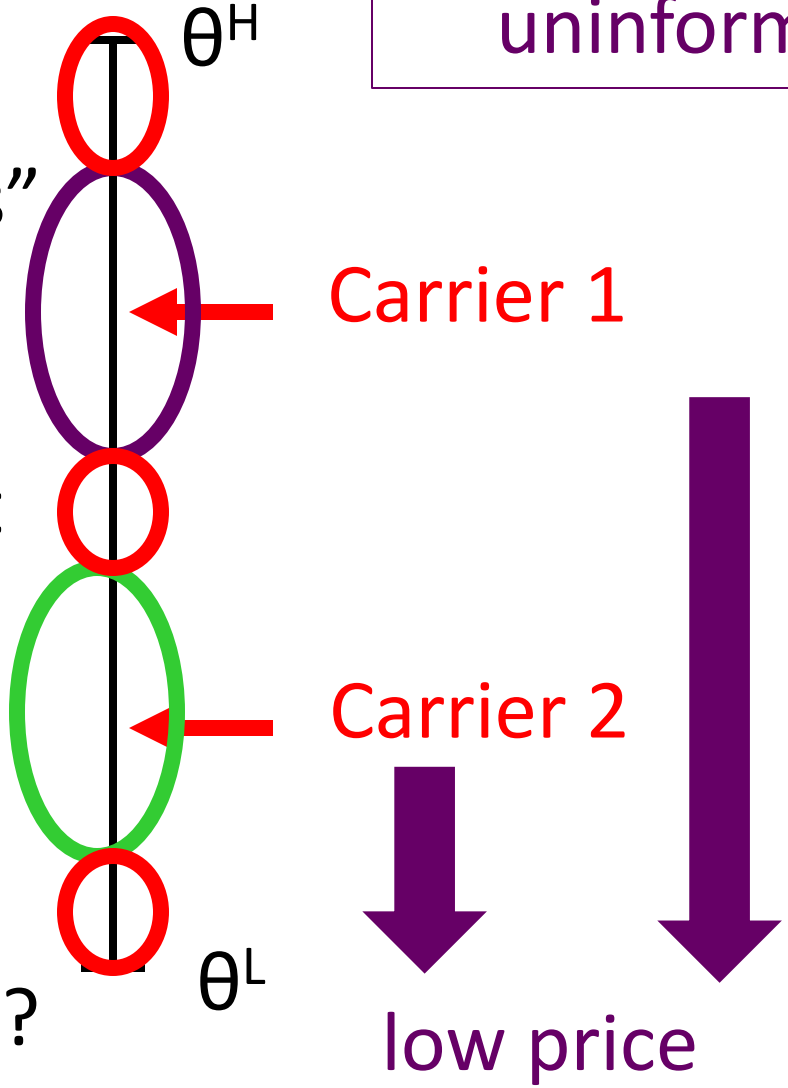
What if consumers were totally uninformed?

Valuation (θ_i)

Constrained if consumers can identify "notorious" carriers

But how and what do consumers learn?

How do carriers signal "high safety"?



Much dispersion

- many carriers
- consumers have varied tastes
- consumers are not bundled together
- consumers are well informed
- “vertical differentiation”

Much dispersion

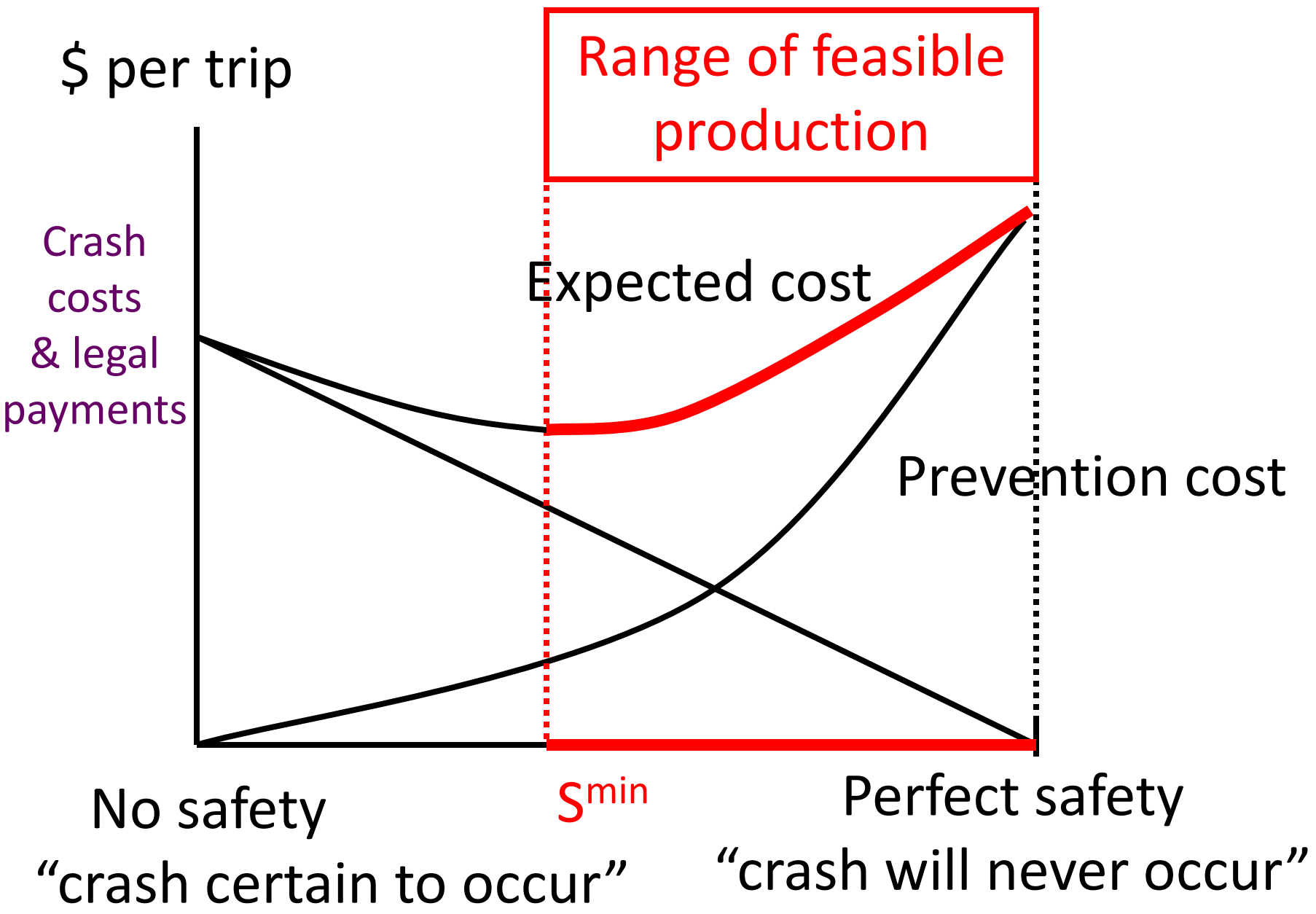
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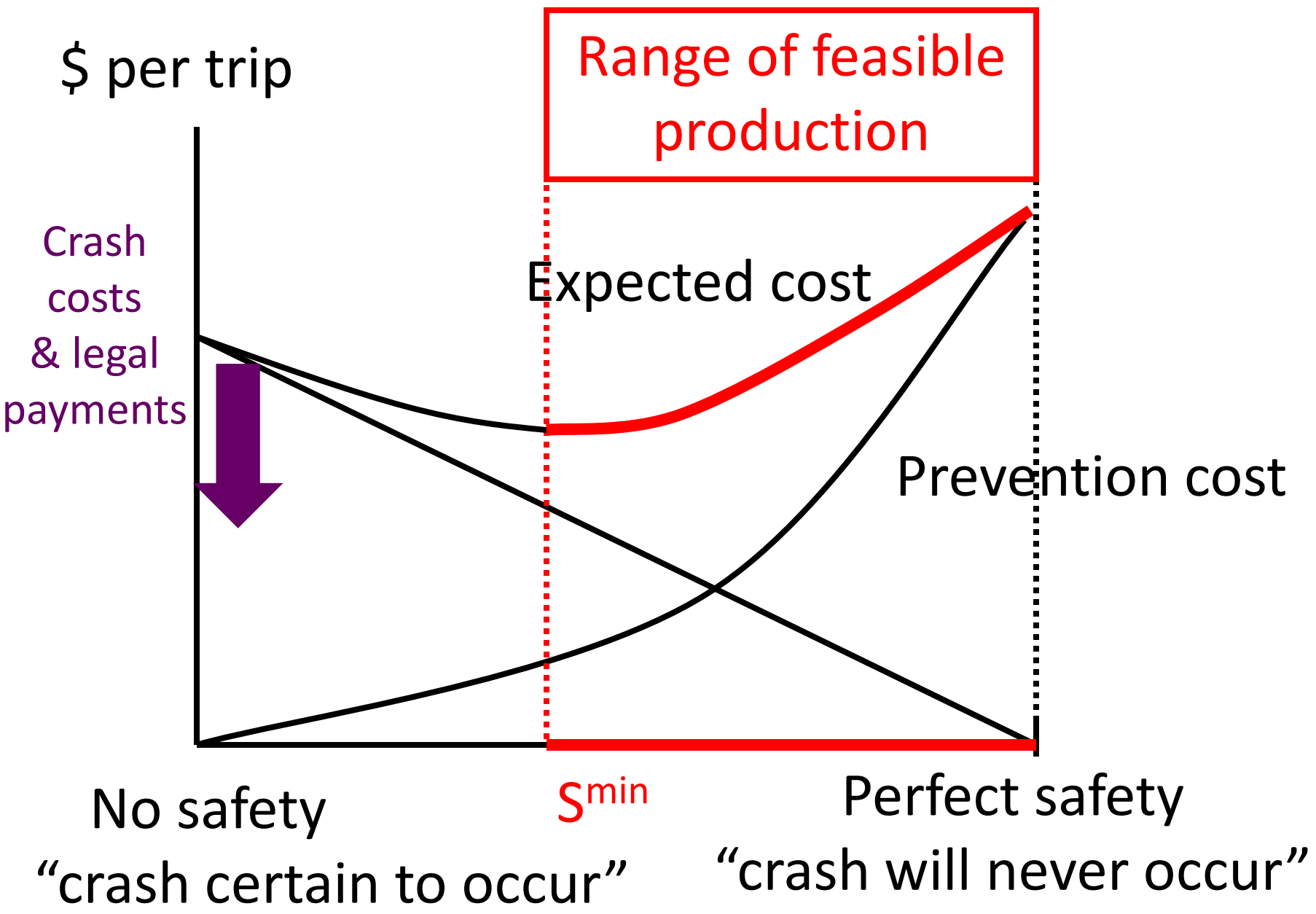
Little dispersion

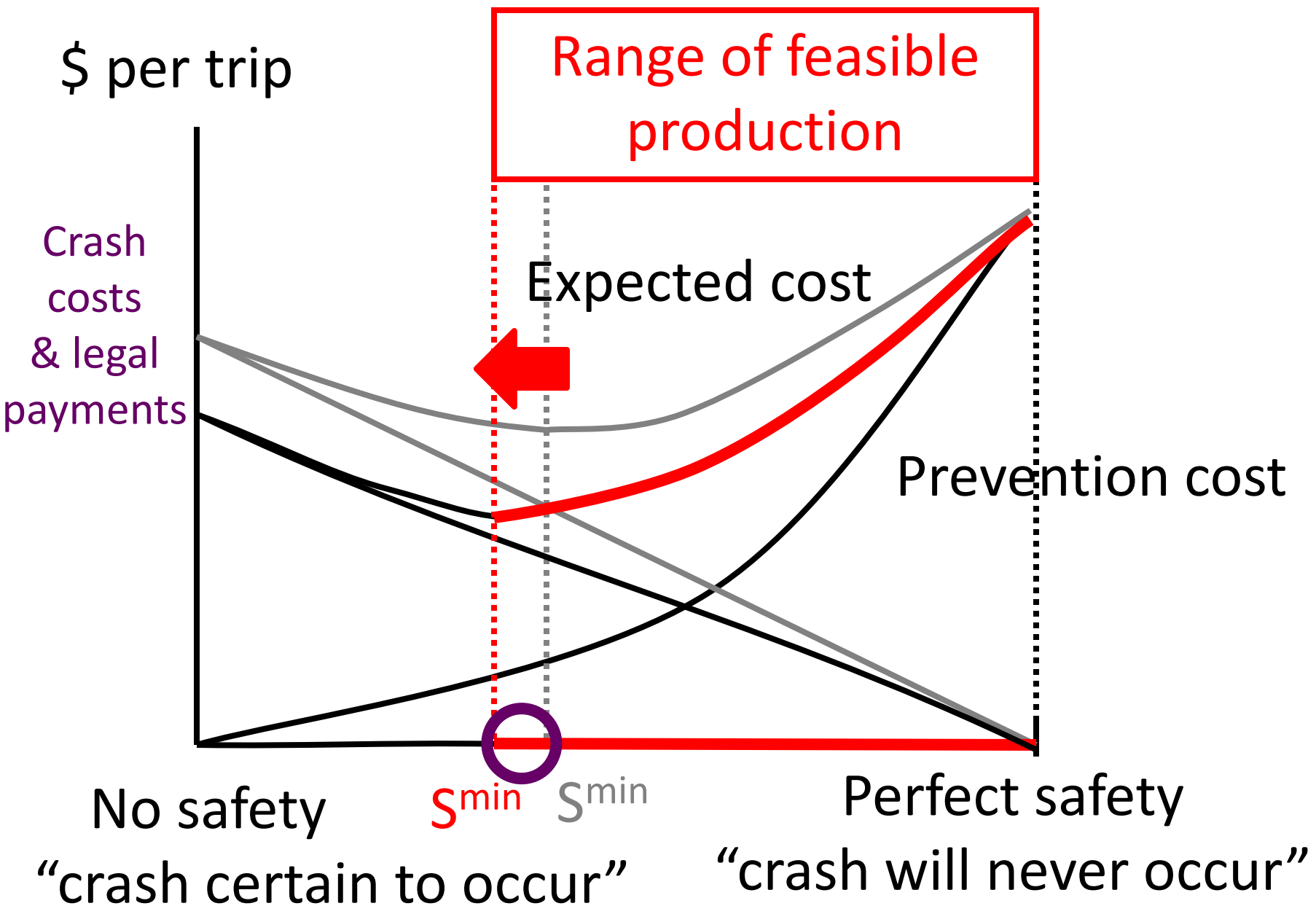
- few carriers
- consumers have similar tastes
- consumers bundled together – “one size fits all”
- difficult to determine carriers’ safety or differentiate between them

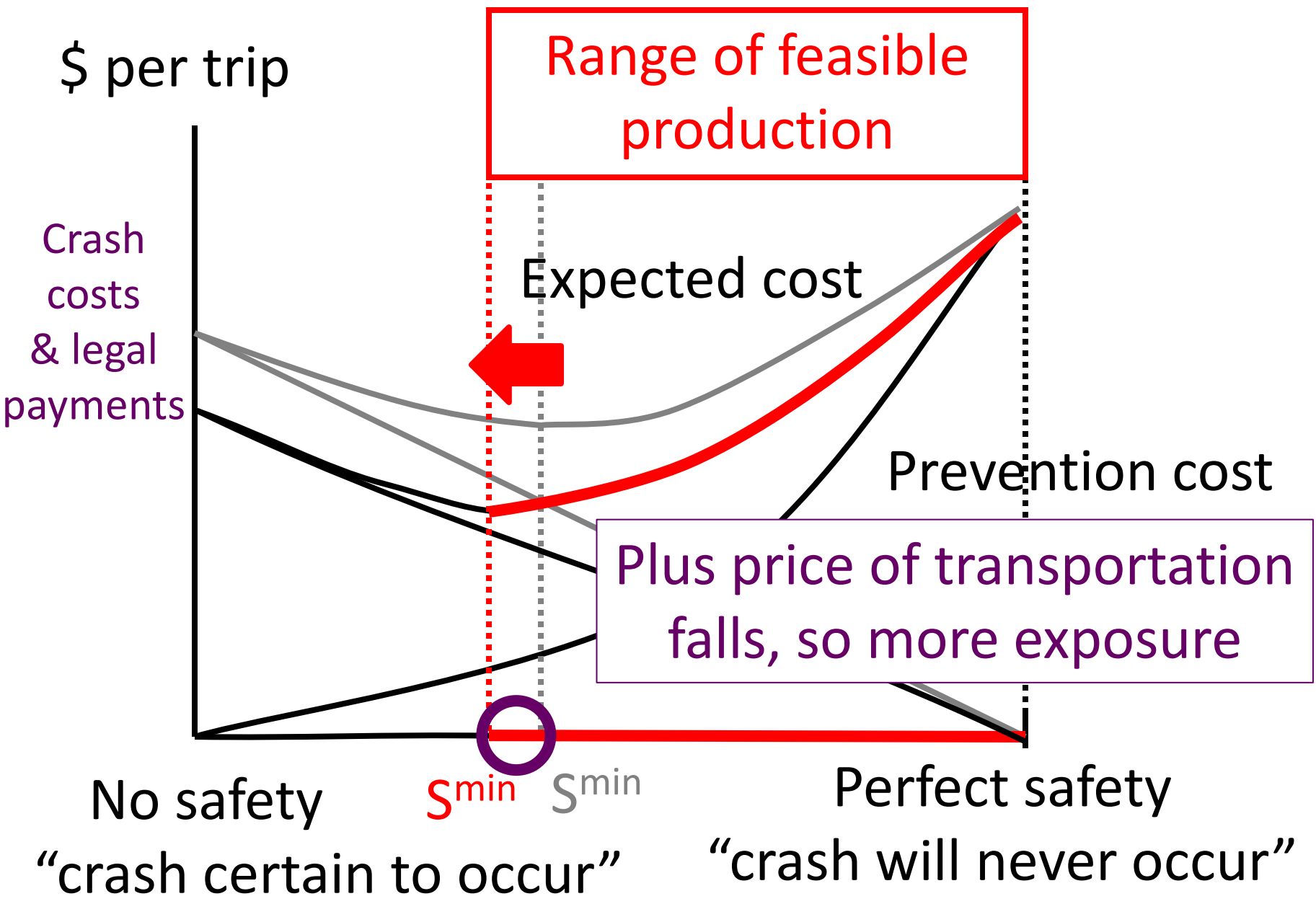
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- All third party effects internalized by carrier
 - Externalities
 - Bilateral crashes









Assumptions for ideal marketplace

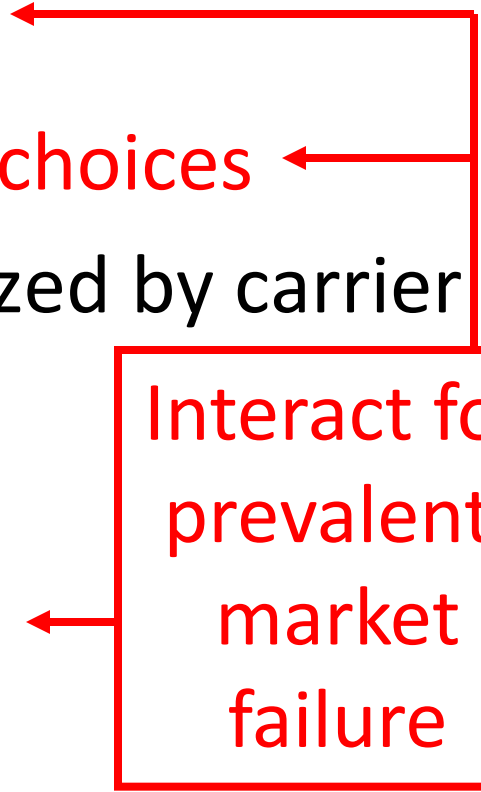
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- Carriers make rational choices

Interact for
prevalent
market
failure



\$ per trip

Crash costs
& legal
payments

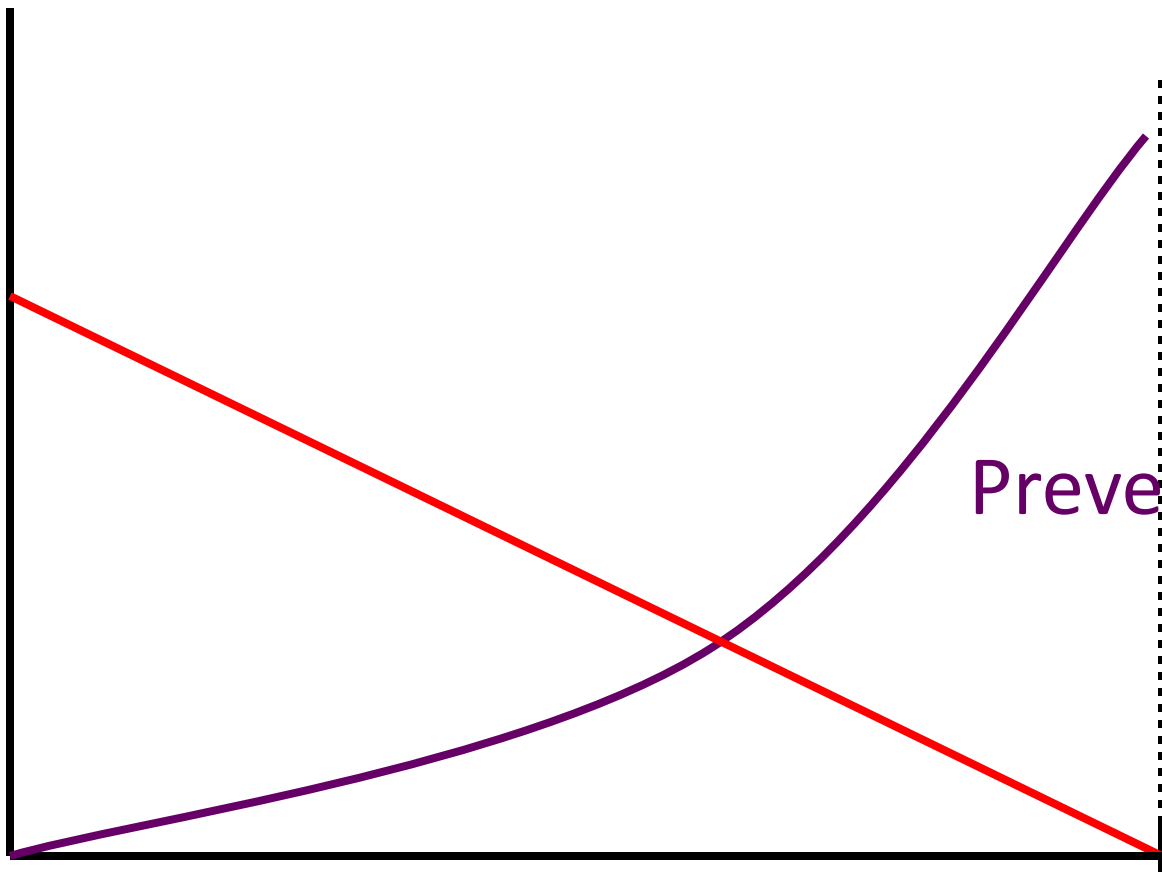
Prevention cost

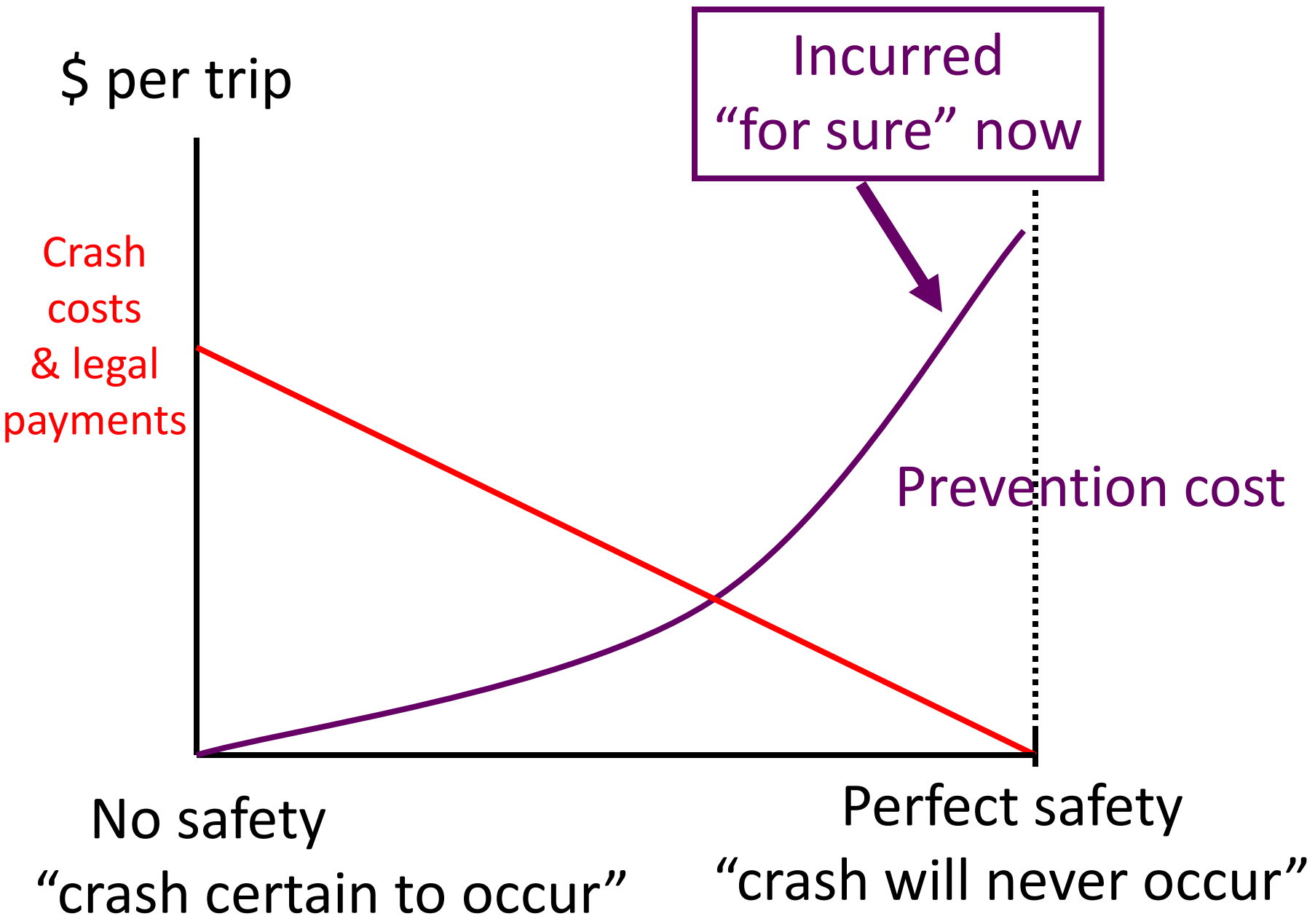
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Perfect safety

“crash certain to occur”

“crash will never occur”





\$ per trip

Crash costs & legal payments

Incurred "for sure" now

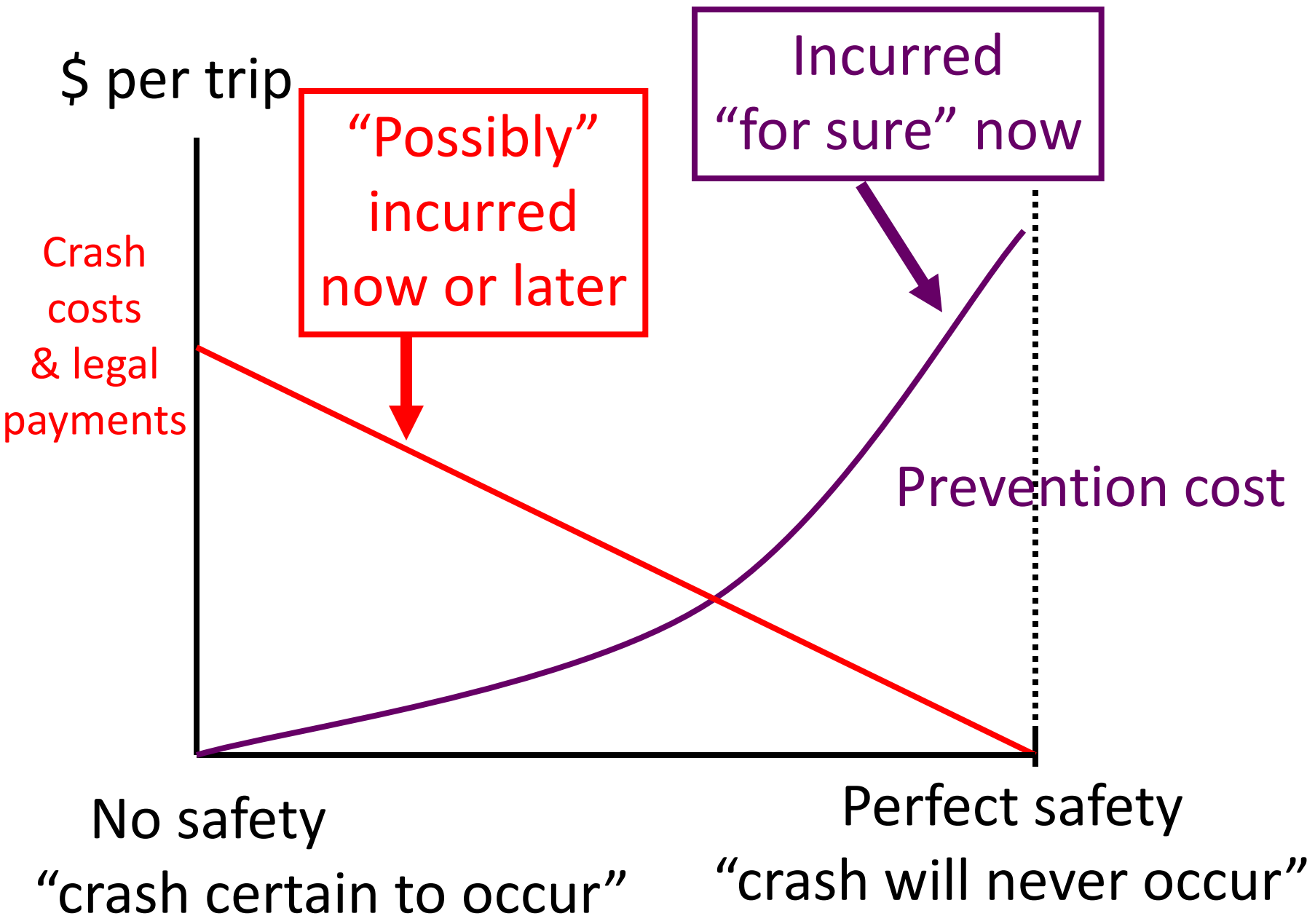
Prevention cost

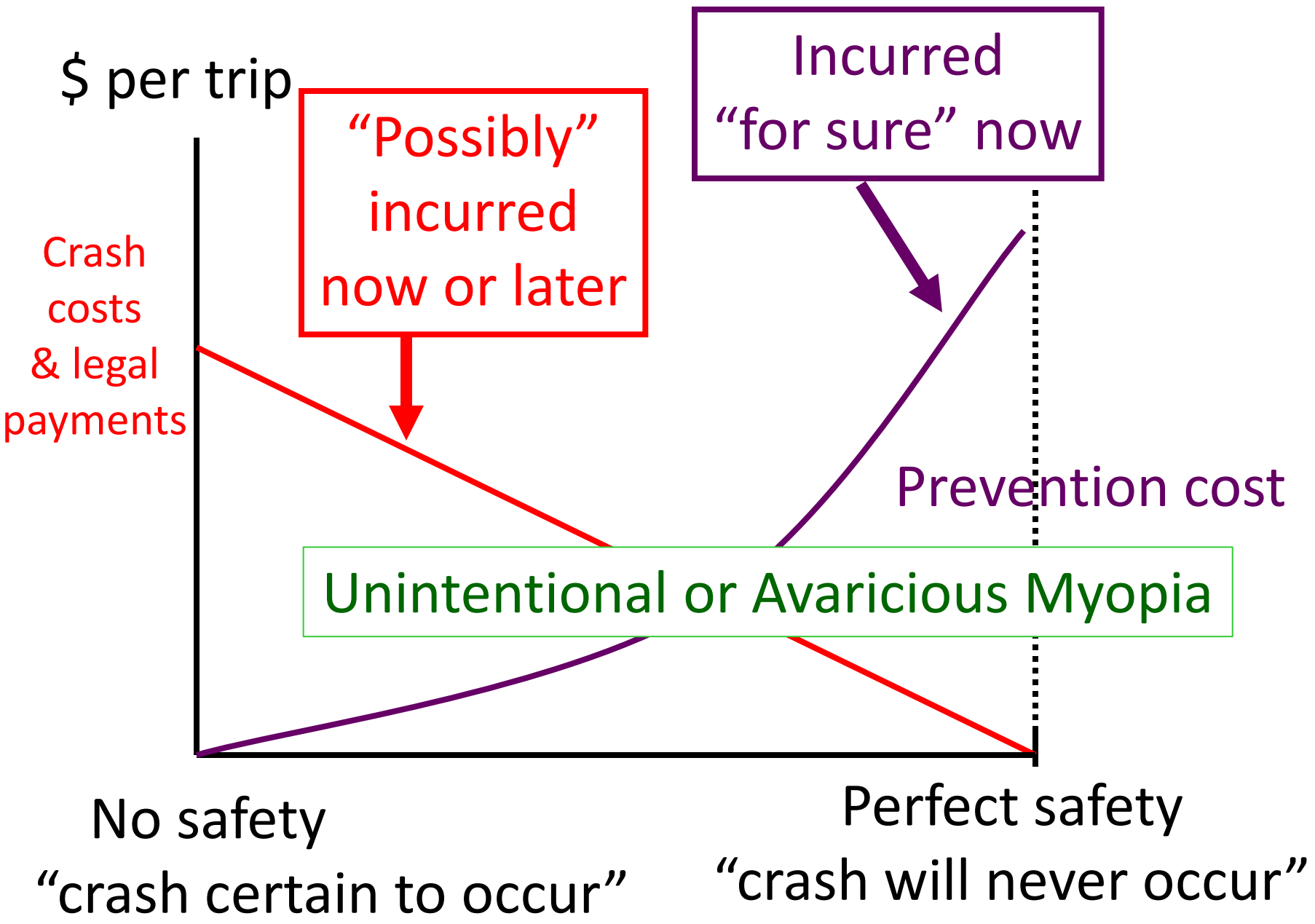
No safety

"crash certain to occur"

Perfect safety

"crash will never occur"





\$ per trip

Crash costs & legal payments

"Possibly" incurred now or later

Incurred "for sure" now

Prevention cost

Unintentional or Avaricious Myopia

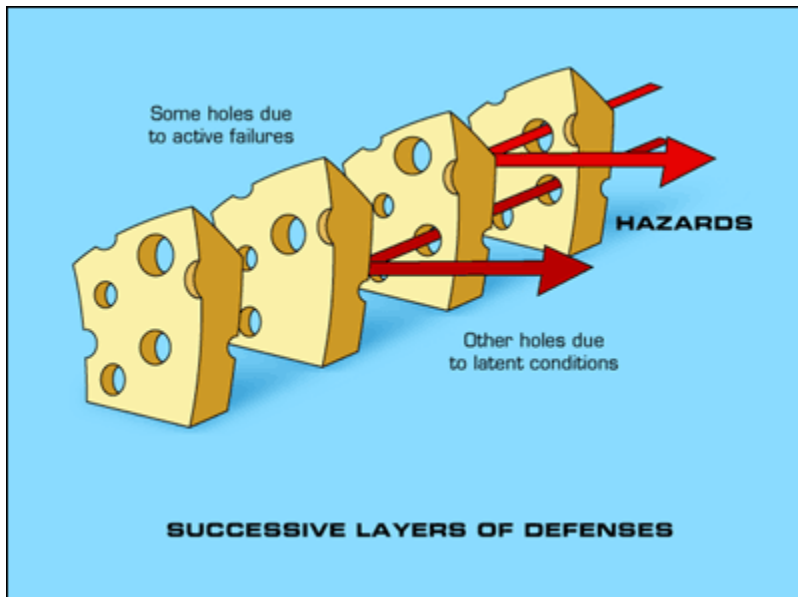
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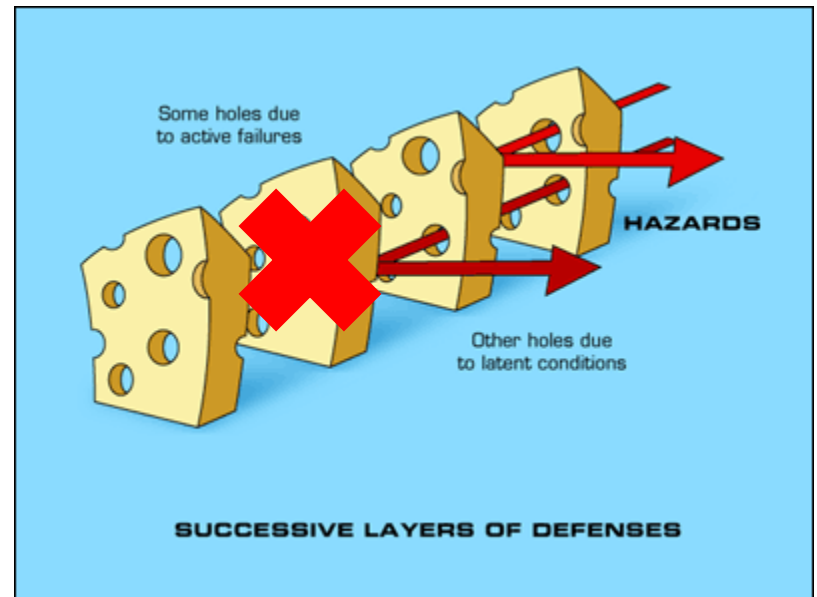
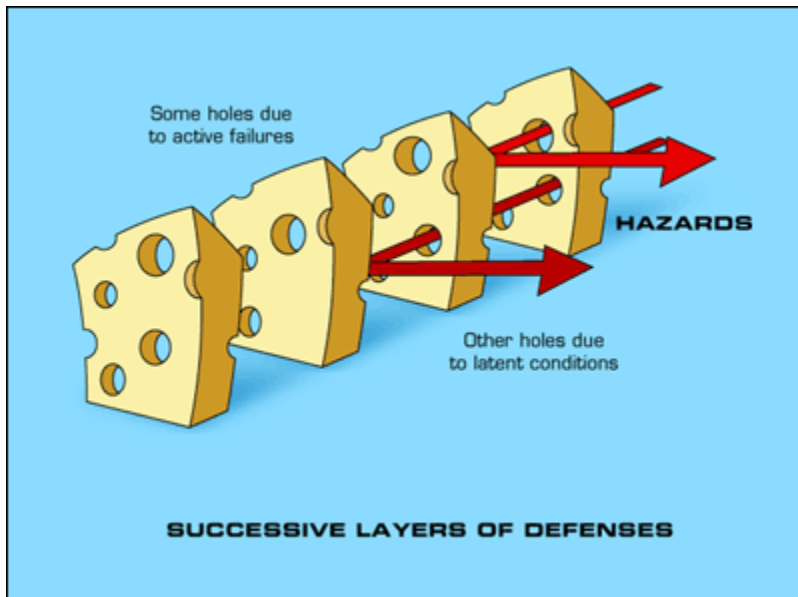
Perfect safety

"crash will never occur"

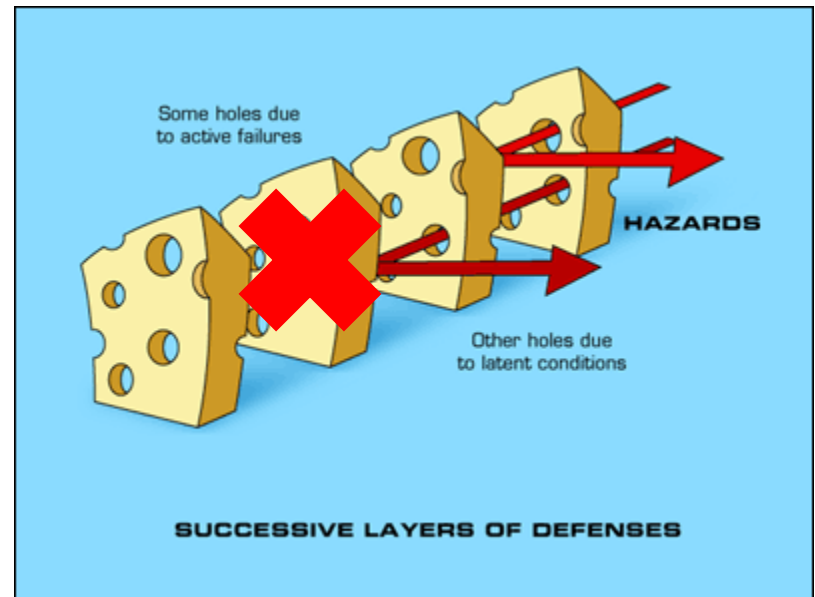
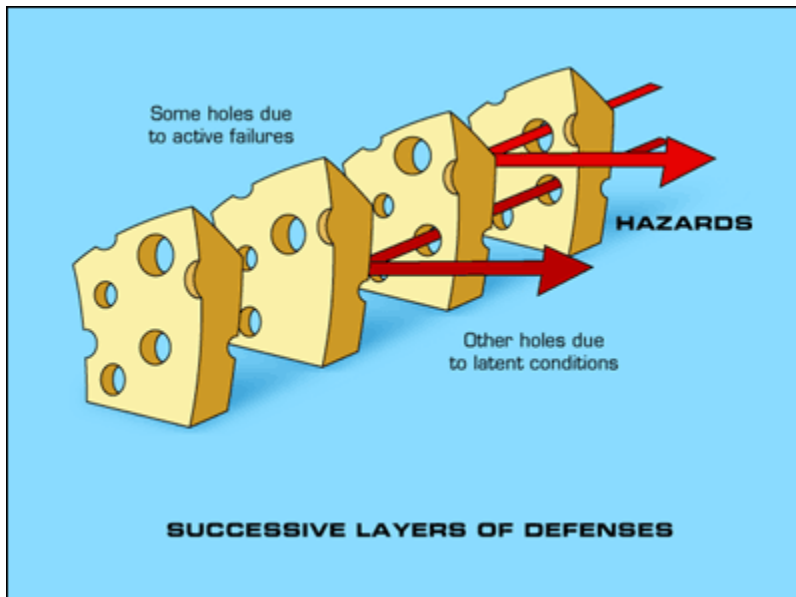
“What is the harm in removing a few slices of cheese”



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Unintentional or Avaricious Myopia requires consumers “not to notice”

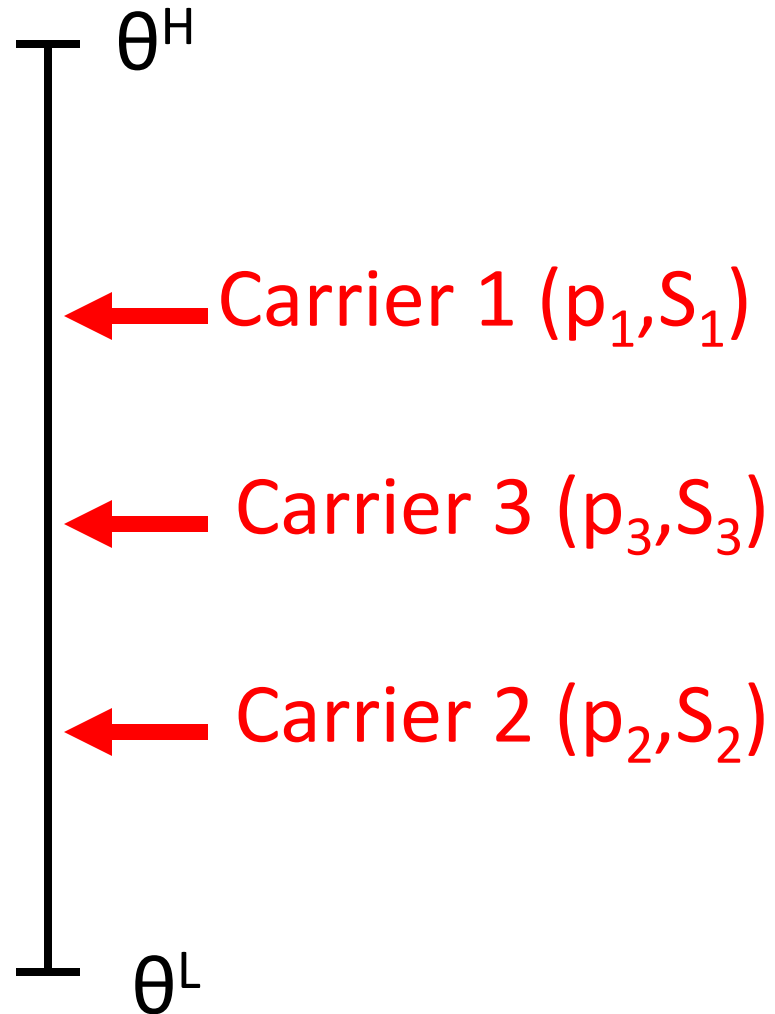
Unintentional myopia

- Primarily associated with inexperienced new entrants
- Basis of most safety regulation
- Initial certification of:
 - Carriers
 - Equipment
 - Employees
- Presumably consistent with S^{\min}

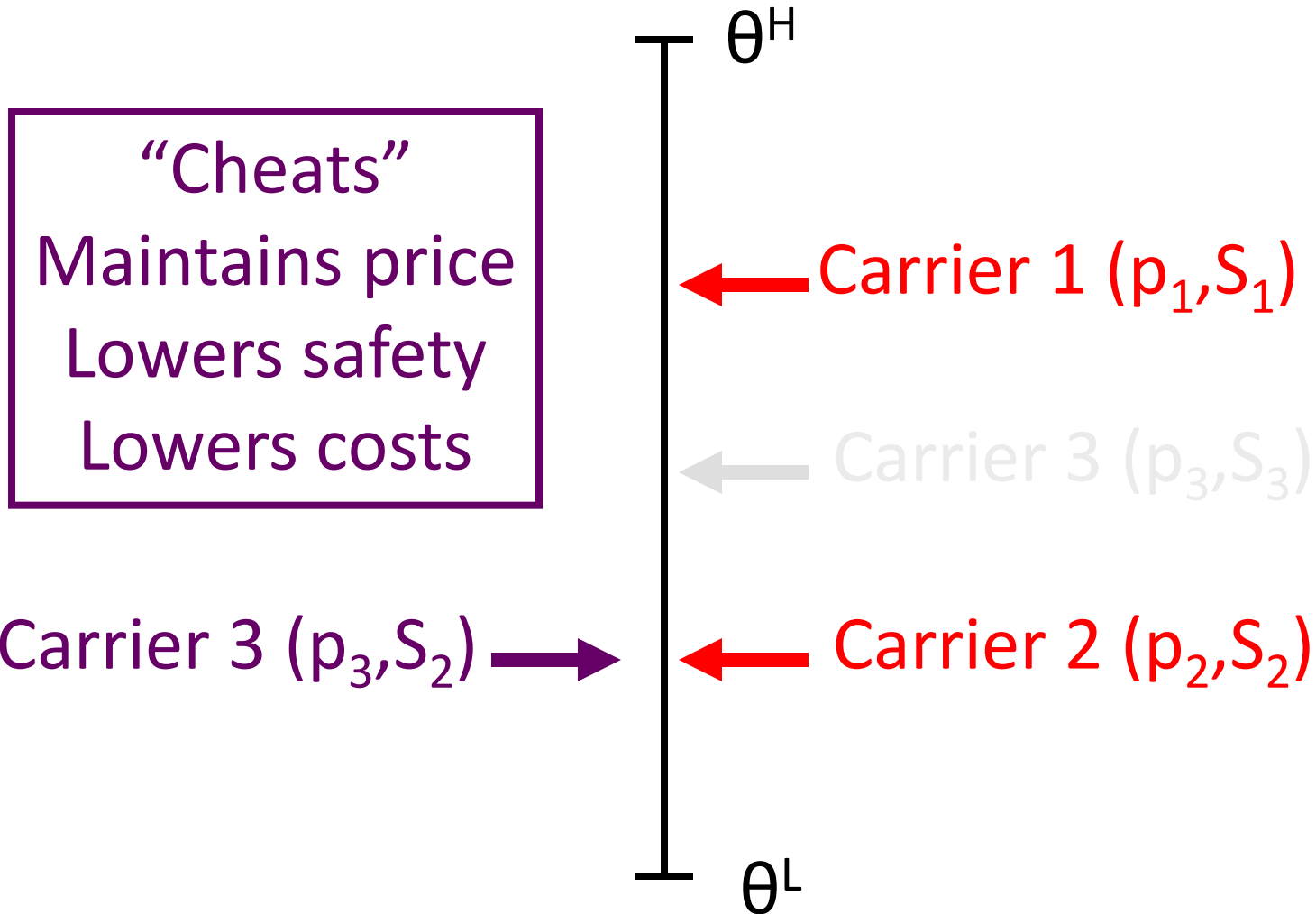
Avaricious myopia – “cheating”

- Incumbent firm deviating from past performance
- We all can think of firms in all modes that we believe have engaged in this
- “Milking” or “burning” a reputation
- Generally associated with firms close to bankruptcy, or needing to “get through” a difficult period

Valuation (θ_i)



Valuation (θ_i)



Avaricious myopia – “cheating”

- Economists are perplexed by the existence of “cheating” in stable markets
- Why is this?

Economics of reputation

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Equilibrium competitive prices are such that there is no incentive to cheat

Part 5

How (relatively) important
are these deviations?

Magnitude of failures varies by mode

	Few Carriers (limited choice)	Consumers Poorly Informed	Consumer Cognitive Failures	External Costs not Covered	Bilateral Crashes	Carrier Myopia
Private Driving	*	*	***	*	***	n/a
Private Aviation & Boating	Few failures					
Commercial Passenger	**	***	***	*	**	***
Road Freight	*	*	none	***	***	***
Maritime Freight	*	*	none	**	*	***
Rail Freight	***	*	none	**	***	**
Pipelines	***	*	none	***	none	**

Part 6

What (more) can we do
about it?

Liability / legal reforms?

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Private Driving	*	*	***	*	***	n/a
Private Aviation & Boating	Few failures					
Commercial Passenger	**	***	***	*	**	***
Road Freight	*	*	none	***	***	***
Maritime Freight	*	*	none	**	*	***
Rail Freight	***	*	none	**	***	**
Pipelines	***	*	none	***	none	**

More extensive insurance holding?

	Few Carriers (limited choice)	Consumers Poorly Informed	Consumer Cognitive Failures	External Costs not Covered	Bilateral Crashes	Carrier Myopia
Private Driving	*	*	***	*	***	n/a
Private Aviation & Boating	Few failures					
Commercial Passenger	**	***	***	*	**	***
Road Freight	*	*	none	***	***	***
Maritime Freight	*	*	none	**	*	***
Rail Freight	***	*	none	**	***	**
Pipelines	***	*	none	***	none	**

More information collection and dissemination in the Internet age?

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Pipelines	***	*	none	***	none	**

The old standby - regulatory action to enforce some minimum standard

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Final Thoughts

What can we conclude?

Take aways

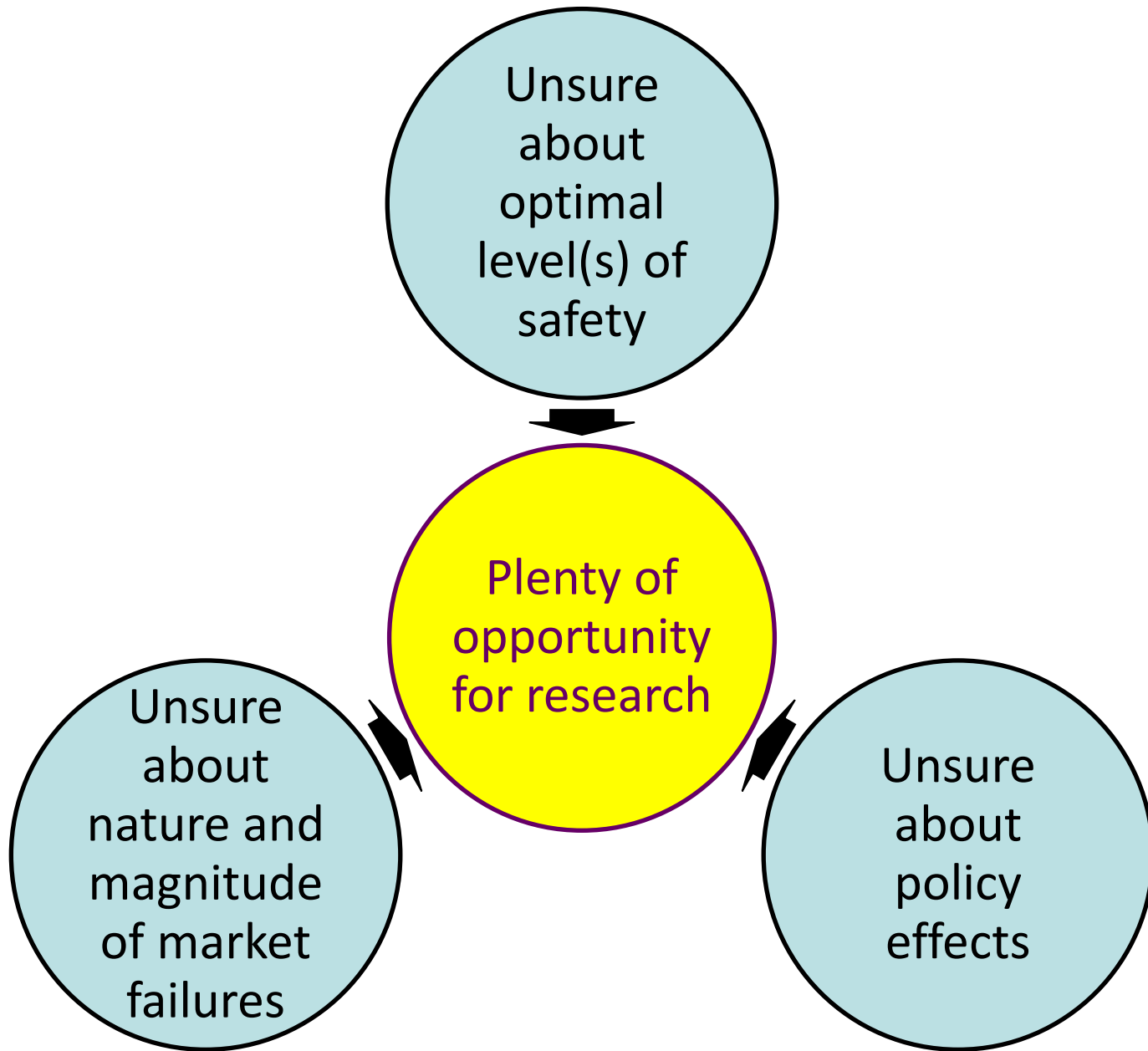
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- Difficult to quantify “optimal safety”
- It will likely involve higher and lower safety carriers coexisting
- Market failures are rife, but their nature and magnitude varies by mode
- Policy responses are numerous
 - Each have their pluses and minuses
 - Non-trivial to implement
 - Should be deployed in combination



“Transportation econ. courses with Leon and his cigar were epic! . . . many of us had careers in transportation because of him.” Vicki Whamond Bretthauer



"When I arrived from Italy at NU I was a 25 year old young kid who did not know anything about the realities of American Life. It was [Prof.] Moses who helped me to adjust at NU's life, and motivate me when I was down, or when I could have done better on an exam. Yet these human qualities where coupled by a great professional rigor and vigor that were for me the ultimate example to imitate in action." Corrado Letta

“Leon was one of my favorites and I often tried to sit at the same table with him during Transportation Center BAC meetings.” **Chuck Lounsbury**



"There is no doubt in my mind that he was one of the few persons who had a very significant impact on me and my spirit. He was great as a scientist and very kind as a human being. I have not seen him for a long time but I always thought about him, now I will carry his memory in my heart."

Yossi Prashker

October 24, 1924 – October 12, 2013



- Friend
- Leader
- Scholar