Decision making from weather forecasts

Lecture B 28 April 2016
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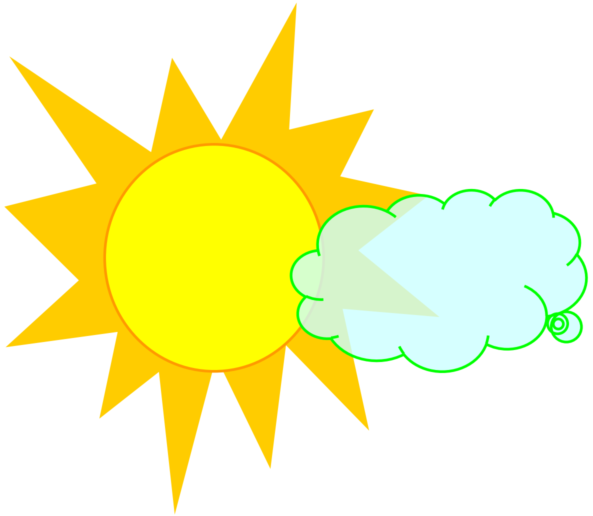
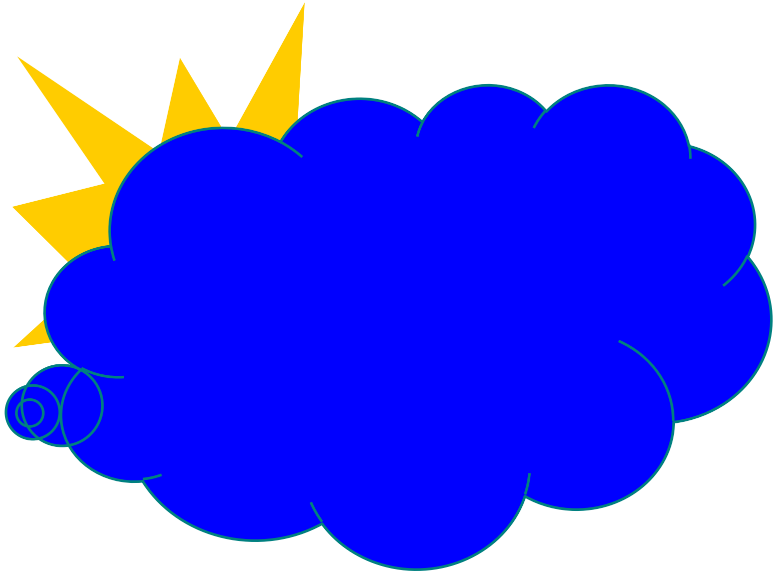
A story from 1930's California

In the 1930's Irving Krick, a meteorologist from Cal Tech, established the first private weather forecast firm in in the USA in competition with US Weather Bureau (USWB).

Irvin Krick's privately made forecasts were very *bad*





When the Weather Bureau promised the public sunny and mostly dry. . .

..the Irving Krick forecast to some of his clients said:

Probably rain

When the Weather Bureau warned the public about probable rain. . .

..the Irving Krick forecast to some of his clients said:

Probably dry

Verifications showed that Irvin Krick's forecasts were very *bad*

Fore casts A	Obs rain	Obs dry
Fc rain	30	30
Fc dry	0	40

Over-forecasting rain (60 days vs 30)

Fore casts B	Obs rain	Obs dry
Fc rain	5	0
Fc dry	25	70

Under-forecasting rain (5 days vs 30)

Still Krick's private weather firm earned him millions

Why?

Customer A: The rain was *over-forecast* for the Hollywood studios because

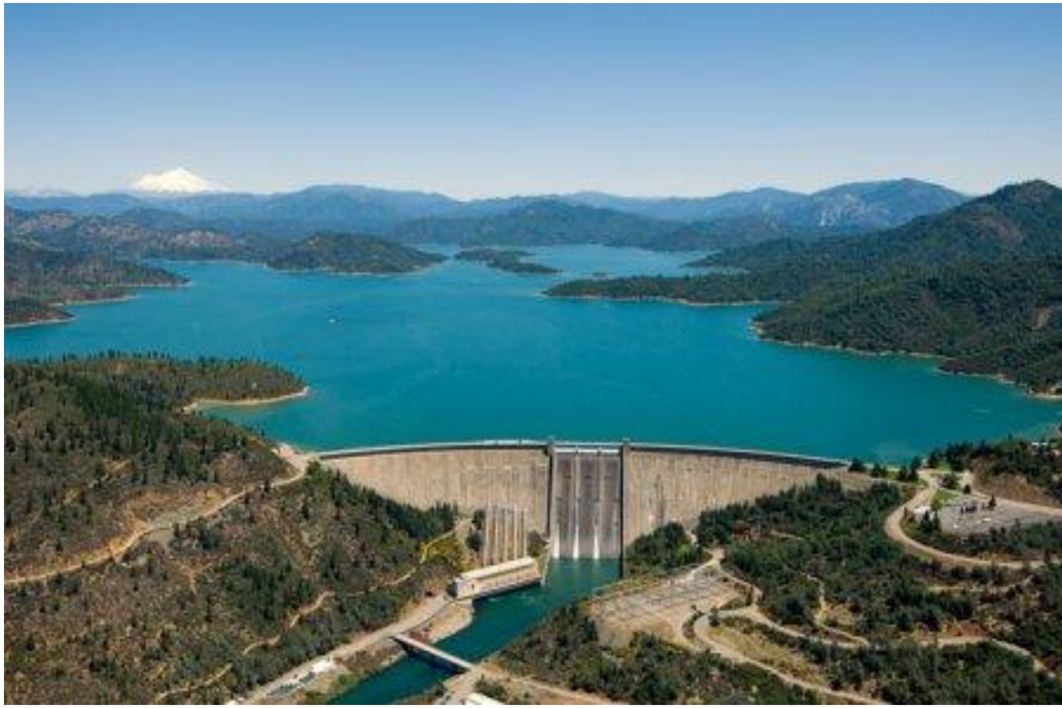
Low cost: Staying at home and risk missing a fine day.

High loss: To have the stars and equipment unnecessarily taken out on the prairie in case of <u>unpredicted rain</u>.

Customer B: The rain was *under-forecast* for the water authorities because

High cost: Spilling expensive water to lower the water levels to avoid over-filling or ability to adjust the prices.

High loss: Unplanned water spill or risk of damaging the dam in case of unpredicted rain.



Assume we are in a region with adverse weather 30% of the time

9 days/month or 122 days/year.

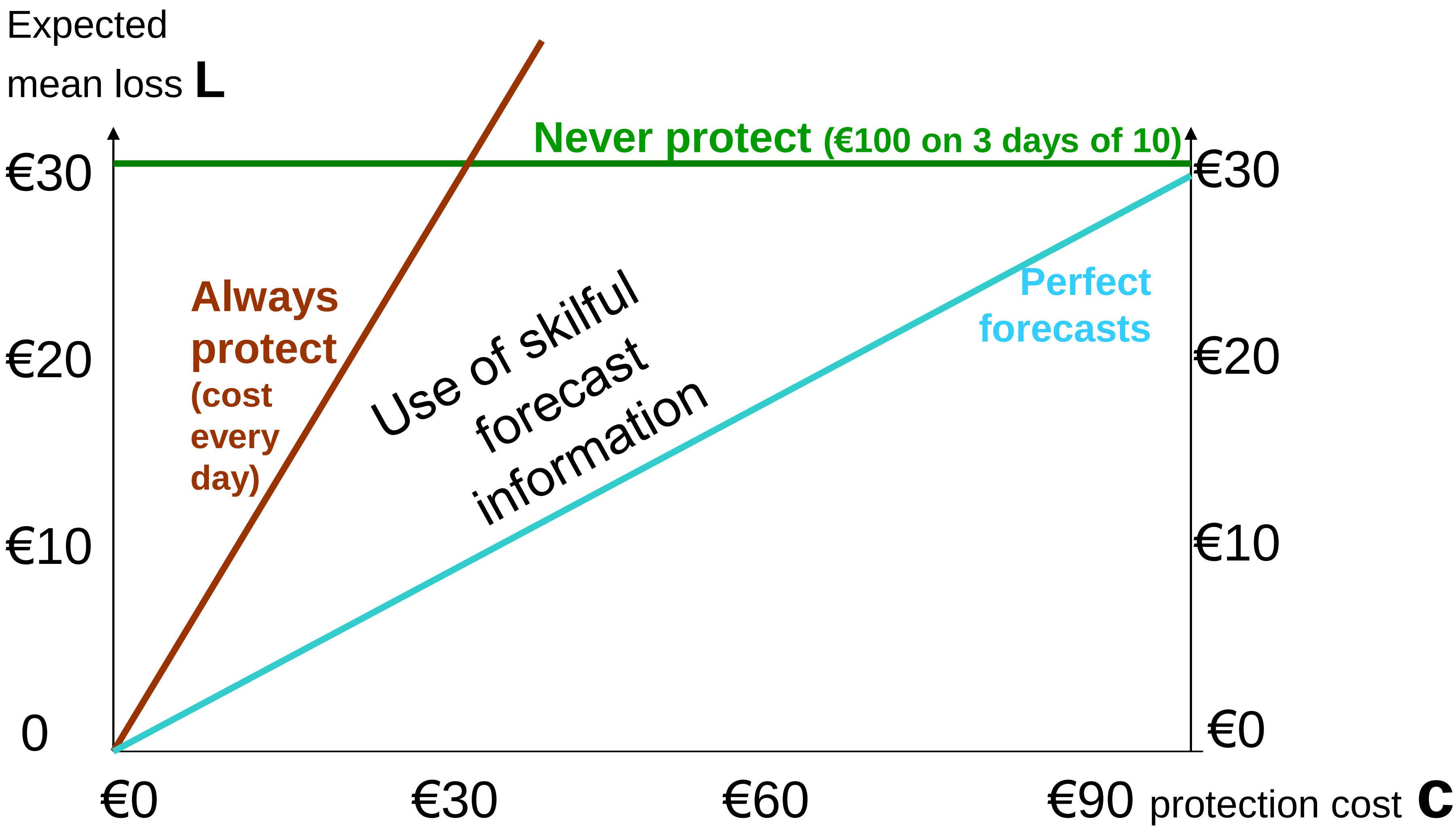
There is generally a 30% probability of e.g. rain

Assume that adverse weather will cause a loss **L = €100** per day

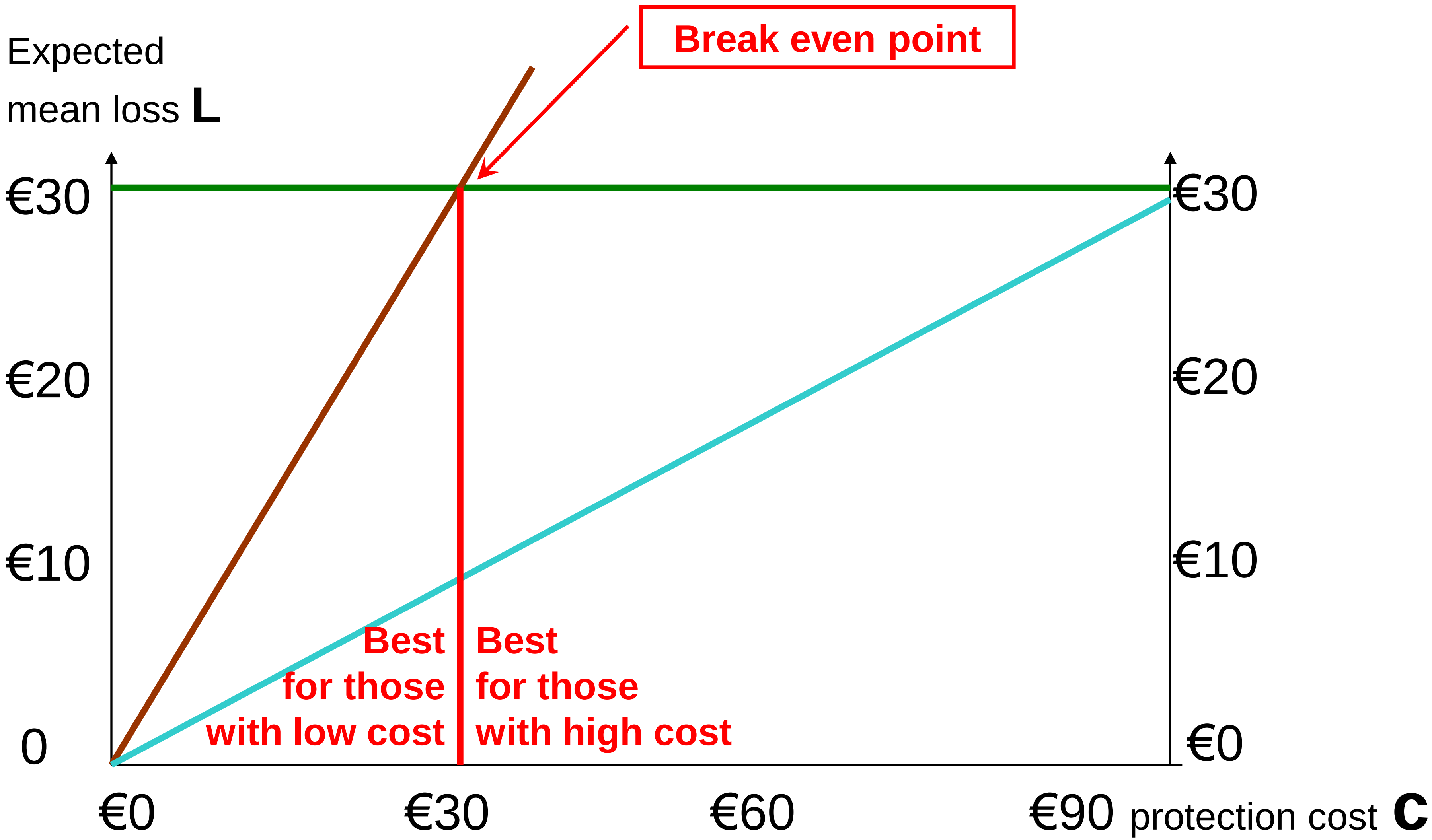
For a certain occupation the cost of protection per day may range from c = **€0** to c = **€100** **(the same as the loss)**

We can now calculate the average Expected Monetary Value per day, i.e. the average cost and loss per day if there is no forecast information

With no forecast information you can chose to a) protect every day or b) never protect



At the break even point c/L = 30% the same as the climatological probability



The local weather forecasters at the USWB make very good forecasts with 80% being correct.

	Obs rain	Obs dry
Fc rain	20	10
Fc dry	10	60

All forecasts were well tuned:

The number of rain forecasts (30) over 100 days matches the number of observed rain days (30)

This matrix also reflects the actions and their consequences

	Obs rain	Obs dry
Fc rain	**20**	**10**
Fc dry	**10**	**60**

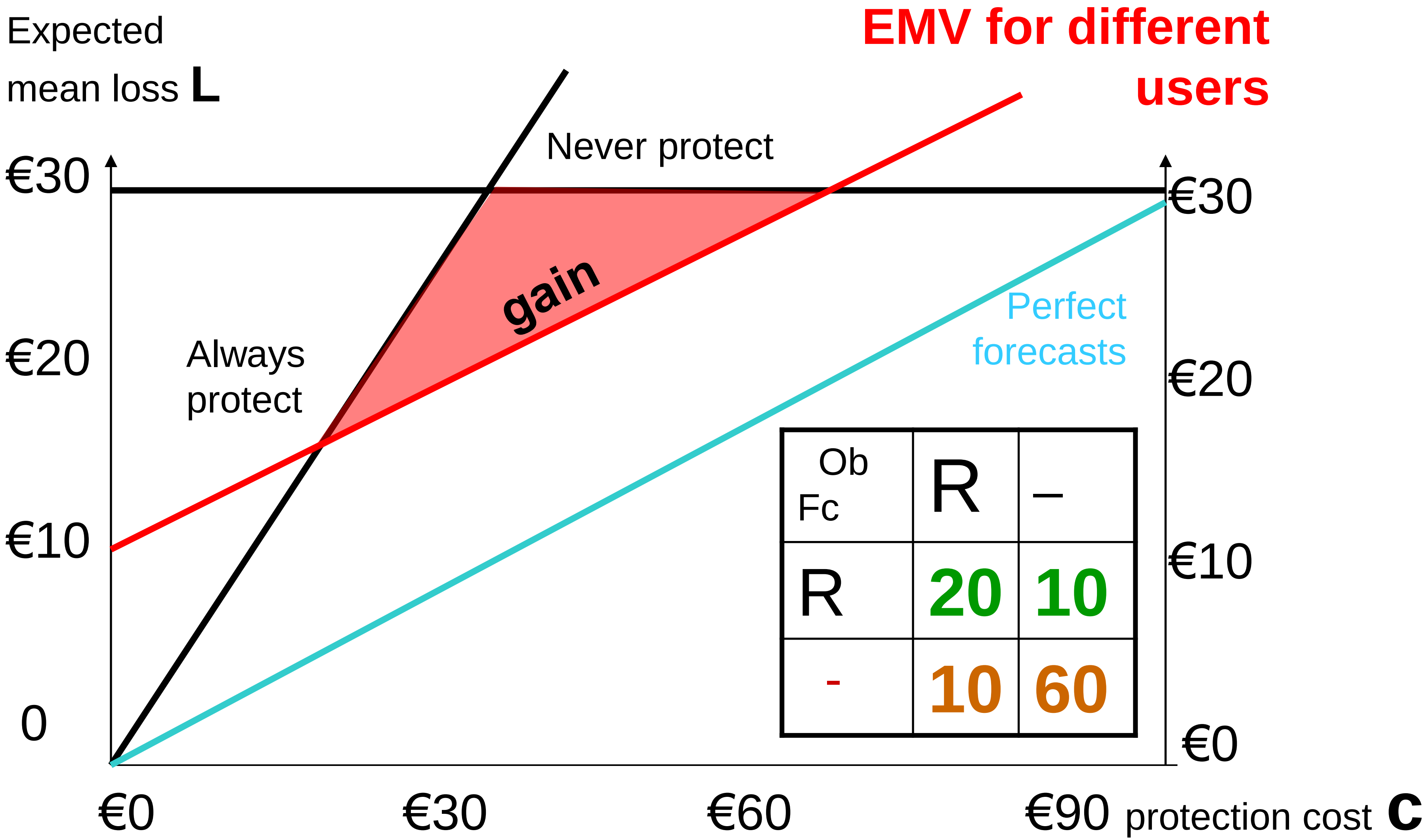
Actions were taken

No actions were taken

Losses

From this it is possible to calculate the Expected Monetary Value (EMV)

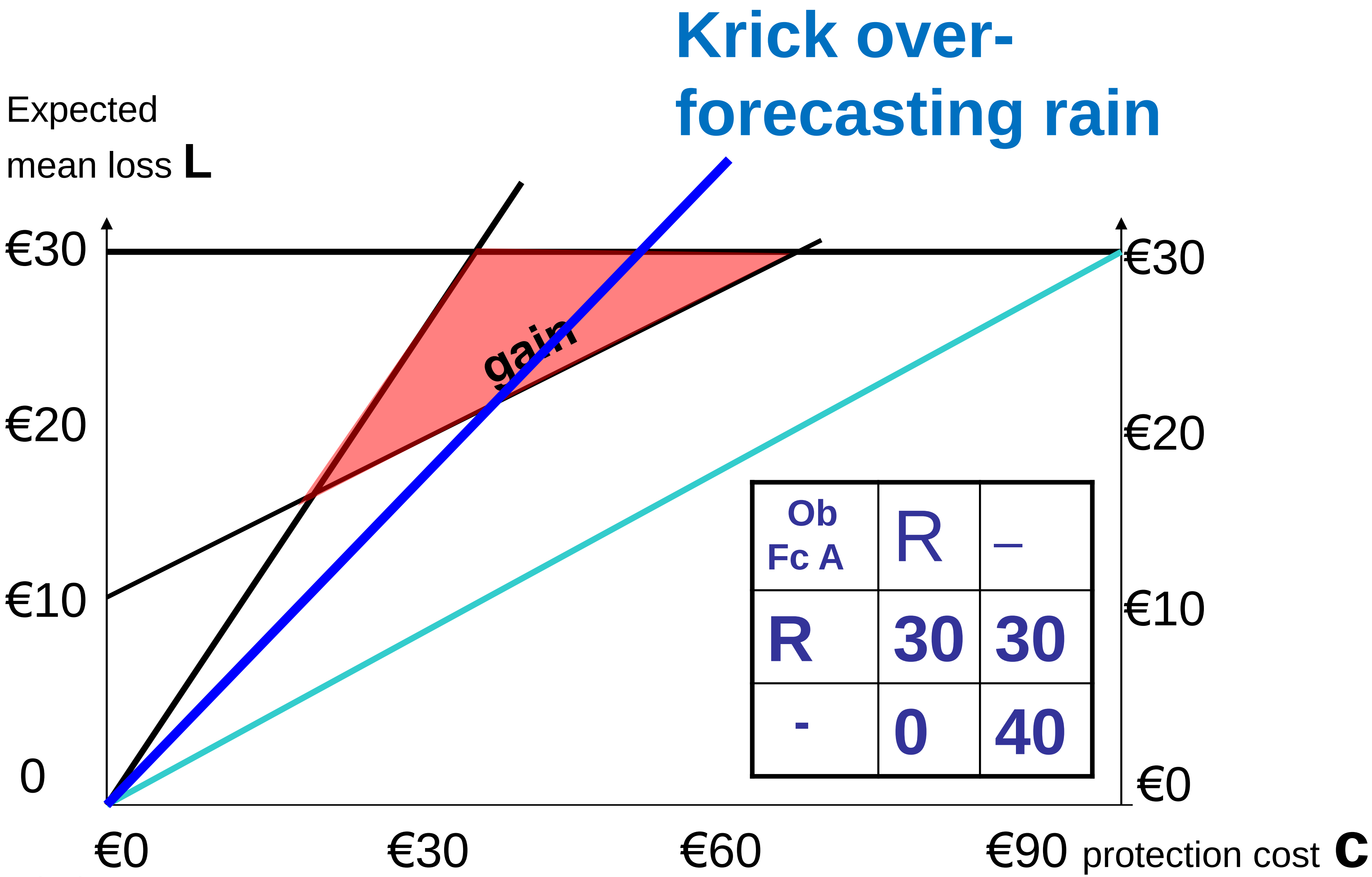
The expected loss per day for different protection costs c



Ob / Fc	R	–
R	20	10
-	10	60

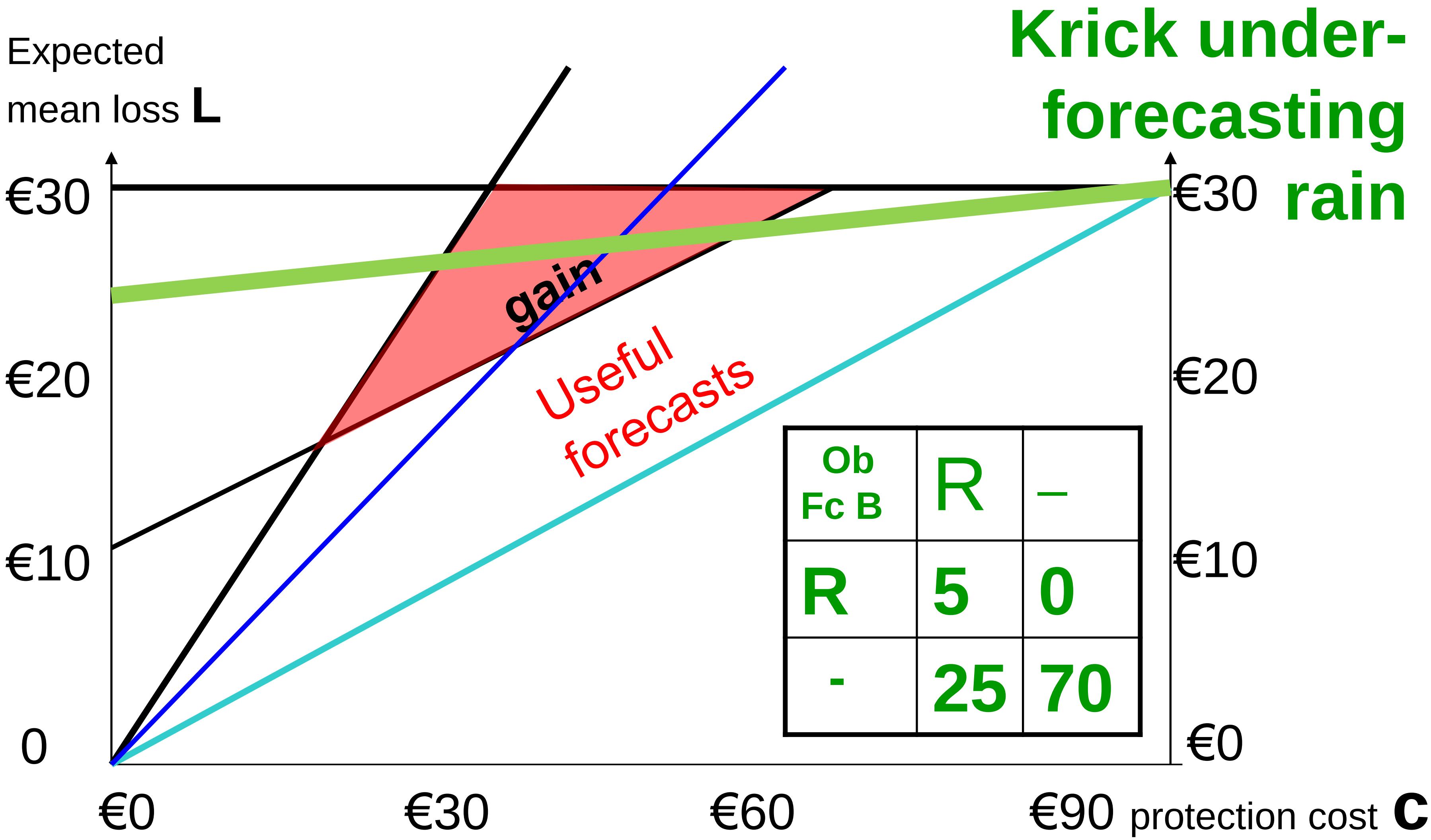
<u>Paradox 1:</u> Irving Krick's bad forecasts were as useful as the US Weather Bureau's

The expected loss per day when Krick over-forecast rain



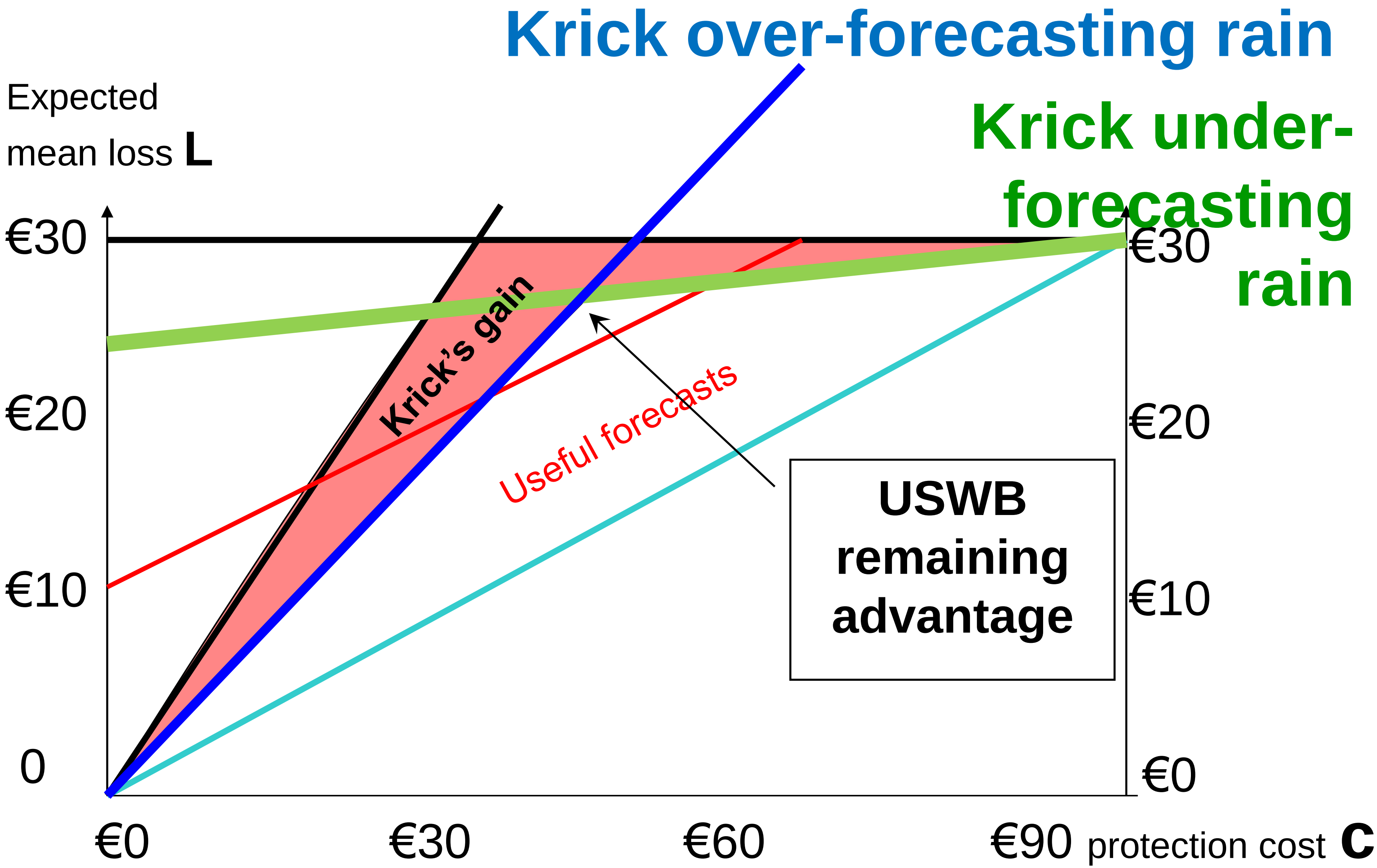
Ob / Fc A	R	–
R	30	30
-	0	40

The expected loss per day when Krick under-forecast rain



Ob / Fc B	R	–
R	5	0
-	25	70

The expected loss per day for different protection costs c



<u>Paradox 2:</u> The US Weather Bureau could have fought Krick by becoming more uncertain

If the US Weather Bureau had chosen to become less categorical it could also have served *both* low and high cost-loss customers

USWB	Obs rain	Obs dry
Fc rain	20	10
Fc dry	10	60

USWB	Obs rain	Obs dry	
Fc rain	10	0	
???	20	20	50-50%
Fc dry	0	50	

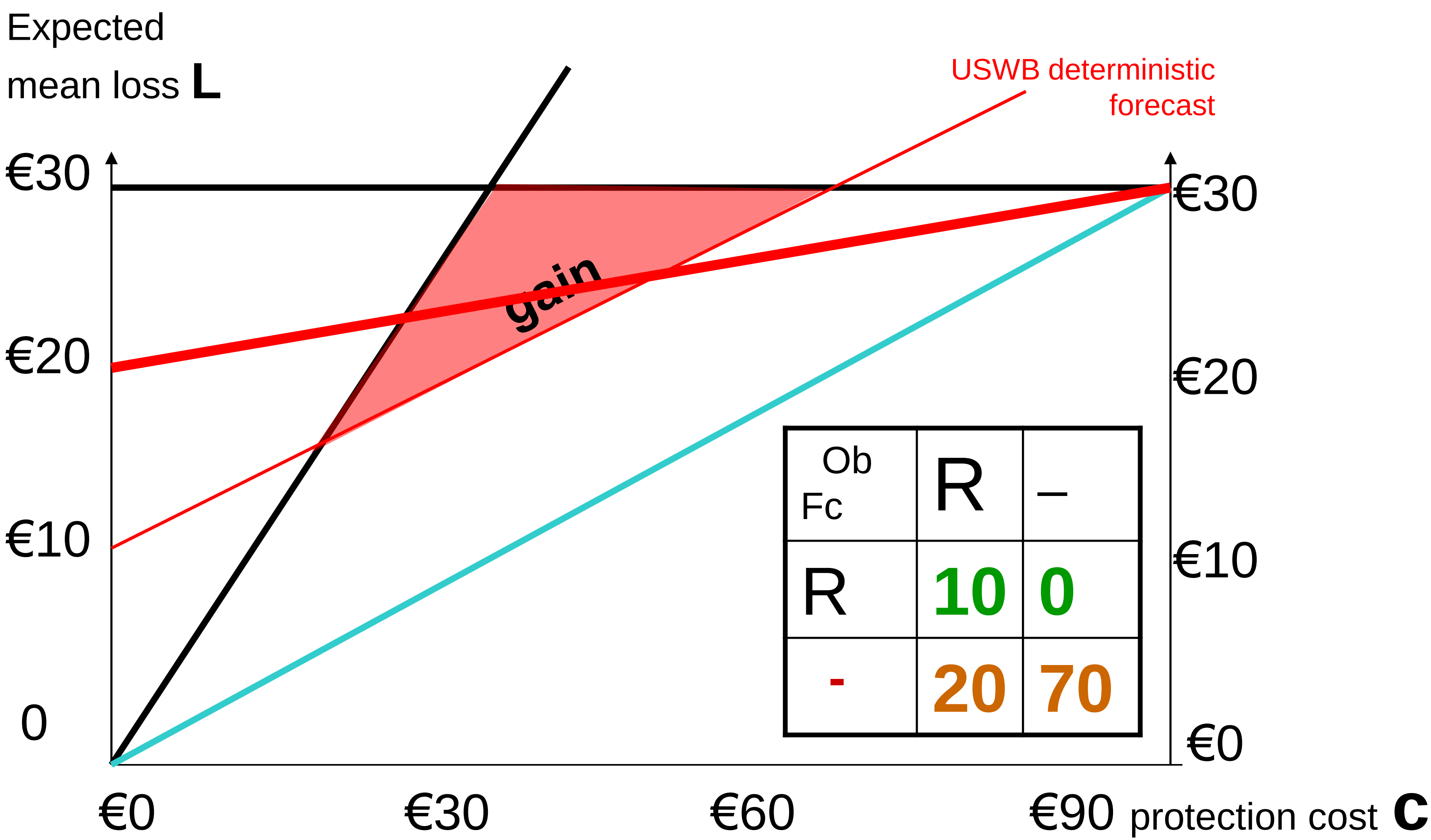
It allows those who are not sensitive to rain to interpret the ??? as "it might not rain"

USWB	Obs rain	Obs dry
Fc rain	10	0
???	20	20
Fc dry	0	50

→

USWB	Obs rain	Obs dry
Fc rain	10	0
Fc dry	20	70

These are the EMV (total cost) for those who interpreted ??? as "it might not rain"



Ob / Fc	R	–
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USWB	Obs rain	Obs dry
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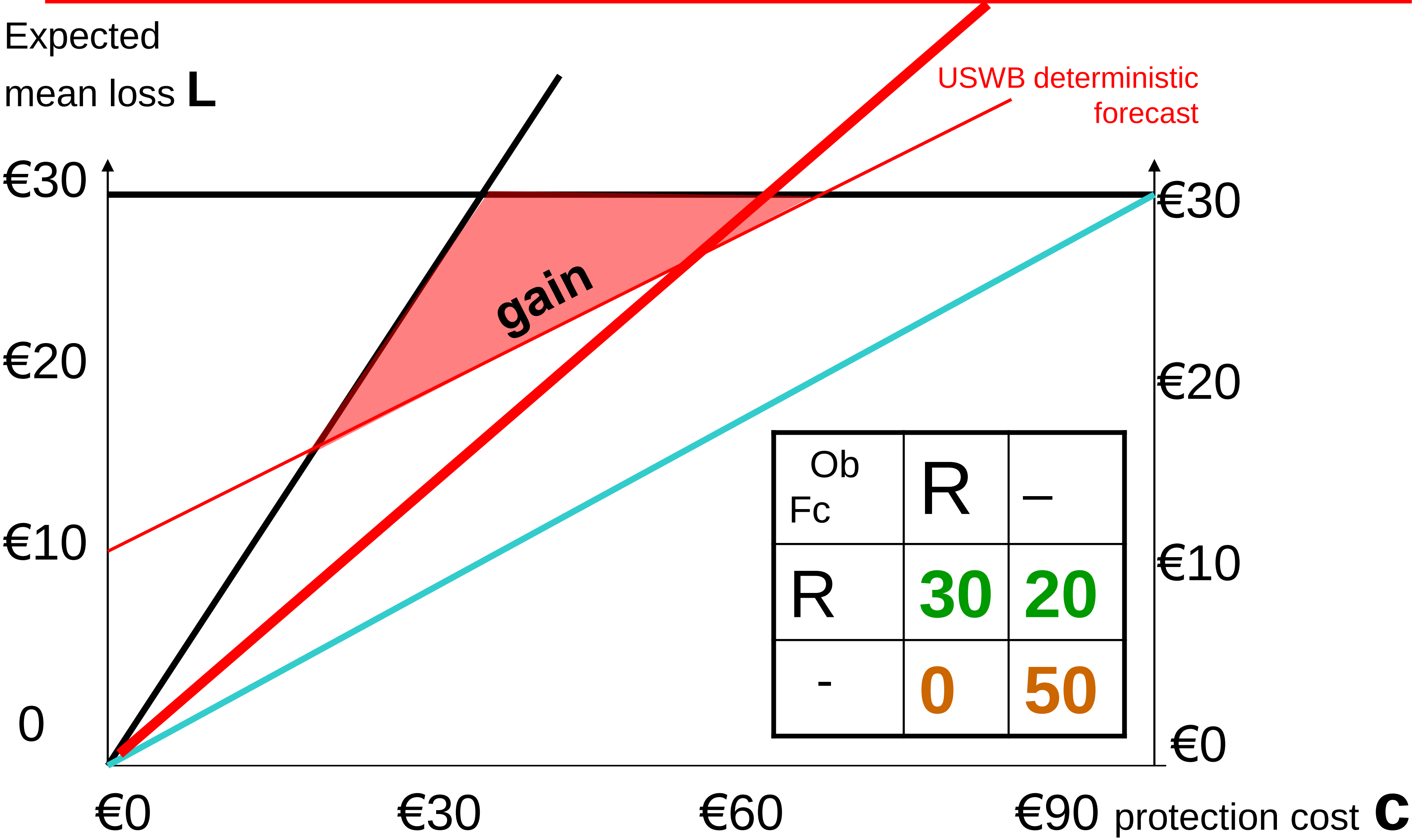
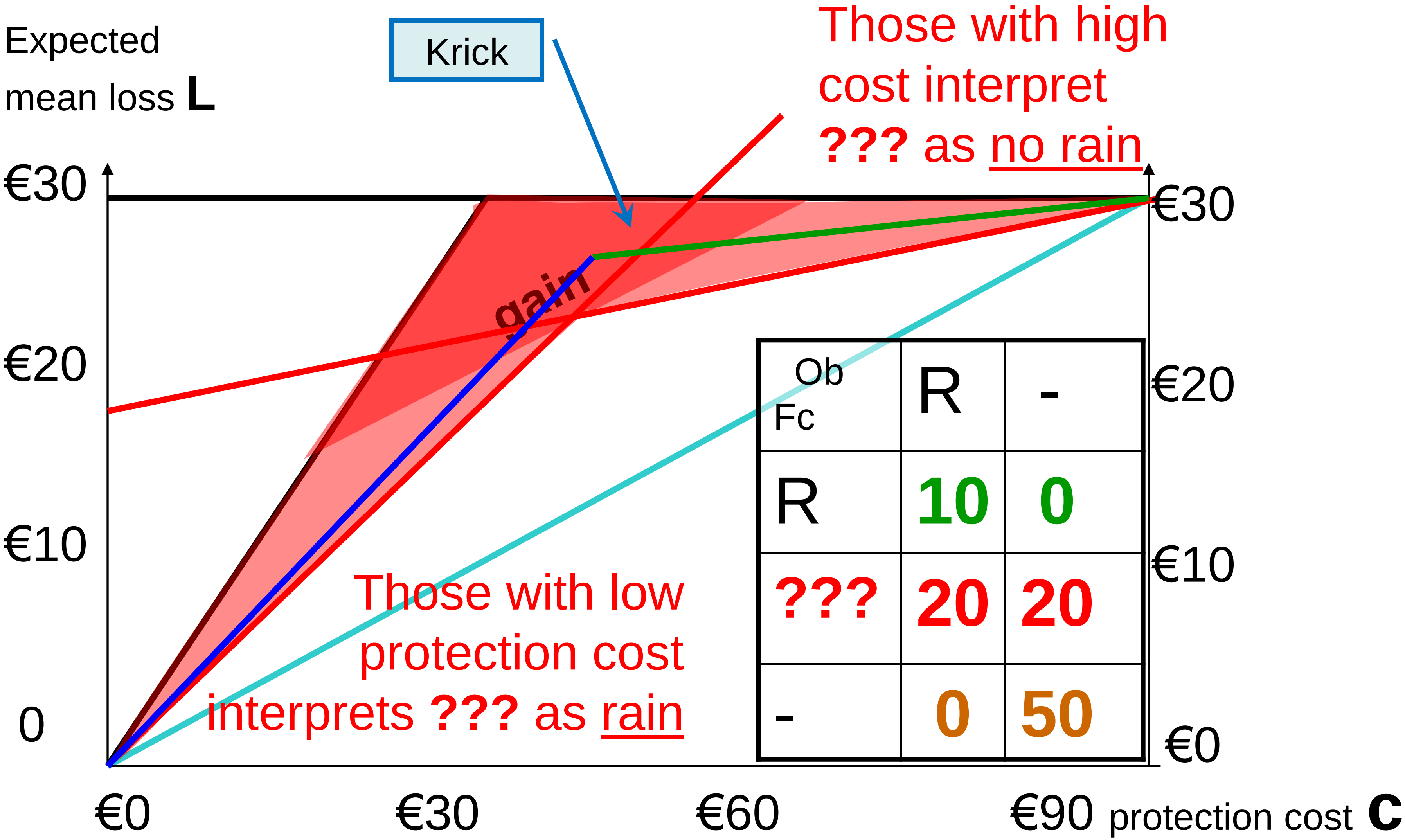
USWB	Obs rain	Obs dry
Fc rain	30	20
Fc dry	0	50

These are the EMV (total cost) for those who interpreted ??? as “it *might* rain”



And them put them together . . .



Ob / Fc	R	-
R	10	0
???	20	20
-	0	50

This is the “sensitivity to rain” approach:

Categorical

Ob / Fc	R	–
R	20	10
-	10	60

Non-categorical

Ob / **Fc**	R	-
R	10	0
??	**20**	**20**
-	0	50

This is the matrix for those

Ob / Fc	R	–
R	30	20
-	0	50

with <u>low</u> protection cost

This is the matrix for those

Ob / Fc	R	–
R	10	0
-	20	70

with <u>high</u> protection cost

...assume rain
to be on the
safe side!

This is the “not sensitivity to rain” approach

Categorical

Ob / Fc	R	–
R	20	10
-	10	60

Non-categorical

Ob / Fc	R	-
R	10	0
??	20	20
-	0	50

This is the matrix for those

Ob / Fc	R	–
R	30	20
-	0	50

with low protection cost

This is the matrix for those

Ob / Fc	R	–
R	10	0
-	20	70

with high protection cost

...I can afford to be hit by the odd shower!

Paradox 3: The US Weather Bureau could have defeated Krick by applying probability forecasting

Can we quantify the ???? uncertainty?

Categorical

Obs / Fc	R	–
R	20	10
-	10	60

Non-categorical

Obs / Fc	R	-
R	10	0
???	20	20
-	0	50

Probabilistic

Obs / Prob%	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

What to do with a probability **p**?

1. If you do nothing there is a chance **p** to lose **L**.
2. On average the loss will be **pL** ("risk")
3. If you take protective action it will cost **c**
4. Only if **p·L > c** is it worth while to take action

5. The "break even" point is **p = c/L**

Decision matrix for people with c/L almost 100%

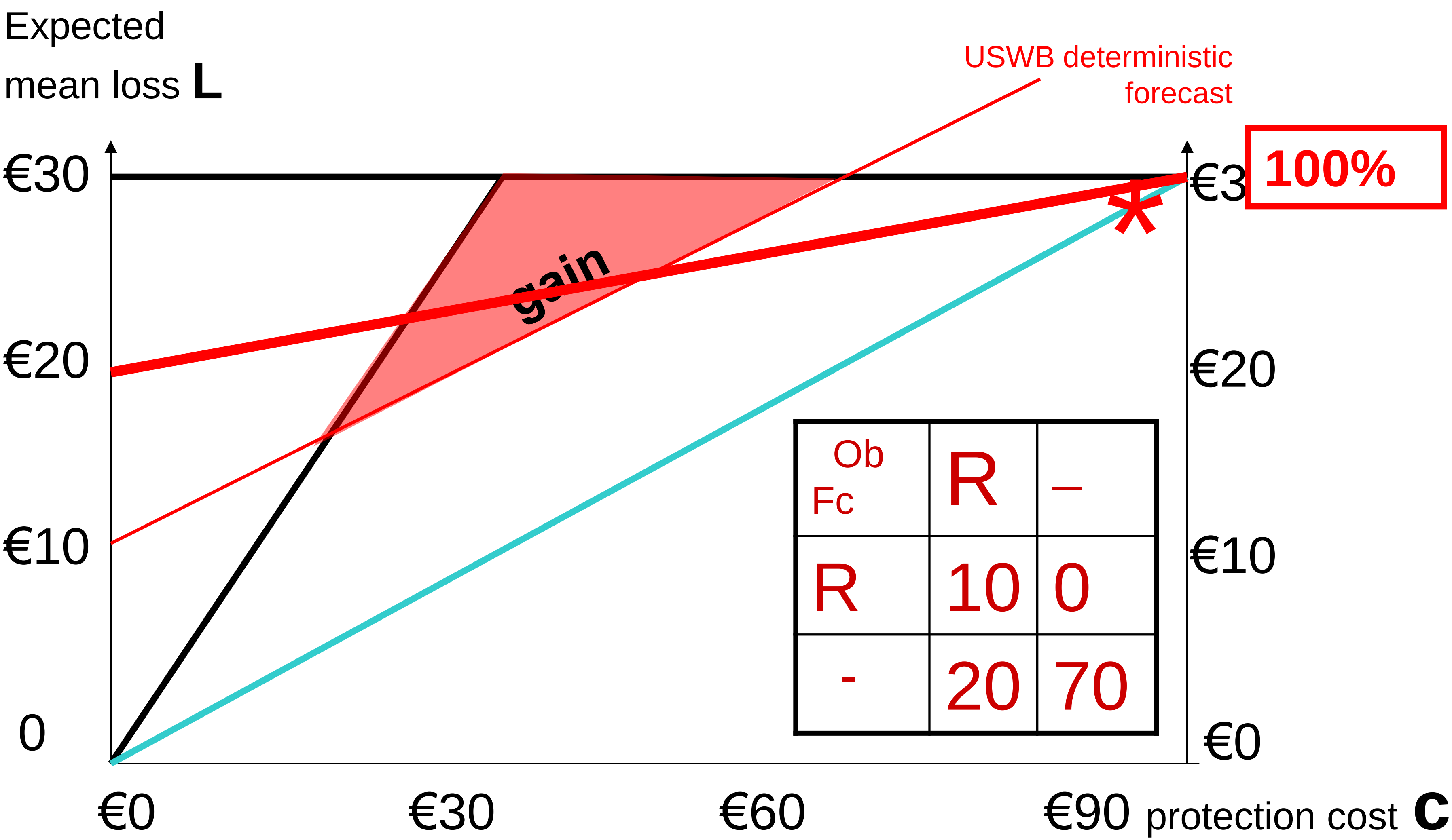
Ob Prob	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

Ob Fc	R	–
R	10	0
-	20	70

Decision matrix

Probability matrix

Gains for people with c/L almost 100%



Ob / Fc	R	–
R	10	0
-	20	70

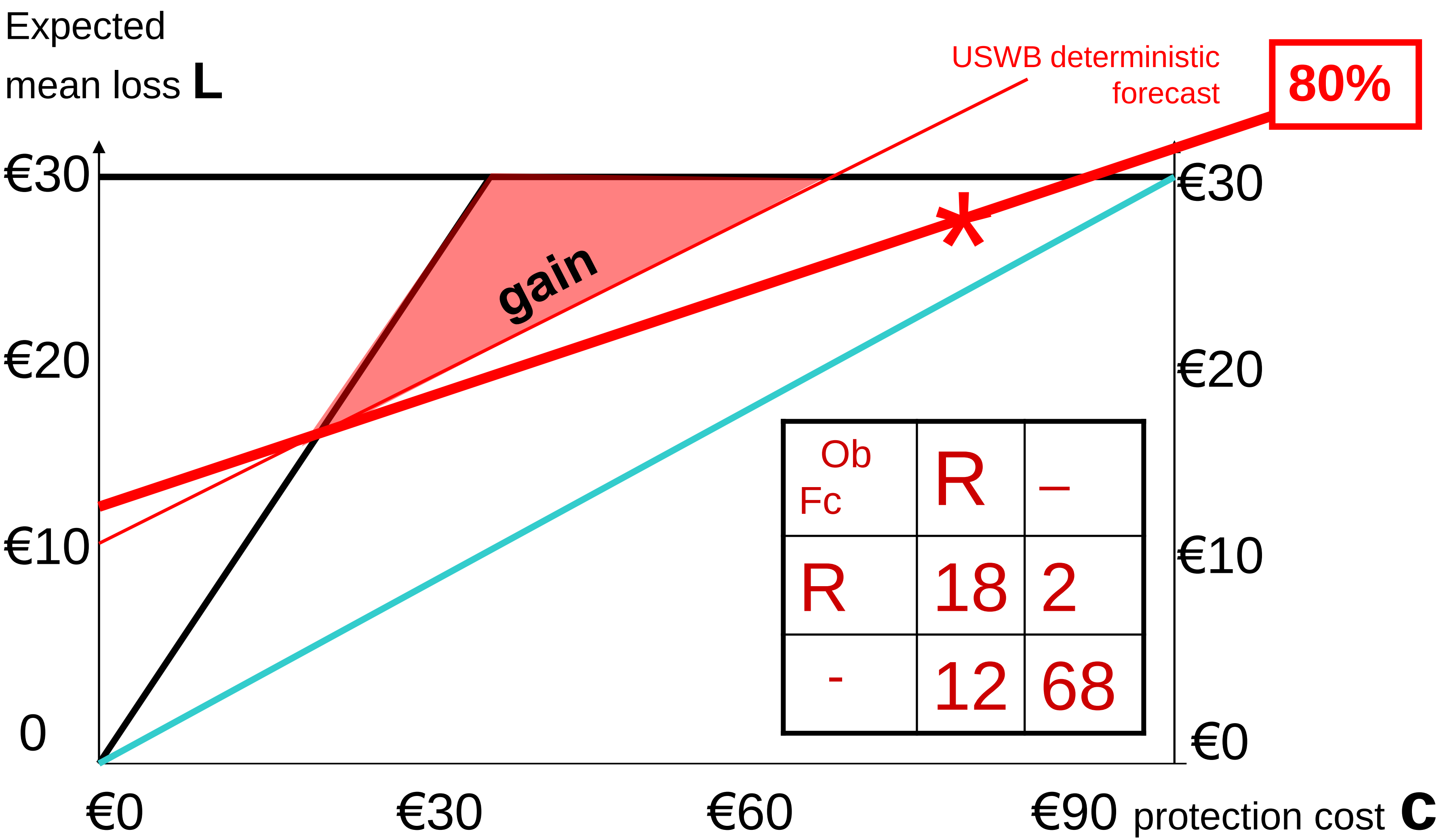
Decision matrix for people with c/L around 80%

Ob / Prob	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

→

Ob / Fc	R	–
R	18	2
-	12	68

Gains for people with c/L around 80%



Ob / Fc	R	–
R	18	2
-	12	68

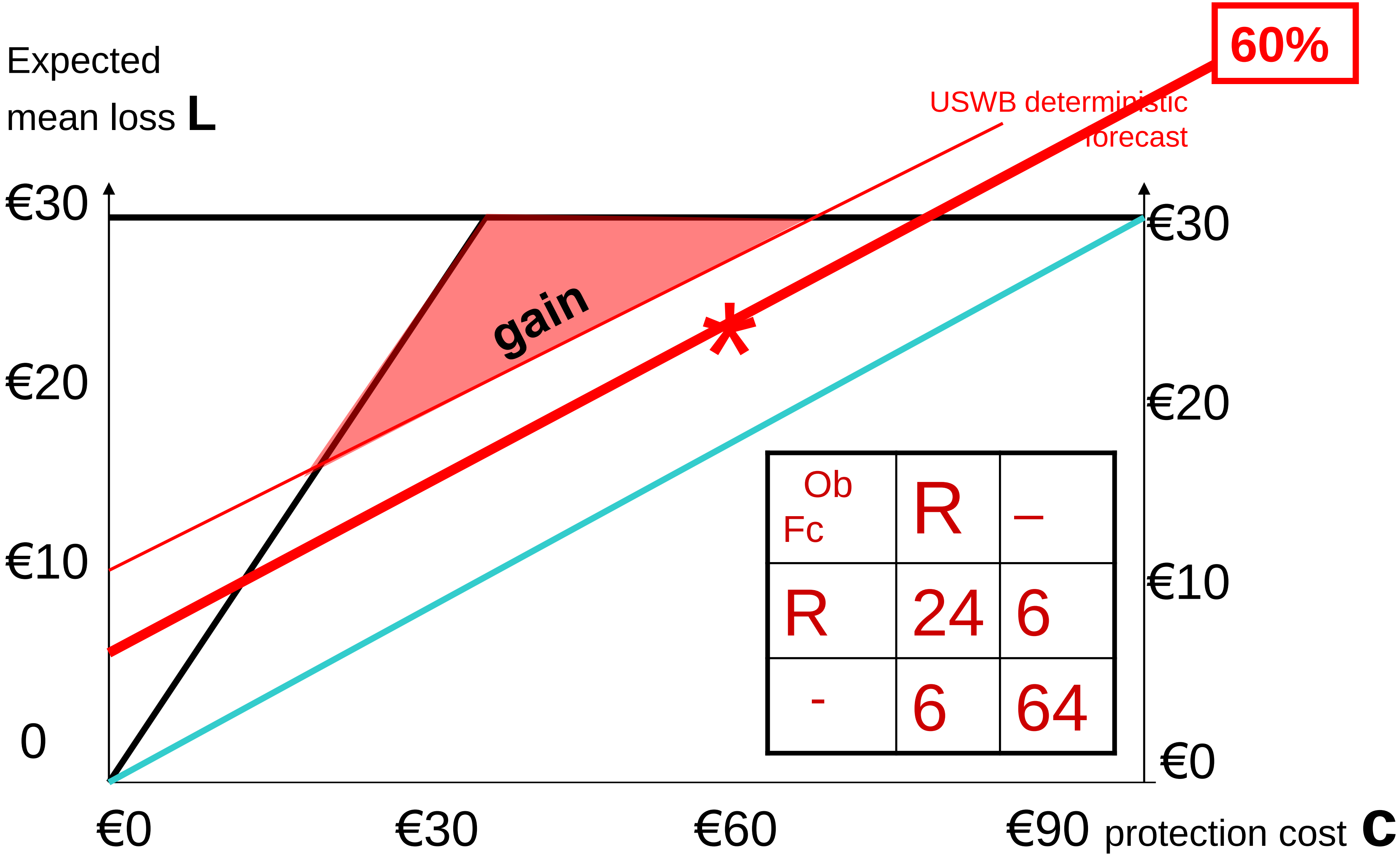
Decision matrix for people with c/L around 60%

Ob / Prob	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

→

Ob / Fc	R	–
R	24	6
-	6	64

Gains for people with c/L around 60%



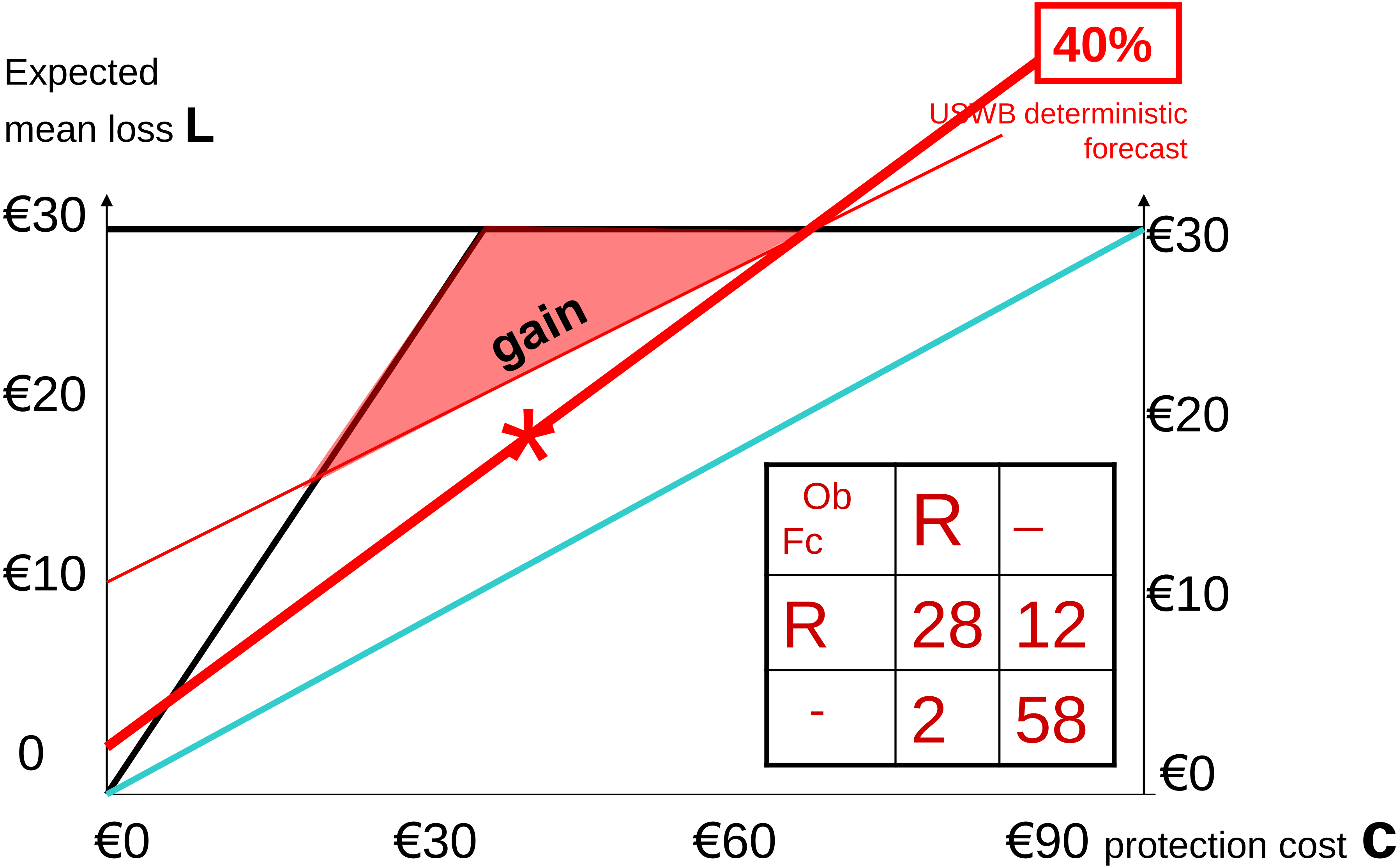
Decision matrix for people with c/L around 40%

Ob Prob	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

→

Ob Fc	R	–
R	28	12
-	2	58

Gains for people with c/L around 40%



Ob / Fc	R	–
R	28	12
-	2	58

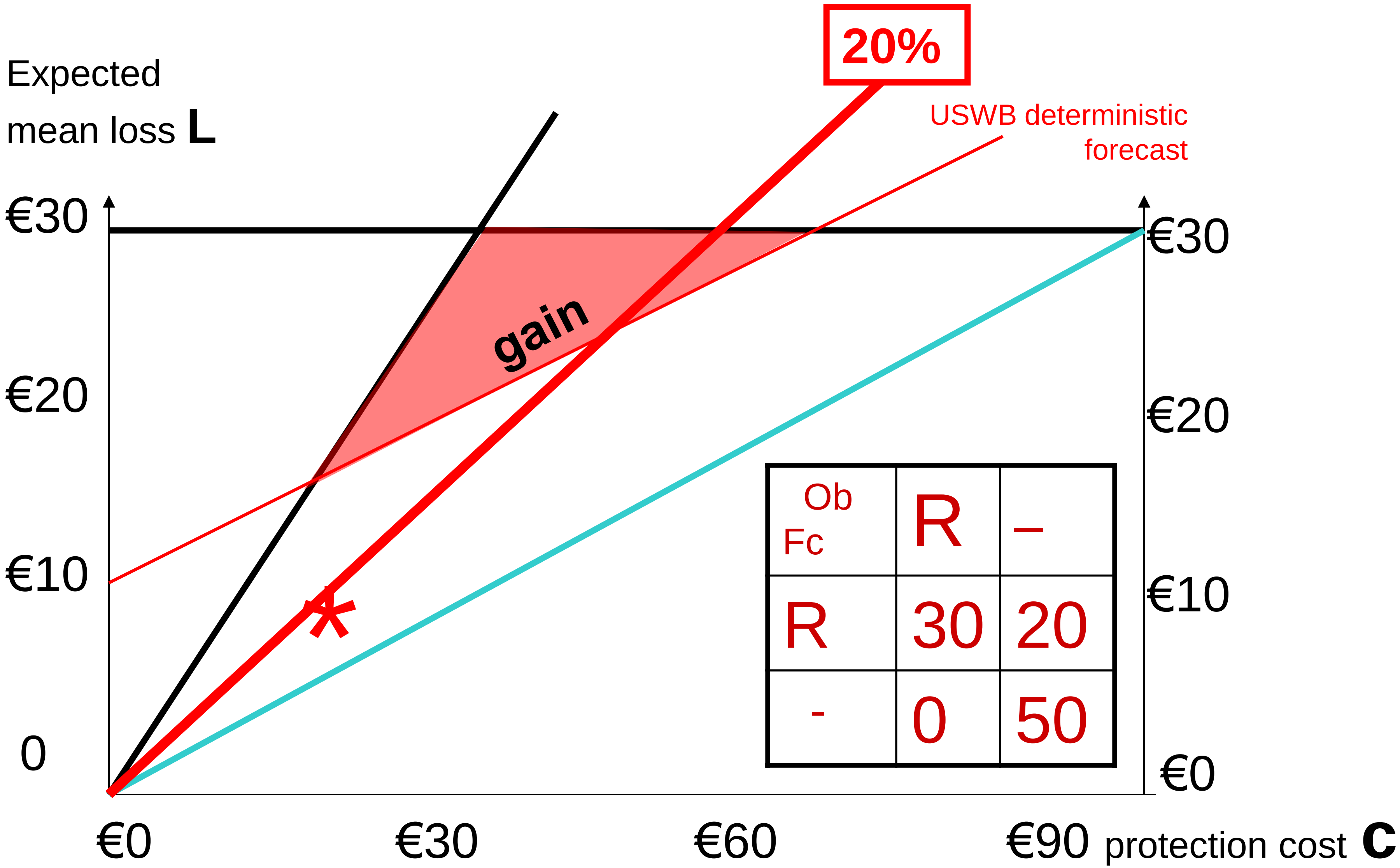
Decision matrix for people with c/L around 20%

Ob / Prob	R	–
100	10	0
80	8	2
60	6	4
40	4	6
20	2	8
0	0	50

→

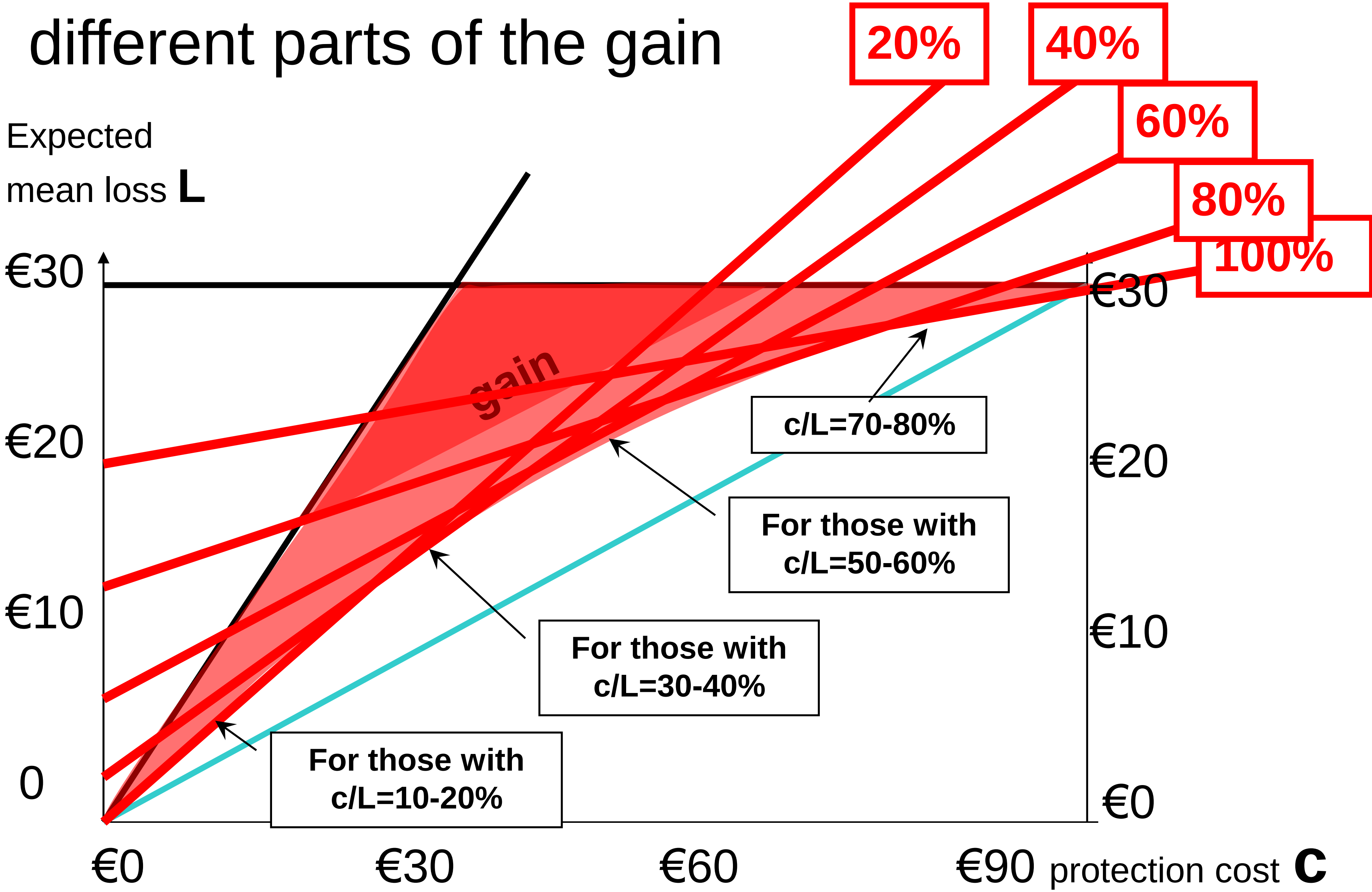
Ob / Fc	R	–
R	30	20
-	0	50

Gains for people with c/L around 20%

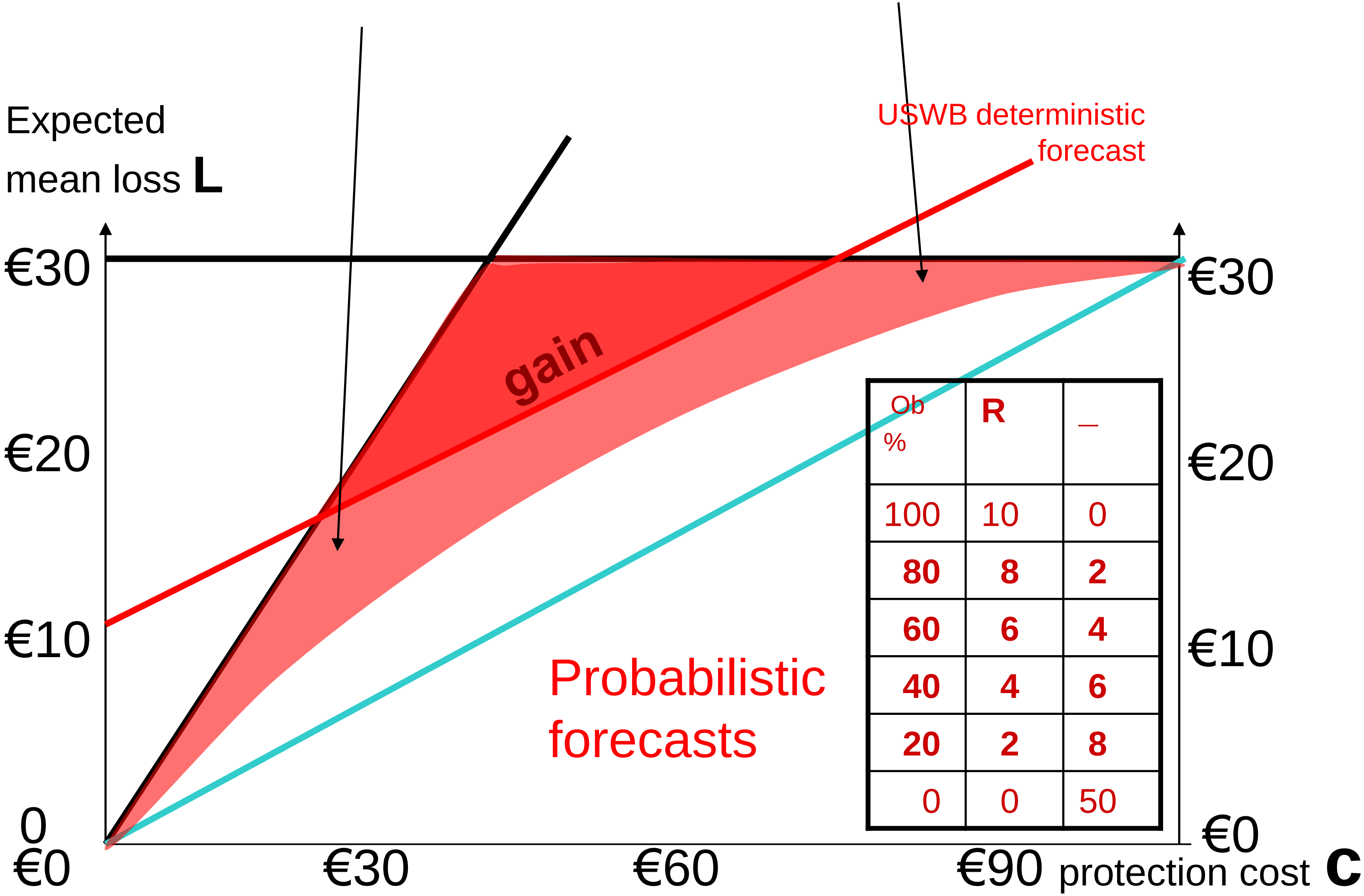


Ob / Fc	R	–
R	30	20
-	0	50

Different users benefit from different parts of the gain



Probabilities yield gains for <u>all</u> possible protection costs



Ob %	R	_
100	10	0
80	**8**	**2**
60	**6**	**4**
40	**4**	**6**
20	**2**	**8**
0	0	50

END