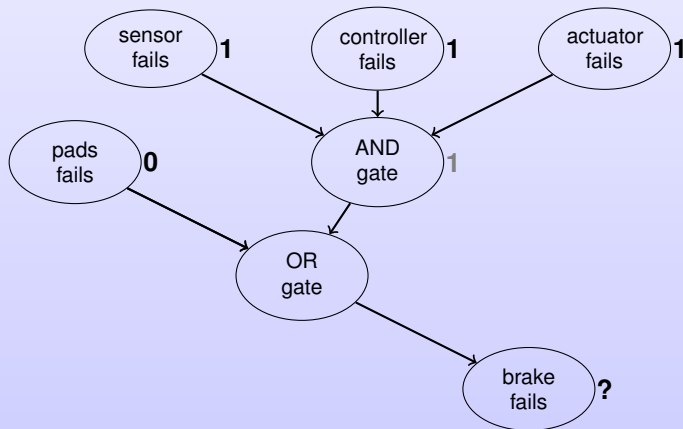


# [Exe #1] Fault trees (Vesely et al, 1981)

brake fails = [ pads  $\vee$  ( sensor  $\wedge$  controller  $\wedge$  actuator ) ]

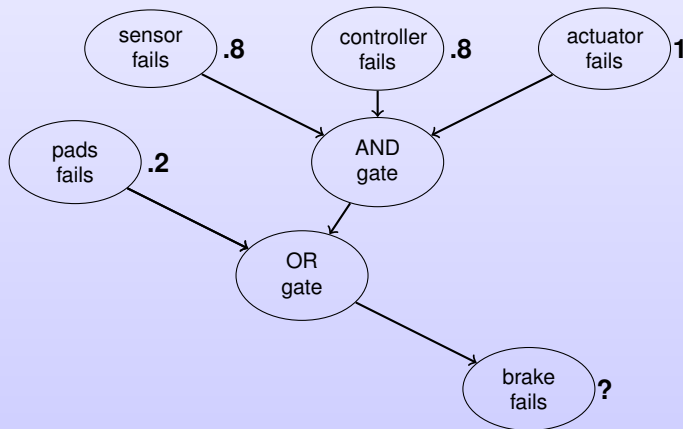
devices failures are independent



# [Exe #1] Fault trees (Vesely et al, 1981)

brake fails = [ pads  $\vee$  ( sensor  $\wedge$  controller  $\wedge$  actuator ) ]

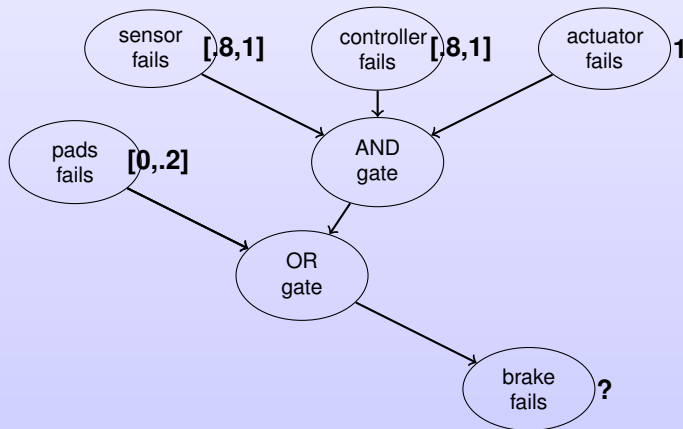
devices failures are independent



# [Exe #1] Fault trees (Vesely et al, 1981)

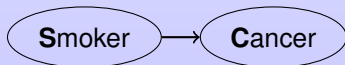
brake fails = [ pads  $\vee$  ( sensor  $\wedge$  controller  $\wedge$  actuator ) ]

devices failures are independent

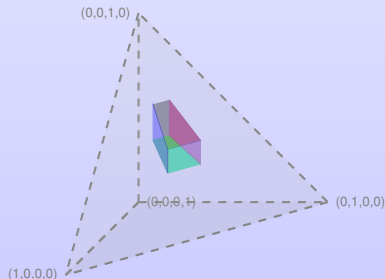


# [Exe #2] An imprecise bivariate (graphical?) model

- Two Boolean variables: **Smoker**, Lung **Cancer**
- Eight “Bayesian” physicians, each one assessing  $P_j(S, C)$
- $K(S, C) = \text{CH} \{P_j(S, C)\}_{j=1}^8$
- Compute:
  - Marginal  $K(S)$
  - Conditioning  
 $K(C|S) := \{K(C|s), K(C|s)\}$
  - Combination (marg ext)  
 $K'(C, S) := K(C|S) \otimes K(S)$
- Is this a (I)PGM?



$j$	$P_j(s, c)$	$P_j(s, \neg c)$	$P_j(\neg s, c)$	$P_j(\neg s, \neg c)$
1	1/8	1/8	3/8	3/8
2	1/8	1/8	9/16	3/16
3	3/16	1/16	3/8	3/8
4	3/16	1/16	9/16	3/16
5	1/4	1/4	1/4	1/4
6	1/4	1/4	3/8	1/8
7	3/8	1/8	1/4	1/4
8	3/8	1/8	3/8	1/8

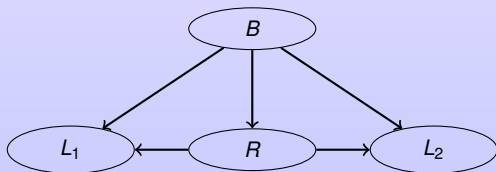


# [Exe # 3] Is the ball in or out?

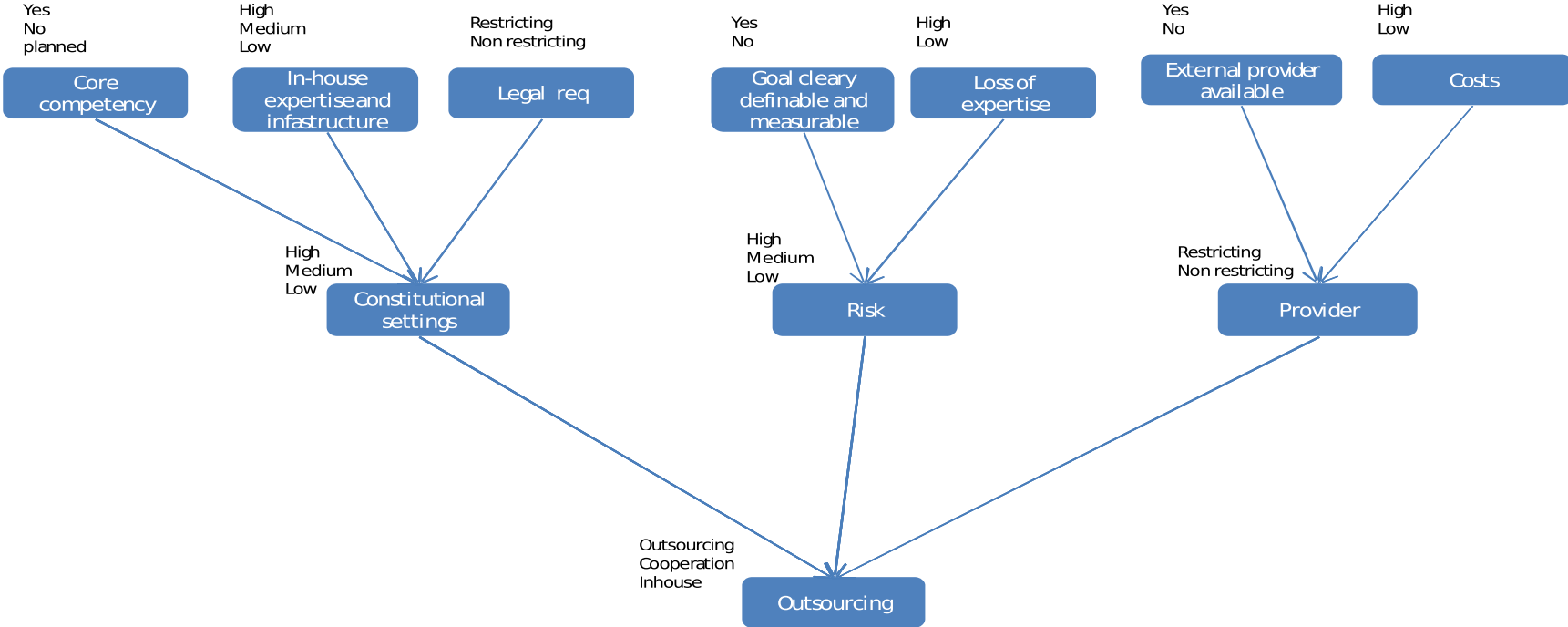
- $B$ , with  $\mathcal{B} = \{1, 0\}$ , means the ball was in
- $R, L_1, L_2$  are the opinions/observation of the referee/linesmen
- A CN over these variables
- Given  $B$ , the three opinions are independent? Not really, the referee has an influence on the linesmen
- Compute bounds of
  - $P(B = 1 | R = 1, L_1 = 1, L_2 = 1)$
  - $P(B = 1 | R = 0, L_1 = 1, L_2 = 1)$
  - $P(B = 1 | R = 1, L_1 = 0, L_2 = 0)$
  - $P(B = 1 | R = 0, L_1 = 0, L_2 = 1)$



$$\begin{aligned}
 P(B = 1) &= .50 \\
 P(R = 1 | B = 1) &\in [.80, .90] \\
 P(R = 1 | B = 0) &\in [.20, .30] \\
 P(L_j = 1 | B = 1, R = 1) &\in [.90, .95] \\
 P(L_j = 1 | B = 1, R = 0) &\in [.50, .60] \\
 P(L_j = 1 | B = 0, R = 1) &\in [.40, .50] \\
 P(L_j = 1 | B = 0, R = 0) &\in [.10, .20]
 \end{aligned}$$



**Knowlegde Map**



**CONSTITUTIONAL SETTINGS**

Input

Core Competence	Inhouse expertise and infrastructure	Legal requirements
Yes	High	Restr
Yes	High	Non- Restr
Yes	Medium	Restr
Yes	Medium	Non- Restr
Yes	Low	Restr
Yes	Low	Non- Restr
Planned	High	Restr
Planned	High	Non- Restr
Planned	Medium	Restr
Planned	Medium	Non- Restr
Planned	Low	Restr
Planned	Low	Non- Restr
No	High	Restr
No	High	Non- Restr
No	Medium	Restr
No	Medium	Non- Restr
No	Low	Restr
No	Low	Non- Restr

Expert

H	M	L	Global definition
certain	-	impossible	
-	probable	impossible	
probable	-	impossible	
-	probable	impossible	
-	probable	-	
-	probable	-	
probable	-	impossible	
probable	-	impossible	
probable	-	impossible	
-	probable	-	
-	probable	impossible	
-	probable	-	
-	probable	-	
impossible	probable	-	
impossible	-	probable	
impossible	-	probable	
impossible	-	probable	
impossible	-	certain	

Probabilites

H	M	L	Global definition
90-100%	-	0%	
-	75-100%	0%	
75-100%	-	0%	
-	75-100%	0%	
-	75-100%	-	
-	75-100%	-	
75-100%	-	0%	
75-100%	-	0%	
75-100%	-	0%	
-	75-100%	-	
-	75-100%	-	0%
-	75-100%	-	
-	75-100%	-	
-	0% 75-100%	-	
-	0%-	75-100%	
-	0%-	75-100%	
-	0%-	75-100%	
-	0%-	90-100%	

certain	90-100%
probable	75-100%
fifty-fifty	40-60%
improbable	0-25%
uncertain	0-10%
impossible	0%
-	-

**PROVIDER**

Input

External provider available	Costs
Yes	High
Yes	Low
No	High
No	Low

Expert

NR	R	Global definition
fifty-fifty	-	
certain	-	
-	probable	
-	fifty-fifty	

Probabilites

NR	R	Global definition
40%-60%	-	
90-100%	-	
-	75-100%	
-	40%-60%	

certain	90-100%
probable	75-100%
fifty-fifty	40%-60%
improbable	0-25%
uncertain	0-10%
impossible	0%
-	-



**RISK**

Input

Goal clearly definable and measurable	Loss of expertise
Yes	High
Yes	Low
No	High
No	Low

Expert opinion

			Global definition
<b>H</b>	<b>M</b>	<b>L</b>	
-	<b>probable</b>	-	
impossible	-	<b>certain</b>	
<b>certain</b>	-	impossible	
-	<b>probable</b>	-	

Probabilites

<b>H</b>	<b>M</b>	<b>L</b>	
-	75-100%	-	
0%	-	90-100%	
90-100%	-	0%	
-	75-100%	-	

certain	90-100%
probable	75-100%
fifty-fifty	50%
improbable	0-25%
uncertain	0-10%
impossible	0%
-	-

**OUTSOURCING**

Input

Constitutional sett	Risk	Provider
High	High	Restr
High	High	Non- Restr
High	Medium	Restr
High	Medium	Non- Restr
High	Low	Restr
High	Low	Non- Restr
Medium	High	Restr
Medium	High	Non- Restr
Medium	Medium	Restr
Medium	Medium	Non- Restr
Medium	Low	Restr
Medium	Low	Non- Restr
Low	High	Restr
Low	High	Non- Restr
Low	Medium	Restr
Low	Medium	Non- Restr
Low	Low	Restr
Low	Low	Non- Restr

Expert opinion

Outsourcing	Collaboration	Intern	Global definition
impossible	-	certain	P(C )>>P(O)
-	-	probable	P(C )>>P(O)
-	-	probable	P(C )>>P(O)
-	fifty-fifty	fifty-fifty	-
-	-	probable	P(C )>P(O)
-	probable	-	-
-	fifty-fifty	fifty-fifty	-
-	probable	-	-
-	probable	-	P(I)>>P(C )
-	probable	-	P(O)>>P(I)
-	probable	-	-
fifty-fifty	fifty-fifty	-	-
-	probable	-	-
probable	-	-	P(C )>>P(I)
-	probable	-	P(O)>>P(I)
probable	-	-	P(C )>>P(I)
quiteprobable	-	-	P(C )>>P(I)
certain	-	impossible	-

Expert opinion

Outsourcing	Collaboration	Intern	Global definition
-	0%	90-100%	P(C )>>P(O)
-	-	75-100%	P(C )>>P(O)
-	-	75-100%	P(C )>>P(O)
-	40-60%	40-60%	-
-	-	75-100%	P(C )>P(O)
-	75-100%	-	-
-	40-60%	40-60%	-
-	75-100%	-	-
-	75-100%	-	P(I)>>P(C )
-	75-100%	-	P(O)>>P(I)
-	75-100%	-	-
40-60%	40-60%	-	-
-	75-100%	-	-
75-100%	-	-	P(C )>>P(I)
-	75-100%	-	P(O)>>P(I)
75-100%	-	-	P(C )>>P(I)
50-75%	-	-	P(C )>>P(I)
90-100%	-	0%	-

certain	90-100%
probable	75-100%
quiteProbable	50-75%
fifty-fifty	40-60%
improbable	0-25%
uncertain	0-10%
impossible	0%
-	-

Remark P(A)>>P(B) means P(A)>5\*P(B)