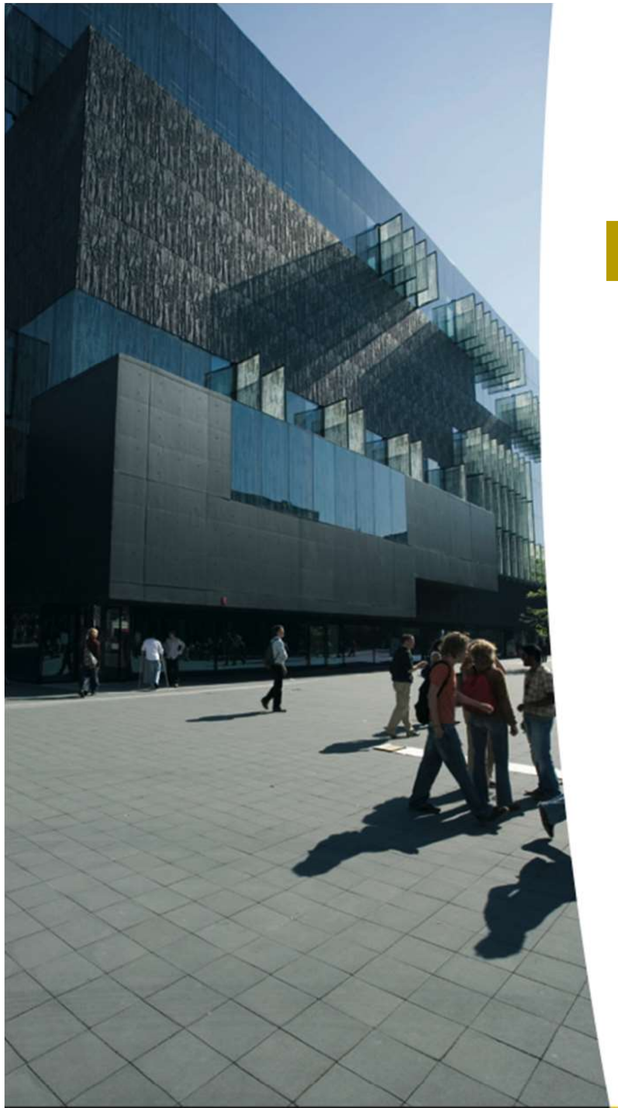

L14: Formal Argumentation
Structured argumentation

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Methods in AI research

(based on slides of Henry Prakken and Floris Bex)

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Structured Argumentation

- Abstract argumentation
  - takes as given a set of arguments and attacks
  - provides semantics

- Structured argumentation
  - provides a model of the structure and origin of arguments and attacks
  - allows to construct/derive arguments (e.g. from a knowledge base using rules of inference)

Structured Arguments

- Arguments are reasons for conclusions
- Infer conclusions from premises using inference rules
- Example:
  - $p, p \rightarrow q$
  - q (Modus Ponens)

  - $p \wedge q$
  - p ($\wedge$-Elim)

Syntax of arguments - ASPIC+

- Arguments are trees
  - Nodes are formulas of a logical language $\mathcal{L}$
  - Links are applications of inference rules
    - $\mathcal{R}_s$ = Strict rules ($\phi_1, \ldots, \phi_n \rightarrow \phi$); or
    - $\mathcal{R}_d$ = Defeasible rules ($\phi_1, \ldots, \phi_n \Rightarrow \phi$)
  - *Reasoning* starts from a knowledge base $\mathcal{K} \subseteq \mathcal{L}$

ASPIC+ Argumentation systems (with symmetric negation)

- An argumentation system is a triple $AS = (\mathcal{L}, \mathcal{R}, n)$ where:
  - $\mathcal{L}$ is a logical language with negation ($\neg$)
  - $\mathcal{R} = \mathcal{R}_s \cup \mathcal{R}_d$ is a set of strict ($\phi_1, \ldots, \phi_n \rightarrow \phi$) and defeasible ($\phi_1, \ldots, \phi_n \Rightarrow \phi$) inference rules
  - n: $\mathcal{R}_d \rightarrow \mathcal{L}$ is a naming convention for defeasible rules

- An argumentation theory is a pair $AT = (AS, \mathcal{K})$ where AS is an argumentation system and $\mathcal{K}$ a knowledge base in AS.
  - A knowledge base in $AS = (\mathcal{L}, \mathcal{R}, n)$ is a set $\mathcal{K} \subseteq \mathcal{L}$ where $\mathcal{K}$ is a partition $\mathcal{K}_n \cup \mathcal{K}_p$ with:
    - $\mathcal{K}_n$ = necessary premises (axioms)
    - $\mathcal{K}_p$ = ordinary premises ("assumptions")

Arguments

- An argument A on the basis of an argumentation theory is:
  - ϕ if $\phi \in \mathcal{K}$ with
    - Prem(A) = $\{\phi\}$, Conc(A) = ϕ, Sub(A) = $\{\phi\}$, DefRules(A) = $\emptyset$
  - $A_1, \ldots, A_n \rightarrow \phi$ if $A_1, \ldots, A_n$ are arguments such that there is a strict inference rule Conc(A_1), ..., Conc(A_n) $\rightarrow \phi$
    - Prem(A) = Prem(A_1) $\cup \ldots \cup$ Prem(A_n)
    - Conc(A) = ϕ
  - $A_1, \ldots, A_n \Rightarrow \phi$ if $A_1, \ldots, A_n$ are arguments such that there is a defeasible inference rule Conc(A_1), ..., Conc(A_n) $\Rightarrow \phi$
    - Prem(A) = Prem(A_1) $\cup \ldots \cup$ Prem(A_n)
    - Conc(A) = ϕ

Structured Arguments

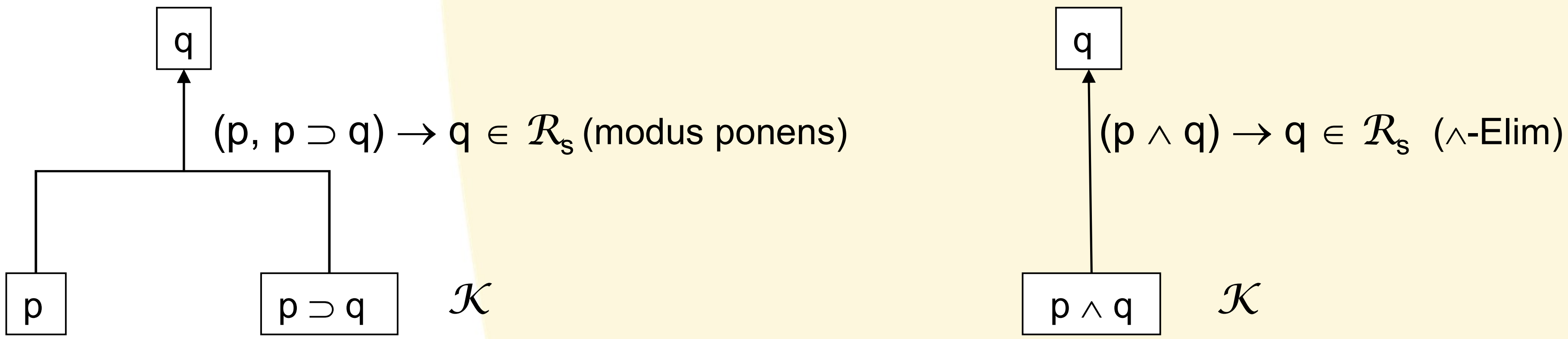
- Classical logical proof trees

$\boxed{p}$ $\boxed{p \supset q}$ $\mathcal{K}$ $\boxed{p \wedge q}$ $\mathcal{K}$

- ($\supset$ is the classical logic implication $\rightarrow$)

Structured Arguments

- Classical logical proof trees



Structured Arguments

- Defeasible arguments

Increased productivity is good

$\mathcal{K}_p$

Prof. P says that "Lower taxes increase productivity"

$\mathcal{K}_n$

Structured Arguments

- Defeasible arguments

Lower taxes increase productivity

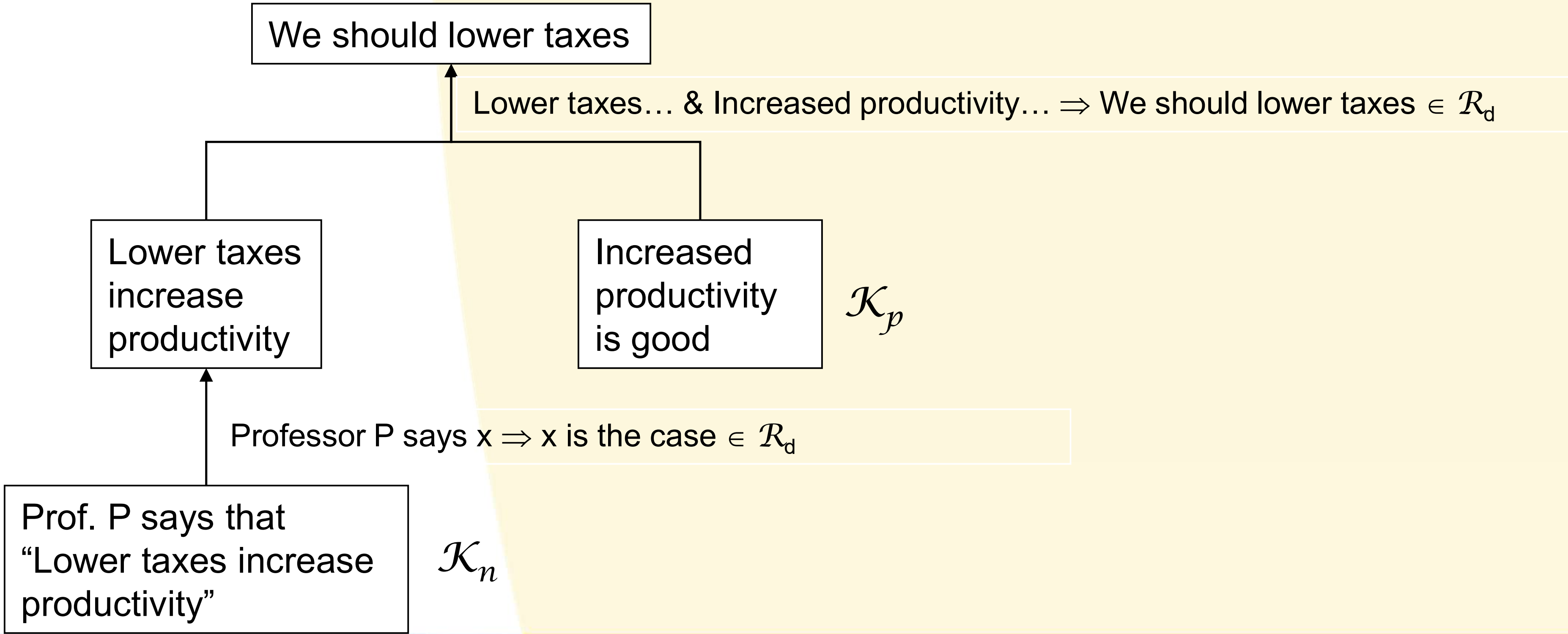
Increased productivity is good $\mathcal{K}_p$

Professor P says x $\Rightarrow$ x is the case $\in \mathcal{R}_d$

Prof. P says that "Lower taxes increase productivity" $\mathcal{K}_n$

Structured Arguments

- Defeasible arguments



Rules and exceptions

Rules are based on typical rules or generalizations we use in everyday reasoning

- Birds can (usually) fly
  - Except penguins or ostriches!
- If expert *E* says *P*, we can usually believe *P*
  - Unless the expert is biased, or *E* is not an expert in the domain that *P* is in

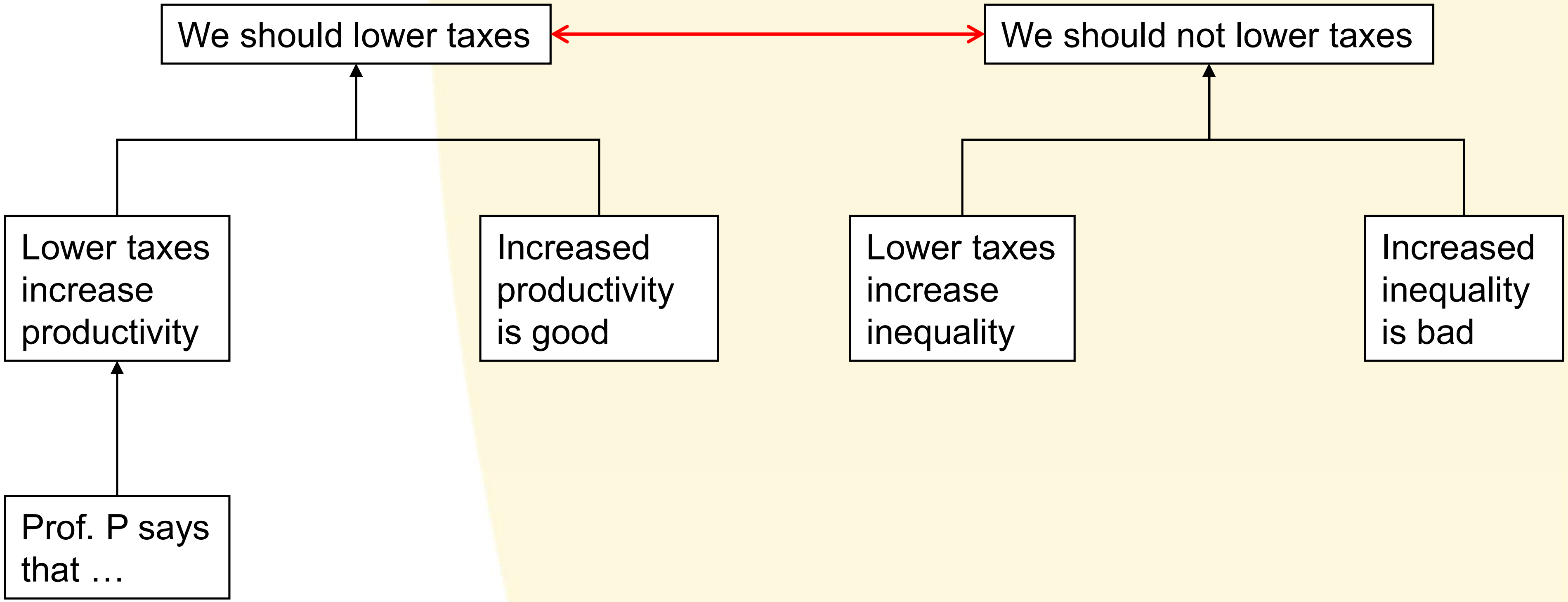
Types of attacks

- Undercutting: providing an exception to the rule
  - Attack the inference
- Undermining
  - Attack an ordinary premise (“assumption”)
- Rebutting
  - Attack a conclusion

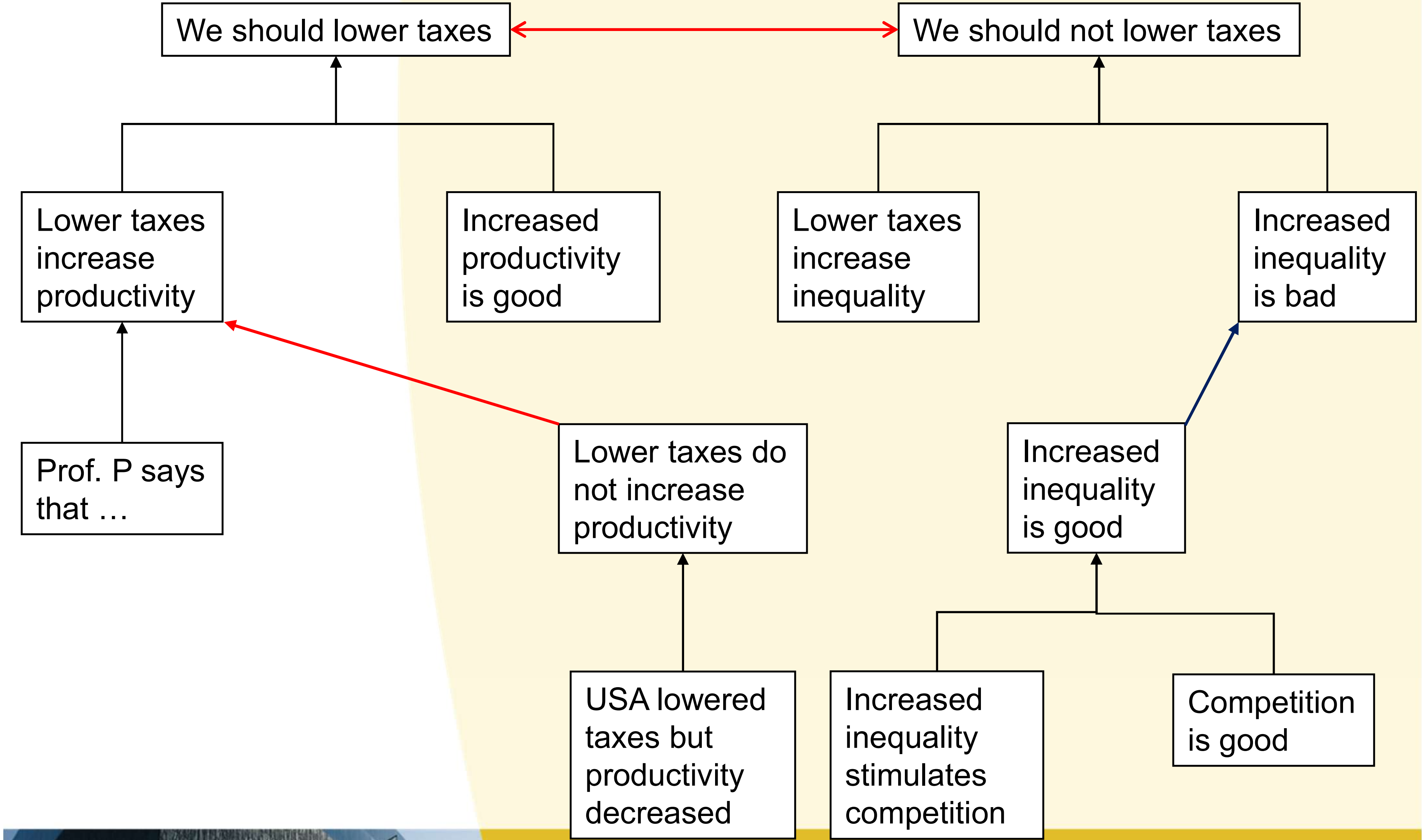
Attack

- A undermines B (on ϕ) if
  - Conc(A) = $\neg\phi$ for some $\phi \in$ Prem(B) and $\phi \in \mathcal{K}_p$;
- A rebuts B (on B') if
  - Conc(A) = $\neg$Conc(B') for some $B' \in$ Sub(B) with a defeasible top rule
- A undercuts B (on B') if
  - Conc(A) = $\neg$n(r) for some $B' \in$ Sub(B) with defeasible top rule r
- A attacks B iff A undermines or rebuts or undercuts B.

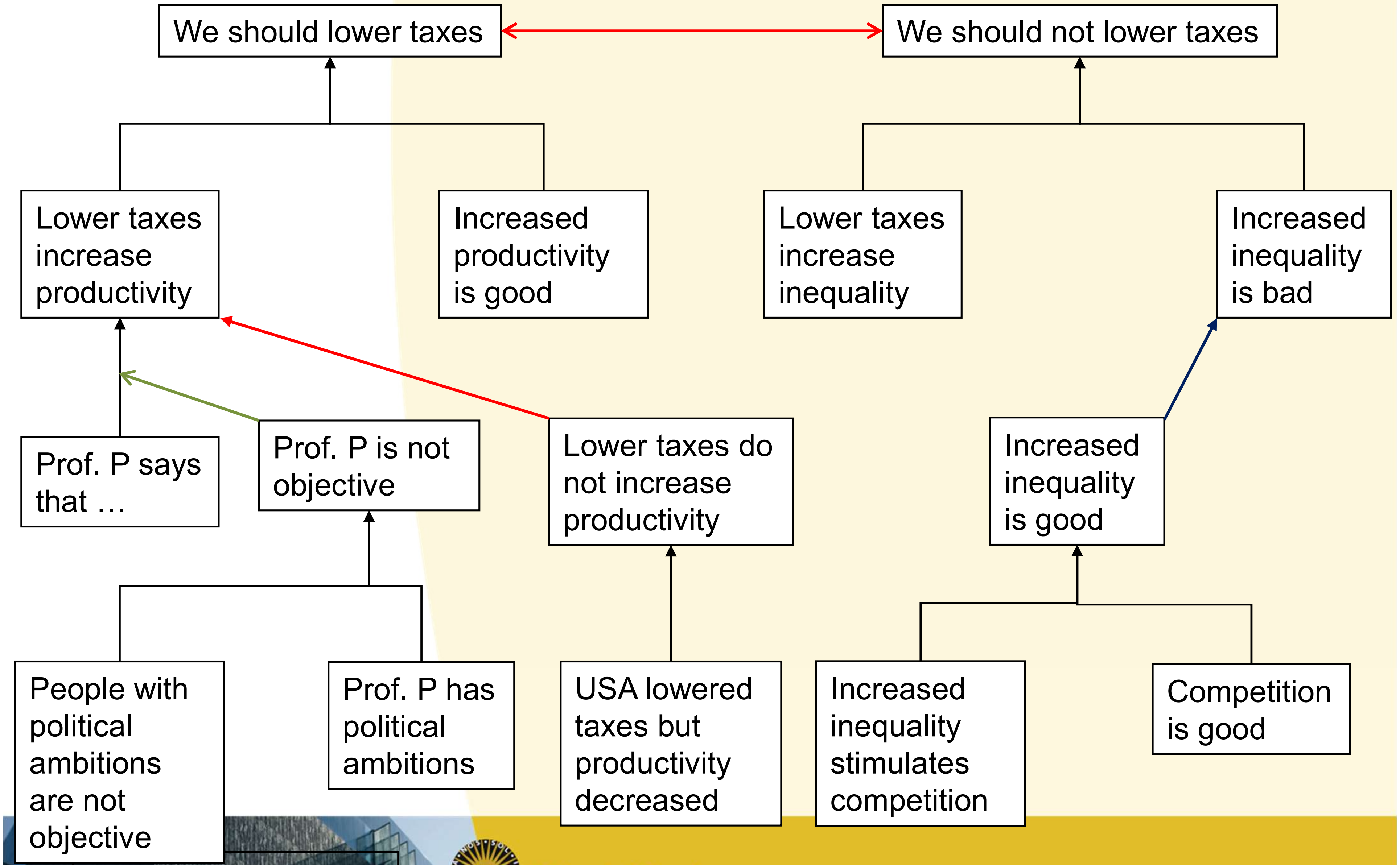
Rebuttal


We should lower taxes
We should not lower taxes
Lower taxes increase productivity
Increased productivity is good
Lower taxes increase inequality
Increased inequality is bad
Prof. P says that …

Undermining



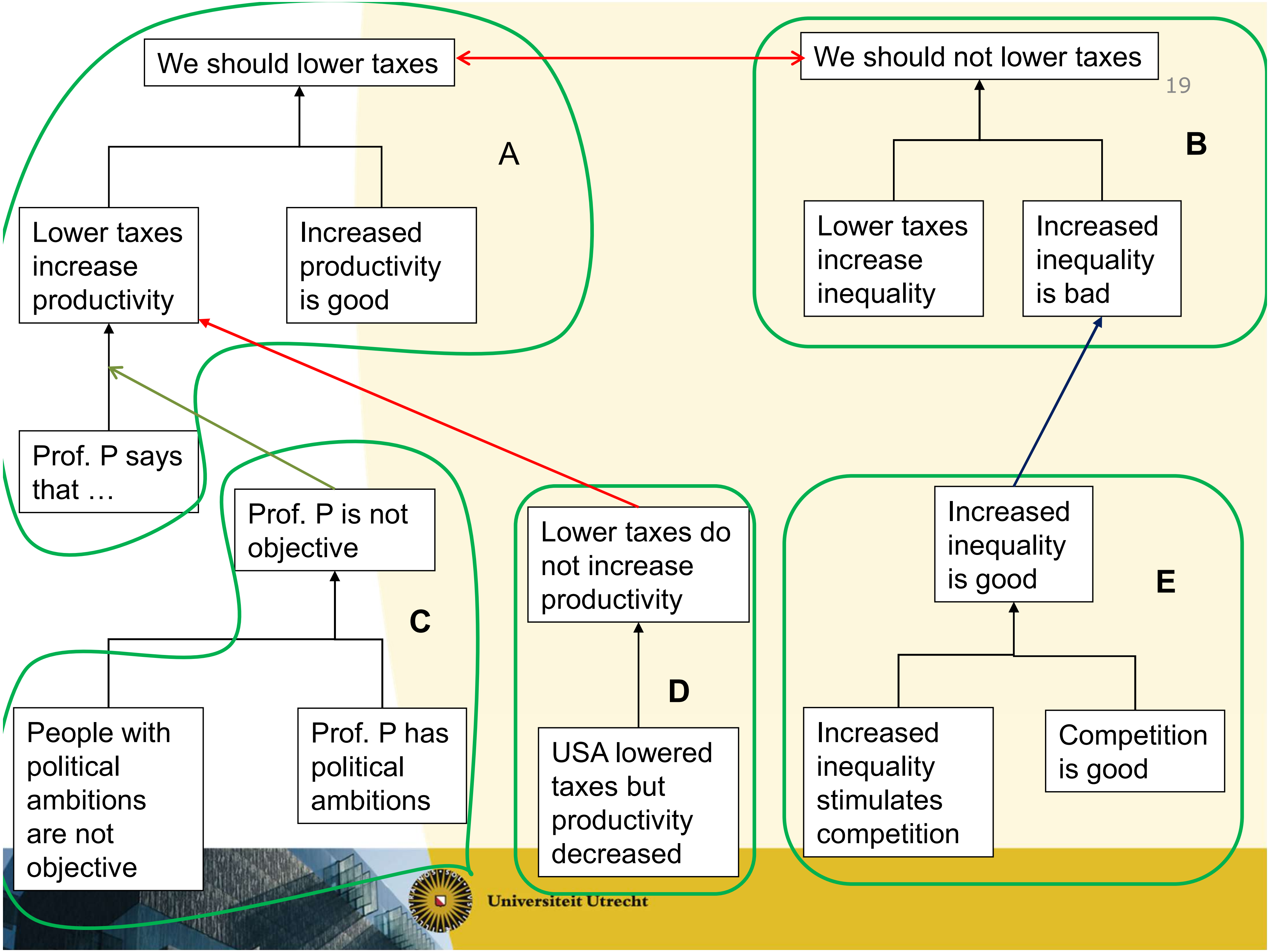
Undercutting



Undercutting

- Attacks the application of the inference rule by providing an exception

- I see a red ball *so* there is a red ball
- I see a blue ball *so* there is no red ball (rebut)
- The ball is illuminated by a red light (undercut)
  - The conclusion (ball = red) might still be true, but the premise (I see red ball) is not a good reason for this conclusion


We should lower taxes
Lower taxes increase productivity
Increased productivity is good
A
Prof. P says that …
We should not lower taxes
Lower taxes increase inequality
Increased inequality is bad
B
Prof. P is not objective
People with political ambitions are not objective
Prof. P has political ambitions
C
Lower taxes do not increase productivity
USA lowered taxes but productivity decreased
D
Increased inequality is good
Increased inequality stimulates competition
Competition is good
E
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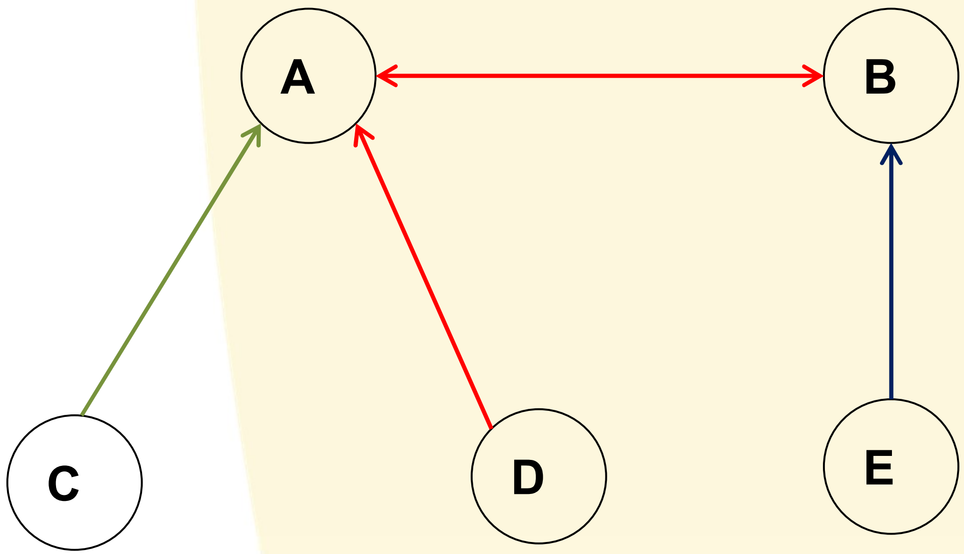
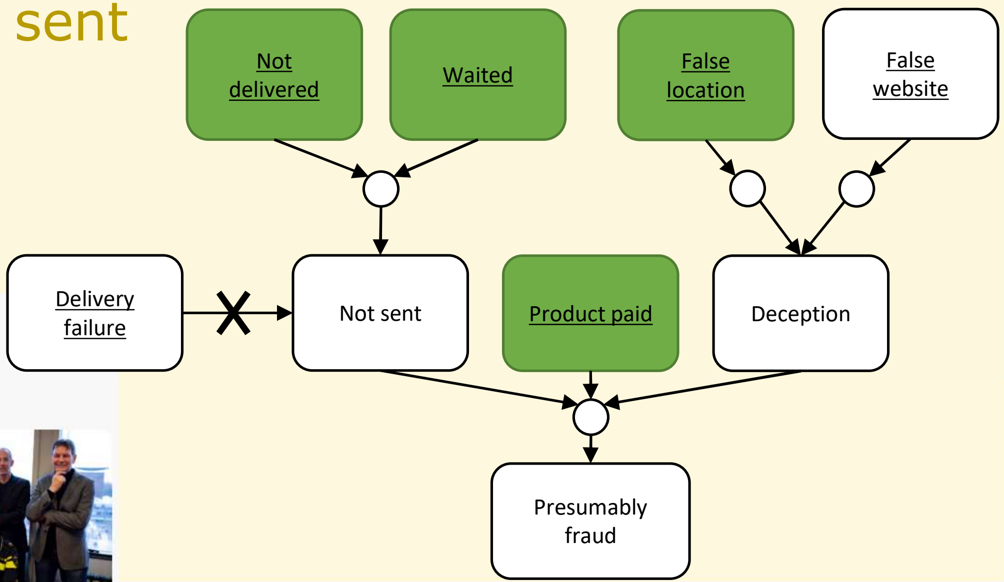
Back to Abstract Argumentation

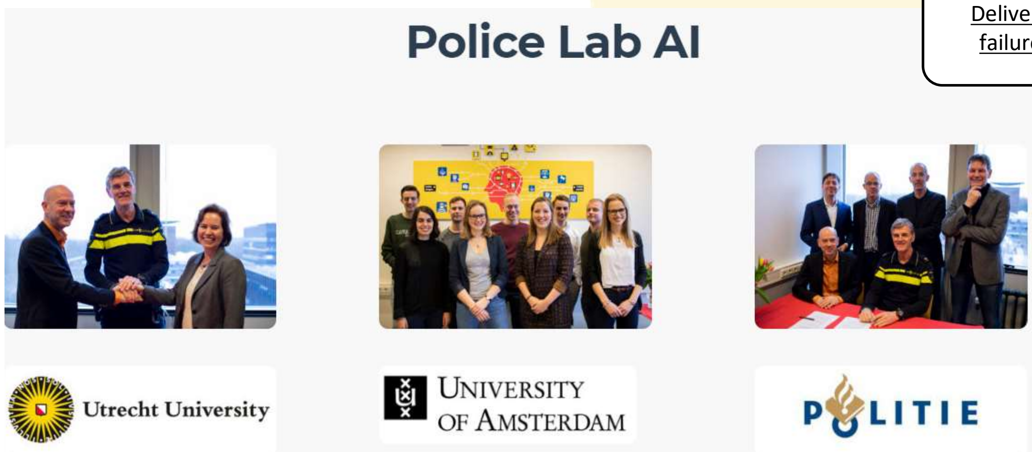
- we don’t care what is inside the arguments, when we calculate the extensions



The National Police Lab AI

- a collaborative initiative of the Dutch Police, Utrecht University and the University of Amsterdam.
- Amsterdam: machine-learning techniques for extracting the right information from different sources (photos, text, video)
- Utrecht: models from *symbolic AI (argumentation, etc.)* that allow us to reason with and communicate this information
- Not delivered ∧ waited → not sent





Types of questions for the exam

- *ASPIC+*: For a given KB $\mathcal{K}$ and the ruleset $\mathcal{R} = \mathcal{R}_s \cup \mathcal{R}_d$
  - construct (some/all) arguments
  - indicate all (3 types of) attacks between them.

- *Abstract argumentation*: For a given argumentation graph
  - calculate all the extensions (for a given semantics)
  - determine all sceptically/credulously justified arguments

Exercise 1 (exam question 2019)

Take the knowledge base

$\mathcal{K} = \{Bird, Penguin\}$

and the rule-base

$\mathcal{R}_d = \{r_1: Bird \Rightarrow Flies, r_2: Penguin \Rightarrow \neg Flies, r_3: Penguin \Rightarrow \neg r_1\}$.

A. Construct all the arguments which can be built using this knowledge and rule base.

B. Indicate which of these arguments attack each other, and what the type of each attack is (rebut/undercut/undermine).

Exercise 2 (advanced)

Take the knowledge base

$\mathcal{K} = \{Bat, Baby\}$

and the rule-base

$\mathcal{R}_d = \{r_1: Bat \Rightarrow Flies, r_2: Baby \Rightarrow \neg Flies, r_3: Bat \rightarrow Mammal,\ r_4: Mammal \Rightarrow \neg Flies, r_5: Baby \Rightarrow \neg r_1, r_6: Bat \Rightarrow \neg r_4\}$

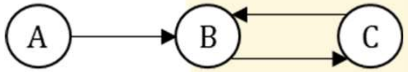
A. Construct all the arguments which can be built using this knowledge and rule base.

B. Indicate which of these arguments attack each other, and what the type of each attack is (rebut/undercut/undermine).

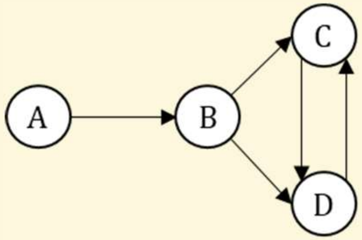
Exercise 3 (exam question 2019)

What are the preferred extensions of the following argumentation frameworks?

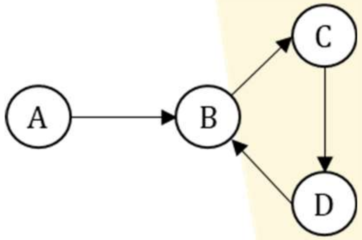
a.



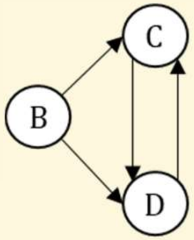
c.



b.



d.



Exercise 1 - Solution A

The following five arguments can be constructed:

- $A_1: Bird$
- $A_2: A_1 \Rightarrow Flies$
- $B_1: Penguin$
- $B_2: Penguin \Rightarrow \neg Flies$
- $C: B_1 \Rightarrow \neg r_1$

Exercise 1 - Solution B

- A_2 and B_2 attack each other: the type of the attacks is rebuttal
- C attacks A_2: the type of attack is undercut

Exercise 2 - Solution A

The following five arguments can be constructed:

- $A_1: Bat$
- $A_2: A_1 \Rightarrow Flies$
- $B_2:\ A_1 \rightarrow Mammal$
- $B_3: B_2 \Rightarrow \neg Flies$
- $C_1: Baby$
- $C_2: C_1 \Rightarrow \neg Flies$
- $D: C_1 \Rightarrow \neg r_1$
- $E: A_1 \Rightarrow \neg r_4$

Exercise 2 - Solution B

- A_2 and B_3 attack each other: the type of the attacks is rebuttal
- A_2 and C_2 attack each other: the type of the attacks is rebuttal
- D attacks A_2: the type of attack is undercut
- E attacks B_3: the type of attack is undercut

Exercise 3 - Solution

a. {A,C}

b. {A,C}

c. {A,C} and {A,D}

d. {B}