Burdens of proof in monological argumentation

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Rather than saying “agent $x$ has the burden of proving proposition $y$”, we shall say “there is the burden of proving literal $w$ in rule $z$”.

Burdens specify conditions for deriving warranted conclusions out of a knowledge base of rules: a rule can fire, only when the burdens concerning each of its antecedents (each literal in the rule’s body) are satisfied.

Burdens themselves can be specified though rules belonging to the same knowledge base: reasoning with burdens and reasoning about burdens are integrated in the same argumentative process.
Burdens and other notions

- burdens
  - burden of production
  - burden of persuasion
- proof standards
  - beyond reasonable doubt
  - clear and convincing evidence
  - preponderance of evidence
  - scintilla of evidence
Two ways of understanding the notion of the burden of production. What do we mean by saying that “there is a burden of production on literal $p_i$ in rule $r : p_1, \ldots, p_n \rightarrow q$”:

- an argument for $p_i$ necessary for the rule to fire (or for the burdened party to make the rule fire) (Prakken and Sartor)
- a credulous argument $p_i$ is necessary for the rule to fire (according to this paper, but weaker notions are also acceptable, as in Gordon-Walton)

Example:

$$r : \text{tort} \land \neg \text{justification} \Rightarrow \text{liability}$$
Kinds of conclusions

- $KB \vdash^s p$ means that $p$ is a *skeptical conclusion* of the knowledge base $KB$ (justified conclusion, established in all extensions, resulting from a justified argument),

- $KB \vdash^c p$ means that $p$ is a *credulous conclusion* of it (established in some extensions, resulting from an argument having no justified defeaters)

- $p$ is a *merely credulous* (credulous and not skeptical) if $KB \vdash^c p$ and $KB \not\vdash^s p$.

Kinds of burdens

- Burden of production: $BPr(r, p)$ means that wrt rule $r$ there is burden of production on $p$

- Burden of persuasion: $BPe(r, p)$ to mean that wrt to rule $r$ there is burden of persuasion on $p$
Given a rule: $r: \ldots p\ldots \Rightarrow q$

- The *burden of production* provides guidance for situations where no credulous arguments against $p$ are available.
  - if $\text{BPr}(r, p)$ to satisfy $p$ supporting arguments are necessary: it must be the case that either $KB \vdash^c p$ or $KB \vdash^s p$ according to the applicable requirement of persuasion.
  - if $\text{BPr}(r, \overline{p})$, then to satisfy $p$ in rule $r$ supporting arguments may not be necessary: it is sufficient that that $KB \nvdash^c \overline{p}$.

Example:

$$r: \text{damage} \land \text{negligence} \rightarrow \text{tort}$$

Assume that $KB \vdash^s \text{damage}$ and $KB \nvdash^c \text{negligence}$.

- If $\text{BPr}(r, \text{negligence})$ the rule won't fire.
- If $\text{BPr}(r, \text{negligence})$, then it will do so (unless undercut or rebutted in other ways).
Given a rule: $r: \ldots p \ldots \Rightarrow q$

- The *burden of persuasion* provides guidance for situations where $p$ only is a merely credulous conclusion.
  - If $BPe(p, r)$, then $KB \vdash^c p$ is not sufficient. In this case, $KB \vdash^s p$ will provide sufficient support for satisfying $p$.
  - If $BPe(\overline{p}, r)$, then to satisfy $p$ it is sufficient that $KB \vdash^c p$ (even though $KB \not\vdash^s p$).

Example:

$$r : \text{damage} \land \text{negligence} \rightarrow \text{tort}$$

Assume that $KB \vdash^s \text{damage}$ and $KB \vdash^c \text{negligence} \land KB \vdash^c \text{negligence}$.

- If $BPe(r, \text{negligence})$ the rule wont fire.
- If $BPe(r, \overline{\text{negligence}})$, then it will do so (unless undercut or rebutted in other ways).
Proof requirements

1. $\text{BPr}(r, p) \land \text{BPe}(r, p)$: the proof-requirements of $p$ in rule $r$ are satisfied iff $KB \vdash^s p$. In fact, given that $\text{BPr}(r, p)$ support for $p$ is required (it is not sufficient that $KB \not\vdash^c \overline{p}$), and since $\text{BPe}(r, p)$, $p$ must be skeptically supported.

2. $\text{BPr}(r, p) \land \text{BPe}(r, \overline{p})$: the proof-requirements of $p$ in rule $r$ are satisfied iff $KB \vdash^c p$ and $KB \not\vdash^s \overline{p}$. Given that $KB \vdash^c p$ entails $KB \not\vdash^s \overline{p}$, it is sufficient that $p$ is credulously supported.

3. $\text{BPr}(r, \overline{p}) \land \text{BPe}(r, p)$: the proof-requirements of $p$ in rule $r$ are satisfied iff one of the following holds: (3a) $KB \not\vdash^c \overline{p}$ or (3b) $KB \vdash^s p$. Alternative sufficient conditions for satisfying $p$: according to (3a) $\text{BPr}(r, \overline{p})$, $p$ is satisfied if $KB \not\vdash^c \overline{p}$ while according to (3b) $\text{BPe}(r, p)$, $p$ is satisfied if $KB \vdash^s p$.

4. $\text{BPr}(r, \overline{p}) \land \text{BPe}(r, \overline{p})$: the proof-requirements of $p$ in rule $r$ are satisfied iff one of the following holds: (4a) $KB \not\vdash^c \overline{p}$ or (4b) $KB \vdash^c p$. Alternative sufficient conditions for satisfying $p$: according to (4a) $\text{BPr}(r, \overline{p})$, $p$ is satisfied if $KB \not\vdash^c \overline{p}$ while according to (4b) $\text{BPe}(r, \overline{p})$, $p$ is satisfied if $KB \vdash^c p$. 

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Example: civil and criminal liability

\[ KB_0 = \{ r_1: \text{tort} \land \neg \text{justification} \rightarrow \text{civilLawLiability}, \]
\[ r_2: \text{crime} \land \neg \text{justification} \rightarrow \text{criminalLawLiability}, \]
\[ b_{1a0}: \text{BPr}(r_1, \text{tort}), \ b_{1a1}: \text{BPe}(r_1, \text{tort}), \]
\[ b_{1b0}: \text{BPr}(r_1, \text{justification}), \ b_{1b1}: \text{BPe}(r_1, \text{justification}), \]
\[ b_{2a0}: \text{BPr}(r_2, \text{crime}), \ b_{2a1}: \text{BPe}(r_2, \text{crime}), \]
\[ b_{2b0}: \text{BPr}(r_2, \text{justification}), \ b_{2b1}: \text{BPe}(r_2, \neg \text{justification}) \} \]

\[ KB_1 = KB_0 + \{ r_3: \text{crime}, \ r_4: \text{tort} \} \]

\[ KB_2 = KB_1 + \{ r_5: \text{threat} \rightarrow \text{justification}, \ r_6: \text{stronger} \rightarrow \neg \text{justification}, \]
\[ r_7: \text{threat}, \ r_8: \text{stronger} \} \]
Arguments about burdens

\[ KB_0 = \{ r_6 : \text{damage} \land \text{negligence} \rightarrow \text{tort}, \ r_7 : \text{damage}, b_{6a0} : BPr(r_6, \text{damage}), b_{6a1} : BPe(r_6, \text{damage}), b_{6b0} : BPr(r_6, \text{negligence}), b_{6b1} : BPe(r_6, \text{negligence}), b_{7a0} : \text{medicalCase} \rightarrow BPr(r_6, \neg \text{negligence}), b_{7b0} : \text{medicalCase} \rightarrow BPe(r_6, \neg \text{negligence}), p_1 : b_{7a0} \succ b_{6a0}, p_2 : b_{7b0} \succ b_{6b0} \} \]

\[ KB_1 = KB_0 + \{ r_2 : \text{damage} \} \]

An amalgamated knowledge base, including rules and information about their burdens. The basic idea: for establishing whether an antecedent \( p \) is satisfied we need to establish

- what are the proof-requirements for \( p \)
- whether those requirements are satisfied
Some issues to be considered

- allocation of burdens according to roles (e.g. prosecution has burden of proof) vs allocation of burdens in rules
- allocation of burdens and presumptions

\[
\{ b_{7a0} : medicalCase \rightarrow BPr(r_6, \neg\text{negligence}) ,
    b_{7b0} : medicalCase \rightarrow BPe(r_6, \neg\text{negligence}) \} \\
\{ r : medicalCase \rightarrow \text{negligence} \}
\]

What is the difference? Do we need to be able to use rules whose antecedents include negligence while being unable to infer negligence?
What have we provided:

- a new analysis of burdens (applicable to monological argumentation, i.e., inference from knowledge-bases)
- a reasoning mechanism in defeasible logic

How to relate it to previous work on burdens/standards for proof? Matter for future research!

Thanks for your attention!