Dimensions and Values for Reasoning with Legal Cases

Trevor BENCH-CAPON, Katie ATKINSON
Department of Computer Science, The University of Liverpool, UK

Abstract. In this paper we build on two recent attempts to formalise reasoning with dimensions. Both of these approaches effectively map dimensions into factors, which enables propositional reasoning, but we show that sometimes a balance between dimensions needs to be struck. To permit trade offs we need to keep the magnitudes and reason more geometrically. We also revisit the link between dimensions and values, showing that values play a number of distinct roles, not only explaining preferences between factors, but also ensuring that all the purposes of the underlying law are considered.

Keywords. legal case based reasoning, dimensions, factors, values.

1. Introduction

One of the major tasks addressed by AI and Law over the last three decades has been to come to a good understanding of reasoning with cases: one influential line of development is followed in [9]. As told in that paper, the story begins with the dimension-based HYPO [7] and moves through the factor-based CATO [5], to expression as a set of rules [22] enabling a formalisation of factor-based reasoning by Horty in [19], which was refined by Rigoni in [24]. Factors can be seen as stereotypical patterns of facts, either present or absent in a case, and, if present, favouring either the plaintiff or the defendant. Dimensions, in contrast, are ranges of values (either numeric or enumerated), running from an extreme pro-plaintiff point to an extreme pro-defendant point. The applicability of dimensions to a case, and the point at which the case lies, is determined by the case facts, and the dimension may favour either party. The relationship between dimensions and factors is discussed in [26]. Since the mid-90s, factor-based representations have been the main focus, and although dimensions have always had their advocates [11], it is only more recently that dimensions have been revived as a way of connecting factors to the facts, and providing a way of capturing additional nuance [23], [2] and [4]. More recently Horty has attempted to extend his formalism to accommodate dimensions [18], and in [25] Rigoni has critiqued this approach from the standpoint developed in [24]. In parallel with these developments, there has been exploration of the relationship between case law decisions and the purposes, or social values, they promote. The idea of its asspciated purpose as a measure of strength of a dimension was introduced in [13] and most fully expressed (in terms of values) in [12]. Recent discussions of the role of values, considering dimensions as well as factors, can be found in [1] and [2].

In this paper we will consider the role of values and their relation to dimensions in the light of [18] and [25]. After some background, we will consider how to argue with dimensions in legal CBR, and the role of values. We do so using the domain knowledge represented as an Abstract Dialectical Framework (ADF) [14] as described in [3]. In particular we will show:

- Any legal CBR problem can be reduced to a series of steps involving at most two dimensions, so that higher dimensional spaces need not be considered;
- The non-leaf nodes of the ADF can be seen as being one of five types, as determined by their children;
- For some nodes dimensions cannot be reduced to factors and need to retain their magnitude, to permit trade offs;
- Values are required to play several different roles, not just the expression of preferences.

2. Formalising Factors and Dimensions

The formalisations of factor-based reasoning of both Horty and Rigoni are based on the method of expressing precedents as rules found in [22]. In that paper a case is considered to be a triple $\langle P, D, o\rangle$, where P is the set of all pro-plaintiff factors present in the case, D is the set of all pro-defendant factors present in the case and o is the outcome, either plaintiff (π) or defendant (δ). Now $P \rightarrow \pi$ will be the strongest reason to find for the plaintiff and $D \rightarrow \delta$ will be the strongest reason the find for the defendant. We can therefore deduce that either $P \succ D$ or $D \succ P$ depending on the value of o. These preferences permit only *a fortiori* reasoning. Although [22] has a notion of *rule broadening* as a dialogue move, a key insight of Horty is that $P \rightarrow \pi$ may be stronger that is required and some subset of P may be sufficient to defeat D. Horty does not specify how exactly the subset is determined, but it could be interpreted as the *ratio decidendi* of the case. In general the use of P gives rise to what Horty terms the *rule* or *result* model and attributes to Alexander [6], and the subset what he terms the *reason* model, and attributes to Lamond [20].

Horty's key idea in [18] is that dimensions can be mapped into factors, with its position on the dimension determining (through precedent cases) whether the corresponding factor is present or absent in a given case. Note that the point at which the factor becomes present may not be the the point in the case facts, which is the result model. Instead it may be a point weaker for the side it favours, giving the reason model. In his example (taken from [22]), a person is attempting to show a change of fiscal domicile on the basis of absence from his home country. In the example a person is absent abroad for 36 months and change is found on the grounds that the absence is longer that a year. Thus the factor is present on the results model if the absence is at least 36 months and on the reason model if the absence is greater than a year. On this approach, however, Horty finds that the result and the reason models collapse into one. Moreover, the reason does not

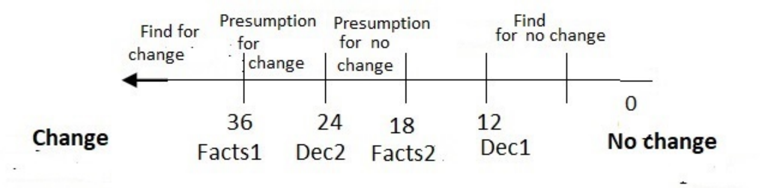

Figure 1. Dimension after 2 cases

constrain. Horty considers a second case in which the person has been absent for 18 months, but the court wishes to apply a stricter standard and rule against change on the grounds that it was less than 2 years. Horty wishes to say that the court can consistently decide in this way, although it cannot offer as a reason that the absence was below a threshold greater than three years, which would contradict the *result* of the precedent case. Rigoni objects in [25] both to the collapse of the two models, and to allowing the court to decide that 18 months is not enough for change, which he claims is counter intuitive, given the reason expressed in the precedent. Essentially Rigoni is happy to adopt the reason given in the decision, and disregard the particular instantiation using the facts of the case in which the reason was stated. That might be expressed as Rigoni treats the reason as *ratio*, whereas Horty treats it as *obiter*.

The dimension and the two cases in the example are shown in Figure 1. There are a number of points of interest within this dimension. One set is the positions occupied by the precedent cases. Another set is the positions used to express reasons (if any) in the precedent cases. Finally we have the point, identified in [25] but not explicitly in [18], at which the dimension ceases to favour *no change* and begins to favour *change*. Rigoni terms this the *switching point* (SP). The question is where SP lies. For Horty it lies somewhere to the right of 36, whereas for Rigoni it cannot lie to the right of 12, if Case1 is serving as a precedent. Rigoni then presents an alternative way of formalising dimensions which avoids the collapse of the two models and satisfies his intuition to disallow the decision in Case 2. Rigoni suggests that a dimension should be thought of as a *series* of factors and uses magnitude to constrain their relative strength and SP to determine their polarity. This is essentially the approach of [23] and [10],

Here we will not attempt to reduce dimensions entirely to factors, convenient as this is for arguing in a conventional style, based on propositions and rules, since this excludes notions of trade offs and balance between dimensions, needed for some legal decisions [21]. Instead we will build on the ideas of [8] and look at the possibilities of a different flavour of argumentation, based on geometry rather than rules. A further aim of the paper is to relate the dimensions to values, which are not discussed in [18] or [25].

3. Arguing with Dimensions

From Figure 1, we can see that the dimension can be divided into a number of zones. Case1 argued that 12 months should suffice for change, and that 36 months

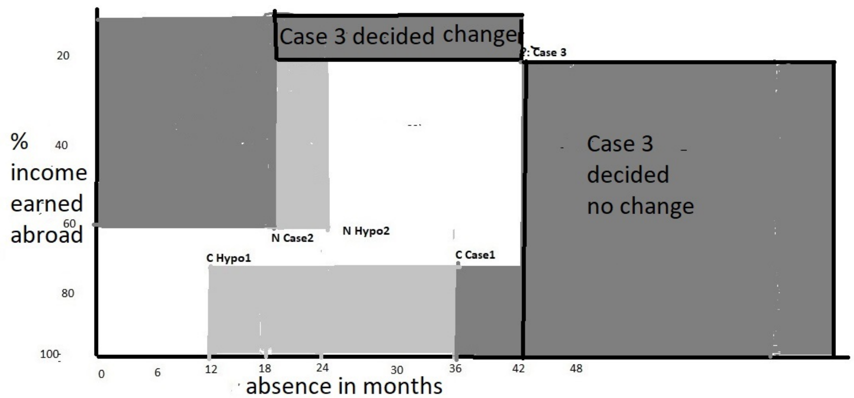

Figure 2. Case 3 with 2 dimensions, showing alternative decisions

conclusively established change. Thus less than 12 months should presumptively find for no change (no precedents to establish a conclusive minimum absence have yet been decided), between 12 and 36 months there is a presumption for change and after 36 months change is conclusively established. The reason is not, however, followed in Case2, which establishes less than 18 months as conclusive for no change, between 18 and 24 months as presumptively favouring no change, reducing the range presumptively favouring change to 24 to 36 months. Beyond 36 months remains conclusive for change. This would put the SP somewhere between 18 and 36 months, presumptively, based on these two cases, at 24 months.

Given such a picture we would expect all the cases for change to appear to left of SP and all the cases for no change to appear to the right of SP. But it is unlikely that this will be so, because it is unlikely that absence will be the only dimension to be considered. Typically a case can be distinguished by pointing to a different aspect which is more favorable to the other party. In [18] Horty adds a second dimension to the example, namely the percentage of income earned abroad. The idea is that the greater this percentage, the stronger the case for change, and so it may well be there there is a kind of trade off whereby a larger percentage of income from abroad will require a shorter absence. If only the absence dimension is considered, some cases decided for change may appear to the right of cases decided for no change. This may be explained by looking at another dimension: perhaps the percentage of income is greater in those cases. The arguments resulting from considering two dimensions were considered in [8]. In two dimensions we need to think in terms of north-west and south-east of the various points, rather than left and right. The facts of the case and its result define an area where the decision must be followed, and the reason given offers a hypothetical set of facts which creates an area which presumptively favours the winning side. A new case may then fall into an area not yet covered by precedents and depending on the outcome, it will claim some of the space for the winning side. Figure 2 illustrates the situation, for the domicile example using absence and income percentage and a third case.

4. Use of 2-Regular ADF

In [8] the discussion was always in terms of two dimensions, but it was left open as to whether higher dimensional spaces might require consideration. In fact, just as any set of relations can be expressed in terms of binary relations and any k-SAT problem can be expressed as 3-SAT, it is possible to represent any domain so as to ensure that no more than two dimensional spaces are needed. In [3] the ANGELIC methodology for representing domain knowledge as an Abstract Dialectical Framework (ADF) [14] was presented. Formally an ADF forms a three tuple: a set of nodes, a set of directed links joining pairs of nodes (a *parent* and its *children*), and a set of acceptance conditions, one per node. The nodes represent statements which, in this context relate to issues, intermediate factors and base level factors. The links show which nodes are used to determine the acceptability of other nodes, so that the acceptability of a parent node is determined by its children. The acceptance condition for a node states how precisely its children relate to that node. In [1] it was shown that such an ADF could be rewritten as a *2-regular ADF*, in which every non-leaf node has at most two children. Since the acceptability of a node in an ADF depends only on its children this means that we need never consider more than two dimensions to resolve the acceptability of a node, and, since an ADF produced by the ANGELIC methodology forms a tree, the topmost node can be resolved without the need to consider more than two nodes at any given step.

Also at this point we should note that not every aspect of a case requires representation of magnitude. In the original HYPO [7] in 10 of the 13 dimensions only the two extreme points were of interest. Such aspects are better seen as two factors, and always favouring a particular side. Recognising this, in [25], Rigoni describes cases using *both* factors and dimensions. Even when the aspect has genuine magnitude, in the context of the particular domain it may be unnecessary to go beyond factors. Thus age is clearly an aspect with magnitude, but in a particular context, it may be possible to reduce it to a set of factors using thresholds. For example it may be that age is relevant only to distinguish between adults and minors, so any age above 18 is equivalent to every other age above 18. (Note both that domain case law is not required to fix the threshold and that the threshold may change: pre-1970, the UK threshold was 21.) This means that a given node in our 2-regular ADF non-leaf may have as children (leaf nodes must be instantiated from the facts of the case):

1. two factors;
2. one dimension and one factor;
3. two dimensions;
4. one factor (the other child is a dummy node, for example, *true*);
5. one dimension (the other child is a dummy node, for example, *true*).

(1) is found in factor-based reasoning as formalised in [19] and [24].

In (2) the factor provides a *context* for the consideration of a dimension. Suppose that in the fiscal domicile example, citizenship is a factor to be considered: if the person is a UK citizen a longer absence may be required before a change is made. Note that this aspect has no natural interpretation with magnitude: either one is a UK citizen or not. SP will depend on the context.

Table 1. IBP Logical Model as 2-Regular ADF

Parent	Child 1	Child 2	Acceptance
Trade Secret Misappropiation	Info Trade Secret	Info Misappropriated	AND
Info Trade Secret	Information Valuable	Maintain Secrecy	AND
Info Misappropriated	OK Means	Improper Means	OR
OK Means	Info Used	Confidential Relationship	AND

In (3) we have the kind of trade off illustrated in Figure 2. The two dimensions describe points in a two dimensional space, and a line is drawn separating the area favouring one outcome from the area favouring the other outcome. There is no difference between dimensions which are best thought of a continuous and those best thought of as a set of discrete points: in the latter case the space can be represented as a lattice, but this still needs to be partitioned into the areas favouring the the two outcomes.

Examples of (4) should be rare: the child can simply replace the parent.

Finally in (5) we have a way of implementing thresholds. Thus the parent will be something like *sufficient absence*, and the purpose of the node is to provide a means of converting a dimension into a factor, much as envisaged by Horty in [19]. Similarly a set of such nodes, all with the actual point of the dimension as their child, would produce the set of factors envisaged in [25] and [23].

5. Relation with Values

Now we can reintroduce a relationship with purposes or values. The idea of values derives from [13] in which values were used to explain preferences between competing factors, and hence to resolve conflicts for which there was no precedent. In the absence of an exact precedent in terms of factors, if the factors involved relate to values between which a preference had been expressed in a precedent, that preference can be applied. This allows us to go beyond *a fortiori* reasoning. This idea was the basis for the formalisation of theory construction found in [12]. As the exploration of values developed it became recognised that, since the object of law was, as argued in [13], to fulfill certain purposes, the various aspects of the case that were considered (that is the factors and dimensions) were required to fulfill these purposes, to ensure the promotion of, and avoid the demotion of, certain values. Thus the existence of factors and dimensions in case law domains was justified by their role in enabling the consideration of particular values. This was the basis of the representation of cases in [16] in which there was a one to one relation between dimensions and values, and in [10], although there some values were represented by two distinct dimensions. In [27] it was recognised that values might play two roles: justifying the presence of a rule, or justifying the inclusion of a particular antecedent in a rule. We will begin by illustrating the ideas with the logical model of the US Trade Secrets domain used in [15], shown as a 2-regular ADF in Table 1.

As given in [16] and [10], US Trade Secrets requires consideration of 5 values, as represented by the 5 leaf nodes of the ADF in Table 1. Where the children are linked by AND, we ensure that both values are promoted, and where they are linked by OR we ensure that at least one of the values is promoted. Thus the role of nodes with two factors as children linked by AND or OR is to ensure that required values are given their due consideration. But there are also cases where the polarity of the two children are different: effectively the connective is UNLESS. As example concerning Trade Secrets taken from [1] is *Info Valuable* which has the pro-child *Info Useful* and the con-child *Info Available*, i.e. the information is valuable if it is useful unless it is available elsewhere. Here we can express a preference between values: the value of the exception is preferred (since otherwise the exception would have no effect). Here we can say that the value of discovery by Legitimate Means outweighs the value of Material Worth. No matter how valuable the information, it cannot be protected against legitimate discovery by a competitor. Unlike [12], different preferences may be used in different nodes.

The second kind of node is where we have a factor providing a context for a dimension. This can be illustrated using our fiscal domicile example. Absence is there to promote stability. But the length of absence might be considered differently for different types of citizen. Thus UK citizens might require a longer absence than citizens of other countries who had been working here on a long term, but not permanent, posting. Thus we may envisage a parent *sufficient given citizenship*, with children *UK citizen* and *absence*. What we have here is *two* distinct dimensions of the sort shown in Figure 1. The cases that fall on each dimension, and the switching point, will depend on the value of the citizenship factor in the particular cases. The value served here is stability, but thr context allows consideration of the value of mobility of labour, since we are allowing non-UK citizens an easier path to restoring their original fiscal domicile. Thus we are able to consider two values, or to consider what promotes a value in a particular context. Similarly nodes of type (5) allow consideration of what is sufficient to promote a value, but here no context need be considered: the switching point at which the dimension becomes sufficient is the same for all cases. This permits a threshold for a factor to be determined by precedents, as envisaged in [18].

This leaves nodes with two dimensions. Where they are linked by AND or OR, the role of values is the same as for two factors. For example, we can determine whether *both* sufficient absence (to promote stability) and a sufficient degree of engagement (shown by the percentage of foreign earnings, and promoting equity between countries) can be shown so that the abstract factor *sufficient commitment* can be seen as present in the case. Thus, for AND and OR, both children will be type (5). Type (3) nodes will be those where a balance needs to be struck (see [21] and [17]) and so there is some kind of trade off between the dimensions, as in Figure 2. This is also the situation considered in [8]. Where the need is to consider a pair of values with no trade-off, type (5) nodes suffice. Thus the parent node is *Sufficient Commitment* which promotes the value of Equity, since the idea of changing fiscal domicile is to enable the country where the work is done to receive its far tax dues, while respecting the need for stability and a certain degree of freedom of movement. Now the line partitioning the two dimensional absence-income space is intended to represent the balance between stability and engagement required to promote equity. Note that, unlike the exception nodes of type (1) above, we are not looking for a preference here: we are looking

Figure 3. Possible trade off between absence and income percentage. The y-axis represents % income earned in UK, so that increasing values of y favour no change

for a *balance* between the competing values, and acknowledging that a greater engagement will require a shorter absence to satisfy our notion of equity.

If we consider that the space can be divided by a single straight line we will have an equation of the form:

$$y = mx + c$$

where c represents the value of y when x is zero and so is positive if the line cuts the y-axis at $y > 0$ and negative if the line cuts the x-axis ay $x > 0$. If we have a minimum absence the line will cut the x-axis and so c will be negative. Meanwhile m represents the slope of the line, and hence the degree of trade off. If $m = 1$, the line is at 45^0: if $m > 1$ the line is steeper (a greater percentage is required for a given amount of absence) and if $m < 1$ the line is shallower (a greater percentage is required for a given amount of absence. Very often, however, m will not be the same for all values of x: the amount of income required to trade off a year's absence, may change as absence increases. A fairly typical situation is shown in Figure 3.

In Figure 3 we have a minimum absence of 12 months, and a minimum percentage of income at 25%. The line rises steeply for absences between 12 and 18 months and then becomes shallower until the maximuum UK income percentage is reached. To describe this we need a set of equations covering the various ranges:

$$0 \leq x \leq 12 : y = 0$$
$$12 \leq x \leq 18 : y = mx$$
$$18 \leq x \leq 30 : y = nx \text{ (where } n < m)$$
$$x \geq 30 : y = 75$$

The coefficient of x (i.e m and n) is important because it represents the degree of trade off, the relative weight to be given to the different values at different points. In Figure 3 we have a sharp change of slope, and this can be represented by a set of line segments, but we may often see a gradual and regular change. This would be better represented by a curve rather than a set straight line segments with the gradient (i.e the differential of the equation representing the curve) varying as a function of x. This function will determine whether the curve becomes increasingly steep, or, as in Figure 3, increasingly shallow.

In some cases we can imagine the curve changing direction entirely. In our example this would mean that at some point a longer absence required a greater degree of engagement, which seems unlikely in our particular example, but might be required by some examples. This would be represented by a point at which the differential of the curve was zero, and negative thereafter. While we could imagine this occurring once, it would seem sensible to say that it could not happen more than once (i.e. to exclude cubic and higher degree curves). Such a constraint would ensure that our line did not have any "kinks", which would be the case if we attempted to distort the line to include particular cases.

6. Conclusion

In this paper we have considered the use of dimensions, building of the work of Horty and Rigoni. Whereas both Horty and Rigoni at some point move from dimensions back to factors (as does [23]), we recognise that, while this can be desirable for some dimensions, if we need to represent trade offs and balancing between dimensions, we need to avoid collapsing them to a set of factors.

The main contributions of this paper are:

- To observe that since any domain can be represented as a 2-regular ADF, we need never consider more than two dimensions at a given time. Thus we can partition our problem into a series on 2-dimensional problems, rather than considering high dimensional spaces: for example the original HYPO has 13 dimensions, and the representation of Trade Secrets in [10] uses 7 dimensions. By confining the reasoning to 2-dimensional spaces we can simplify the reasoning and argumentation to that described in [8].
- Recognition that the non-leaf nodes of the ADF can be distinguished into 5 types, according to the nature of their children.
- Realisation that not every dimension can be reduced to factors, which means that the propositional reasoning ultimately used in [18] and [25] needs to be supplemented by an additional form of reasoning, to handle trade offs. We have suggested the use of a geometric formalism, such as the Cartesian equations described in section 5.
- We have also linked the accounts to purposes and values, and shown that the values play different roles, depending on the nature of the parent nodes being considered, rather than expression of preferences being their only, or even their most important, role. Although they do, on occasion, have this role, they are mainly there to explain why various aspects of the case need to be considered if the purposes of the law are to be fulfilled. We have explained how the structure imposed by the ADF ensures that due consideration is given to all the desired purposes and values.

Our next step will be to apply this to a complete example covering a real domain, and attempt to reproduce the arguments found in it.

References

[1] L Al-Abdulkarim, K Atkinson, and T Bench-Capon. Factors, issues and values: Revisiting reasoning with cases. In *Proceedings of the 15th International Conference on Artificial Intelligence and Law*, pages 3–12. ACM, 2015.

[2] L Al-Abdulkarim, K Atkinson, and T Bench-Capon. Angelic secrets: bridging from factors to facts in US Trade Secrets. In *JURIX 2016*, pages 113–118. IOS Press, 2016.

[3] L Al-Abdulkarim, K Atkinson, and T Bench-Capon. A methodology for designing systems to reason with legal cases using abstract dialectical frameworks. *Artificial Intelligence and Law*, 24(1):1–49, 2016.

[4] L Al-Abdulkarim, K Atkinson, and T Bench-Capon. Statement types in legal argument. In *Proceedings of JURIX 2016: The Twenty-Ninth Annual Conference*, pages 3–12. IOS Press, 2016.

[5] V Aleven. Using background knowledge in case-based legal reasoning: a computational model and an intelligent learning environment. *Artificial Intelligence*, 150(1-2):183–237, 2003.

[6] L Alexander. Constrained by precedent. *S. Cal. L. Rev.*, 63:1, 1989.

[7] K Ashley. *Modeling legal arguments: Reasoning with cases and hypotheticals*. MIT press, Cambridge, Mass., 1990.

[8] T Bench-Capon. Arguing with dimensions in legal cases. In *Proceedings of CMNA 2017*, pages 1–5, 2017.

[9] T Bench-Capon. Hypo's legacy: introduction to the virtual special issue. *Artificial Intelligence and Law*, 25(2):205–250, 2017.

[10] T Bench-Capon and F Bex. Cases and stories, dimensions and scripts. In *Proceedings of JURIX 2015: The Twenty-Eighth Annual Conference*, volume 279, pages 11–20. IOS Press, 2015.

[11] T Bench-Capon and E Rissland. Back to the future: Dimensions revisited. In *Proceedings of JURIX 2001*, pages 41–52. IOS Press, 2001.

[12] T Bench-Capon and G Sartor. A model of legal reasoning with cases incorporating theories and values. *Artificial Intelligence*, 150(1-2):97–143, 2003.

[13] D Berman and C Hafner. Representing teleological structure in case-based legal reasoning: The missing link. In *Proceedings of the 4th ICAIL*, pages 50–59, 1993.

[14] G Brewka, S Ellmauthaler, H Strass, J Wallner, and P Woltran. Abstract dialectical frameworks revisited. In *Proceedings of the Twenty-Third IJCAI*, pages 803–809. AAAI Press, 2013.

[15] S Bruninghaus and K Ashley. Predicting outcomes of case based legal arguments. In *Proceedings of the 9th ICAIL*, pages 233–242. ACM, 2003.

[16] A Chorley and T Bench-Capon. An empirical investigation of reasoning with legal cases through theory construction and application. *AI and Law*, 13(3):323–371, 2005.

[17] T Gordon and D Walton. Formalizing balancing arguments. In *Computational Models of Argument - Proceedings of COMMA 2016*, pages 327–338, 2016.

[18] J Horty. Reasoning with dimensions and magnitudes. In *Proceedings of the 16th ICAIL*, pages 109–118. ACM, 2017.

[19] J Horty and T Bench-Capon. A factor-based definition of precedential constraint. *Artificial Intelligence and Law*, 20(2):181–214, 2012.

[20] G Lamond. Do precedents create rules? *Legal Theory*, 11(1):1–26, 2005.

[21] M Lauritsen. On balance. *Artificial Intelligence and Law*, 23(1):23–42, 2015.

[22] H Prakken and G Sartor. Modelling reasoning with precedents in a formal dialogue game. *Artificial Intelligence and Law*, 6(3-4):231–87, 1998.

[23] H Prakken, A Wyner, T Bench-Capon, and K Atkinson. A formalization of argumentation schemes for legal case-based reasoning in ASPIC+. *Journal of Logic and Computation*, 25(5):1141–1166, 2015.

[24] A Rigoni. An improved factor based approach to precedential constraint. *Artificial Intelligence and Law*, 23(2):133–160, 2015.

[25] A Rigoni. Representing dimensions within the reason model of precedent. *AI and Law, available on line October 2017*, 2017.

[26] E Rissland and K Ashley. A note on dimensions and factors. *Artificial Intelligence and Law*, 10(1-3):65–77, 2002.

[27] T Zurek and M Araszkiewicz. Modeling teleological interpretation. In *Proceedings of the 14th ICAIL*, pages 160–168. ACM, 2013.