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The Four Regions in Settlement Space: A Game-Theoretical Approach to Investment Treaty Arbitration. Part I: Modelling

Mark Broom, David Collins and Trung Hieu Vu
City, University of London

and
Philip Thomas
Safety Systems Research Centre, Queen's School of Engineering, University of Bristol

Keywords: International Investment Law; Investor-State Dispute Settlement; Game Theory; Litigation Costs

Abstract
This article uses game theory to investigate investor-state dispute settlement and related dispute resolution strategies through international arbitration. When deciding whether either to bring or to defend a claim rather than pursue settlement, investors and states will select strategies to maximize their respective payoffs, either by securing compensation or successfully defeating a claim for compensation. This article develops a model decision making strategy for claimant investors and defendant states based on the observed patterns of outcomes in actual investment treaty arbitration awards. Embedding the problem in the context of utility and hence risk-aversion, it will offer a general solution for the arbitration "game". Four regions will be identified in the settlement space consisting of the respondent offer against claimant success probability. It will be shown that no settlement is possible in three of these four regions. The go-no-go probability of claimant victory below which it would not be reasonable for a potential claimant to proceed will be quantified. An algorithm is developed for calculating the settlement sum that the respondent may offer with a reasonable expectation of acceptance by the claimant.

1. Introduction

1.1 Thesis and Structure

The aim of this article is to model the strategy behind the use of a specific kind of international litigation, investor-state dispute settlement (ISDS), as its users seek individually to maximize their private utility function. As the risks involved with ISDS compel both parties to evaluate the potential benefits and costs in a rational, systemic manner,[1] this article will suggest that such assessment could be achieved through the application of generalised mathematical modelling, which can then be applied to specific situations. In short, investors and governments can more effectively ascertain whether it is desirable to pursue international arbitration to reach a binding decision and award as opposed to the alternatives, namely abandoning the claim or defence in favour of settlement. The modelling developed in this article embraces game theory (the natural methodology to model optimal decisions which depend critically upon the decisions of others**)** and utility theory **(**to take account of both the potentially huge sums of money

[1] This article will not engage with behavioural economics literature stressing irrational features of decision-making, such as those incorporating biases and heuristics: see further e.g. T Ulen, 'The Importance of Behavioral Law' in E Zamir and D Teichman eds. *Oxford Handbook of Behavioral Economics and the Law* (Oxford University Press, 2014)

involved and the potential asymmetry in the wealth and attitude to risk of the protagonists).

This article, which comprises Part I of a two-part paper, will proceed as follows. The continuation of Section 1 will describe the process of ISDS and outline the methodology that will be employed to analyse it. Section 2 introduces a game-theoretical model for investment arbitration, including the notion of a general solution pointing to optimal courses of action for investors and states for any given scenario. Section 3 develops the model and provides analysis, including the application of utility theory to the arbitration strategy of investors and host states. A general solution is derived for the "game" being played by the potential claimant and respondent. Conclusions are provided for Part I of the paper in Section 4. Three appendices are included, the first providing a list of the symbols used in the mathematical model and the last two providing details and proofs for mathematical statements made in the main text.

Part II[2] will consider the reasons why cases are not settled between the parties and so proceed to arbitration. It moves on to examine a selection of real cases that went to arbitration before drawing overall conclusions.

1.2 Investor-State Dispute Settlement (ISDS)
States seeking to attract foreign investment enter into International Investment Agreements (IIAs) of which there are now more than three thousand worldwide. These are treaties which offer protections for foreign investors, helping mitigate the risk of expending significant resources in politically unstable environments where there is limited prospect of redress through the domestic legal system. Among the most vital of the guarantees contained in the treaties is access to ISDS, since it allows aggrieved foreign investors to bring claims directly to neutral international arbitration rather than pursuing remedies in the courts of the host state, which may be biased, lacking independence or simply lack sufficient expertise to adjudicate claims fairly and efficiently.[3] Each year tribunals constituted under the International Centre for the Settlement of Investment Disputes (ICSID) and under ad hoc tribunals using rules such as those promulgated by the United Nations Conference on International Trade Law (UNCITRAL) hear an increasing number of claims by foreign investors against host states in relation to alleged breaches of these treaties.[4] While many decisions of arbitration tribunals remain private because of the option of confidentiality available to parties under the system, during the 10 year period from 2004 to 2014, the number of published decisions issued by investment tribunals has risen fourfold, from 149 cases to more than 600.

ISDS poses very significant financial risks in terms of wasted legal expenses without compensation for governmental interference (for the claimant investors), and wasted expenses as well as a major adverse damages award potentially in the hundreds of

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[2] M. Broom, D. Collins, H. Vu and P. Thomas, 'The Four Regions in Settlement Space: A Game-Theoretical Approach to Investment Treaty Arbitration. Part II: Cases', *Journal of Law, Probability and Risk*, Vol. xx, No. yy (20zz)
[3] See e.g. R Dolzer and C Schreuer, *Principles of International Investment Law* (Oxford University Press, 2012) at 235-238 and D Collins, *An Introduction to International Investment Law* (Cambridge University Press, 2016) at 214-249
[4] UNCTAD, World Investment Report 2014 at xxiii
<http://unctad.org/en/PublicationsLibrary/wir2014_en.pdf>

millions of dollars (for the respondent governments). Such expenses do not capture other intangible and often unquantifiable risks associated with international litigation, such as damage to a government's reputation as a safe place for doing business. Non-compliance with international law (as embodied by the violation of an investment treaty guarantee) generates reputation costs, inhibiting other states from cooperating with that state in the future and undermining its capacity to attract capital.[5] Argentina, the most common respondent in ISDS, is a good example of this phenomenon. Such risks can be further contextualized in that host states are developing countries with limited financial resources facing severe competition for scarce capital among often highly mobile firms. For the firms themselves, their resources are largely sunk at the point of litigation and the reputational effects of international arbitration are minimal, particularly since in many (but not all) cases legal costs are small relative to the value of the claims themselves. In one third of ISDS cases there was little to no public information provided on the type of claimant (size or corporate structure).[6]

While there is an established tradition of law and economics scholarship in relation to litigation strategies for domestic civil adjudication[7], there are key differences between these traditional fora and that of ISDS which make this study unique. Firstly, in ISDS, unlike almost any other forum of dispute settlement, only investors can sue. Counterclaims by host states, which are exceedingly rare, are typically brought in domestic courts rather than in the same arbitration proceedings. Secondly, as suggested above, there are significant reputational consequences which may be faced by defendant states which act as repeat players, often sued many times by different investors. Thirdly, costs in ISDS may be quite low relative to the value of claims, unlike some domestic litigation where costs can act as a significant deterrent. Caution is needed here, however, because the spread of relative costs among cases is wide. While one study reported that costs in ISDS amounted to less than 2% of amounts claimed[8], the analysis reported in this paper suggests that litigation costs are highly variable: while legal and administrative costs may in many cases constitute a very small proportion of the claim, costs came to 10% or more of the claim in 45% of the cases (see Section 3.3.3 and Figure 2). Lastly, the advantage of confidentiality that is available through settlement in conventional litigation is less likely to motivate parties in ISDS because they have the option of full or partial confidentiality in arbitration to begin with. In the case of publicly available disputes, both

[5] A van Aken, 'Effectuating Public International Law through Market Mechanisms' Osgoode Hall Law School Research Report No. 34/2008 (2008) at 8

[6] Investor-to-State-Dispute Settlement: Some Facts and Figures, European Commission Report (12 March 2015) at 4.

[7] E.g. R Cooter and T Ulen, 'An Economic Theory of the Legal Process' in *Law & Economics* (4th ed, Pearson, 2004); W Landes, 'An Economic Analysis of the Courts' in G Becker and W Landes eds. *Essays in the Economics of Crime and Punishment* (National Bureau of Economics Research, 1974); R Posner, 'An Economic Approach to Legal Procedure and Judicial Administration' 2 Journal of Legal Studies 399 (1973); G Priest and B Klein, 'The Selection of Disputes for Litigation' 13:1 Journal of Legal Studies 1 (1984); D Rosenberg and S Shavell, 'A Model in Which Suits are Brought for their Nuisance Value' International Review of Economics (1985) 5, 3; D Gould, 'The Economics of Legal Conflicts' 2:2 Journal of Legal Studies 279 (1973)

[8] 'Investor-to-State-Dispute Settlement: Some Facts and Figures', European Commission Report (12 March 2015) at 8-9. http://trade.ec.europa.eu/doclib/docs/2015/january/tradoc_153046.pdf . The average claim was $622 million with average costs at $8 million. The actual awards averaged $16 million (making costs closer to 50% of awards). The link between costs and settlement in civil trials has been identified by others, e.g. R Posner, 'An Economic Approach to Legal Procedure and Judicial Administration' 2 Journal of Legal Studies 399 (1973); S Shavell, 'Suit, Settlement and Trial: A Theoretical Analysis under the Alternative Methods for the Allocation of Legal Costs' 11:1 Journal of Legal Studies 55 (1981)

parties have chosen to waive this confidentiality, possibly because public attention is either a political imperative or because it may be expected to affect outcomes (i.e. pressure settlement by the host state). In that sense, confidential settlement is a less attractive option in ISDS than it may be in other realms of binding adjudication where keeping the dispute out of the public courts may be a primary motivation. This may explain why observed regularity of settlement in ISDS (approximately 28% of cases[9]) is considerably lower than that of many domestic civil litigation systems, where some studies have shown less than 5% of disputes actually reach trial.[10]

1.3 Methodology

We use game theory to represent ISDS as a game in sequential form. We assume that each party to the dispute constructs estimates of likely rewards, costs and the probability of the claimant winning the dispute. Incorporating these within our game allows us to find a unique solution to the game for any given combination of estimates. The actual solution will depend upon the utility functions of each party in addition to both sets of estimates (i.e. to make the correct choice one party needs to know the estimates of the other party). We are then able to apply our model to any specific situation, and consider some of the cases from the database in this context.

Following both standard economic theory[11] and game theory,[12] each of the arbitral parties, claimant investor and respondent host state, will be seen as attempting to maximize the expected utility of its assets. This will determine the monetary resources it can mobilize for the purposes of contesting or defending legal rights through international arbitration. Viewing the process as a game played between claimant and respondent, the expected utilities provide the key to explaining the likely actions of the two players and lead to a general solution. As a game with complete information, the players know precisely what moves have been made previously by themselves and the other player, and consequently which branch-point or vertex of the "game tree" has been reached. It is reasonable to assume such transparency in the case of ISDS, as the claimant will notify the respondent of its intention to pursue the matter in arbitration.

Additional insight is provided by utility theory, which takes into account the fact that the different participants may value the different outcomes in very different ways, so that choosing a strategy may be about more than simply optimizing the expected financial gain. Utility theory is widely used in the insurance industry[13], where it is a commonplace that the utility each party sets on a given asset will depend on that party's aversion to risk. Risk aversion may be described as a measure of the feeling influencing a person's

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[9] 'Investor-to-State-Dispute Settlement: Some Facts and Figures', ibid at 7. ICSID Caseload Statistics 2016-1(June 2016) reported that 36% of ICSID disputes were either settled or the proceedings were otherwise discontinued (at 13). This figure includes both settlements embodied in the award and proceedings terminated at the request of one or both of the parties, presumably because a confidential settlement was reached, as well as terminations initiated by the tribunal itself (at 15). http://documents.worldbank.org/curated/en/372121468186843932/pdf/106048-NWP-PUBLIC-ICSID-Web-Stats-2016-1-English-final.pdf

[10] G Priest and B Klein, 'The Selection of Disputes for Litigation' 13:1 Journal of Legal Studies 1 (1984) at 2.

[11] See, for example, R. G. Lipsey and K. A. Chrystal, *An introduction to positive economics*, 8th Edition, Oxford University Press, Oxford, UK (1995)

[12] J von Neumann and O Morgenstern, *Theory of Games and Economic Behavior*, (Princeton Classic Editions, 1944, 2007)

[13] R Kaas, M Goovaerts, J Dhaene, M and Denuit, *Modern actuarial risk theory*, (Kluwer Academic Publishers, 2001)

decision made in the face of uncertain outcomes. These outcomes can be about money or happiness or anything else that is important to him/her.[14] Risk-aversion[15], ε, (given a hyphen here to signify its status here as a mathematically defined parameter; see Appendix B) is fundamental in determining how much satisfaction or utility we obtain from a good or money.

Whether it is a government or firm, the utility of any organization's assets or wealth is the value that the organization places on the assets that it owns. It is important to recognize that this may differ from their monetary equivalent, depending on the risk-aversion of the organization in question. For the purposes of this study we will not explore the issue of misalignment between the risk aversion of individuals who compose the organization (namely shareholders and citizens) as they consider whether or not to engage in arbitration.[16] Risk assessment in this decision-making will be approached from the perspective of the organization as a single entity.

We use utility theory to explore the nature of the problem, including discussion of the influence of risk-aversion. The base model developed in the main text assumes that both state and investor are risk neutral in the sense that the risk-aversion is zero for each and so money gained or lost is the sole determinant. In one sense this should be viewed as an accurate representation of the state's position, which can normally be expected to have large resources. It should also capture the status of most investors which tend to be large, well-resourced companies. The settlement amount derived from this model will tend to be conservatively large in the case of an investor possessing a positive risk-aversion, possible when the investor is a small or medium-sized enterprise. We note, however, that we only consider the single quantity of financial return. In reality the participants will have other considerations than simply money, for example a state's reputation as a good place to do business. Such considerations would manifest themselves in a strictly positive value of risk-aversion. While it has been argued in the past that one party to a court action would exhibit a strictly positive risk-aversion but that the other would be risk neutral[17], we go further in this article by considering that either the claimant or the respondent or both may develop a non-zero value for risk-aversion, and consider the likely effects. Appendix B discusses ways of extending the analysis in detail to cover aversion to risk. A circumstance is also noted in Appendix C where the behaviour of an organisation may be characterised independent of the value of its risk-aversion, a result of importance in determining the go-no-go probability for claimant success before the

[14] PJ Thomas, 'The importance of risk-aversion as a measurable psychological parameter governing risk-taking behavior', Proc. of the 2013 Joint IMEKO TC1-TC7-TC13 Symposium *Measurement across physical and behavioural sciences*, 4-6 September 2013, Genova, Palazzo Ducale – Italy. Journal of Physics: Conference Series 459 http://iopscience.iop.org/1742-6596/459/1/012052

[15] PJ Thomas, 'Measuring risk-aversion: The challenge', Measurement, Volume 79, pages 285–301 (2015) http://dx.doi.org/10.1016/j.measurement.2015.07.056

[16] Problems with assessing the decision-making of organizations as opposed to individuals has been noted by a number of scholars e.g. C Engel, 'The Behavior of Corporate Actors: A Survey of Empirical Literature' 6 Journal of Institutional Economics 445 (2010). See further A Sundaram and A Inkpen, 'The Corporate Objective Revisited' 15:3 Organizational Science 350 (noting different conceptions of wealth maximization within a firm). For a discussion on the application of risk aversion to governance and international relations see B O'Neill, 'Risk Aversion in International Relations Theory' 45:4 International Studies Quarterly 617 (focusing on the decisions of country leaders as individual decision-makers)

[17] W. M. Landes, 'An Economic Analysis of the Courts', in *Essays in the Economics of Crime and Punishment*, eds. G. S. Becker and W. M. Landes, p. 164 – 214, (National Bureau of Economic Research, 1974). Available at http://www.nber.org/chapters/c3629 . Landes suggests that the defendant will have a positive risk-aversion, but that the state prosecutor will be risk neutral.

tribunal below which the case should not be brought forward.

Because of the large number of mathematical symbols needed to describe a realistic ISDS case, a full list and explanation are included in Appendix A, Nomenclature.

2. Game Theoretical modeling

2.1 General overview

Briefly, game theory is a methodology commonly applied to situations involving multiple decision-makers, in particular where their interests are in conflict. It has been used in a wide variety of contexts, including sciences such as biology,[18] social sciences such as economics where it originated[19] and law.[20] It has been applied to international investment law in the context of evaluating strategic options when a country is considering signing an IIA for the purposes of attracting investment.[21] However, game theory has not yet been applied to the strategies underpinning investment arbitration itself.

In game theory, "games" are specified by three key properties: the set of players who play the game, the strategies available to the players, and the rewards, termed 'payoffs', to the players. Each player selects a strategy, and given the strategies chosen the expected payoffs to each individual can be determined. In general, an individual may have many potential choices to make, and his/her strategy is the full set of choices that he/she would make in any conceivable situation. In general, we seek Nash equilibrium strategies where no player can improve its payoff by a unilateral change in strategy.

2.2 Games in extensive form

A game in extensive form is one governed by a sequence of moves, where at each point the move is made by one of the players, or by chance (i.e. a probability is allocated to each possible outcome). Such a game may be represented by a tree (see Figure 1), where the game starts at an initial branch-point or vertex known as the root. The game proceeds from the root vertex, following a path through the tree governed by the choice of the players or random moves, until it ends at one of the *terminal vertices*, at which the payoffs allocated to each player are decided.

Sensible strategies for such games (which may be optimal in some sense) can be determined using backwards induction, i.e. starting at the vertices nearest the terminal vertices, and having decided upon the optimal choices at this point, moving backwards towards the root vertex. In simpler terms, we can derive reasonable strategies for investor and host state in a given situation when contemplating bringing or defending an arbitration claim respectively, by working backwards from generalized outcomes.

3. Model development and general analysis

3.1 The game tree

In this section we will outline how the arbitration strategies can be modelled for the

[18] M Broom and J Rychtar, *Game-Theoretical Models in Biology* (Taylor and Francis, 2013) and J Maynard Smith, *Evolution and the Theory of Games* (Cambridge University Press, 1982)
[19] von Neumann and O Morgenstern, above n 12
[20] D Baird, *Game Theory and the Law* (Cambridge University Press, 1994)
[21] E.g. A Guzman, 'Why LDCs Sign Treaties that Hurt Them: Explaining the Popularity of Bilateral Investment Treaties' 38 Virginia Journal of International Law 639 (1998)

purposes of game theory analysis via a 'game tree' which captures the various choices and outcomes at each stage. Figure 1 shows the game tree for our extensive form game. The root node X denotes the start of the game, where the claimant must decide whether to bring the case forward or not, meaning to initiate a formal claim through the ISDS provisions of an IIA or investment contract with the host state. If it does not bring the case forward, there is no further action, and there is no reallocation of resources (i.e. the payoff to each party is zero). If the claimant decides to bring the case forward, we reach vertex Y, where the respondent must choose whether to contest the claim, or to attempt to pursue a settlement, either through conciliation or some other means. Vertex Y differs from the other vertices in that here the active "player" is not required simply to make a binary choice, but to decide from a continuum of possible offers which one to make.

We present this as the respondent making a single offer of a settlement sum of value v to the claimant at vertex Y (a respondent wishing to contest the case will make a settlement offer of 0). The claimant at vertex Z_v can either accept or decline the offer. Acceptance of the offer by the claimant leads to rewards or "payoffs" to the claimant and respondent of A_{v1} and A_{v2} respectively.

If the claimant declines the offer then the matter will proceed to the arbitration stage involving a tribunal, vertex P. The outcome of the arbitration is obviously out of the control of either player[22]. The tribunal's verdict will depend on extraneous factors including most notably the strength of each party's legal claims and cannot be predicted with certainty, so that it must be treated as a chance event (represented by a circle in Figure 1). The tribunal decides in favour of the claimant (with payoffs, B_1 and B_2, to the claimant and the respondent respectively) with probability p, and in favour of the respondent (with payoffs, C_1 and C_2, respectively) with probability equal to 1-p.

We should note, however, that the game situation can be complicated by reputational factors, as discussed in Section 1.2. Individual states, and sometimes companies, can be involved in many disputes. This might be in the form of a series of disputes against the same opponent, in which case a repeated game model would be appropriate (see Mailath and Samuleson, 2006). More likely disputes would be against other opponents, and the consideration of a population of potential players would be required. Here the methodologies of evolutionary game theory (Maynard Smith, 1982) would be more appropriate. In either case the model would be considerably more complicated, and so we have chosen to consider the model as a single contest in this initial exposition of our model.

3.2 Evaluating the payoffs

In what follows, the subscript 1 will be used to denote properties or characteristics of the claimant, while the subscript 2 will denote those of the respondent. We will assume that both claimant and respondent are able to estimate accurately the B-payoffs, B_1 and B_2, which occur when the claimant wins, and the C-payoffs, C_1 and C_2, which come into force when the claimant loses.

[22] We do not consider here specific litigation strategies which are within the control of the parties such as the choice of specific legal arguments, the selection of counsel or of tribunal members.

Figure 1, which shows the game tree, is also marked up with the incremental costs incurred at each vertex for the two parties, where the index i is used to identify the party, with $i = 1$ denoting the claimant while $i = 2$ denotes the correspondent. Referring to this figure, the claimant will no doubt incur some costs up to the point marked X in considering whether or not to bring the case, likely by engaging counsel for an initial opinion as to the merits of the claim, but these will be common to all routes through the decision tree including that of dropping the case (path x_2). Thus these costs may be subsumed in the claimant's assets or wealth, W_1, just before vertex X. The respondent's wealth just before vertex X will be W_2. The respondent's wealth at this point will not be affected by the claimant's possible decision to pursue a claim, since it would not know about such a decision until after vertex X has been passed.

A decision to take the case forward (path x_1 in Figure 1) will lead to extra expenses being incurred by the claimant and new expenses by the respondent. These 'pre-arbitration tribunal legal expenses', will be called E_{PT1}, where the subscript, '$PT1$', stands for 'pre-tribunal for party 1', where party 1 denotes the claimant.

If the claimant follows path x_1, then the respondent will need to decide, at vertex Y, the sum of money, v, it should offer in settlement. No such offer corresponds to $v = 0$. The process now moves via path y_v to the vertex Z_v, where the claimant needs to decide on whether or not to accept the offer. The associated paths are marked z_{v1}, signifying acceptance, and z_{v2}, the latter denoting the claimant's decision to reject the offer and proceed to the tribunal.

The claimant following path z_{v1} will experience a gain or payoff of A_{v1}, relative to wealth at X, W_1, where:

$$A_{v1} = v - E_{PT1} \qquad (1)$$

Meanwhile the respondent will experience a (negative) gain or payoff, A_{v2}, relative to wealth at X, W_2, where:

$$A_{v2} = -v - E_{PT2} \qquad (2)$$

Bringing the case to arbitration, path z_{v2}, will incur additional legal costs for the tribunal, E_{Ti} for party i, where, in line with the convention adopted above, i = 1 denotes the claimant and i = 2 the respondent. The full legal costs for each of the two parties will then be the sum of pre-tribunal and at-tribunal legal costs:

$$E_i = E_{PTi} + E_{Ti} \qquad i = 1, 2 \qquad (3)$$

Let E_{Ai} be the arbitration costs assigned to each party in the tribunal judgement (the award stage). The total arbitration costs will be the sum of these two costs:

$$E_A = E_{A1} + E_{A2} \qquad (4)$$

If the claimant wins its case, path p_1, the tribunal will order the respondent to pay a compensation award, S_C, to the claimant. In addition, it may require the respondent to pay some fraction, $f_2: 0 \le f_2 \le 1$, of the claimant's total legal costs, E_1, leaving the latter with a residual cost burden of $(1 - f_2)E_1$. Hence the claimant will experience a gain or payoff, B_1, relative to wealth at X, W_1, given by:

$$B_1 = S_C - E_{A1} - (1 - f_2)E_1 \qquad (5)$$

while the respondent's (negative) gain, relative to wealth at X, W_2, will be:

$$B_2 = -S_C - E_{A2} - E_2 - f_2 E_1 \qquad (6)$$

If the claimant loses its case, no award will be made, and, moreover, the claimant may be asked to pay some fraction, $f_1: 0 \le f_1 \le 1$, of the respondent's legal expenses, E_2. Hence the claimant's (negative) gain, C_1, relative to wealth at X, W_1, will then be:

$$C_1 = -E_{A1} - E_1 - f_1 E_2 \qquad (7)$$

while the respondent's gain, C_2, relative to wealth at X, W_2, will be:

$$C_2 = -E_{A2} - (1 - f_1)E_2 \qquad (8)$$

C_2 will often be negative, indicating a cost to the respondent. However, in the respondent's best-case scenario, the arbitral tribunal will order the claimant to pay all the arbitration costs, possibly because the claim was wholly lacking in legal merit: $E_{A1} = E_A$, implying $E_{A2} = 0$, and, moreover, require the claimant to pay all the respondent's legal costs, implying $f_1 = 1$. In this scenario, the best as far as the respondent is concerned, $C_2 = 0$.

It is illuminating to sum the payoffs of claimant and respondent for the three cases where the case is brought forward (ending in paths z_{v1}, p_1 and p_2 in Figure 1). In the case of a settlement (path z_{v1}), adding equations (1) and (2) gives

$$A_1 + A_2 = -E_{PT1} - E_{PT2} \qquad (9)$$

signifying that the overall cost to the two parties is simply the sum of the pre-tribunal costs. In the case where the case goes to arbitration and the claimant wins, path p_1, adding equations (5) and (6) gives

$$B_1 + B_2 = -E_A - E_1 - E_2 = -E_{total} \qquad (10)$$

where E_{total} is the sum of both parties' legal and arbitration costs. In the case where the respondent wins, path p_2, adding equations (7) and (8) gives the same result:

$$C_1 + C_2 = -E_A - E_1 - E_2 = -E_{total} \qquad (11)$$

Combining equations (10) and (11) yields:

$$B_1 + B_2 = C_1 + C_2 \qquad (12)$$

3.3 Solving the game using backwards induction

3.3.1 Vertex P; conservation of money when the case goes before the tribunal

Let the claimant's change in wealth after the tribunal be $\Delta W_1 | T$, where *T* indicates the decision taken by the arbitration tribunal, and the notation $(x|y)$ indicates that the value of the variable, *x*, is that pertaining given that the action, *y*, has occurred. The change in wealth is measured relative to its value, W_1, just before vertex X.

In a similar way, the respondent's wealth will change by $\Delta W_2 | T$ from the value, W_2, it had just before vertex X. Since the total costs (each party's legal fees and tribunal expenses), E_{total}, will be funded entirely by one or both of claimant and the respondent and not from any outside source, conservation of money requires that:

$$\Delta W_1 | T + \Delta W_2 | T + E_{total} = 0 \qquad (13)$$

The tribunal's decision, *T*, will be uncertain in advance to both parties, and hence may be modelled reasonably as a random variable. While both $\Delta W_1 | T$ and $\Delta W_2 | T$ will thus be random variables also, the expenses term, E_{total}, will be independent of *T*. Thus applying the expectation operator, $E(.)$, to equation (13) gives:

$$E(\Delta W_1 | T) + E(\Delta W_2 | T) + E_{total} = 0 \qquad (14)$$

Since the legal and tribunal expenses will never be zero in practice, equation (14) demonstrates that the tribunal process will not constitute a zero-sum game between claimant and respondent. Equation (14) will prove useful in defining relationships between the payoffs to the claimant, B_1, C_1, and to the respondent, B_2, C_2.

Referring to Figure 1, $E(\Delta W_1 | T)$ will be the sum of the products of each of the claimant's possible payoffs, B_1 on winning, C_1 on losing, weighted by its probability of occurrence, *p* and 1 – *p* respectively:

$$E(\Delta W_1 | T) = pB_1 + (1-p)C_1 \qquad (15)$$

where *p* is the probability of the claimant succeeding at the tribunal.

In an analogous way, the respondent's expected change in wealth, $E\left(\Delta W_2 \middle| T\right)$, is given by:

$$E\left(\Delta W_2 \middle| T\right) = pB_2 + (1-p)C_2 \qquad (16)$$

3.3.2 Vertex Z_v

Having reached vertex Z_v, the claimant will be in receipt of the respondent's offer, v. The claimant's criterion for acceptance may be stated most generally in terms of utility (see Appendix B for an introduction to utility and related equations). The offer will be judged favourably only if it is sufficient to render the claimant's change in utility under settlement, $\Delta u_1 | S$, at least as much as the expected change in the claimant's utility if the case went before the tribunal, $E\left(\Delta u_1 \middle| T\right)$:

$$\Delta u_1 | S \geq E\left(\Delta u_1 \middle| T\right) \qquad (17)$$

We will assume, in the base model, that the claimant is risk neutral, so that its risk-aversion, ε_1, will be zero. Risk neutrality implies that the claimant's change in utility will be the same as its change in wealth, an assumption that will be reasonable when the amount of money being sought represents only a small fraction of the claimant's wealth. Hence

$$\Delta u_1 | S = \Delta W_1 | S \qquad (18)$$

and

$$E\left(\Delta u_1 \middle| T\right) = E\left(\Delta W_1 \middle| T\right) \qquad (19)$$

By the definition of the claimant's payoff under settlement,

$$A_{v1} = \Delta W_1 | S \qquad (20)$$

so that combining equations (15), (18), (19) and (20) with inequality (17) gives:

$$A_{v1} \geq pB_1 + (1-p)C_1 \qquad (21)$$

Applying equation (1) to inequality (21) allows a minimum offer level, $v_{\min}$, to be established:

$$v \geq v_{\min} = pB_1 + (1-p)C_1 + E_{PT1} \qquad (22)$$

The claimant should reject any settlement, v, that is less than $v_{\min}$ since a risk neutral claimant could expect better from the tribunal. However, if no negotiation is allowed and the respondent makes a single “take it or leave it” offer, following the game tree in Figure 1, then any offer of $v_{\min}$ or greater should be accepted.

3.3.3 Vertex Y

The respondent needs to decide, at vertex Y, the size of the settlement offer, *v*, it should make to the claimant, where the range of possible *v* will include zero, equivalent to the absence of an offer.

The respondent may identify two constraints in making an offer:

(i) the respondent's offer, v, must be sufficient to satisfy inequality (22)

(ii) the respondent will wish its change in utility under settlement, $\Delta u_2 \middle| S$, to be at least as much as its expected change in utility if the case were to go before the tribunal:

$$\Delta u_2 \big| S \geq E\left(\Delta u_2 \big| T\right) \qquad (23)$$

The condition of risk neutrality assumed for the respondent in the base case implies

$$\Delta u_2 \big| S = \Delta W_2 \big| S \qquad (24)$$

and

$$E\left(\Delta u_2 \big| T\right) = E\left(\Delta W_2 \big| T\right) \qquad (25)$$

The respondent's change in wealth, $\Delta W_2 \big| S$, is shown in Figure 1 as the payoff to the Respondent under settlement:

$$A_{v2} = \Delta W_2 \big| S \qquad (26)$$

Equations (16), (24), (25) and (26) may now be combined with inequality (23) to give

$$A_{v2} \geq pB_2 + \left(1-p\right)C_2 \qquad (27)$$

Substituting from equation (2) into inequality (27) gives the second constraint on the settlement sum to be offered by the respondent

$$v \leq v_{\max} = -pB_2 - \left(1-p\right)C_2 - E_{PT2} \qquad (28)$$

The respondent would not be advised to offer any more than $v_{\max}$ in settlement, as a better outcome could be expected from the tribunal.

We may compare the limiting values, $v_{\max}$ and $v_{\min}$, using the equations associated with the conservation of money. Combining equations (14), (15) and (16):

$$pB_2 + \left(1-p\right)C_2 = -pB_1 - \left(1-p\right)C_1 - E_{total} \qquad (29)$$

Substituting from equation (29) into equation (28) gives

$$\begin{aligned} v_{\max} &= pB_1 + (1-p)C_1 + E_{total} - E_{PT2} \\ &= pB_1 + (1-p)C_1 + E_A + E_{PT1} + E_{T1} + E_{PT2} + E_{T2} - E_{PT2} \\ &= pB_1 + (1-p)C_1 + E_A + E_{PT1} + \sum_{i=1}^{2} E_{Ti} \end{aligned} \qquad (30)$$

Comparing equations (23) and (30), it is clear that $v_{\max}$ is greater than $v_{\min}$ at any given value of claimant success probability, *p*, by an amount equal to the total arbitration costs, E_A, plus the sum of both parties' at-tribunal legal fees, $E_{T1} + E_{T2}$:

$$v_{\max} = v_{\min} + E_A + \sum_{i=1}^{2} E_{Ti} \qquad (31)$$

Thus the respondent will indeed be willing to offer $v_{\min}$, and since the claimant would accept this, then that is the offer that should be made.

The disparity illustrated by equation (31) occurs because the additional cost of holding the tribunal means that there is a range of offer levels where both respondent and claimant would achieve a higher reward from the associated settlement than the expected reward that they would receive from going to the tribunal. This may be demonstrated by subtracting the claimant's expected payoff, $E(\Delta W_1 | T)$, from the negative of the respondent's payoff, $-E(\Delta W_2 | T)$ using equations (15) and (16):

$$-E(\Delta W_2 | T) - E(\Delta W_1 | T) = p(C_2 - B_2) - C_2 - p(C_1 - B_1) - C_1 \qquad (32)$$

But from equation (12), $C_2 - B_2 = B_1 - C_1$, while from equation (11), $-C_2 - C_1 = E_{total}$. Hence

$$-E(\Delta W_2 | T) - E(\Delta W_1 | T) = E_{total} > 0 \qquad (33)$$

In plain terms, the difference, E_{total}, between $v_{\min}$ and $v_{\max}$ is a direct result of the respondent expecting to lose more than the claimant can expect to gain.

The size of the difference between them will vary considerably from case to case. For the 25 cases considered in Part II for which a claim was declared, the distribution of the ratio, r_{ATC}:

$$r_{ATC} = \frac{\text{total arbitration and at-tribunal fees}}{\text{claim}} \qquad (34)$$

has a substantial mean, 0.60, but a very large standard deviation of 1.92. The distribution has a median of 0.082 and is approximately lognormal with a long tail, see Figure 2. It may be deduced that while the sum of the arbitration and at-tribunal legal costs can be negligible in many cases, in others these costs can be highly significant: at least 10% of the claim for about 45% of claims, based on data from Table 1 of Part II.

3.3.4 Vertex X

The claimant must decide at vertex X whether or not to bring the case forward. It knows that it cannot control the behaviour of the respondent, and it cannot assume that the respondent will make a satisfactory settlement offer. Thus the claimant will pursue its case only if it expects that its utility will rise as a result of the verdict of the arbitration tribunal: $E\left(\Delta u_1 \middle| T\right) > 0$. It is shown in Appendix C that $E\left(\Delta u_1 \middle| T\right) > 0$ implies $E\left(\Delta W_1 \middle| T\right) > 0$ not only for the risk neutral case ($\varepsilon = 0$), but also for any positive risk-aversion. Hence it is sufficient under rather general conditions to stipulate that the claimant should pursue its claim only if:

$$E\left(\Delta W_1 \middle| T\right) > 0 \qquad (35)$$

Combining this condition along with equation (15) above gives the condition:

$$pB_1 + (1-p)C_1 > 0 \qquad (36)$$

so that

$$p(B_1 - C_1) > -C_1 \qquad (37)$$

Since the claimant's payoff on winning its case at the tribunal will be positive: $B_1 > 0$, while its payoff on losing will be negative: $C_1 < 0$, it follows that $B_1 - C_1 > 0$. Hence inequality (36) may be rearranged to:

$$p = p^* > \frac{C_1}{C_1 - B_1} \qquad (38)$$

This means that the claimant will proceed only if its probability of success before the tribunal is greater than the go-no-go value, p^*, the probability of claimant victory below which it would not be reasonable for a potential claimant to proceed.

The value p^*, given in equation (38) in terms of the claimant's tribunal payoffs may also be expressed in terms of the respondent's payoffs by noting from equation (12) that

$$C_1 - B_1 = -(C_2 - B_2) \qquad (39)$$

while from equation (11):

$$C_1 = -(E_{total} + C_2) \qquad (40)$$

Substituting from equations (39) and (40) into inequality (38) gives:

$$p > p^* = \frac{E_{total} + C_2}{C_2 - B_2} \qquad (41)$$

Calculating p^* in this way requires the respondent to estimate only its own payoffs having won or lost at the tribunal, C_2 and B_2 respectively, as well as making an assessment of the legal and arbitration costs to be borne by the two parties.

3.4 The settlement space

The theory developed above allows the settlement space to be divided as shown in Figure 3, which plots the respondent's offer, *v*, against the claimant's success probability, *p*. The space is partitioned into 4 regions, numbered 1 to 4.

Region 1: the claimant will not bring the case forward if it estimates its probability of success to be less than the go-no-go probability, p^*.

Region 2: the respondent will not make an offer above $v_{\max}$.

Region 3: the claimant will not accept an offer below $v_{\min}$.

Region 4: the existence of Region 4 is a consequence of the process not being a zero sum game, as discussed in Section 3.3.3. If both parties are risk neutral, so that only the monetary outcome matters, and the game sequence follows Figure 1, then any successful settlement will lie on the line of $v_{\min}$ versus *p*. This raises two questions. Firstly why would a settlement occur that did not lie on this line? We will address this issue in Section 3.5. Secondly, why would any case go to the tribunal rather than reach a settlement? We will address this point at the beginning of Part II.

Figure 3 represents the general solution for settlement under ISDS.

The analysis is obviously idealized in that it assumes that both the claimant and respondent are able to estimate the various parameters accurately. Nevertheless its identification of 4 distinct regions defining the settlement space in the plane of (*p*, *v*) provides a novel and useful framework for evaluating the problems facing both claimant and respondent when contemplating a settlement. We shall apply the new analysis results to real data in Part II of this paper.

3.5 Effect of non-zero risk-aversions on the inclination to settle

3.5.1 The claimant

It is possible for the claimant to have a risk-aversion greater than zero. In general terms, the claimant's risk-aversion, ε_1, will rise significantly above zero when the size of the potential arbitration award is comparable with its wealth.[23] Estimation of ε_1 will require a

[23] P. J. Thomas, R. D. Jones and W. J. O. Boyle, 2010, 'The limits to risk aversion. Part 2: The permission point and examples', *Process Safety and Environmental Protection*, Vol. 88, No. 6, November, pages 396 – 406; I. Waddington, W. J. O. Boyle and J. Kearns, 2013, 'Computing the Limits of Risk Aversion', *Process Safety and Environmental Protection*, Vol. 91, Nos. 1 – 2, pages 92–100. doi:10.1016/j.psep.2012.03.003

prior estimation of the claimant's assets, possible in the case where the claimant is a publicly listed company. Inequality (17) will still be satisfied when the claimant has a positive risk-aversion even though inequality (22) will not: the claimant's gain in utility will render it content to accept a settlement sum less than $v_{\min}$. Obviously an aware respondent could take advantage of this situation by issuing a lower settlement offer.

On the other hand, the difference between $v_{\min}$ and $v_{\max}$ might have a complicating effect on the claimant's strategy on whether or not to accept the respondent's offer. Suppose that the respondent offers a settlement sum, $v_{\min}$. If the offer is a one-off and the claimant's risk-aversion is zero, it ought logically to accept, since the alternative would be to go before the tribunal, where the claimant could not expect to do better.

However, suppose that the offer is not a one-off. This would correspond to the process in Figure 1 being extended to allow for negotiation at vertex Z_v, making it possible that the respondent would make a second offer. The claimant's estimates of the costs and legal fees associated with the case would enable it to calculate that the respondent could be pushed harder while still complying with its "red-line" condition, $v \le v_{\max}$. The realisation that the respondent has some margin in hand might conceivably lead the claimant to reject a settlement offer of $v_{\min}$. But even in this case the claimant cannot be certain, when refusing $v_{\min}$ as a settlement, that the respondent will make an improved offer, and here the details of the negotiation process would be crucial. This will be discussed at the beginning of Part II of the paper. But the only guaranteed alternative is to pursue a claim before the arbitration tribunal, and the claimant is turning down an offer equal to its expected tribunal payoff. To reject such an offer, the claimant might need to become at least marginally risk confident rather than risk neutral. While the claimant might be succesful in winning a better result from the tribunal, it is nevertheless clear that the strategy is riskier (and with a no better expected return) than accepting $v_{\min}$.

3.5.2. The respondent

It is reasonable to assume in most cases that the respondent's potential loss would be a small fraction of its total assets, making it likely that the respondent should be risk neutral, with $\varepsilon_2 = 0$. This would predispose the respondent to making an offer of $v_{\min}$ in settlement.

However, as noted in Section 1.3, there might be factors that would lead to the respondent adopting a higher risk-aversion. For example, the rapid closing out of a case through early settlement could reduce the potential for bad publicity that might accompany a tribunal case, a consideration of greater significance in recent times because of growing pressure to waive confidentiality of proceedings combined with heightened media scrutiny over ISDS. The respondent state might also wish to avoid a clear adverse judgement by an international arbiter, since both the fact of the negative judgement and the text accompanying that judgement might bring significant reputational damage over and above the direct financial loss, jeopardizing future inward foreign investment.

The disparity between $v_{\min}$ and $v_{\max}$ might influence the risk averse respondent (for which now $\varepsilon_2 > 0$) to make a settlement offer above $v_{\min}$ and closer to $v_{\max}$. But while a significantly risk averse respondent might be inclined to offer more than $v_{\max}$, it would almost certainly be restrained from doing so by its duty as custodian of public funds. A higher offer might be interpreted by polical opponents as a gross waste of public money. Hence $v_{\max}$ may be regarded in practice as the absolute maximum offer that the respondent will make.

4. Conclusions

This article has applied game theory to develop a model of the process of international arbitration between investors and host states under international investment law. Attention is drawn thereby to the strategic issues and associated decisions facing the two parties to the dispute.

The development of the settlement space diagram provides a new and easily understood conceptualisation of the economic principles behind the strategy of investor-state dispute settlement through which the structure of the settlement problem is laid bare. Furthermore, the mathematical framework developed here allows data available from previous arbitration cases to be organised into a usable model that can offer both claimant investors and respondent states benchmarks against which to judge their respective arbitration strategies when allegations of treaty breach are made.

The method presented in this article should be of immediate interest to a respondent state seeking guidance on the size of the offer it should make to a claimant with a reasonable expectation of acceptance. By the same token, the method should be of value to potential claimants considering taking a case to international arbitration through fora such as ICSID.

Part II of this paper applies the model developed here to a selection of ISDS cases that went to arbitration between 2012 and 2014.

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Appendix A. Nomenclature used in Part I

Symbol	**Meaning**
A	positive constant
A_{v1}	claimant payoff on accepting offer, v
A_{v2}	respondent payoff on having offer, v, accepted
B	constant
B_1	claimant payoff after winning at the tribunal
B_2	respondent payoff after claimant wins at the tribunal
C	claimant (label in Figure 1)
C_1	claimant payoff after losing at the tribunal
C_2	respondent payoff after claimant loses at the tribunal
E_1	claimant's total legal fees (pre-tribunal and at-tribunal)
E_2	respondent's total legal fees (pre-tribunal and at-tribunal)
E_A	arbitration costs
E_{A1}	arbitration costs borne by the claimant
E_{A2}	arbitration costs borne by the respondent
E_{PT1}	claimant pre-tribunal legal fees
E_{PT2}	respondent pre-tribunal legal fees
E_{T1}	claimant at-tribunal legal fees
E_{T2}	respondent at-tribunal legal fees
E_{total}	total legal fees and arbitration costs
f_1	fraction of the respondent's legal expenses borne by the claimant
f_2	fraction of the claimant's legal expenses borne by the respondent
M	rate of change of utility with wealth

P	vertex representing the judgment of the tribunal
p	claimant's probability of winning at the tribunal
$p*$	lowest probability of the claimant winning at the tribunal that will allow the claimant to bring its case forward
p_1	game tree path when claimant wins at tribunal
p_2	game tree path when claimant loses at tribunal
R	respondent (label in Figure 1)
r_{ATC}	ratio: $\left(\text{total arbitration and at-tribunal fees}\right) \div \text{claim}$
S	settlement
S_C	tribunal award
T	tribunal decision
$u(.)$	utility
v	settlement offer
v_{max}	absolute maximum settlement offer
v_{min}	maximum settlement offer made by a risk neutral respondent
W	wealth
X	1st vertex on game tree, where the claimant decides whether or not to bring the case forward
x_1	game tree path followed when the claimant decides to bring case forward
x_2	game tree path followed when the claimant decides not to bring case forward
Y	vertex at which the respondent decides on what size offer to make
y_v	path connecting vertex Y to vertex, Z_v
Z_v	vertex at which the claimant decides on whether or not to accept the offer, v
z_{v1}	path to settlement when the claimant accepts offer, v
z_{v2}	path to tribunal when the claimant rejects offer, v
ε	risk-aversion
ε_1	claimant's risk-aversion
ε_2	respondent's risk-aversion

Appendix B. The use of utility as an indicator of satisfaction

In the most general statement of the problem, each of the arbitral parties, claimant investor and respondent host state, will be seen as attempting to maximize the expected utility of its assets. Whether it is a government or firm, the utility, $u(W)$, of any organization's assets or wealth, W, is the value that the organization places on the assets that it owns. It is important to recognize that this may differ from their monetary equivalent, depending on the risk-aversion, ε, of the organization in question.

A rise in risk-aversion above zero, $\varepsilon_1 > 0$, renders the utility function non-linear and concave, a situation envisaged by von Neumann and Morgenstern. Those authors pointed out[24] that, for the case where options, B, A, and C are put in that order of preference by an individual, then a numerical measure of utility can be obtained by eliciting a further piece of information, namely the probability, p, at which he/she would be prepared to accept a

[24] von Neumann and Morgenstern, above n 12

probabilistic combination of *B* and *C* as equivalent to option A. The individual's indifference between option *A* and the probabilistic combination of options *B* and *C* produces an equality in expected utility:

$$E\left(u\left(A\right)\right) = pu\left(B\right) + \left(1-p\right)u\left(C\right) \qquad \text{(B.1)}$$

where $u(.)$ is the utility function used to calculate the person's utility from the option. The right-hand side of equation (B.1) may be recognised as the expected utility of the probabilistic offering of options *B* and *C*.

Equation (B.1) may be applied to the current problem by identifying option *B* as the claimant's change in utility of wealth after a win at the arbitration tribunal and option *C* as the change in its utility of wealth if the case is lost. Analogously defined options *B* and *C* may represent the respondent's changes in utility of wealth when the claimant wins and loses respectively.

Application of equation (B.1) requires a utility function to be found with the appropriate value of risk-aversion, ε. It has been argued that the 'Power family' of utility functions, with risk-aversion, ε, as sole parameter, is the only class of utility functions that conforms to what is the necessary condition for a decision, namely that the risk-aversion of the decision maker remains unchanged during the course of his/her making the decision.[25] This is because risk-aversion depends on the wealth of the decision maker or, by extension, that of his/her organization. (The much lower risk-aversion of wealthy insurance companies compared with their clients is the theoretical basis on which insurance companies can exist, as pointed out first by Daniel Bernoulli in 1738 and then, more recently by Kaas et al. (2001). See also Thomas (2016)) This wealth will not change during the short time when the decision is being taken, even if the decision will lead to a different wealth being held in the future. It is the current wealth that will inevitably inform the decision being taken. Of the Power utility functions, the Atkinson version of equation (B.2) below offers the advantage that it can cope with the full range of risk-aversions, in particular risk-aversions numerically higher than 1.0, corresponding to a high degree of caution. The Atkinson utility function is defined by:

$$u\left(W\right) = \begin{cases} \dfrac{W^{1-\varepsilon}-1}{1-\varepsilon} & \text{for } \varepsilon \neq 1 \\ \ln W & \text{for } \varepsilon = 1 \end{cases} \qquad \text{(B.2)}$$

The form of $u\left(W\right)$ conforms to the necessary conditions that utility should be both monotonically increasing in wealth and concave when $\varepsilon \geq 0$. The latter condition provides a good model of normal human behaviour and embodies the "law of diminishing returns", *viz*. successive increments in wealth lead to progressively lower increases in

[25] PJ Thomas, 'An absolute scale for measuring the utility of money', *Proc. 13th IMEKO TC1-TC7 Joint Symposium Without Measurement no Science, without Science no Measurement* , 1-3 September 2010, City University London, UK, IOP Publishing, Journal of Physics: Conference Series 238 (2010) 012039 doi:10.1088/1742-6596/238/1/012039. Also PJ Thomas, 2015, 'Measuring risk-aversion: The challenge', *Measurement*, http://dx.doi.org/10.1016/j.measurement.2015.07.056

utility. It is possible, however, for risk-aversion to be negative, with the person or organisation possessing this characteristic being risk confident as opposed to risk averse or risk neutral.

Risk-aversion, ε, is dimensionless, which means that it is a general parameter that can explain the desire to reduce risk to wealth whether that wealth is expressed in UK pounds, US dollars or Japanese yen, for example. It is a normalized derivative in the sense defined by equation (B.3):

$$\varepsilon = -\frac{W}{m}\frac{dm}{dW} \qquad \text{(B.3)}$$

where *m* is the rate of change of utility with wealth, expressed mathematically as the derivative: $m = du/dW = u'$, so that

$$\varepsilon = -W\frac{u''(W)}{u'(W)} \qquad \text{(B.4)}$$

It has been shown that when the amount of wealth at risk is small compared with the organization's assets, then $\varepsilon \to 0$, which implies from equation (B.2) that $u(W) \to W - 1 \approx W$, so that the utility is then the same as the wealth. On the other hand, risk-aversion can climb to very high levels, $\varepsilon >> 1$, when a large fraction of the organization's assets is at risk.[26]

The gain in utility, Δu_i, for each party will depend on which outcome occurs:

$$\Delta u_i = \begin{cases} u(W_i + A_{vi}) - u(W_i) & \text{in an out-of-court settlement} \\ u(W_i + B_i) - u(W_i) & \text{if the Claimant wins the arbitration} \\ u(W_i + C_i) - u(W_i) & \text{if the Claimant loses the arbitration} \end{cases} \qquad \text{(B.5)}$$

So called "gains" may be negative, indicating a loss, as well as positive.

Clearly an important factor influencing both the respondent and the claimant is the perceived probability of the claimant winning, p.[27] This enters the model via the expected change in utility of each of the parties:

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[26] PJ Thomas, RD Jones and WJO Boyle, 'The limits to risk aversion: Part 1. The point of indiscriminate decision', Process Safety and Environmental Protection, Vol. 88, No. 6, November, pages 381 – 395. (2010); PJ Thomas, RD Jones and WJ O Boyle, 'The limits to risk aversion. Part 2: The permission point and examples', Process Safety and Environmental Protection, Vol. 88, No. 6, November, pages 396 – 406. (2010) ; PJ Thomas, and RD Jones, 'Extending the J-value framework for safety analysis to include the environmental costs of a large accident', Process Safety and Environmental Protection, Vol. 88, No. 5, September, pages 297 – 317 (2010); I Waddington, WJO Boyle, and J Kearns, 'Computing the Limits of Risk Aversion', Process Safety and Environmental Protection, 91, 92–100 (2013). doi:10.1016/j.psep.2012.03.003

[27] In addition to the perceived chances of victory, the respondent government may be motivated by the political gains from appearing to contest a claim vigorously rather than being seen to capitulate in a settlement. These factors of course depend on the extent of public attention tied to the dispute, which may be null where the dispute has remained entirely confidential.

$$E\left(\Delta u_i \middle| T\right) = p\left(u\left(W_i + B_i\right) - u\left(W_i\right)\right) + \left(1-p\right)\left(u\left(W_i + C_i\right) - u\left(W_i\right)\right) \\ = pu\left(W_i + B_i\right) + \left(1-p\right)u\left(W_i + C_i\right) - u\left(W_i\right) \qquad \text{(B.6)}$$

Meanwhile the expected change in utility for each party if it decides to pursue settlement becomes deterministic. In other words, the element of chance has been removed, so that there is no reference to probability in equation (B.7) below:

$$E\left(\Delta u_i \middle| S\right) = u\left(W_i + A_{vi}\right) - u\left(W_i\right). \qquad \text{(B.7)}$$

where *S* denotes the action of proceeding to an out of court settlement. The party should seek or accept a settlement if

$$E\left(\Delta u_i \middle| S\right) \geq E\left(\Delta u_i \middle| T\right) \qquad \text{(B.8)}$$

The equality condition included in inequality (B.8) reflects the fact that a settlement will generally be the simpler process. The process of achieving settlement itself tends to be less costly than that of litigation in many domestic civil justice systems.[28] Hence settlement is generally to be preferred even when the monetary and therefore utility outcomes are indistinguishable. From equations (B.6) and (B.7), inequality (B.8) is equivalent to the condition

$$u\left(W_i + A_{vi}\right) \geq pu\left(W_i + B_i\right) + \left(1-p\right)u\left(W_i + C_i\right). \qquad \text{(B.9)}$$

Using equation (B.1), and assuming $\varepsilon \neq 1$, inequality (B.9) may be recast as:

$$\frac{\left(W_i + A_{vi}\right)^{1-\varepsilon_i} - 1}{1-\varepsilon_i} \geq p\frac{\left(W_i + B_i\right)^{1-\varepsilon_i} - 1}{1-\varepsilon_i} + \left(1-p\right)\frac{\left(W_i + C_i\right)^{1-\varepsilon_i} - 1}{1-\varepsilon_i} \qquad \text{(B.10)}$$

When the respondent's risk-aversion is less than unity, $\varepsilon_i < 1$, this reduces to

$$\left(W_i + A_{vi}\right)^{1-\varepsilon_i} - 1 \geq p\left(\left(W_i + B_i\right)^{1-\varepsilon_i} - 1\right) + \left(1-p\right)\left(\left(W_i + C_i\right)^{1-\varepsilon_i} - 1\right) \qquad \text{(B.11)}$$

In the risk neutral case, $\varepsilon_i = 0$ and so

$$A_{vi} \geq pB_i + \left(1-p\right)C_i \qquad \text{(B.12)}$$

Putting *i* = 1, 2 produces inequalities (21) and (27) in the main text.

Appendix C. Expected change in utility and expected change wealth

[28] In an early study on economic analysis of litigation strategy it was suggested that only one dispute in ten proceeds to litigation partly because of this reason: R Cooter and D Rubinfeld, 'Economic Analysis of Legal Disputes and their Resolution' 27 Journal of Economic Literature 1067 at 1070 (1989), although as suggested in the introduction the value of settlement over litigation may be less applicable to ISDS because parties do not need to settle to achieve confidentiality since confidentiality is built into the process.

Because of the need to distinguish compactly in this appendix between variables that are subject to uncertainty and those that are not, the common convention will be adopted that a random variable is given an upper case letter while deterministic variables are written in lower case. In line with this usage, let the claimant have starting wealth, w_1, and let it consider going before a tribunal that will leave it with wealth, $W_1|T$. It will regard its post-tribunal wealth, $W_1|T$, as a random variable, since, while it may increase its chance of success by the power of its arguments, the final judgment will obviously be that of the arbiters. The change in the claimant's wealth, $\Delta W_1|T$, will be given by:

$$\Delta W_1|T = W_1|T - w_1 \qquad \text{(C.1)}$$

which will also be a random variable. Applying the expectation operator, $E(.)$, gives:

$$E(\Delta W_1|T) = E(W_1|T) - w_1 \qquad \text{(C.2)}$$

The claimant's starting utility will be $u(w_1)$ and its utility after appearing before the tribunal will be $u(W_1|T)$, which could be higher or lower than $u(w_1)$, depending on whether the claimant wins or loses. The change in utility will be $\Delta u(W_1|T)$, given by:

$$\Delta u(W_1|T) = u(W_1|T) - u(w_1) \qquad \text{(C.3)}$$

The expectation of the change in utility is

$$E(\Delta u(W_1|T)) = E(u(W_1|T)) - u(w_1) \qquad \text{(C.4)}$$

The claimant may be assumed to be either risk averse, in which case the risk-aversion, ε, will be strictly positive, or risk neutral, in which case $\varepsilon = 0$ and the utility is a positive linear transformation of wealth: $u(w_1) = aw_1 + b$; $a > 0$. The requirement that a is positive reflects the general requirement that utility be a monotonically increasing function of wealth. Substituting $u(w_1) = aw_1 + b$ into equation (C.4) gives:

$$E(\Delta u(W_1|T)) = E(aW_1|T + b) - (aw_1 + b) = a(E(W_1|T) - w_1) \qquad \text{(C.5)}$$

Substituting from equation (C.2) into equation (C.5) and rearranging shows that the expected wealth is linearly related to the expected utility

$$E(\Delta W_1|T) = \frac{1}{a} E(\Delta u(W_1|T)) \qquad \text{(C.6)}$$

so that a rise in expected utility $E(\Delta u(W_1|T))$ will imply a rise in expected wealth, $E(\Delta W_1|T)$ when $\varepsilon = 0$.

Meanwhile a positive risk-aversion, $\varepsilon > 0$, implies that the utility function is strictly concave. It will thus obey Jensen's inequality[29]:

$$E(u(W_1|T)) < u(E(W_1|T)) \qquad \text{(C.7)}$$

Substituting for $E(u(W_1|T))$ from equation (C.4) and for $W_1|T$ from equation (C.1) gives

$$E(\Delta u(W_1|T)) + u(w_1) < u(E(\Delta W_1|T) + w_1) \qquad \text{(C.8)}$$

or

$$E(\Delta u(W_1|T)) < u(E(\Delta W_1|T) + w_1) - u(w_1) \qquad \text{(C.9)}$$

Suppose now that the change in expected utility is positive (it is only in this case that the claimant will want bring its case forward):

$$E(\Delta u(W_1|T)) > 0 \qquad \text{(C.10)}$$

It follows from inequality (C.9) that

$$0 < u(E(\Delta W_1|T) + w_1) - u(w_1) \qquad \text{(C.11)}$$

or

$$u(E(\Delta W_1|T) + w_1) > u(w_1) \qquad \text{(C.12)}$$

Since the utility function is monotonically increasing in its argument and $w_1 > 0$, this implies that

$$E(\Delta W_1|T) > 0 \qquad \text{(C.13)}$$

Hence for all feasible utility functions, that is to say when $\varepsilon \geq 0$, a rise in expected utility will imply a rise in expected wealth.

[29] JLWV Jensen, 1906, 'Sur les fonctions convexes et les inégalités entre les valeurs moyennes' ("On convex functions and the inequalities between mean values"), *Acta Mathematica*, Vol. 30, No. 1, 175 – 193, doi:10.1007/BF02418571

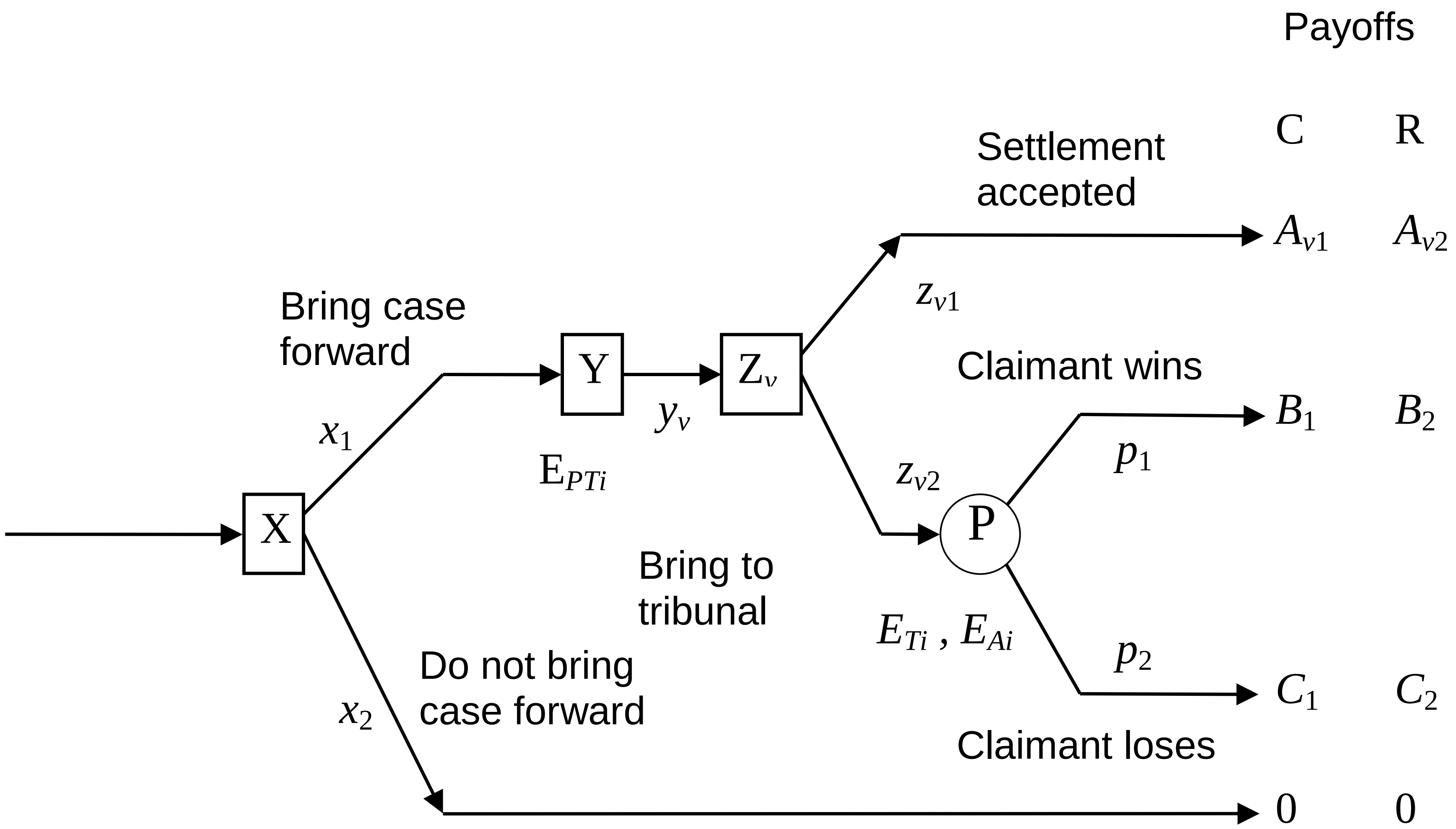
Payoffs
C
R
Settlement accepted
A_{v1}
A_{v2}
z_{v1}
Bring case forward
Y
Z_v
Claimant wins
B_1
B_2
x_1
y_v
p_1
E_{PTi}
z_{v2}
X
P
Bring to tribunal
E_{Ti} , E_{Ai}
Do not bring case forward
p_2
C_1
C_2
x_2
Claimant loses
0
0

Figure 1. Game tree for arbitration. (C = claimant, R = respondent). The range of offers the respondent may make at vertex Y is very large. The analysis will show that there will a unique offer that the respondent would make that will be acceptable to the claimant.

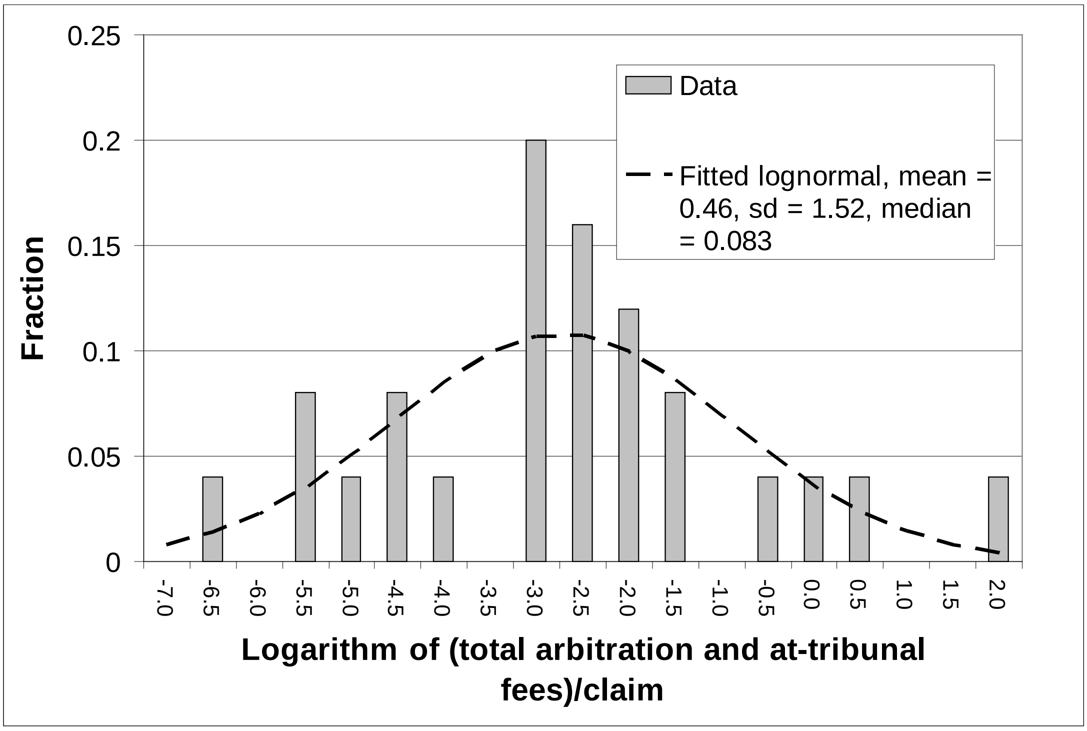

Figure 2. Histogram for the logarithm of r_{ATC}, the ratio of (total of arbitration costs and at-tribunal legal fees) to the size of the claim. Best-fit logarithmic distribution to data from Table 1 of Part II.

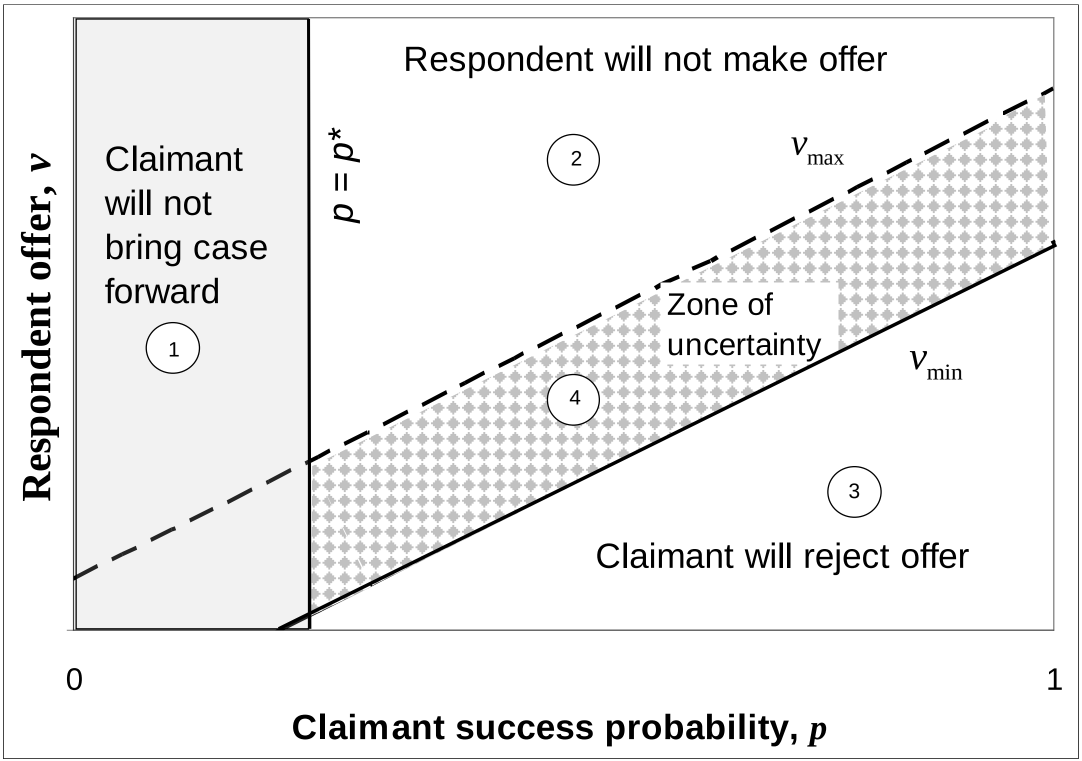

Figure 3. The settlement space in the plane of (p, v)