Chapter 6
A Non-classical Logical Approach to Social Software

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Abstract The term *social software* was coined by Rohit Parikh in 2002. Social software can be viewed as a research program which studies the construction and verification of social procedures by using tools in logic and computer science. However, to the best of my knowledge, social software has not been considered from a non-classical logical perspective. In this paper, I argue how non-classical logical approaches can enrich, broaden and support the agenda of social software.

Keywords Social software · Non-classical logics · Paraconsistent logic

6.1 Introduction and Motivation

The term *social software* was coined by Rohit Parikh in his 2002 paper (Parikh 2002). Social software can be viewed as a research program which studies the construction and verification of social procedures by using tools in logic and computer science. By definition, it relates closely to a variety of neighboring fields including game theory, social choice theory and behavioral economics. However, to the best of my knowledge, social software has not been considered from a non-classical logical perspective. In this paper, I argue how non-classical logical approaches can enrich, broaden and support the agenda of social software. Additionally, I will claim that incorporating non-classical elements to the program of social software aligns very well with its initial motivation.

Parikh himself does not seem to commit himself to the classical logic in the original paper, yet the de facto logic he utilizes in his work is classical. On the other hand, classical logic does not seem to be an essential element of the program of social software:

> I want to argue that (...) no doubt we shall never have social procedures which work ideally, we can nonetheless have a theory of social procedures which is analogous to the formal

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> theories for computer algorithms which exist in computer science. I am referring here to a whole group of theories, some of which have come into existence during the early seventies and some are newer.
>
> (Parikh 2002)

I argue that the above quoted claim and, in general, the research program of social software, suggest the inclusion of formal tools beyond classical logic to study social software. Plurality of social procedures and their various anomalies (such as lies, jokes and speech acts) necessitate a pluralistic approach. Moreover, truth *gaps* and truth *gluts* are ordinary parts of logical formalisms which can be used to give a formal account of a variety of social phenomena. In fact, this is one of the main motivations behind logical pluralism: classical Boolean logic suffers from various restrictions which render it rather problematic in explaining human behavior and reasoning. In some cases, we can have different notions of logical consequence; in some cases, we may need more truth values; in some cases, we may have to reevaluate and redefine the logical connectives. Furthermore, it is not entirely clear how exactly people reason in social situations, and to which logical framework they are usually committed (Kahneman 2011).

In this work, in terms of logical pluralism and non-classical logics, I mainly focus on paraconsistent logics. I use the term *paraconsistency* for the logical systems in which the rule of explosion fails. In such systems, for some φ, ψ, we have $\varphi, \neg\varphi \nvdash \psi$. In short, paraconsistent systems are the logical frameworks that allow non-trivial inconsistent theories where a trivial theory is a set of sentence from which everything logically follows. Paraconsistent logic, therefore, allows us build inconsistency-tolerant models. I believe this is a key notion in understanding social software.

There are various reasons for that. First of all, contradictions occur in social phenomena. People lie, cheat, make mistakes, and misunderstand each other, they happen to be wrong in their thoughts and actions, and all of these situations (and possibly many more) require an inconsistency-friendly framework for expressive power and normative predictions. Moreover, various data from behavioral economics indicate that people usually do not reason in the way that the classical logic predicts (Kahneman 2011; Ariely 2008, 2010). This observation, by no means, entails that people always reason in a non-classical logical way. However, it casts doubt on the soundness of classical logical tools and encourages us to consider non-classical logical apparatus. Also, there can be found a variety of situations in social software that seem to fit well with non-classical logical reasoning. For instance, when people make an error in reasoning that can cause an inconsistency, the very existence of the inconsistency does not render the formalism trivial. People keep reasoning in their inconsistent model in a sound way. Sometimes they revise their beliefs, sometimes they reason non-monotonically, sometimes they ignore the inconsistency.

Yet, there also exist some other sort of inconsistencies in human reasoning and social procedures. Perhaps, a canonical example for such cases comes from normativity. The problem is how people *should* act under the presence of contradictory obligations. This is a social software issue as well as a problem in legal philosophy.

There are various approaches to obligations and normativity, yet very few of them mention the above critical point (Başkent et al. 2012; Priest 2006).

Priest, for example, describes inconsistent obligations as the "situations where someone is obliged both to do x and not to do x" (Priest 2006, p. 182). He further elaborates on inconsistent obligations as follows.

> The source of contradictory obligations need not be different contracts, but may be one and the same contract. Of course, in practice it is rare for a contract per se to be blatantly inconsistent, but it is not unusual for a contract plus contingent circumstances to give someone inconsistent obligations. Suppose, for example, that I contract to do z under condition X, but refrain from doing z under condition Y. We may suppose that X and Y are events not under the control of the parties of the contract, and that there is no reasonable likelihood of X and Y both occurring. Suppose that, despite this, both do occur. Can I then be held in breach for whichever of the actions I do not perform?
>
> (Priest 2006, p. 183)

The issue, raised by Priest here, has some ontological commitments to the contradictory co-existence of X and Y, and the philosophical implications of this situation go beyond the scope of the current article. Nevertheless, it shows that paraconsistent approach to social situations presents itself as an important perspective, and there seems to be no reason why it should not be included within the agenda of social software.

Another example of a contradictory situation comes from one of Parikh's recent papers. In my opinion, the "Kitty Genovese" case that Parikh and his coauthors discussed illustrates similar concerns.

> [I]n the Kew Gardens section of Queens, New York City, Catherine Genovese began the last walk of her life in the early morning hours of March 13, 1964. As she locked her car door, she took notice of a figure in the darkness walking towards her. She became immediately concerned as soon as the stranger began to follow her.
>
> As she got of the car she saw me and ran, the man told the court later, I ran after her and I had a knife in my hand... I could run much faster than she could, and I jumped on her back and stabbed her several times, the man later told the cops.
>
> Many neighbours saw what was happening, but no one called the police. Mr. Koshkin wanted to call the police but Mrs. Koshkin thought otherwise. I didnt let him, she later said to the press, I told him there must have been 30 calls already.
>
> When the cops finished polling the immediate neighbourhood, they discovered at least 38 people who had heard or observed some part of the fatal assault on Kitty Genovese.
>
> Some 35 min passed between Kitty Genovese being attacked and someone calling the police. Why?
>
> (Pacuit et al. 2006)

In this case, the classical logic oriented analysis that the authors suggested is of deontic and epistemic logical in nature. That is, the witnesses did not call the police, thus did not fulfill their moral duty as they did not possess the full information of the event and their agency in relation to each other. Simply put, witnesses thought that some other people might have called the police already. This analysis is plausible. Yet, some other analyses can also be given for the Genovese case underlining that people may behave inconsistently in a non-trivial way.

One of the descriptive analysis of the situation calls for a paraconsistent framework. It is assumed that the witnesses are morally obliged to call the police, and these moral obligations are generally assumed to be factual and truthful, and they must be fulfilled. Yet, they sometimes are not. Based on these deontic presuppositions, this is what we have:

$$\mathsf{WitnessAMurder} \rightarrow \mathbf{Obliged}(\mathsf{CallPolice}), \mathsf{WitnessAMurder} \nvdash \mathsf{CallPolice}$$

If we endorse modus ponens, and assume that moral obligations need to be fulfilled (that is if $\mathbf{Obliged}(\mathsf{CallPolice}) \rightarrow \mathsf{CallPolice}$), then we derive both $\mathsf{CallPolice}$ and $\neg\mathsf{CallPolice}$ which is contradictory and incoherent under the classical negation and consequence relation. As widely known, there are various ways to modalize the above formulation by using deontic operators that stand for obligations, yet we will not dwell on the matter by entering into deontic logical debates and their paradoxes here.

It should be noted that the paradoxical situation in this case is avoidable. As the standard analysis for the Genovese example explicates, if the witnesses knew individually that none of the other witnesses called the police, they could have fulfilled their moral obligation.

Additionally, a simple game theoretical analysis of the situation can be considered. If a witness calls the police to report the incident, the cost to the witness for the call is less than a dollar and couple minutes which is by far negligible compared to the possible benefit that the call might bring about: saving the life of Kitty Genovese. Simply put, even if a moral agent i assumes that 1000 people saw the incident, and the chances that i will be the one who will report the incident first to the police is 0.1 %, it is still the rational move to make, since a person's life (nearly universally) is more valuable than the troubles that i needs to go through to report the incident—yielding a much higher expected utility for the call. Therefore, regardless of attaining the full knowledge of the case, I maintain that the witnesses have the obligation *to the best of their knowledge* to report the incident. Perhaps, they would be the 999th person to report it, which is perfectly acceptable, but maybe they would be the first. Additional irregularities can also be the case in the Genovese example. For the legal authorities, receiving multiple calls for the same incident may backfire or perhaps can be ignored, and consequently trigger a higher cost for the individuals when they consider making the call. Moreover, as *The New York Times* article reporting the event quoted, witnesses were afraid to get involved and thought that it was a "lover's quarrel".[1] Such reasons are perfectly justifiable but may not rationally be the best move for not making the call. In either of these cases, game theoretical reasoning dictates that rational agents should make the call. Yet, they did not. Then, the classical analysis suggests that the agents in this case are not rationa—perhaps excluding the ones with imperfect information. Paraconsistent analysis, on the other hand, prevents this over-reaching revision. It can very well be the case that agents could be perfectly rational (and most likely they were), had perfect information about the incident (they were the witnesses), yet they still did not make the call.

[1] *37 Who Saw Murder Didn't Call the Police*, Martin Gansberg, The New York Times, 27.03.1965.

Therefore, adopting a paraconsistent view point helps us construct a broader formal framework where we do not need to revise the initial assumptions of the theory just because an inconsistency occurred. In paraconsistent social software, we can very well have perfectly rational agents that can make *mistakes*. This simple example, in my opinion, argues that social software can easily allocate non-classical logics, and can be enriched by it. This seems as a powerful research direction within the domain of social software by extending the discussions on rationality, action-based models and utility theory.

The Kitty Genovese example and many others from law[2] illustrate the possibility of applying non-classical logical methods to social software. The central claim of this paper is to argue that social software lies within the interesting intersection of logical, moral and economical pluralisms, and it can further benefit from incorporating non-classical logical methods into the theory. Additionally, apart from the descriptive perspective it provides, non-classical logical theories in social software can depict normative theories. In this work, we will not go into the details of this distinction.

In short, in order to analyze a variety of interesting social procedures and phenomena, we may need to use a variety of different logics. And social software, in all its richness, seems to provide an ideal domain to test the strengths (and weaknesses) of different formalisms. Similar to logical pluralism, I will argue for pluralism in social software, and this clearly falls within the agenda of social software as a research program. Rich formalisms in non-classical logics, the extensive research in behavioral economics and the way it discusses the pluralities in rational and social behavior, and finally alternative economic theories open up new avenues for social software and relate it to a broader audience. I will argue for these points by suggesting a pluralistic framework—logically, morally and economically.

6.2 A Broader Social Base for Social Software

The recent rise of behavioral economics in both popular literature and academic research points out a well-known missing link between formal logic, and social and individual human behavior: people do not reason or behave as normatively as manifested by the classical logic. People often times make various deductions that diverge from the classical logic, hinting at the possibility of adopting logical pluralism to address the *logic of society*.

There is a rich literature that discusses real-life examples combining various logical issues in game and decision theory (Ariely 2008, 2010; Brafman and Brafman 2008; Gigerenzer 2008; Harford 2009; Kahneman 2011; Smith 2010). What is relevant for our purposes here is the immediate observation that classical logic falls short when analyzing individual and social human reasoning and interaction. If a logic claims to be *the* system of correct reasoning, there seems to be a problem here.

[2] A canonical example from law is *civil disobedience* where agents deliberately break the law and create an inconsistent situation where moral obligations and legal duties clash. Yet, still we obtain a *non-trivial* and coherent inconsistent situation.

More precisely, at a descriptive level, classical logic is not sufficient to explicate and analyze many interesting social phenomena—but perhaps is sufficient in some others. This, by no means, entails that non-classical logics are normatively the only logics that the epistemic and rational agents need to employ—this is exactly the opposite of logical pluralistic view point. Granted, it is not only non-classical logic that may help us understand human behavior within the domain of social software. Decision and game theory and formal epistemology are among the formal sciences that attempt at analyzing similar issues. Nevertheless, from a logical perspective, it can be argued that social software not only can enrich itself by focusing on such pluralistic cases, but also, perhaps more importantly, can help us analyze the examples in behavioral economics. As an illustration, let us consider a very simple example, the two horsemen, that Parikh also discussed.

Example 6.2.1 (Parikh 2002) Two horsemen are on a forest path chatting about something. A passerby, the mischief maker, comes along and having plenty of time and a desire for amusement, suggests that they race against each other to a tree a short distance away and he will give a prize of $100. However, there is an interesting twist. He will give the $100 to the owner of the slower horse.

I maintain that the way negation (or game duality) treated in this puzzle is not strong enough to generalize, and more importantly can be limiting for the overall agenda of social software. The idea of switching to the dual role (which is obtained by using the classical negation) is not a universal strategy that can apply to other similar games. In general, players do not necessarily deal with negated statements in this fashion. The dual game in this example possesses some simple properties: it is easier to determine, and the negation of *slow* is clear to decide. Yet, such properties do not exist in all games. Can we play checkers in this way? Can we play football as such?

For example, for the games with three players, computing the dual game and permuting the roles for the players are not trivial (Olde Loohuis and Venema 2010). If we modify the Example 6.2.1 by allowing a third player, then we can have 2 "dual" games—the permutations of horsemen and horses where nobody rides their own horse. The number of "dual" games increases if we consider even more players and additional intermediate states besides slow / fast.

First and foremost, Example 6.2.1 shows that the formal analysis of social phenomena has traditionally restricted itself to some well-defined and well-behaved subset of the society. On the other hand, it is quite evident that Parikh's recent work incorporates a broad variety of examples and phenomena to social software, somehow supporting my point by expanding the domain of social software (Parikh 2014).

It is possible to take one more step and use this perspective that social software provides to question the basic tenets of traditional game theory and rational choice theory. These two theories construct a utilitarian understanding of society with a quite restricted notion of rationality. Yet, utilitarian rationality is a very controversial assumption—which largely remains unearthed. Recently, some authors in economics and finance communities criticized this approach heavily. For instance, Yves Smith, the author of the popular book *ECONned*, remarks the following.

> The dominant economic paradigm, neoclassical economics, became ascendant in part because it offered a theory of behavior that could be teased out in elegant formulation. Yet it rests on assumptions that are patently ridiculous: that individuals are rational and utility-maximizing (which has become a slippery notion as to be meaningless), that buyers and sellers have perfect information, that there are no transaction costs, that capital flows freely.
>
> (Smith 2010)

Hartford argues along similar lines.

> Fundamental to von Neumanns approach was the assumption that both players were as clever as von Neumann himself. (...) The second problem is that game theory becomes less useful if your opponent is fallible. If player two is not an expert, player one should play to exploit his mistakes rather than defend against brilliant strategies that will never be found. The worse the opponent, the less useful the theory is.
>
> (Harford 2009)

Such limitations of the classical theory of games and rationality do not directly carry over to social software. As Parikh himself has been underlining more and more, social software encompasses a broader outlook to society, and it seems to me that it emerges as a more grounded theory to analyze social behavior and procedures, compared to the classical and traditional theory of games. I will now argue that social software can also be broadened if an alternative understanding of utilities are considered, as an alternative to the traditional utilities of von Neumann–Morgenstern.

Even though such a direct game theoretical and ideological influence is difficult to trace in Parikh's works, some utilitarianism based understanding of rationality and semantics seems to be the one that Parikh endorses (Parikh 1994). Parikh argues that "Roughly speaking, if an agent has a choice among several actions, we would expect that the agent will carry out that (pure) action which the agent thinks will bring the maximal benefit (utility) to the agent" (Parikh 2002). As widely known, ordinal utilities can be translated to preference orderings at the cost of losing some information, yet, the main problems of the traditional von Neumann–Morgenstern framework still remain.

It can be argued that a *deontological* approach can live side-by-side with the utilitarianism within the domain of social software. The deontological approach suggests that utility based moral analysis does not fully consider the deontological commitments of the moral agents. My suggestion here can be considered as an instance of moral pluralism for social software. Such a pluralism argues that utilitarianism based understanding of rationality can be a perfect fit for some social phenomena, but also deontological analysis can be beneficial in understanding some other social situations.

Let me illustrate this point with an example. In his Parikh (2002), Parikh mentions the well-known theorem of Gibbard and Satterthwaite that suggests that any social choice function which takes preference orderings of the voters as inputs, and returns a social preference ordering for the society, will be vulnerable to manipulation in the form of strategic voting. Here, Parikh discusses the United States presidential election of 2004 as an example of Gibbard and Satterthwaite theorem, and concludes that "this is murky territory and I shall not venture further into it." (Parikh 2002).

I believe that strategic voting and manipulations in elections constitute a very interesting focal point for social software, and they can be helpful illustrating the need to expand the agenda of social software. If we consider voting as a form of utilitarian calculus, and take strategic voting as a legal and permissible strategy in it (which it is), then we will be puzzled with the results like Gibbard and Satterthwaite or Arrow's Impossibility Theorem or even Sen's result on the Impossibility of Pareto Liberal. One of the main reasons for negative results in the social choice theory is that the theory does not generally take the moral and ethical compass of the society into account.[3] Moreover, such considerations are not even representable in most social choice theories. The reason why people did not vote strategically in the 2004 US elections is not only epistemic, and perhaps epistemic reasons do not even count among the main reasons.[4] One of the real reasons, in my opinion, is that many people (if not most) people consider strategic voting as a *betrayal* to their political conviction for understandable reasons.[5] For many people, voting represents their commitment and loyalty, and honoring their own opinions, and even if they feel that the party/candidate they support will clearly not win, they do not switch to another one for the aforementioned reasons.

Some disagree with my perspective (Brennan 2011; Chisholm 1963). Chisholm discusses those imperatives which are "telling us what we ought to do if we neglect certain of our duties", and argues that the deontic logic (with its deontic modality O) is not sufficient to formalize them (Chisholm 1963). He argues as follows.

> Ordinarily the rules of a game do not tell us how to proceed with the game after the rules have been violated. In such a case, we may: (1) go back to the point at which the rule was broken, correct the mistake, and resume the game; (2) call off the game; or (3) conclude that since one rule has been broken, others may now be broken, too. But these possibilities are not open to us when we have broken a rule of morality. Instead we are required to consider the familiar duties associated with blame, confession, restoration, reparation, punishment, repentance, and remedial justice, in order to be able to answer the question: 'I have done something I should not have done-so what should I do now?' (Or even: 'I am going to do something I shouldn't do-so what should I do after that?') For most of us need a way of deciding, not only what we ought to do, but also what we ought to do after we fail to do some of the things we ought to do.
>
> (Chisholm 1963)

This argument is interesting in-itself. For my purposes it is a valid example to justify strategic voting. For this reason, this subject becomes even more interesting for social software, especially once it is supplemented by a logical framework (classical or non-classical) that can formalize contrary-to-duty actions (Carmo and Jones 2002; da Costa and Carnielli 1986; Hansen 2006).

[3] Other reasons being, no cost of information, no reference to the actual society, etc.

[4] It is generally argued that, in the 2004 US elections, if Greens—which is a very small political party in the US—had voted strategically against Bush, he might not have been reelected.

[5] Brennan mentions Habermas who argued that "strategic voting is disrespectful to other citizens" (Brennan 2011).

Chisholm's argument can possibly be suggested as a counter-argument to my point. Contrary-to-duty obligations can be viewed as "second degree obligations" that may seem to by-pass the social and individual moral preferences. Nevertheless, notice that the second degree obligations (the ones you are supposed to do, after violating your initial duties) still depend on social, political and economical morality and the ethics of the individual and his priors. Moreover, the first violation of moral duties (which come from the very definition of "contrary-to-duty actions") calls for a inconsistency-friendly framework, at least for expressive strength. Because, after a violation of a moral obligation, not any proposition but only contrary-to-duty actions become obligatory. Thus, Chisholm formulated how the agents reason under some moral inconsistencies in a sound and non-trivial way. This is nothing but a paraconsistent reasoning.

Similarly, if an individual decides to vote strategically, then, the candidate he is going to vote for strategically reflects his "second degree" duties which are also shaped by his own individual and social moral compass. An individual voting for his second best choice to block the worst candidate based on his preferences, is still reflecting his own preferences. In the 2004 US elections, Greens were expected to vote strategically, because, in a broader perspective, it can be argued that they prefer the Democratic candidate to the Republican one, and this choice between the two major parties reflects their own choices.

Brennan discusses various forms of strategic voting and concludes that, for him, "there is no objection in principle to strategic voting, so long as strategic voting does not impose too much risk and tends to produce better outcomes than one justifiedly believes otherwise would occur" (Brennan 2011). Yet, the logical and mathematical complications of strategic voting make it a philosophically interesting subject for social software—broadly construed. On the other hand, discussions on "ethical voters" have been initiated by Harsanyi in late 70s (Harsanyi 1977) and it can be seen as a relatively new field. In short, incorporating some of the ideas suggested here only enriches the field and relates it to some current debates.

Also, a deontological extension of social software, which we account for as moral pluralism, can be suggested based on similar motivations. For this purpose of mine, let us reconsider the Kitty Genovese example which was discussed in Sect. 6.1. Besides its epistemic analysis, there is also a strong deontic component in this case. Namely, it is fair to assume that people are obliged to help others when they do not risk anything comparable, and we can take this principle as our deontological commitment. Regardless of the cost of the phone bill or even of the risk of overwhelming the authorities or whether it was a lover's quarrel, it can very well be argued from a deontological perspective that the witnesses are morally obliged to call the police. Moreover, the questions that whether others made a similar call or whether the police would make it on time to the crime scene do not exclude anyone from following their deontological moral obligations. In short, possibly undesired consequences of making the call do not constitute enough of a reason to nullify the *a priori* deontological commitments. It may minimize or economize an individual's personal duty if it is shared by the others, yet the individual is still obliged to help according to the deontological commitments we have formulated above.

The dichotomy between deontological morality and utilitarian calculus to evaluate the moral actions is an exciting research field. The discussion in this field extends to many major social debates ranging from capital punishment to abortion. A formal and analytical approach to such problems falls within the scope of social software. More precisely, developing a deontic logic for Kantian priors and incorporating it to social choice and game theories appear as a rather big research agendas within social software.

Similarly, language games, a special favorite of Parikh's, exhibit similar issues. Parikh himself argued that language has a utilitarian element (Parikh 1994). We choose the nouns (or in general any other language elements) that work. Parikh develops this thought and connects it to vagueness in a very interesting way in the aforementioned work. This explains a significant part of semantics, except perhaps literature and poetry, where ambiguity and vagueness in meaning are intentional and even desirable. Therefore, on some occasions, language games can take another form in art where the utility based analysis of semantics becomes complicated if not impossible.

As another example of a non-utilitarian social phenomena, the case of having children can be considered. As is widely known, numerous reasons can be given to bear and have children. Let us consider them in two main categories following Overall: deontological and consequentialist (Overall 2012). Deontological reasons include carrying on the family line and name, duty towards the society and the family, whereas the consequentialist ones include the traditional economical benefit (of the children) to the family, and psychological benefits to the parents. Overall goes ahead and argues from a moral perspective that none (and more) of these reasons cannot be ethically justified as a reason to have children. Nevertheless, the same issue can be approached from a social software point of view. As we all know, having children has a lot of difficulties as well. They increase the stress level of the parents, and in many societies, it is very expensive to raise them. In short, the quantitative and measurable cost of having children (for instance, increased stress hormones and diminishing bank accounts) needs to be compared with the qualitative and unmeasurable benefit of having children (happiness and all that), according to the traditional game theoretical approach. Yet, the traditional approach appears to be not very fruitful in this direction. That is, how can we compare the utility value of having a baby with the university tuition that the parents will need to pay for the child.[6] For such examples, where self-sacrifice and deontological commitments play a central role, we need a broader understanding of social software that goes beyond the traditional consequentialist method of game theory and formal epistemology.

Another interesting argument towards some game theoretical concepts can be found in Graeber (Graeber 2011). He questions Hobbes's use of "self-interest" to describe human motivation. Graeber comments on "self-interest" as follows.

[6]Clearly, putting all of the financial and emotional burden of raising a child (with tuition and care cost etc.) to couples is a socio-economical decision taken by governements, and does not apply equivalently to all countries and societies. We leave such issues aside in this paper, even if they constitute an interesting direction for social software as well.

> Part of the terms appeal was that it derived from bookkeeping. It was mathematical. This made it seem objective, even scientific. Saying we are all really pursuing our own self-interest provides a way to cut past the welter of passions and emotions that seem to govern our daily existence, and to motivate most of what we actually observe people to do (not only out of love and amity, but also envy, spite, devotion, pity, lust, embarrassment, torpor, indignation, and pride) and discover that, despite all this, most really important decisions are based on the rational calculation of material advantage which means that they are fairly predictable as well.

Graeber does not only skeptically argue that the utilitarian social choice based analysis of games in society are missing an important component, but also implies that such calculations, if possible at all, are more complicated than they look.

I see no reason as to why social software cannot be approached from a perspective that can allocate the cases I mentioned so far. Parikh himself seems to agree with his point when he considered even a broader set of examples in his recent work (Parikh 2014).

In short, I believe that society exhibits many interesting cases which reflect a wide variety of cultural and historical pluralism, and recent anthropological work argues that people exhibit a broad variety of behavior when it comes to rational decision making (Graeber 2011). Incorporating such observations to the agenda of social software will result in a mutually beneficial and stronger cooperation between these research areas and the formal sciences of social software.

6.3 A Broader Logical Formalism for Social Software

Logical pluralism is a "*pluralism* about logical consequence" asserting that there can be more than one logical consequence relation (their emphasis Beall and Restall 2006). Logical pluralists endorse the view that from a given set of sentences, it is possible (whenever a formalism can be given) to deduce various conclusions. I maintain that logical pluralism is essential to social software, and it can be viewed as the counter-part of moral and social pluralism.

As widely known, in an intuitionistic universe, law of excluded middle does not hold as it can be ontologically possible that there are propositions which are *neither* true nor false. Similarly, in a paraconsistent (or dialetheic) universe, the law of non-contradiction is not valid. Because, it is thought that there are propositions which are *both* true and false. The important point here is the fact that non-classical logics are motivated not only by logical and mathematical observations, but also by various social, epistemological and ontological phenomena.

For instance, quantum physics provide us with various ontological and epistemological examples with undetermined truth values such as the Pauly Indeterminacy Principle. Similarly, law raises various issues where dialetheism and paraconsistent consequence relations can be put in use, as we have discussed earlier (Priest 2006). Moreover, there are various other situations where paradoxes appear in social and game theoretical contexts.

Take *Parrondo's Paradox*. Consider the following two games: Game 1 and Game 2. In Game 1, you lose $1 every time you play. In Game 2, if you have left an even number of dollars, you win $3, if you have an odd number of dollars left, you lose $5. Say, you start playing this game with $50. If you play Game 1, you will lose all your money in 50 rounds. If you play Game 2, you will still lose all your money in 50 rounds following the sequence:

$$50 - 53 - 48 - 51 - 46 - 49 - 44 - \ldots$$

However, the catch point is, if you play the games in the order of "Game 2–Game 1–Game 2–Game 1–…", then you will always win following the sequence:

$$50 - 53 - 52 - 55 - 54 - 57 - \ldots$$

The *paradoxical* result here is the fact that by combining two losing strategies, it is possible to obtain a winning strategy which is somehow surprising and unintuitive. Non-classical logical elements in this analysis are quite striking.

Another major example is *dialectic*. Consider an agent, let us call him Karl the CEO, struggling to make a decision. Assume that he has been suggested two opposing points of view: φ and $\neg\varphi$, the thesis and the antithesis respectively. Then, any rational agent would not give up his logical system or decision procedure as there are contradictory and plausible statements expressed formally in the system and therefore rendering it inconsistent. In this case, we would expect Karl to reach a conclusion, a *synthesis*, say ψ, after a dialectical procedure. Thus, we will have for Karl, $\varphi, \neg\varphi \vdash \psi$ yet $\varphi, \neg\varphi \nvdash \neg\psi$. For Karl, the decision ψ follows from the given contradictory evidence $\{\varphi, \neg\varphi\}$ whereas the decision $\neg\psi$ simply does not. In short, the system of dialectic reasoning is not *explosive*: there is a statement (namely, $\neg\psi$) which did not follow from a contradiction. As this example illustrates, there is an interesting relation between dialectic, dialetheism and paraconsistency, and to do justice to the subject, we refer the reader to the following work in the subject for a broader treatment (Ficara 2013; Priest 1989, 2006). Nevertheless, taken as a decision procedure, it is clear to see how dialectic can fall within the domain of social software and how it carries along non-classical logic with it to social software.

Finally, as I underlined earlier, case studies from behavioral economics provide rich examples which demonstrate that people do not usually reason in the way that the classical logic predicts (Ariely 2008, 2010; Gigerenzer 2008; Harford 2009; Smith 2010; Stenning and van Lambalgen 2008). Such examples direct us towards logical pluralism where the logical consequence of what is given can be, to say the least, unexpected and surprising from a classical logical perspective. People do not end up with trivial theories when they encounter paradoxical situations. They simply work their way through it—usually in a sound and rational way. Non-classical logics can be viewed as formalisms attempting to give a formal account for such situations. Let us see it in more examples.

6.3.1 More Examples

I will now examine some more cases starting with some examples from Parikh's original paper, and observe how they can be inspiring and motivating to introduce non-classical logical elements into social software.

Example 6.3.1 (*Carousel Example,* Parikh 2002) In order to prevent the overcrowded carousels at the airports, Parikh mentions a simple solution. The airport authorities should paint a line a certain distance from the carousel and post signs that say "Do not cross the line until you see your suitcase".

Let us assume that this solution is implemented. Without doubt, there will still be people who approach the carousel before seeing their luggage.

An intuitionistic approach to this anomaly suggests that there are people who neither know nor do not know that they should approach the carousel. In other words, these are the people *who did not care about the sign*. It does not mean that they disagree with the solution procedure. It also does not mean that they agree with it. They are simply indifferent to this solution concept. Thus, the solution, taken as a proposition, has no truth value in those people's mental models. Anyone who has observed people breaking some simple rules carelessly might agree that this is a very common phenomenon.

Paraconsistent logicians might argue that some people, even if they approve of the solution, would still not wait until they see their luggage. This clearly creates an incoherent if not inconsistent situation within the mental model of the agents. The agent agrees with the solution, and thinks that she should wait. Nevertheless, she simply does not wait. Those are perhaps the agents who intentionally break the rules. For such situations, which arguably happens quite often, paraconsistency suggests an inconsistency-tolerant framework for those agents with inconsistent mental models.

Clearly, one can also unify the above approaches, at least formally, in the framework of First-Degree-Entailment (Dunn 1976; Routley and Routley 1972). We refrained ourselves from using the First-Degree Entailment for this formalization as the incompleteness- and inconsistency-tolerant logics may separately provide a clearer understanding of the phenomenon.

Example 6.3.2 (*Russellian Barbers*) The example of two horsemen (Example 6.2.1, also in Parikh (2002) suggests that sometimes it is wiser to switch to the dual game with dualized strategies. A non-classical variation of the puzzle presents an interesting approach. Let us consider the following situation which we call *Two Russellian Barbers*. Take two Russellian barbers who can only cut the hair of the people who cannot cut their own hair themselves.

Assume that in the case of Russellian barbers, they were asked to compete in a game where the one who gets his hair cut fastest wins. Let us apply the solution concept which we mentioned for Two Horsemen example. If the barbers switch to the dual game and cut each other's hair, they will be slow, and not even cut the hair. Then, it seems, then each barber should cut his own hair. If they commit themselves cutting their own hair, then they can compete to be the fastest, it seems. Yet, recall

that these barbers are Russellian who only cut the hair of the people who cannot cut their own hair themselves. Thus, the strategy of switching to the dual game does not directly work for Russellian barbers. Perhaps, it can be argued that the solution concept of Two Horsemen applied to the Russellian Barbers call for an auxiliary agent who would be willing to cut the barbers' hair. The strategy that is entailed by this solution concept require auxiliary players, which in-itself an interesting concept.

The logical implications of this problems aside, this example illustrates how non-classical ideas can introduce interesting cases to social software.

Example 6.3.3 (*King Solomon Example,* Parikh 2002; van Eijck and Verbrugge 2009) This example is a very old Biblical story about King Solomon. In the story, two women claim a baby and ask the King's help to resolve the issue. The King threatens to cut the baby into two and share it between the women, thinking that the real mother would not allow it, and let the other woman take the baby. Therefore, the woman who denies the motherhood under the presence of this procedure is indeed the real mother, according to the solution concept of this procedure.

As it is pointed out in van Eijck and Verbrugge (2009), the surprise element in Solomon's procedure is essential—this is what prevents the players from playing strategically. Yet, logically, surprises seem to be difficult to formalize. This point begs the question whether surprises are the focal points that require a non-classical analysis.

The surprise element here involves a component that renders the problem and the solution void. In other words, in this puzzle, a hidden assumption requires the puzzle solver to keep the baby alive—otherwise there would be no need to determine the motherhood. Suggesting that the baby will be killed is not actually a surprise at the moment of it being suggested. It is deemed as a surprise *later* when the solution is fully introduced by the King. Therefore, *when* it is suggested, it creates an inconsistency and requires a logical framework that can tolerate it.

Some further discussion on the King Solomon example can be found in (van Eijck and Verbrugge 2009). This problem can also be analyzed from the view point of counterfactual conditionals, yet we shall not delve into that aspect here—even though it also supports our claim that non-classical analysis can enrich our understanding of social phenomena.

Example 6.3.4 (*Game Semantics as a Language Game*) Conceived as a meaning-construing procedure by Hintikka, game semantics provides a very interesting perspective on formal semantics. *Semantic verification game* is played by two players, *falsifier* and *verifier* which we call Abelard and Heloise respectively. The goal of Heloise in the game is to verify the truth of the formula whereas for Abelard it is to falsify it. The rules of the semantic verification game are specified syntactically based on the form of the formula. During the game, the given formula is broken into subformulas step by step by the players. The game terminates when it reaches the propositional literals and when there is no more moves to make. If we end up with a propositional literal which is true in the model in question, then Heloise wins the game. Otherwise, Abelard wins. When the main connective is a conjunction, it is

Abelard's turn to choose, and similarly, disjunction yields a choice for Heloise. The negation operator switches the roles of the players. The major result of this approach states that Heloise has a winning strategy if and only if the given formula is true in the given model. For an overview of the field and its relation to various epistemic and scientific topics, we refer the reader to (Pietarinen 2003). Moreover, (Pietarinen and Sandu 2000; Hintikka and Sandu 1997) provide expositions of game theoretical semantics and its relevance to philosophy.

Not much argument is needed to show the relevance of game semantics to language games which was Parikh's starting point in his article (Parikh 2002). However, a non-classical analysis of game semantics reveals that semantic verification games can formalize non-classical behavior. By using non-classical logics as the underlying formal framework, it is possible to have verification games with additional players, concurrent play, and variable sum games where more than one player can win, or one's loss does not entail the opponent's win (Pietarinen 2000).

Example 6.3.5 (*Law*) Real-life paradoxes in social situations are not easy to pin point. However, law provides a unique playground both for paraconsistency and social software. Almost without exceptions, every legal system contains inconsistencies, and one way or the other, they still function. Priest gives various examples of legal dialetheias and inconsistent obligations, and considers the following simple example.

> Suppose that there is a certain country which has a constitutional parliamentary system of government. And suppose that its constitution contains the following clauses:
>
> > In a parliamentary election:
> > (1) no person of the female sex shall have the right to vote;
> > (2) all property holders shall have the right to vote.
>
> We may also suppose that it is part of common law that women may not legally possess property. As enlightenment creeps over the country, this part of common law is revised to allow women to hold property. We may suppose that a de facto right is eventually recognized as a *de jure* one. Inevitably, sooner or later, a woman, whom we will call Jan, turns up at a polling booth for a parliamentary election claiming the right to vote on the ground that she is a property holder. A test case ensues. Patently, the law is inconsistent. Jan, it would seem, both does and does not have the right to vote in this election.
>
> (Priest, 2006, pp. 207–8)

This shows that legal systems can be very well viewed as non-trivial inconsistent theories, exemplifying paraconsistent reasoning. Moreover, in many real-life cases, the point is not genuinely to create a legal system with no inconsistencies or incompletenesses whatsoever. Yet, the real focus is to make this system work—whatever the phrase *working system* entails. By itself, such situations call for a social software based analysis.

Similar examples can be multiplied especially when *dialogues* are considered (Carlson 1983; Rahman and Carnielli 2000). Taken as a formal model about a social

situation, dialogues contain inconsistencies, and are genuine examples for paraconsistency. Since language and communication are essential parts of social interaction, thus of social software, formal models of dialogues constitute interesting case studies which fall within the intersection of social software and paraconsistent reasoning.

The examples which we have discussed so far show that various social procedures call for various different logical and computational paradigms. By itself, this constitutes a quite central meta-problem: which logical framework would be an ideal fit for which social phenomenon? Such problems and meta-problems suggest further extensions of social software and illustrate how logical and social issues interact.

6.4 A Broader Economics for Social Software

The real-world economics movement, which was born in Paris in 2000, heavily criticizes the foundations of neoclassical economics (Fullbrook 2008; Reardon 2009). Even if we accept the assumption of *homo economicus*, we will stumble upon many problems when we consider the *markets* as described by the neoclassical economics and game theory (Benicort and Guerrien 2008). The proponents of real-world economics argue that focusing on equilibrium points, which are not even predictive of the future outcomes, misses the point. They argue that "in an uncertain world, making sophisticated calculations before making each decision is nonsense", and conclude provocatively with the observation that "to understand the real world, one has to forget microeconomics" (Benicort and Guerrien 2008).

Similarly, there is an increasing number of works that criticize the heavy mathematical machinery used in economics. As Milton Friedman put it "... economics has become increasingly an arcane branch of mathematics rather than dealing with real economic problems" (ibid). Solow argues that "economics as taught in America's graduate schools ... bears testimony to a triumph of ideology over science" (ibid). Moreover, Guerrien and Jallais argue that:

> Game theory does not resolve concrete problems or make predictions about player choices. It focuses on the complexity of the decision interactions of persons conscious of being in interaction. As the renowned game theorist Ariel Rubinstein explains,
>
> > game theory is a fascinating and abstract discussion that is closer to philosophy than to the economics pages of the newspaper. It has no direct applications, and if it has any practical utility (which I doubt), then it is in the winding and inscrutable way that our minds absorb ideas and use them when the time comes for real action. And this too must be proved.[7]
>
> (Reardon 2009 pp. 37–8)

Without much effort, we can find similar approaches, albeit not as radical and explicit, in various other works as well (Ariely 2008, 2010; Gigerenzer 2008; Har-

[7]November 17, 2000 in Israeli daily *Haaretz*. In a similar way, his 2009 (2012, in English) book is called *Economic Fables* to underline the fact that game theorists are tellers of fables.

ford 2009; Kahneman 2011). I believe there is some truth in this criticism towards micro-economics, and this body of criticism easily carries over to game theory and social choice theory. More importantly, for our purposes here, social software and more generally mathematical and logical analysis of social algorithms and social phenomena become a target of the aforementioned criticism as both game theory and social software make similar (perhaps, implicit) assumptions.

The central claim of above approaches of the real-world economics is the fact that neoclassical economics fails to address a broad spectrum of social and economical phenomena. Behavioral economics and real-world economics suggest some sound conceptual alternatives within the field, and I believe that logical approaches to such problems should address those concerns—either affirmatively or negatively. I argue, *economic pluralism*, that is crystallized in the real-world economics, may help illustrate the use of logical pluralism in social software. Furthermore, I claim that logical pluralism can be the key point to address different economical paradigms within logic and game theory, and hence in social software. The limitations of the traditional game theory can therefore be an opportunity for social software to expand its domain.

One of the central demands of the real-economics movement is to have a pluralistic understanding of economics (Fullbrook 2008; Reardon 2009). This provides the field of economics with different theories for different economical phenomena, as opposed to a monist and monolithic methodology that strives to explain and predict it all. Simply put, different social situations presuppose different logical reasoning. Therefore, plurality in social norms and rules and interactions presuppose a pluralistic view of logic. Real-world economics, in this manner, provides examples and ideas from the same domain that social software attempts to analyze. A theory of economics which rely on pluralistic foundations will therefore be pluralistic.

An interesting argument in favor of real-world economics perspective is that the economics should not be approached from an individual-centric perspective. In terms of social software theory, this translates into the thesis that agents-based analysis of epistemic, doxastic and deontic situations lack an important component of social interaction: the society itself. Clearly, it can be argued that "markets" can play the role of the society, and be expressed as an agent. Nevertheless, this gives rise to the notion of "invisible hand" which can be considered as one of the problematic points of the theory. Such different approaches can easily be discussed within the domain of social software.

Reconsider the "Kitty Genovese" case. A real-economics oriented "real-social software" would approach this example by considering the social dynamics of the community in which the incident took place. For instance, if it was a small town in a closely knit society where the incident took place instead of a New York City neighborhood where social interaction among the neighbors are much looser or perhaps non-existent, the analysis of the case would be much different—both epistemically and deontologically. The histories of the agents would have much more in common, they would share a larger common language, supposedly they would share a common moral background and moral priors, and the cost of not calling the police would be much higher. In cosmopolitan New York City, the social dynamics are obviously

much different, and "the real-world social software" should reflect this parameter in its analysis of the case.

Interesting enough, the reason that such considerations have not received their fare share of analytical treatment within social software is not due the initial assumptions or restrictions of the program. The broad outlook of social software seems to be eager to analyze, both computationally and logically, such variants of different micro-economical theories.

6.5 Conclusion

In this paper, I managed to avoid game theoretical and social choice theoretical formalisms. My pragmatic goal was to clarify some foundational ideas in social software, and to investigate the connection between non-classical logical, specifically paraconsistent perspectives and social software. If, I argued, social software has a strong emphasis on logic and computation, then different logical traditions might provide it with a broader outlook.

On the other hand, perhaps at a more personal level, based on my long discussions with him, I am more or less convinced that my thoughts put together in this paper simply complement what Parikh had in mind when he originally suggested the idea of social software. The theory should be comprehensive and powerful, and based on this conviction, the ideas put forward in this work do not suggest otherwise, but provides a broader outlook and paradigm for social software.

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