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Fair shares? Advancing land economics through cooperative game theory

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Abstract

Site consolidation is a perennial issue in the study of land economics. The emergence in many contexts of policies that follow variations on 'land readjustment' represent a common way for policy makers to overcome the barriers to wholesale redevelopment. In several important respects the nature of the problems that land readjustment seeks to confront are best thought of as questions in cooperative game theory. In this contribution we seek to explore the underpinning logic of land-readjustment using fundamental concepts in cooperative game theory: the Shapley value and the Core. In addition, we present results of an experiment on coalition and value distribution in four European countries. Our results shed light on a range of important practical issues for the policy ranging from the conditions under which development might be self-initiated to coalition stability, and to the value of an animating agency such as urban planning.

Introduction

Site consolidation is a perennial issue in the study of land economics. In many contexts around the globe wholesale urban transformation is hindered by multiple ownership of often small, contiguous parcels of land that would ideally be considered together as a coherent whole for redevelopment purposes. The corresponding power accorded to one unwilling seller to 'hold out', either for pecuniary or sentimental reasons, has resulted in delay and sometimes prevention of development becoming a hallmark of urban planning in some contexts, such as the UK (Cheshire and Sheppard, 2005; Nathan and Overman, 2011; White, 2014; Adams et al., 2017) and Norway (Falleth and Nordahl, 2017; Falleth et al., 2011, Nordahl and Eika, 2017). In response some nations have begun to experiment with new policy responses designed to overcome what is in effect a collective action problem and catalyse the development process. In many parts of the world the first choice for policy makers has been variations on land readjustment where the promise of a corresponding uplift in land values associated with site consolidation and subsequent planning consent, it is hoped, should provide an incentive for cooperative behaviour between landowners (Adams et al., 2001; Turk, 2008; van der Krabben and Jacobs, 2013; van der Krabben and Heurkens, 2015; Nordahl and Falleth, 2011). At root this approach turns on some important economic concepts/assumptions. Firstly, for land readjustment to work it would be essential that individual landowners are able to decode what cooperative action – the willingness to pool their asset with those of their neighbours – would mean for them as individuals. Secondly, we would ideally need to know if the viability of the approach is in any way dependent upon the various potential roles for the state, for example, as a holding agency to guarantee a fair pooling and subsequent distribution of assets. On this second point it would be desirable to know under what conditions individual landowners might be able to reach a solution themselves without the requirement for the state to referee the process. Any evidence on this would speak directly to the wider question of the degree to which self-organisation can be prompted by policy design and, by extension, if self-organisation is a realistic and viable vision of an achievable urban policy yet to come (Boonstra and Boelens, 2011; de Roo, 2016; Moroni, 2015; Portugali, 2000, 2011; Swyngedouw and Moulaert, 2010; Zhang and de Roo, 2016).

On these important questions we have only clues. The degree to which such cooperative outcomes, particularly those that imply some form of self-organisation, are likely to result from variations on the land readjustment formula is an open question upon which there is a paucity of research. For example, the fundamental issue of the degree to which the apportionment of land holdings to be returned to landowners accords with a shared or broadly consensual interpretation of what would constitute 'fair shares' is a centrally important issue. Moreover the degree to which cooperative action depends upon the existence of a mutually binding trust between stakeholders is also under-researched.

In this paper we aim to use cooperative game theory to explore these questions of how collective agreement over the pooling and reallocation of an asset, in this case land holdings, might proceed. To explore these questions, we first use a thought experiment in which, rather than the state assigning values for compensation payments on a case by case basis, landowners and developers do this collectively based upon their own expectations of what the surplus subsequently to be shared might be. Using Shapley values to illustrate how the process might work in theory we hope to show that under very specific conditions a self-determined solution would be theoretically possible. In taking this approach we hope to illustrate in theoretical terms what some of the implied differences might be between urban planning systems that allow for some degree of self-organisation compared to those where a state or para-state agency, such as an urban development corporation, plays an active economic role either as regulator or broker. Secondly we present empirical evidence from a recent JPI-funded project, *SIMS City: Testing new tools for value capture*,[1] which seeks to explore the degree of trust present amongst actors who are at the core of the redevelopment process across varying national contexts (Li et al 2019).

Land readjustment policy: history, context and mechanics

Land readjustment has been used in a wide variety of international contexts across the globe, although it has been particularly popular in Europe and South East Asia. If a specific geographic origin can be found the principal candidate is Japan where an early version of the approach was employed following the Tokyo earthquake of 1923 and in the reconstruction of Japanese cities following the Second World War (Larsson, 1997). More recently land readjustment has been used in varying contexts within mainland China (Li and Li, 2007), and Hong Kong (Yau, 2012) as well as Australia, where it is known as 'land pooling', Israel, and South Korea. In Europe, the idea has gained most currency in the north of the continent where it can be witnessed in urban planning policies enacted in nations such as Germany, France, the Netherlands, Norway and Sweden (Turk, 2008). Nevertheless, the potential for land readjustment to act as a vehicle for urban transformation in extreme settings – such as post-conflict Japan – has moved the World Bank to

[1] Details of this JPI-funded project can be found at https://jpi-urbaneurope.eu/project/simscity-valuecap

advocate the policy as a measure that might have some traction in developing countries (Doebele, 2007).

The core principle of land readjustment is that it enables the consolidation of separately held, adjacent plots into a new configuration more amenable to wholesale development. In a typical model of urban land readjustment, private property rights are temporarily transferred to a public development agency that proceeds to assemble and re-parcel the site – often into a greater number of smaller units – before installing infrastructure and thus raising the value of each individual plot. Property rights are subsequently returned to the original landowners. The upfront costs incurred by the state (through the public development agency) are designed to be recovered by the sale of new additional plots created by the process. Compensation to the original landowners, whose cooperation is essential to the process as a whole, comes through the enhancements to their (typically reduced) land holdings resulting from the creation of fully serviced sites complete with planning consent (van der Krabben and Needham, 2008).

Variations on the model include scenarios in which no new plots are created, landowners cover the costs of the redevelopment themselves from the subsequent anticipated increase in the value of their holdings and where a public use (e.g. a municipal building, green space) may also be incorporated with private holdings in the allocation and re-allocation of holdings (Needham, 2007; van der Krabben and Needham, 2008). In the UK, Adams et al (2001) draw inspiration from urban land readjustment in proposing the 'urban partnership zone' as a way of tackling the barrier sometimes posed to redevelopment by one or more landowners obstructing development. In such circumstances, urban land readjustment has been valued for its potential to build the recovery of infrastructure costs into the development process thus providing an automatic way of capturing the uplift in land values associated with the granting of planning consent and obviating the need for any form of *ex post* development levy (such as that discussed in Lord, 2009). From this perspective, land readjustment is a policy tool that may be used to address situations where, "the boundaries of the rights to land ownership or land use may impede the desired use of the area as a whole" (Needham, 2007: 115).

To date the effectiveness (or otherwise) of urban land readjustment has largely been judged inductively on the basis of experience. As a result conclusions are in many instances predicated on conjecture and circumstantial evidence regarding what might or might not work in various contexts, thus making context potentially the most salient variable. However, the underlying principles upon which urban land readjustment are based – the division of an asset between a small number of self- and collectively-interested agents speaks very closely to a common theoretical question in game theory – an increasingly popular way of thinking about such questions (Lord, 2009, 2012; Samsura et al., 2010, 2015). In this contribution we seek to explore one of the most fundamental questions relating to how coalitions might decide on what constitutes 'fair shares' within the process by which individual assets are collectivised and then returned, subdivided, to their original owners.

Cooperative game theory

When considered in the abstract the questions with which land readjustment deals in practice can be understood as analogous to those that are routinely explored in cooperative game theory. This branch of game theory explicitly sets out to understand group decision making and is therefore distinct from the best known examples – such as the prisoners' dilemma and the ultimatum game – that seek to explore the microeconomics of decision making under non-cooperative conditions (for a thorough treatment of the differences between cooperative and non-cooperative game theory see, e.g., Osborne and Rubinstein, 1994). For cooperative game theory the aim is to investigate the conditions under which some form of cooperative action might be necessary and the outcomes that might follow. There is, therefore, a clear point of tangency between the goals of cooperative game theory and the specifics of land readjustment policies.

In relation to the specific question of site consolidation and subsequent reallocation we have a set of issues that can very neatly be codified as a problem in cooperative game theory. Our asset, the full potential site, is pooled, subdivided and then returned to the original landowners in modified form. The anticipated spur to the initial cooperative act is the prospective incentive that the holding that will be returned from the land (remediated, consolidated with its neighbouring plots, possibly serviced by infrastructure and with planning consent provided) will be of enhanced value compared to the asset that the individual landowner had initially submitted to the pool.

The predictions of cooperative game theory would suggest that each individual landowner will evaluate the degree to which their outcome is acceptable not on the basis of the uplift in value that pertains to their land holding *per se* but as a function of the relative redistribution of the asset *as a whole* between the group *as a whole* (Young, 1988). This concept, called the Shapley value after its founder Lloyd Shapley, allows us to theorise and predict the behaviour of individual economic agents when confronted with a collective asset that must be divided amongst them relative to their marginal contribution to its creation (Shapley, 1953; Roth, 1988; Winter, 2002). Applied to a public policy question such as a land-readjustment exercise we can use this theoretical framework to explore the degree to which cooperation might be sustained over the full duration of the pooling/reallocation process and the conditions under which a self-organised solutions might be possible and those where a state/regulatory referee might be required.

To explore this range of questions we propose a thought experiment. This method of thinking about a problem in the abstract is the most common method of analysis in much of Western philosophy, particularly the analytic tradition, and those disciplines, such as game theory, which follow this lead. Thought experiments allow us to conceive of a problem in terms of its first principles. Common examples include *Schrödinger's Cat* (Schrödinger, 1935) where we are invited to think about the conditions under which we might claim certainty of knowledge and Hardin's (1968) *Tragedy of the Commons* which posits varying outcomes as a result of individual and collective actions. Many thought experiments have had enduring appeal as devices to extrapolate from the abstract to the material world (e.g. Cole et al., 2014; Feeny et al., 1990; Ostrom, 1990).

The following thought experiment allows us to explore the foundational issues in land readjustment by formulating a simple game that mirrors the interactions that land readjustment creates. Although in simplified form we have just three participants, the results provide insights into fundamental mechanics of this approach to redevelopment and point to important lessons for policy design. Likewise, although our experiment is restricted to just three players the experiment can be extrapolated for any number of participants.

Rethinking land readjustment using Shapley Values

Consider a situation where three participants have the opportunity to redevelop a site as a whole. In keeping with the terminology of game theory, let the participants be labelled players 1, 2, and 3, respectively. In practical terms, they can be either landowners or developers. Suppose each player on their own cannot start any project and hence the "worth" of coalitions of a single player is normalised to 0. That is, in the language of cooperative game theory, the characteristic function v has the value

$$v(\{1\}) = v(\{2\}) = v(\{3\}) = 0.$$

When two players collaborate, a small redevelopment project becomes possible. However, only when all three players work together, can they realise the full potential of the site. Specifically, let the value of all potential coalitions be defined as:

$$v(\{1,2\}) = 300,\ v(\{1,3\}) = 350,\ v(\{2,3\}) = 400 \text{ and, } v(\{1,2,3\}) = 900.$$

We note that to reflect the possibility that the players may differ in their endowments/capabilities, we have allowed the value of two-player coalitions to be different. Note also that the union of any two sets of players is always worth no less than the sum of the two individual sets or, in game theoretical terms, our land readjustment game is 'superadditive'.

We now first apply the concept of the Shapley value to this cooperative game which determines each player's fair payoff in the efficient grand coalition, N={1,2,3}. The Shapley value is defined by players' average marginal contribution over possible coalition formations. In the table below we find for each player their marginal contribution in each permutation of the grand coalition. In the first column we list the 6 possible orderings of the grand coalition. In the second column we record player 1's marginal contribution in each ordering - player 1's added worth to the coalition formed by all players *preceding* her. For example, in the permutation (2,3,1), player 1 contributes to the coalition {2,3} by increasing the worth of the coalition from $v(\{2,3\})$ *to* $v(\{2,3,1\})$, i.e., from 400 to 900. In the ordering (3,1,2), player 1's marginal contribution is v({3,1}) - v({3}) = 350 - 0 = 350. Similarly, in columns 3 and 4 we record marginal contributions of players 2 and 3, respectively.

TABLE ONE ABOUT HERE

The Shapley value - defined as a player's *average* marginal contribution over the permutations - are thus 270, 300, and 325 for players 1, 2, and 3 respectively. Let Sh_i denote player i's Shapley value payoff in this land adjustment game. We have $Sh_1 = 270$, $Sh_2 =300$, and $Sh_3 =325$. In this solution, the three players efficiently and fairly divide the total value from the land adjustment project: the maximum total value is realised and players who contribute more receive more.

The Shapley value represents one important interpretation of a fair division of the grand coalition's worth. Intuitively, each player is rewarded by their average marginal contributions to other coalitions. Notably, the Shapley value is the only value that satisfies a set of simple and intuitive axioms. For instance, Young (1985, 1988) demonstrates that the Shapley value is the only solution that satisfies axioms of efficiency, symmetry and the "marginality principle". The efficiency axiom means that the worth is fully divided, and symmetry requires that the payoffs to any two players should be the same whenever they make exactly the same marginal contributions. A value satisfies the marginality principle if a player receives the same payoffs in two different games of the same set of players whenever the player makes the same marginal contributions in the two games. These three axioms characterise the Shapley value.

A more intuitively compelling argument in favour of a Shapley value to solve a land readjustment dilemma is perhaps the balanced contributions property. Suppose ψ is an arbitrary value or division rule. Imagine that player 2 is able to say to player 1: "give me more of the proceeds of the development or I will leave the coalition, causing you to obtain only ψ_1 ({1,3}) rather than the larger payoff of ψ_1 ({1,2,3}). This will mean that you lose the positive amount ψ_1 ({1,2,3}) - ψ_1 ({1,3})." We call this an *Objection* of player 2 against player 1. If, on the other hand, player 1 can say to player 2 that "it is true that if you leave then I will lose, but if I leave then you will lose at least as much: $\psi_2(\{1,2,3\}) - \psi_2(\{2,3\}) \geq \psi_1(\{1,2,3\}) - \psi_1(\{1,3\})$", then we say player 1 has a *counter-objection* to player 2's objection. Note that in our example the Shapley value, $Sh_1(\{1,2,3,\}) - Sh_1(\{1,3\}) = 275 - 175 = 100$ while $Sh_2(\{1,2,3,\}) - Sh_2(\{2,3\}) = 300 - 200 = 100$. Thus, under the Shapley value player 2 does have an objection against player 1 but player 1 also has a counter-objection to player 2's objection against player 1. Therefore, there is the potential that the objection and counter-objection that the two players have against one another will nullify each other and act as a principle for sustained mutual cooperation between the two players: the presence of an objection and counter-objection mean that neither player has any incentive to withdraw from the coalition.

Another type of objection involves a threat which proceeds as follows. A player may say to another, "give me more or I will persuade the other players to exclude you from the game, causing me to obtain more than my current payoff." Under these circumstances a counter-objection requires the player being threatened to able to respond that "it is true that if you exclude me then you will gain, but if I exclude you then I will gain at least as much".

Theoretically, the Shapley value is the only division rule or value that satisfies the balanced contributions property which requires that for every objection of any player i against any other player j there is a counter-objection available to player j.

The Core

Although theoretically appealing, in naturally occurring situations it is not obvious that the Shapley value will always prevail.[2] One of the most well-known disadvantages of the Shapley value is that

[2] For example, Williams (1988) reports empirical tests of cooperative game solution concepts with observations taken from naturally occurring markets and concludes that empirical results support the theory of the core in general and the "equal propensity to disrupt" solution concept in particular. On the other hand, the Shapley value and the nucleolus received weaker empirical support.

it ignores the stability of the grand coalition. Would the players in real life situations be willing to form the grand coalition given the particular way the Shapley value divides the worth of the grand coalition?

It could be expected that the grand coalition would be stable when there exists no smaller subset of players who can make a Pareto improvement for themselves.[3] Formally, the grand coalition is stable, or, in other words, the players will want to form the grand coalition if and only if the payoff profile is drawn from a set called *the Core* of this coalitional game. In the above land readjustment game, a payoff vector x where $\sum_{i\in N} x_i = v(N)$ is in the core of the coalitional game if and only if for *every* subset S of the grand coalition, N, $\sum_{i\in S} x_i \geq v(S)$.[4] That is, the core of this game consists of all individual payoffs $x_1, x_2, x_3 \geq 0$ such that:

$$x_1 + x_2 + x_3 = 900,$$

$$x_1 + x_2 \geq 300,$$

$$x_1 + x_3 \geq 350, \text{ and}$$

$$x_2 + x_3 \geq 400.$$

Intuitively, the core rules out payoff profiles under which one or more players as a coalition can make a profitable deviation.[5] For all payoff profiles in the core, we can be confident that the grand coalition is stable.

The core of the above land readjustment game is clearly non-empty. Indeed, one can straightforwardly verify that the Shapley value payoff profile, $x_1 = 270$, $x_2 = 300$, and $x_3 = 325$, is in the core of this game. In general, however, there is no guarantee that the core of a coalitional game is non-empty or unique.

In this land readjustment game, the grand coalition is stable with the allocation of the Shapley value. However, the same can be verified for many other payoff profiles. In particular, the equal

[3] A Pareto improvement for a group of players is a change in allocation that benefits at least one player without hurting any other players in the group.

[4] For a formal, textbook treatment, see, e.g., Osborne and Rubinstein (1994).

[5] This is analogous to the concept of Nash equilibrium in noncooperative games where, however, only unilateral individual deviations are considered.

division of the worth of the grand coalition, $x_1 = 300$, $x_2 = 300$, and $x_3 = 300$, is also in the core of this game. This allocation is of particular interest because it has been long argued in the literature that humans often exhibit a preference for equal division.

Is an equal split a plausible outcome?

When it comes to dividing a surplus among a group of participants, it has long been recognised that individuals do not behave purely selfishly as the standard economic theory would predict (Güth and Tietz, 1990; Bolton et al, 1998; Engle, 2011; Güth and Kocher, 2014). As a workhorse model in behaviour economics, the Dictator Game has been widely implemented and tested, mostly in laboratory experiments, where, in the most simplistic form, one player is given a certain amount of money to be divided between themselves and one other player. The standard economic theory would predict that the first player, the dictator, will keep everything for themself and leave nothing for the other player. However, based on observations in more than a hundred dictator game experiments published in the span of 25 years, Engel (2011) reports that on average the dictator gives out more than 28% of the money which highlights that there are important and significant concerns in the subjects' preferences other than their own materialistic payoff.

Closely related to the dictator game is the Ultimatum Game where the first player proposes a division and the other player can either accept it or reject it. The division is implemented only when the second player accepts the offer. Otherwise, both players receive nothing. While the standard economic theory predicts that the receiver will accept any offers, it has been wildly established that individuals will reject a proposed division if they perceive it as unfair. Indeed, the receivers usually accept all offers above 50% (for themselves) and their acceptance rate decreases and quickly approaches zero for offers below 20% (Güth and Kocher, 2014). There is by now a large volume of evidence that allows us to claim that in such experiments the *equal split* offer is an extremely robust phenomenon (Dawes et al, 2007; Fehr et al, 2008). Such observations demonstrate that people will take into account the interests of others, are sensitive to norms of cooperation, and may have other concerns. Theoretically, Fehr and Schmidt (1999) offers a compelling treatment of fairness that reconciles seemingly contradicting observations and the standard economic theory.

From the foregoing discussion we have two possible predictions for how a land readjustment game might proceed. The Shapley value is the only division rule that satisfies the balanced contributions property where each player's outcome is related to their contribution to the coalition. If the worth of the grand coalition is allocated *in any other way* than in strict accordance with the principles of the Shapley value, then there can exist objections to which there is no counter-objection. However, the Shapley value is not the only allocation that is conducive to the formation of the grand coalition. Indeed, the grand coalition is stable under any allocation in the core of the game. In particular, a rival allocation – an equal split - is in the core of the game and may represent an intuitively appealing solution as indicated in many published experiments in the literature.

In what follows we present the results of an experiment on coalition and value distribution conducted in four European countries. The experiments examine the tendency for participants to form a grand coalition and the manner in which they agree how value should be distributed. In so doing we seek to explore empirically participants' preferences for how a consolidated land asset should be split.

Experiment design, analysis and results

Illuminating as theories are to the fundamental thinking of how a land readjustment game might proceed, only empirical evidences can speak of their validity. On the other hand, as it is challenging to collect observational data in real-world situations that allow us to investigate the working of a cooperative process, we opt to designing and running experiments involving subjects who play the roles in a land readjustment game. In addition, a carefully designed experiment can help avoid the usual problems associated with observational data such as endogeneity issues.[6] To this end, an experiment that mirrors our theoretical exposition was designed (set out in Appendix A) and run in four European national settings: Belgium, the Netherlands, Norway and the UK.[7] Participants were student volunteers drawn from cognate programmes in urban planning, architecture and economic geography. This method of finding participants rather than through a random set of experiment subjects was to ensure that participants had some grounding in the subject area and could readily comprehend the nature of the questions being posed.

The design of the experiment was for groups comprising three subjects to assume the position of three developers - A, B, and C – who own three contiguous parcels of land. The scenario then

[6] For a more thorough discussion on experimental methods in Economics, see, e.g., Smith (2010). Experiments are also gaining popularity as a research apparatus in studies of land use policies. See, e.g., Banerjee et. al. (2015) and Tanaka (2007) among others.

[7] The students came from University of Liege in Belgium, Nijmengen University in the Netherlands, Norwegian University of Life Sciences in Norway and Liverpool University in England. The number of groups varies as a result of number of students in the classes in the different countries.

described a situation where the local municipality invited the three developers to develop a plot as a whole with the condition that a coalition of at least two developers was required to undertake the project (to encourage wholesale over piecemeal development). Due to different capacities, and in line with our theoretical example, the possible coalitions have different net payoffs as follows.

- **300** million (national currency) if developer **A and B** develop the area together
- **350** million (national currency) if developer **A and C** develop the area together
- **400** million (national currency) if developer **B and C** develop the area together
- **900** million (national currency) if developer **A, B, and C** develop the area together

The coalition parties will then divide the payoff as they see fit. The subjects had 15-25 minutes to make a coalition and a distribution of the payoff. After an experimenter introduced the experiment to the subjects, they were given a handout with the assignment text, an answer sheet, and a short survey. The experimenter also assigned the A, B, or C role to each student.[8]

It might be expected that each group should be able to reach the formation of a grand coalition as the structure of the game means payoffs are high enough to make every participant better off than they could hope to be in any smaller coalition. This proved to be the case. From 92 groups only 3 did not form a grand coalition. As Figure 1 ~~Table 2~~ shows there was significant variation amongst nations with respect to which distribution was favoured. In the Netherlands the even split was strongly preferred by a majority of participants. A similar outcome prevailed in Belgium. However, in Norway participants had a marginal preference for the Shapley value with a simple majority choosing this approach. However, in the UK the strength of preference for the Shapely value was much stronger with a large majority preferring this method of allocating the proceeds of the land readjustment game.

FIGURE ONE ABOUT HERE

In the game, the Shapley value is 275, 300 and 325 million to A, B and C respectively. None of the groups who did not choose an even distribution chose the exact Shapley distribution. However, 26 of the 92 groups (28 %) reached distributions similar to the Shapley prediction

[8] We note that due to logistical challenges the subjects in our experiment are non-financially-incentivised. However, we believe psychological incentives can potentially act as a reward medium that ensures incentive-compatibility and hence non-financially-incentivised decision making can also be effective in shedding light on our research questions. For example, Camerer and Hogarth (1999) review 74 experimental studies which study the effect of different monetary incentives, including zero monetary incentives, and find the modal result is no effect on mean performance (though variance is usually reduced by higher payment). More recently, DellaVigna and Pope (2018) also demonstrate the effectiveness of psychological incentives in experiments.

(hence 'Shapley-like'), with the player in position A receiving less than the player in position C, and B somewhere in between. Of the seven groups that reached other results, three formed pairs, three failed to reach any agreement in the allotted time, and one group formed a grand coalition with a distribution of 400, 100, and 400.

FIGURE TWO ABOUT HERE

In the subsequent questionnaire all but five of the players that achieved the grand coalition thought that the distribution was unfair: The three players who distributed 400, 100, 400 all agreed it was unfair, plus two of the "A developers" who received a smaller share. Most of the other A developers who received less than 300 saw it as reasonable for the others to earn more, as their participation contributed more to the project.

The game set out above illustrates the conditions under which a (small) collection of interests, which otherwise may not work together, might assemble into a functioning coalition. The alignment of individual payoffs with the corresponding contribution made by each member of the coalition to that coalition points to ways of both initiating development and ensuring stability across the group of interested parties through the full duration of the development process.

We anticipated that if we could establish a reallocation to all interested parties that implies payoffs that accord with the principles of the Shapley value, we would have created a settlement that is stable and mutually incentivises cooperative action such as would be necessary to realise wholesale redevelopment. However, the experiments indicated that, particularly in some national settings, a distribution based upon an even split was preferred. This finding chimes with that of Li et al., (2019) that 'culture' may be an important variable in explaining variations in outcomes in these national comparisons. The experiments indicated, firstly, that all participants saw the value of a grand coalition but, secondly, that participants in different nations then differed with regard to how they chose to share the asset: in Belgium and the Netherlands an even distribution was generally preferred even though the parties contributed unevenly in the first place; in the UK and Norway outcomes that balanced outcome and input, close to the Shapley value, were more routine.

The fact that the equal split was a popular choice for many participants, particularly in some national settings, may be a reflection of the fact that all participants were, *ex ante*, symmetric. The subjects were randomly assigned to one of the three developer roles with equal chances. Correspondingly, the equal split may have been incentivised in these experiments following the parallel arguments that rationalise equal split outcomes in ultimatum game experiments discussed earlier in this paper. Nevertheless, the popularity of the equal split outcome is an interesting phenomenon and may point to norms of practice or heuristics that are culturally and behaviourally inscribed into different understanding of what constitutes 'fair shares'. Further research would be valuable on how enduring these arrangements are: economic theory would suggest that in circumstances where a coalition is required to hold together, division rules which deviate from the Shapley value may be unstable as any design that deviates from the Shapley value represents an arrangement that has the potential for objections and counter-objections.

What remains is the question of whether we would arrive at a different outcome to the self-organised solutions discussed in this research if an informed broker had 'nudged' the players towards a different allocation (such as the Shapley distribution). In the example set out above just three players are included – we did not include a role for any state or quasi-state agency which might be able to broker a deal between landowners and developers as this would be inconsistent with our test of what happens under self-organisation. In our analysis the results are clear: in some circumstances (or national settings) our instincts to be cooperative and even-handed mean that we may be able to form a grand coalition and harmonise to an equal split when left to our own devices, but this is potentially unstable. When we have planning law and (well-informed) institutions to implement that law a different allocation may prevail that differs from the self-organised solution but may be more stable. The implications of this finding suggest the desirability of further research on this issue in other national settings where a statutory actor is an essential player – for example in land tenure systems where development rights in land are nationalised, such as China.

Conclusion

In recent years a huge amount of academic attention has been devoted to 'mechanism design' – using the principles of game theory and behavioural economics to develop new insights into a whole range of public policy questions (Börgers, 2015; Chetty, 2015; Hu et al., 2016). In our example, a properly designed planning 'mechanism' could be instituted to be played non-cooperatively which could implement the grand coalition and the division of surplus defined by the Shapely value. To illustrate how such an observation might be translated into mechanism design, Pérez-Castrillo and Wettstein (2001) offer a bidding mechanism in which players first bid to become the "proposer" and then the proposer makes a proposal to each of the other players. If the proposal is accepted by all the other players, the proposer forms the grand coalition, collects the value generated and makes the proposed payments to the rest of the players. If the proposal is rejected, the proposer will be on their own and the rest of the players play the bidding mechanism again. The authors show that in the subgame perfect equilibria of this bidding mechanism the net payoff of every player is his/her own Shapley value. Relatedly, Serrano and Vohra (1997) explore mechanisms that are motivated by the concept of the core and possess the property that their non-cooperative equilibrium outcomes coincide with the core.

Much greater research on mechanism design in relation to planning questions is required. In particular more work is required that speaks to the central importance of planning institutions in animating markets – especially those that relate to/depend upon the natural environment (Bromley, 2014, 2016; North, 1990, 1995; Ostrom, 2005). In the case of our specific thought experiment the behavioural complexities of real estate markets are well-noted (Brzezicka and Wisniewski, 2014; Evans, 1991; Jackson and Watkins, 2008; Pavlidis et al., 2016; Roberts and Henneberry, 2007). Although we could expand the game to encompass a greater number of players across a larger coalition with similar theoretical results, the degree to which the behavioural economics of strategy might affect outcomes remains a very salient question. For example, signalling strategies or the emergence of shifting, or nested, coalitions of actors (partition games) might make a different outcome more likely in practice. Within this real world context there would almost certainly be a need for an agency, such as a development corporation or urban planning, as a formal statutory function that might make the 'state of the world' described by the Shapley value a reality. This type of activity would correspond to the idea of urban planning as a 'market maker' (Lord et al., 2015) – the type of economic agency that can, if suitably well-informed, encourage outcomes, such as coordinated self-organisation. Defining and applying Shapley values to guide the design of land readjustment policies might be one such role a market making planning agency could explore although we are sorely in need of further applied research on how such approaches might work out in practice.

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Appendix A

Coalition Game for Area Development

A municipality would like to develop an area by inviting developers to plan and carry out the development process. Three private land developers, A, B, and C are interested in the project. The municipality will only give a development permit if the development is carried out through a coalition or a joint-venture initiative of at least two developers because by doing this, they can make a better project and create more value for the area. Therefore, if no coalition is formed (by at least 2 developers), no value will be created, and everybody will get nothing. Due to differences in the capacity of the developers, the value created from the joint venture will differ according to the members of the coalition. The expected values from the development are:

- nothing if developer A, B, or C develops the area alone
- 300 million kroner if developer A and B develop the area together
- 350 million kroner if developer A and C develop the area together
- 400 million kroner if developer B and C develop the area together
- 900 million kroner if developer A, B, and C develop the area together

Note:

- If 2 developers agree to make a coalition/joint venture, the value they create will only be divided between them, while the third player will get nothing.

Your Task:

You are developer (A/B/C), sitting together with (A/B/C) and (A/B/C). Please negotiate with each other, what coalition are you going to form, and how are you going to divide the value created by the coalition among the coalition members?

When you have decided on a coalition and a distribution, please turn over the page.

Answer sheet (all three players fill in the same):

- Circle the coalition you formed
    - (A, B)
    - (A, C)
    - (B, C)
    - (A, B, C)
    - None

- Distribution of created values:
    - A: ________________________ kroner
    - B: ________________________ kroner
    - C: ________________________ kroner

Questionnaire (fill in individually):

1. Please explain the motivation of your decision (in forming or not forming a coalition)

2. Do you think that you have distributed the created value in a fair way among the members of the joint venture, and why do you think so? Please also explain what, in your opinion, is the fair distribution if you think you have not distributed the value in a fair way.

3. Years of completed university/college education
4. Gender:
5. Age:
6. Do you work outside of the university?
    a. No
    b. Yes, but not related to planning or development
    c. Yes, with development or urban planning in the private sector
    d. Yes, with development or urban planning in the public sector
7. Income:
    a. Less than 200,000 kroner a year

b. 200,000 – 500,000 kroner a year
c. More than 500,000 kroner a year

8. Type of education
    a. ByReg
    b. Eiendomsutvikling
    c. Eiendomsfag
    d. Other (please specify):

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