Draft

MAKING EMPATHY OBSOLETE: ENFORCING EQUILIBRIUM SELECTION DESPITE PATH-DEPENDENCY

ALEXANDER FUNCKE

A main results from epistemic game theory is that for games with multiple reasonable equilibria the predictive devil really is in the details, and may hinge on the exact type of belief revision employed, the players' initial belief distributions and to what extent they are common knowledge. Changing perspective from the theorist to the real world insight implies that for a large class of games we can not predict outcomes.

In this paper we are interested in how much a principal would need to alter the specifics of a multiple equilibria game (keeping labels intact) to instill a shift from one equilibrium to another. A mechanism design-like approach is taken, where a principal prefer that the agents in a population play a certain strategy. Every agents' strategy choice will depend on an unknown, the ratio of choosing the principal's preferred strategy. It is shown that with the introduction of a system of fines and rewards where the sizes are a function of an approximation of the same ratio can be tweaked such that the problem gets epistemically reduced from a complex to a trivial one, by making empathy obsolete. That is to make the player's decision independent of the choices of the others and doing so without any new transfers (in equilibrium).

Lastly, conventions and by extension norms are explored in relation to this mechanisms e.g. as ways to instill norm change.

KEYWORDS: policing, rewards and fines, equilibrium selection, common knowledge, conventions, norms.

1. INTRODUCTION

Mechanism design is a field in game theory concerned with private information games. Typically there are two roles, one principal that may at least partially select the game structure and an agent that have some private information. The question asked is then how the principal can incentivize the agent to share information and thereby maximize utility.

In this paper we consider a mechanism design problem of sorts, again there is a principal that selects aspects of the game structure, but here the main interaction is between agents, the principal still experiences an externality.

In rational choice theory empathy is usually restricted to common knowledge of rational expectations. For a large class of games this limited empathy is insufficient to find a unique equilibrium, not even given the many refinements to the Nash equilibria.

We interest ourselves in repeated games where an agent's choice of strategy hinges on the strategy choices of the others. Focality here tend to be dominated by the history of play and therefore exercise strong path-dependency.

To further complicate things, the design task asks the principal to determine when a critical mass have changed their focal point. A classical analysis of this

Center for the Study of Cultural Evolution, Stockholm University, Edmond J. Safra Center for Ethics, Harvard University

would require a fruitful model of each agents empathy; its level-k reasoning, inductive standard, preferences and so forth.

This paper contribution is to design mechanisms that let us police a disregard for the others in the population. That is to make the expected utilities of the various choices non-contingent on how the others will act, whilst keeping the fines and rewards under control.

2. CONVENTIONS, NORMS AND THE HARD PROBLEM

In England we expect people to drive to the left and to ask strangers "how do you do?" without expecting open-hearted answers. Accustomed with the conventions, most's incentive structure will strongly suggest to adapt and act English in say Bristol. One could however argue, and for sake of the discussion, let us assume rightly so, that everyone would be better off if all nations drove to the right, and if all questions posed were inquiring ones. If so, then the English have inferior conventions. Let us further assume that every Englishman is perfectly aware that her conventional behavior is substandard. Despite the insight, it is unfeasible for any one of them to act differently.

History has shown that shifts of some types of conventions, such as to change what side to drive on, may be instigated in a top-down manner.[1] History also suggests that planned shifts of other types can be utterly impractical. The choice between driving to the left or right seem to depend (almost) exclusively on the expectations one have on how the others will act. Unsurprisingly so, as miscoordination is expensive. To update expectations, all a somewhat respected governing body need to do is to instill common knowledge of the upcoming change. Now, even if the English would have grown a strong preference for left-hand driving to a degree that it could breed expectations of disobedience, a governing body would still easily be able to quench them as the setting allows for effective monitoring and enforcement.

Considering the other case, even if a governing body managed to instill common knowledge about its intention to end the "how do you do"-convention, it will almost certainly fail. Unlike the driving example, the preference for language conventions run deeper than the mere preference for successful coordination, not least as malcoordination is only somewhat costly and monitoring is impractical.

Many conventions that govern pro-social behavior is of the latter kind, and top-down attempts to shift conventions in regard to e.g. systemic petty corruption, littering and excessive fishery tend to be hard to impose. How to make this at least theoretically feasible is the topic of this paper.

Throughout, conventions and norms will be taken to be a strictly coordinative phenomenon in the sense introduced by Lewis.

[1] Portugal, Italy and Canada changed to right-hand traffic in 1920s. Sweden changed at "Dagen H" in 1968. All did so after central top-down decisions.

DEFINITION 1 *A regularity R in the behavior of members of a population P when they are agents in a recurrent situation S is a convention if and only if it is true that, and it is common knowledge in P that, in any instance of S among members of P,*

1. *everyone conforms to R;*
2. *everyone expects everyone else to conform to R;*
3. *everyone has approximately the same preferences regarding all possible combinations of actions;*
4. *everyone prefers that everyone conform to R, on condition that at least all but one conform to R;*
5. *everyone would prefer that everyone conform to R', on condition that at least all but one conform to R',*

where R' is some possible regularity in the behavior of members of P in S, such that no one in any instance of S among members of P could conform both to R' and to R. [Lewis, 1969, p. 42]

There is an extensive literature on how convention and norms gets established, using both static and dynamic modeling [Kim, 1996, Crawford and Haller, 1990, Kramarz, 1996] as well as experimental methods [Mehta et al., 1994]. The literature on the dynamics of recoordination is less impressive. This should not come as a surprise as it typically require a catalog of psychological assumptions. Agents need believes about the rests' preferences, expectations and empathetic abilities, and level-k reasoning thereof.

Further, many coordinations are upheld by path-dependency alone, even as everyone would prefer to change the convention and this preference was common knowledge, a change can only occurs if everyone believe that it will change from this specific point on-wards. Often there are no such credible synchronization, and hence recoordination may be hard to facilitate.

The obvious candidate to change a norm is to introduce a fine, but how large does that fine need to be? Let us consider an example: A neighborhood has a littering problem. In a meeting where everyone is present, all agree to change their littering behavior. The problem is that no one believe that any of the other will adhere. So, even if all of them would rather live in a neighborhood where no one litters (including themselves), they don't believe a critical mass will stop—and to be one of the few stopping would not make sense, as littering is convenient and the neighborhood would still be littered. Next week there is a follow-up meeting. To tackle the continued littering, they unanimously decide to setup a monitoring and fine system. The fines are set to \$50, but monitoring is kept sparse due to its high running costs. Unfortunately the fines are not substantial enough, most still believe that few of the others will stop, and again it makes no sense for anyone to stop. In the next follow-up meeting fines are raised by \$50 more, and continue to be at every follow-up until the littering stops.

So, how big a fine does it take to change the behavior? We know that the expected fine[2] will not be greater then the cost of being the only one that stops littering. To estimate how close to this maximum the fine will be raised is difficult.

In this paper we introduce systems of fines and rewards designed to counterbalance the uncertain variable: how the other will act. This implies that each neighbor will face incentives to refrain from littering that are independent of the number of others that refrain. Further, we show that such a system can be implemented in a budget balanced manner, that is having the fined neighbors finance the rewards.

3. THE BASIC SETTING

Consider a repeated 2x2 normal form game G, the column player is randomly drawn from a population, how the agent (and row player) is selected will turn out to be of no importance, but for simplicity, assume that the row-agent too is drawn randomly. Each agent choose a strategy from the strategy set, $A_i = \{C, B\}$. This type of repeated game will henceforth be referred to as the *original repeated game*.

Now, we introduce a governing body. The body prefers action C to B, for one reason or another, we will think of the strategies as to "[C]omply" or "[B]reach" the governing body's (possibly unspoken) will.

G:

	C	B
C	a_{CC}, b_{CC}	a_{CB}, b_{CB}
B	a_{BC}, b_{BC}	a_{BB}, b_{BB}

FIGURE 1.— An original game.

A rational agent i will base her strategic choice on the basis of each strategies' expected utility, which in turn hinges on her belief about likelihoods of a randomly drawn opponent's strategic choices. Let $x \in \chi$ be the ratio of agents that choose strategy C, and let $x^i \in \chi^i$ be agent i's belief about what ratio of C choosers among the other agents. To make the notation less messy, a population's post-hoc x will only be notationally differentiated from x^i and x^s (to be introduced) if there is a risk of confusion.

The expected payoff of a strategy is given by $u_G : A_i \times \chi^i \to \mathbb{R}$, such that for strategy C,

$$\begin{aligned} u_G(C, x) &= E[Prob(\sigma_j = C)f(C, C) + Prob(\sigma_j = B)f(C, B)] \\ &= xa_{CC} + (1 - x)a_{CB}, \end{aligned} \tag{1}$$

and for the strategy B,

$$\begin{aligned} u_G(B, x) &= E[Prob(\sigma_j = B)f(B, B) + Prob(\sigma_j = C)f(B, C)] \\ &= (1 - x)a_{BB} + xa_{BC}. \end{aligned} \tag{2}$$

[2]That is, the probability of being monitored times the size of the fine.

3.1. *An alternative n-player interpretation*

Alternatively, we can reinterpret the basic setting as an n-player coordinative game, where the left and right-hand sides of the two equations (1) and (2) are the utilities from playing C if nx players choose C.

4. INSPECTION MECHANISMS

A governing body can not directly observe the agents' choices. In order for her to police agents into a certain strategy she must therefore implement a mechanism for inspection.

4.1. *Spot-check inspection*

The first inspection mechanism considered is an intrusive spot-check mechanism, that is, in every round a governing body may inspect a player's chosen strategy. On inspection the agent will not play G, instead she will be fined or rewarded according to her intended action in the game.

DEFINITION 2 *A spot-check mechanism is a mapping, $spot_{F,R,m} : G \mapsto spot_{F,R,m}(G)$, from an original normal form repeated game to an extensive form repeated game. The original game's rounds are partitioned into batches of N rounds each. The governing body samples k rounds from each batch for inspection at a cost of m per round. That is, in every round there is a k/N probability for an agent to be inspected. If not inspected, the stage game G is played. If sampled, agent i is randomly drawn, and her chosen strategy σ_i is observed by the governing body. If $\sigma_i = C$, the governing body rewards agent i, the size of the reward is given by $R : \chi_s \to \mathbb{R}$, where χ_s is the ratio set for C-choosing agents in the sample. Else, if $\sigma_i = B$, the governing body fines the agent, the fine size is given by $F : \chi_s \to \mathbb{R}$.*

Before proceeding, let us explicate the timing and the strategies' expected utilities.

TIMING 1

1. *Natures picks m.*
2. *The governing body chooses N, k, and the functions F and R; and inform the agents of her choices.*
3. *For each round in a batch:*
   (a) *Nature draws an agent: i.*
   (b) *Agent i chooses a strategy: σ_i.*
   (c) *Nature determines if agent i will be inspected or not.*
4. *Payoffs and/or transfers are distributed.*
5. *Repeat the last step for the next batch*

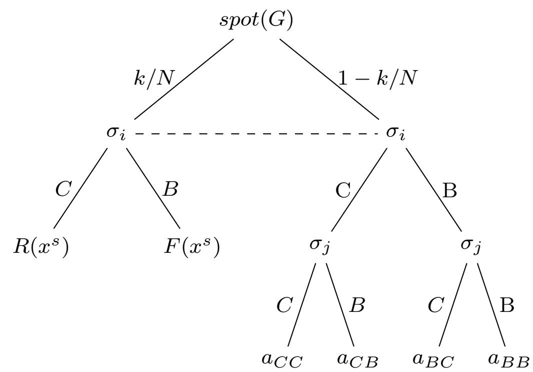

FIGURE 2.— The extensive form spot-check inspection mechanism applied to G.

The expected utility of $spot(G)$ for an agent is given by $u_{spot(G)} : A_i \times \chi^i \to \mathbb{R}$, which for strategy C by equation (1) is

$$u_{spot(G)}(C,x) = E[Prob(\neg\text{sampled})u_G(C,x) + Prob(\text{sampled})R(x)] \\ = (1-s)[xa_{CC} + (1-x)a_{CB}] + sR(x), \tag{3}$$

and for strategy B by equation (2) is

$$u_{spot(G)}(B,x) = E[Prob(\neg\text{sampled})u_G(B,x) - Prob(\text{sampled})F(x)] \\ = (1-s)[(1-x)a_{BB} + xa_{BC}] - sF(x). \tag{4}$$

The rewards and fines imposed by the governing body will affect her budget as follows

$$Y(k,x^s) = k[(1-x^s)F(x^s) - x^sR(x^s) - m], \tag{5}$$

where x^s is the ratio of C-choosers in the inspected sample.

The spot-check mechanism applied to the original repeated game (Figure 1) is depicted in Figure 2.

4.2. *Surveillance inspection*

The surveillance inspection mechanism is non-intrusive, i.e. it does not interfere with the repeated play of the stage game G. It only observes the choice made by the sampled agent, and let the governing body hand out a reward or fine on top of G's payoff.

DEFINITION 3 *A* surveillance *mechanism is a mapping* $CCTV_{F,R,m} : G \mapsto CCTV_{F,R,m}(G)$ *from an original normal form repeated game to an extensive form*

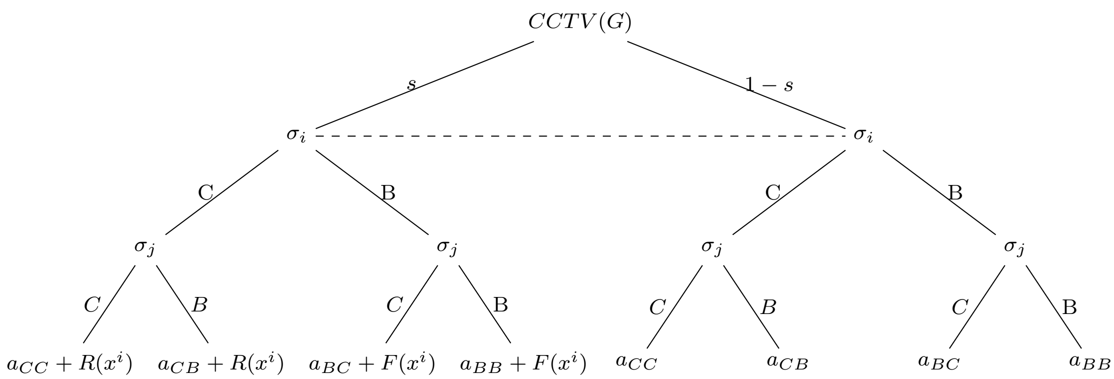

FIGURE 3.— Extensive form of the game and surveillance mechanism, $M_{\mathrm{CCTV}}(G)$.

repeated game. The original game's rounds are again partitioned into batches of N rounds each, from which the governing body samples k rounds at a cost of m per round. That is, in every round there is a k/N probability for an agent to be inspected. Whether inspected or not, the drawn agent plays the original stage game G and pockets the payoffs. If sampled, the randomly drawn agent i's choice of strategy, σ_i, is observed by the governing body. If $\sigma_i = C$, the governing body rewards the agent. The size of the reward is given by $R : \chi_s \to \mathbb{R}$, where χ_s is the ratio set for C-choosing agents in the sample. If instead $\sigma_i = B$, the governing body fines the agent, the size of the fine is given by $F : \chi_s \to \mathbb{R}$.

Timing 1 applies to the surveillance mechanism too, the expected utilities however differ. The expected utility is given by $u_{CCTV(G)} : A_i \times \chi^i \to \mathbb{R}$, which for strategy C by equation (1) is

$$
\begin{aligned}
u_{CCTV(G)}(C, x) &= u_G(C, x) + Prob(\text{sampled})R(x) \\
&= xa_{CC} + (1-x)a_{CB} + sR(x),
\end{aligned}
\tag{6}
$$

and for strategy B by equation (2) is

$$
\begin{aligned}
u_{CCTV(G)}(B, x) &= u_G(B, x) - Prob(\text{sampled})F(x) \\
&= (1-x)a_{BB} + xa_{BC} - sF(x).
\end{aligned}
\tag{7}
$$

The surveillance mechanism applied to the original repeated game (Figure 1) is depicted in Figure 3.

5. MECHANISMS THAT SOLVES FOR EMPATHY

5.1. *Spot-check: Constant payoff difference and balanced budget*

In this section we will show that for each original repeated game there exist a spot-check mechanism (from Section 4.1) tuned such that the expected utility difference between strategy C and B is constant with respect to the agent's belief about the ratio of C-choosers in the population (x^i). To ensure that the expected utility difference is a positive constant the functions R and F from the spot-check mechanism must be determined with care. That is, such that

$$u_{spot(G)}(C,x) - u_{spot(G)}(B,x) = \Delta > 0, \tag{8}$$

for all x and some Δ. We also intend to enforce a budget constraint on the governing body, the budget is given by equation (5) and hence keeping the budget balance implies that

$$Y = (1-x^s)F(x^s) - x^s R(x^s) - m = 0. \tag{9}$$

THEOREM 1 *For every original repeated game G and cost of inspection m there exist fine and reward functions F and R such that the spot-check inspection mechanism enforces a constant difference in expected payoff between the two strategies.*

PROOF: Let us assume that the difference constraint (8) and budget constraint (9) holds. To determine F and R we solve the implied system of equations.

Substitute the expressions for the expected utilities in (3) and (4) into the difference constraint. Next, solve for R keeping F as an unknown, in the budget constraint and plug it into the expanded difference constraint, which determines F. Use F to determine R by plugging it back into the budget constraint, and we have determined

$$R(x^s) = \frac{1-x^s}{s}(\Delta - (1-s)[u_G(C,x) - u_G(B,x)]) - m, \tag{10}$$

$$F(x^s) = \frac{x^s}{s}(\Delta - (1-s)[u_G(C,x) - u_G(B,x)]) + m. \tag{11}$$

Now, substituting our fine and reward functions into the expressions for expected utility, (3) (4),

$$\begin{aligned} u_{spot(G)}(C,x) = {} & (1-x)\Delta - sm + (1-s)[a_{BB} \\ & + (a_{CB} + a_{BC} - 2a_{BB})x \\ & + (a_{CC} - a_{CB} - a_{BC} + a_{BB})x^2], \\ u_{spot(G)}(B,x) = {} & -x\Delta - sm + (1-s)[a_{BB} \\ & + (a_{CB} + a_{BC} - 2a_{BB})x \\ & + (a_{CC} - a_{CB} - a_{BC} + a_{BB})x^2], \end{aligned}$$

The difference of the two expressions is by assumption constant and equal to Δ. *Q.E.D.*

Remark 1 *For some applications negative fines and rewards are not only a peculiar concept, but also an impossible one. Restricting the choices of R and F such that they are non-negative for all x^s implies that we need to restrict Δ. To find the necessary restriction, construct the inequalities $F(x^s) \geq 0$ and $R(x^s) \geq 0$ from the expressions in equation (10) and (11), and solve for Δ. This produces the following restrictions*

$$\Delta \geq \max_x (1-s)[x(a_{CC} - a_{BC}) + (1-x)(a_{BB} - a_{CB})] - \frac{sm}{x},$$
$$\Delta \geq \max_x (1-s)[x(a_{CC} - a_{BC}) + (1-x)(a_{BB} - a_{CB})] - \frac{sm}{(1-x)}.$$

5.2. *Spot-check: Constant comply-payoff and balanced budget*

This section introduces an alternative to the mechanism in Section 5.1, it is again based on the spot-check mechanism (from Section 4.1), but instead of keeping the difference constant the idea here is to ensure that the expected utility from choosing the C-strategy is constant in itself and strictly larger than the expected utility of choosing the B-strategy.

Theorem 2 *For every original repeated game G and cost of inspection m there exist a fine and reward functions F and R such that the spot-check inspection mechanism enforces a constant expected utility for the C strategy, such that it is greater than the expected utility of choosing the B strategy for all x^i.*

Proof: Assume that the budget is balanced,

$$Y = (1-x^s)F(x^s) - x^s R(x^s) - m = 0,$$

and that the implicit rationality constraint holds,

$$u_{spot(G)}(C, x) > u_{spot(G)}(B, x). \tag{12}$$

Also, assume that the C strategy implies constant expected utility. That is that

$$\frac{du_{spot(G)}(C,x)}{dx} = 0 \Leftrightarrow (1-s)(a_{CC} - a_{CB}) + sR'(x) = 0$$

for all $x \in [0, 1]$.

We may now solve for R' and integrate with respect to x to determine the reward function

$$R(x^s) = \frac{1-s}{s}(a_{CB} - a_{CC})x^s + c_R.$$

Plugging R back into the budget constraint and solving for F we determine the fine function

$$F(x^s) = \frac{1}{1-x^s}\left[\frac{1-s}{s}(a_{CB} - a_{CC})x^{s2} + c_R x^s + m\right].$$

It remains to determine for what value of c_R the governing body's rationality constraint in equation (12) holds. Solving the inequality for c_R gives[3],

$$c_R > \frac{1-s}{s}[(a_{BB} - a_{CB} + \max_x(a_{BC} - a_{BB} + 2a_{CB} - 2a_{CC})x] + \frac{m}{s}. \tag{13}$$

As we constructed F and R given the assumptions the existence is evident.

Q.E.D.

5.3. *Spot-check: Constant payoffs and budget constraint*

Yet another variation on the spot-check mechanism (from Section 4.1) is introduced in this section. This time designed to keep the expected payoff for both strategies constant, rather than just one of them. In order to achieve this the budget balancing constraint have to go, instead a positive budget constraint is upheld.

THEOREM 3 *For every original repeated game G and cost of inspection m there exist fine and reward functions, F and R, such that a budget-constraint spot-check inspection mechanism enforces constant expected utilities for both C and B strategies over all x^i.*

PROOF: Assume that the strategies have constant expected utilities

$$\frac{\partial u_{spot(G)}(C,x)}{\partial x} = 0 \Leftrightarrow (1-s)(a_{CC} - a_{CB}) + sR'(x) = 0, \tag{14}$$

$$\frac{\partial u_{spot(G)}(B,x)}{\partial x} = 0 \Leftrightarrow (1-s)(a_{BC} - a_{BB}) - sF'(x) = 0, \tag{15}$$

over all x.

---

[3]Let A, B and D be such that they are given by,

$$u_{spot(G)}(C,x) = (1-s)A(x) + sR(x)$$
$$u_{spot(G)}(B,x) = (1-s)B(x) - sF(x)$$
$$R(x^s) = \frac{1-s}{s}Dx^s + c_R.$$

Now, equation (12) transforms to,

$$(1-s)(A + Dx) + sc_R > (1-s)(B - D\frac{x^2}{1-x}) + \frac{sx}{1-x}(m - c_R), \forall x$$

and equivalently,

$$c_R > \frac{1-s}{s}[(1-x)(B-A) - Dx] + \frac{m}{s}, \forall x$$

which in turn equals equation (13).

Solving equation (14) and (15) for R' and F' respectively, and then integrating with respect to x, we find

$$R(x) = \frac{1-s}{s}(a_{CB} - a_{CC})r + c_R, \tag{16}$$

$$F(x) = \frac{1-s}{s}(a_{BC} - a_{BB})r + c_F, \tag{17}$$

where c_R and c_F are constants.

Substituting the expressions for R and F in equations (16) and (17) into the expected utilities, equation (3) and (4), we determine

$$u_{spot(G)}(C, x) = (1-s)a_{CB} + c_R, \tag{18}$$

$$u_{spot(G)}(B, x) = (1-s)a_{BB} + c_F, \tag{19}$$

The constants c_R and c_F remain to be determined and must fulfill the following system of inequalities

$$\begin{cases} R(x^s) \geq 0 \\ F(x^s) \geq 0 \\ u_{spot(G)}(C, x^s) > u_{M_{spot}(G)}(B, x^s) \\ (1-x^s)F(x^s) - x^s R(x^s) - m = Y \geq 0 \end{cases}, \tag{20}$$

substituting in (20) with the expressions in equations (16), (17), (18) and (19), letting $A = a_{CB} - a_{CC} + a_{BC} - a_{BB}$ and $B = a_{BB} - a_{BC}$,

$$\begin{cases} c_R \geq \max(\frac{1-s}{s}(a_{CC} - a_{CB}), 0) \\ c_F \geq \max(\frac{1-s}{s}(a_{BB} - a_{BC}), 0) \\ c_R + c_F > (1-s)(a_{BB} - a_{CB}) \\ c_F \geq \max_r \frac{1-s}{s}\left(Ar^2 + Br\right) + (c_R + c_F)r + m \end{cases}. \tag{21}$$

Hence, large enough constants for a pure coordination game are given by,

$$c_F = max(0, \frac{1-s}{s}(a_{CC} - a_{CB}), \max_r -\frac{1-s}{s}Ar^2 + m),$$

$$c_R = max(0, \frac{1-s}{s}(a_{BB} - a_{BC}), (1-s)(a_{BB} - a_{CB}) - c_F + \Delta),$$

where $\Delta > 0$ is the smallest acceptable gap. *Q.E.D.*

5.4. *Surveillance: Constant payoff difference and balanced budget*

In this section analogies to the systems in Section 5.1 are constructed based on the surveillance mechanism (from Section 4.2). That is, we choose reward and fine functions such that the difference in the expected utility between the two strategies is constant.

Theorem 4 *For every original repeated game G and cost of inspection m there exist reward and fine functions R and F such that a surveillance inspection mechanism enforces a constant difference in expected payoff between the two strategies.*

Proof: Again, assume that the difference between the expected utilities is constant

$$u_{CCTV(G)}(C,x) - u_{CCTV(G)}(B,x) = \Delta.$$

Also, assume that the budget constraint holds

$$Y = (1-x^s)F(x^s) - x^s R(x^s) - m = 0.$$

Solving the implied system of equations determines R and F. Start by substitute the expressions for the expected utilities in (6) and (7) into the difference constraint. Next, solve for R keeping F as an unknown, in the budget constraint and plug it into the expanded difference constraint, which determines F. Use F to determine R by plugging it back into the budget constraint, and we have determined

$$R(x^s) = \frac{1-x^s}{s}(\Delta - u_G(C,x) + u_G(B,x))]]) - m, \tag{22}$$

$$F(x^s) = \frac{x^s}{s}(\Delta - u_G(C,x) + u_G(B,x))]]) + m. \tag{23}$$

Substituting these fine and reward functions into the expressions for expected utility in equations (6) and (7)

$$\begin{aligned} u_{CCTV(G)}(C,x) = {} & \Delta(1-x) - sm - (a_{CC} - a_{BC} - a_{CB} + a_{BB})x^2 \\ & + (a_{BC} - a_{CB} - 2a_{BB})x + a_{BB}, \\ u_{CCTV(G)}(B,x) = {} & -\Delta x - sm - (a_{CC} - a_{BC} - a_{CB} + a_{BB})x^2 \\ & + (a_{BC} + a_{CB} - 2a_{BB})x + a_{BB}. \end{aligned}$$

The difference of the two expressions is by assumption constant and equal to Δ.
Q.E.D.

6. EXTENSIONS

Three extensions are under development. First a version of the system that considers iso-elastic utilities with single-peaked distribution of risk-aversion (η). Secondly, we are looking at how an imperfect inspection system effect our conclusions. And lastly, we are doing experiments to see if within a laboratory setting it is possible to police a disregard for the others.

7. CONCLUSION

In coordinative situations, a population playing a pure coordination game, stag hunt or prisoners dilemma, each agent need to form believes about how her opponent reasons, and how she reasons about her others, and so on.

To model the dynamics in these situations we need assumptions about the agents' empathetic skills, how they perceive the others' inductive standard, preferences (what game they play), background information and potential common knowledge thereof.

This paper develops a simple idea, that faced with a coordinative problem a governing body may introduce an institution that balances the agents' uncertainty sprung out of not knowing how the other agents will act. It does this by letting a fine and reward system depend on an approximation of the same uncertain variable: the ratio of the inspected population acting in accordance with the convention. As methods for inspection we consider an intrusive spot-check and a passive surveillance system, for both reward and fine functions are calculated to keeping relevant aspects constant as the ratio of convention followers vary.

For situations where cost-less non-intrusive monitoring is feasible (Section 5.4) we show that we can change norms and enforce conventions without unbalancing the budget, loose utility or have expected fine or reward levels different from zero.

REFERENCES

Vincent P. Crawford and Hans Haller. Learning How to Cooperate: Optimal Play in Repeated Coordination Games. *Econometrica*, 58(3):571–595, 1990.

Youngse Kim. Equilibrium selection in n-person coordination games. *Games and Economic Behavior*, 15(2):203–227, 1996.

F. Kramarz. Dynamic focal-points in n-person coordination games. *Theory and Decision*, 40 (3):277–313, 1996.

David Lewis. *Convention: A Philosophical Study*. Harvard University Press, Cambridge, 1969.

Judith Mehta, Chris Starmer, and Robert Sugden. The nature of salience: An experimental investigation of pure coordination games. *American Economic Review*, 84(3):658–73, June 1994.

APPENDIX A: EXAMPLE PLOTS

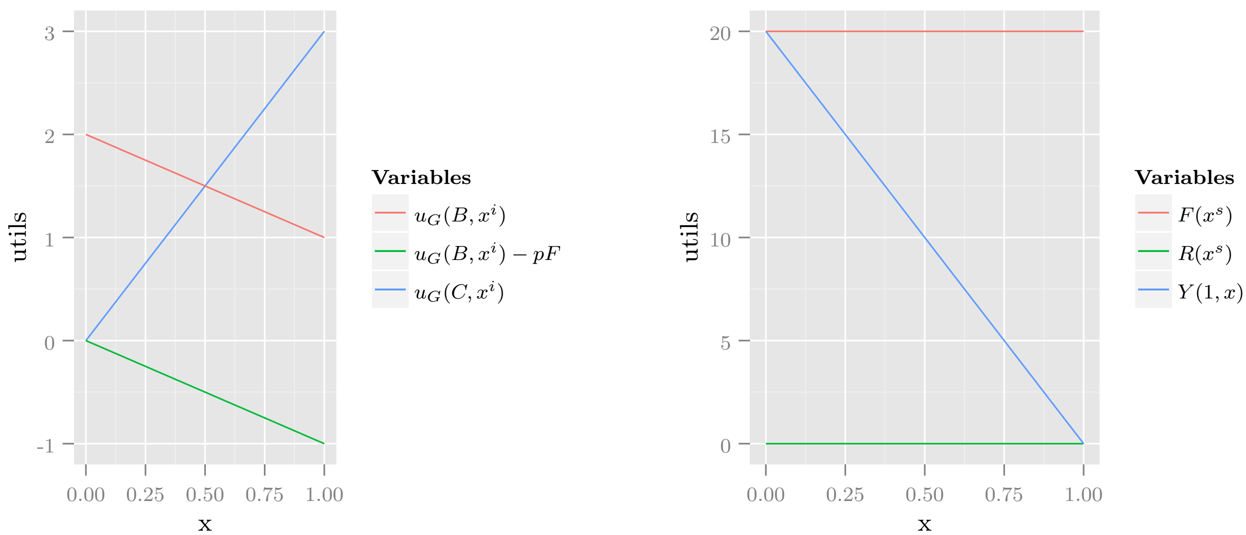

FIGURE 4.— The original game (Section 3), plus the lowest expected fine that would change a coordination for any x.

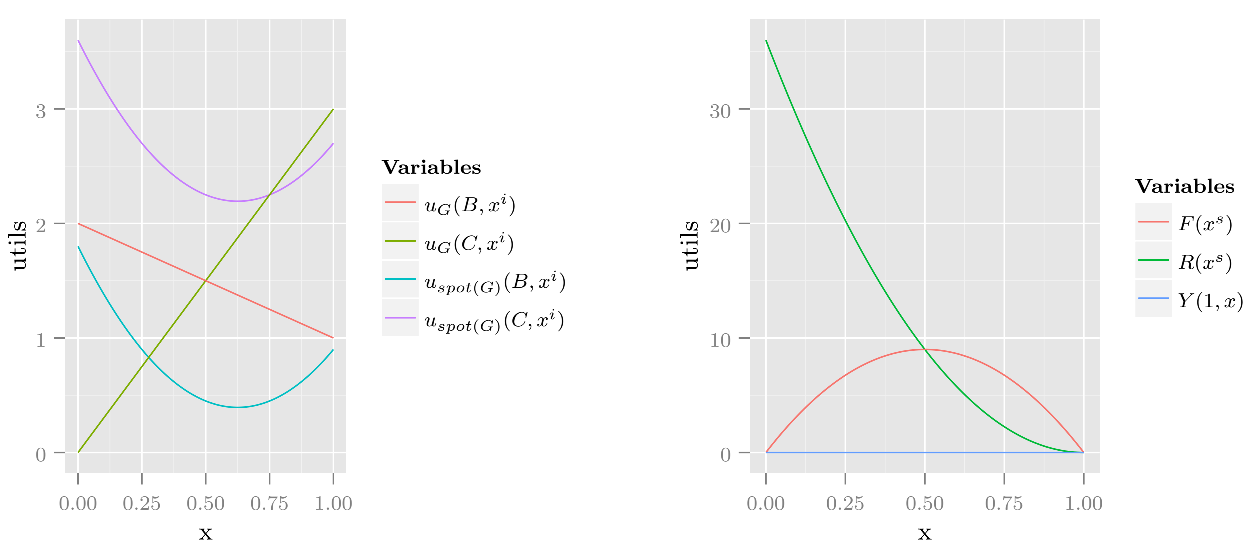

FIGURE 5.— Spot-check: Constant payoff difference and balanced budget (Section 5.1).

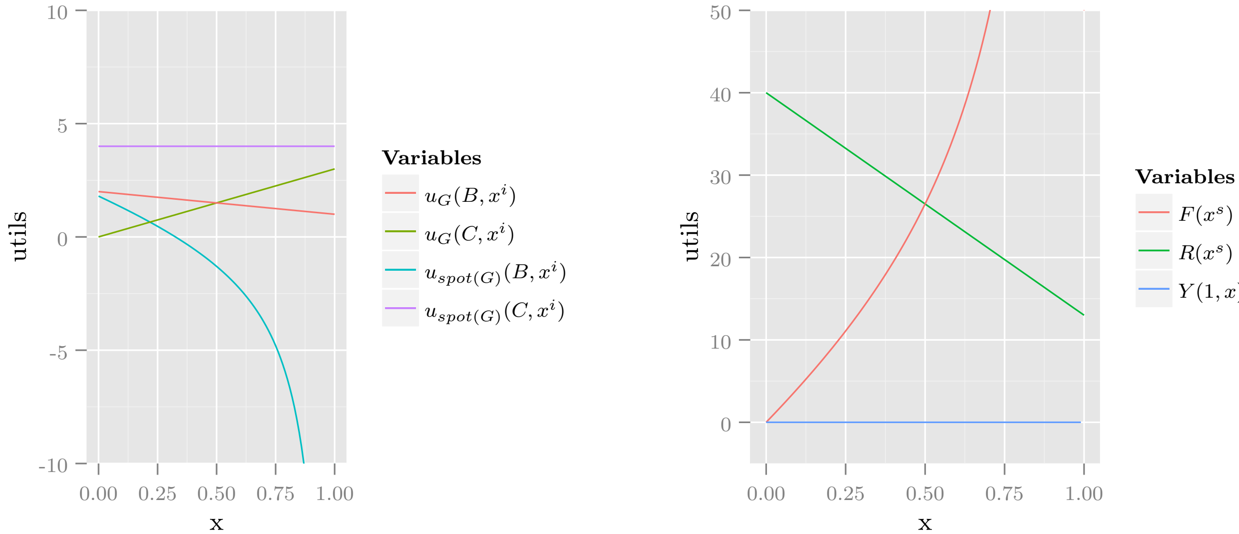

FIGURE 6.— Spot-check: Constant comply-payoff and balanced budget (Section 5.2).

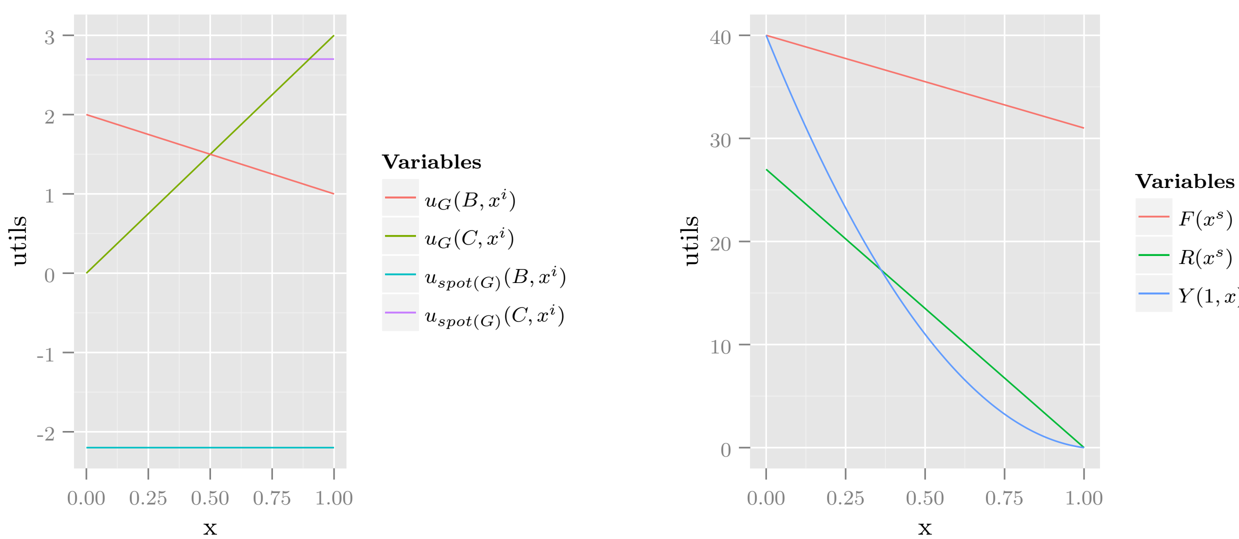

FIGURE 7.— Spot-check: Constant payoffs and budget constraint. (Section 5.3).

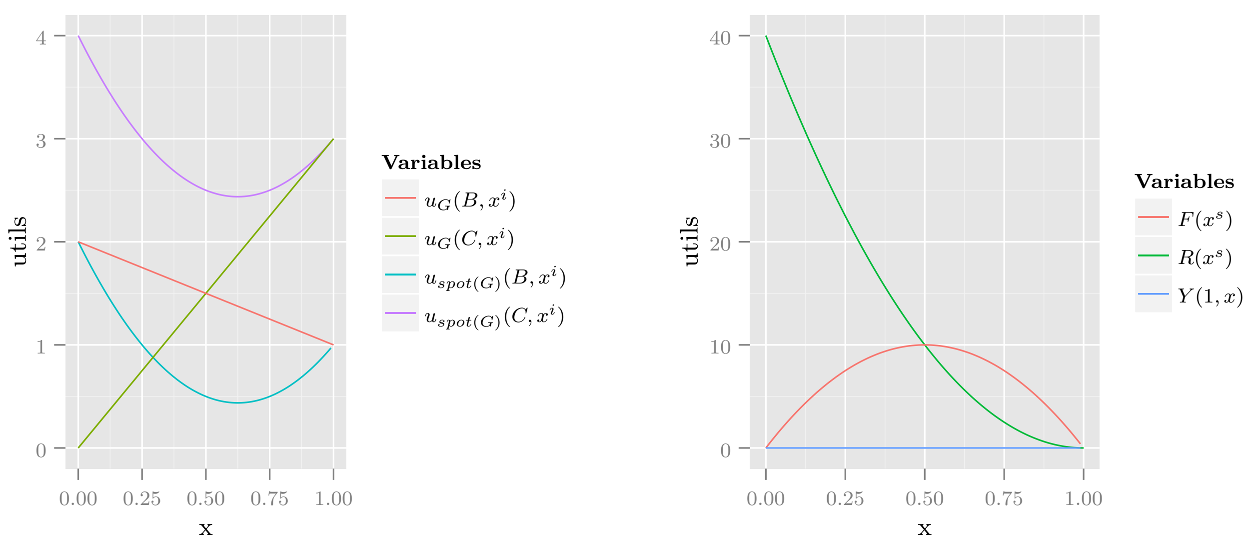

FIGURE 8.— Surveillance: Constant payoff difference and balanced budget. (Section 5.4).