Coordination Problems and Communication

Abstract

Coordination problems arise when a game has multiple Nash equilibria and all players have a common interest in avoiding a non-equilibrium state. To achieve an equilibrium state, agents must come to understand one another's intentions. Communication can facilitate this understanding under some, but not all, circumstances. In the absence of communication among agents, coordination may also sometimes be achieved with the aid of extrinsic signals that have come to be associated with the actions of others. In some settings, past actions themselves serve as precedents, without the benefit of any communication.

Coordination and Communication

Lewis (1969) defined a ***coordination equilibrium*** as a Nash equilibrium in which no agent would be better off if any other agent had chosen a different action. . When there are multiple coordination equilibria, agents face an obvious coordination problem. The resolution of coordination problems rests upon individuals coming to understand the intentions of one another. The most explicit way of developing this understanding is for the individuals to communicate with one another. Common knowledge of a language must precede communication. Even with common knowledge of a language, individuals may not be bound to do what they say they will do. In such circumstances, talk is 'cheap'.

When will the receiver, having received a message from a sender, behave differently than the receiver would have behaved if no message had been sent? According to Farrell and Rubin (1996) *highly credible* messages will not be ignored. A message that signals an intention to take action X is highly credible if it satisfies two conditions: (1)*Self signaling* and (2) *Self-committing*. A message that the sender is taking action X is self-signaling if, and only if, it is both true and it is in the sender's interest to have it believed to be true. A message is self-committing if a belief by the receiver that the message is true creates an incentive for the sender to do what the sender said s/he would do. A message that is self-committing, if believed, will lead to an outcome that is a Nash Equilibrium. A message can be self-committing without being self-signaling. For example, in the classic game of Chicken if one player announces that he will be Passive, that message is self-committing since if it is believed the other player's best response is to be Aggressive, and the best response of the sender to the receiver's aggression is to be Passive. However, the sender would prefer to have the receiver believe that the sender will play Aggression. So, the message, "I intend to play Passive," is not self-signaling because it is not in the interest of the sender to have the receiver believe it is true.

A message is *cheap talk* if the sender is not bound to do what the message says. Crawford (1998) provides a survey of a number of cheap talk experiments. In experiments with structured communication, either only one player may send a message (one-sided communication), or more than one player can send a message. When the payoff functions of the players are symmetrical, one-sided communication breaks the symmetry of the game without communication. This is

sufficient to allow a very high level of coordination. Indeed, in such games one-sided communication is much more effective in promoting coordination that is simultaneous, two-sided communication. This suggests that when payoff functions are symmetric, but players have different preference orderings over equilibria, as in the Battle of the Sexes, the principal impact of one-sided communication is to create an extensive form game in which the symmetry is broken by designating one player as the first mover. In games with Pareto ordered equilibria communication is not needed to break symmetry, but may be effective in reducing uncertainty about the intentions or, in Crawford's terms, to give 'reassurance. Empirically this 'reassurance' appears to be most effective in achieving coordination on the Pareto dominant equilibrium when communication is two-sided, but even one-sided communication has a positive effect on the likelihood of achieving the Pareto Optimal outcome. Furthermore, this effect has been found to be greater when a message was self-signaling than when such a message was only self-committing.

When there are multiple players each player must be interested in, and possibly condition his actions on, the entire message profile. Therefore, the concepts of self-signaling and self-committing messages may not have much meaning in this context. Nevertheless, there is some evidence that costless pre-play communication can help groups whose members repeatedly interact to achieve more efficient outcomes than is attainable without such communication. Blume and Ortmann (2005)

Correlated Equilibria

A signal that is commonly observed may be used to coordinate actions even if the signal does not emanate from any of the players. Traffic signals play this role. We do as these signals say we should do because we believe that others will also do what the signals say they should do. This belief is reinforced by experience, so doing as the signals suggest has simply become a convention that is adopted by drivers. While this convention is backed by law, there is good reason to believe that it is so ingrained in people's expectations that they would continue to act as the signals suggest even in the absence of any law. Can signals be effective in coordinating actions when the signals are not sent by any of the players and do not themselves have any payoff consequences? Van Huyck et al(1992) found that when a game has multiple coordination equilibria, all of which yield the same payoff, a signal from an outside 'moderator' that specifically says "play a particular equilibrium" produces a very high degree of coordination on the suggested equilibrium, even though absent any signal there is a high frequency of coordination failure. However, in games where the equilibria are Pareto ordered the introduction of a recommendation to play any equilibrium other than the payoff dominant equilibrium significantly reduces the degree of coordination that is achieved. They also found that when there was an equilibrium that provided equal payoff a recommendation to play an equilibrium with unequal payoffs had little influence on how the game was played. Evidently, some features, such as symmetry, may be sufficiently strong focal points that the introduction of extrinsic signals may have little influence. Similarly, some features of a game may make some coordination equilibria, once achieved by repeated interaction, exceedingly difficult to displace through the introduction of communication, even if everyone would gain by moving to another coordination equilibrium. (Cooper (2006))

A ‘sunspot’ is a commonly observable event that may have been correlated in the past with different outcomes. For example, published forecasts may have this property. When agents coordinate their actions on a ‘sunspot’ the resulting equilibrium is called a ‘sunspot equilibrium’. Marimon et al (1993) devised an experiment to see whether they could generate a sunspot equilibrium where prices fluctuate with an extrinsic signal even though the fundamental parameter values remained fixed. During a ‘training interval’, the color of a blinking light on a screen was perfectly correlated with a change in a parameter that induced changes in equilibrium prices. After this ‘training period’ the parameter value was fixed, but the signal continued to vary according to the same process. Prices continued to be volatile but there was little evidence that the variation in the ‘sunspot’ variable had any effect on the observed price volatility. Duffy and Fisher (2005), using a quite different design, were able to induce ‘sunspot’ equilibria under restricted conditions. They found that the semantics of the ‘sunspot’ variable mattered. There were two fundamental equilibria in their design. One equilibrium had a high price, the other a low price. When the ‘sunspot’ message was either ‘high’ or ‘low’ the outcomes of the actions were sometimes correlated with the message. But when the message was either ‘sunshine’ or ‘rain’ this correlation was never observed. Evidently, correlation of expectations with the signal depends upon how confident people are that everyone is interpreting the signal in the same way. They also found that information that is generated by observable actions subsequent to the observation of the signal itself tends to diminish the focal power of the signal.

Sometimes actions might ‘speak’ louder than words. In a Prisoners’ Dilemma game the cooperative outcome is not a Nash Equilibrium, but it does Pareto dominate the Nash equilibrium. Since non-cooperation is a dominant strategy a message that one intends to play ‘Cooperate’ is neither self committing nor self signaling. Nevertheless, Duffy and Feltovich (2002) found that when this message was sent it tended to be truthful and also tended to induce a cooperative response. Similarly, when their past actions with other players were observable, subjects were more likely to cooperate than if neither communication nor observability was possible. Furthermore, observation increased the frequency of cooperative choices by more than cheap talk. This suggests that observability of past actions may sometimes be more effective than mere words in helping people achieve a good outcome.

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