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Organizational Languages

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ORGANIZATIONAL LANGUAGES

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ORGANIZATIONAL LANGUAGES

Abstract

The paper is concerned with communication within a team of players trying to coordinate in response to information dispersed among them. The problem is nontrivial because they cannot communicate all information instantaneously, but have to send longer or shorter sequences of messages, using coarse codes. We focus on the design of these codes and show that members may gain compatibility advantages by using identical codes, and that this can support the existence of several, more or less efficient, symmetric equilibria. Asymmetric equilibria exist if coordination across different sets of members is of differing importance, and fewer symmetric equilibria exist if the member's local environments are sufficiently heterogeneous. The results are consistent with the stylized fact that firms differ even within industries and that coordination between divisions is harder than coordination inside divisions.

I. INTRODUCTION

The paper explores the implications of coarse communication with individually constructed codes. This problem is most notably found in firms, but its properties are present in a great number of other situations of economic interest. Each member of a team has private knowledge about the state of his or her local environment, and the team needs at least some information from all members in order to coordinate. It is impossible to transmit all information (Polanyi, 1962; Simon, 1976, p. 238), so each member needs to design an ordered set of coarse categories – a code - for use in sending messages. The paper characterizes the set of codes that can be supported in equilibrium. Under reasonable assumptions, it is found that members may gain compatibility advantages by using identical codes, and this supports the existence of several more or less efficient equilibria. Asymmetric equilibria may exist if coordination across different subsets of members is of differing importance and fewer symmetric equilibria exist if the member's local environments are sufficiently heterogeneous.

More specifically, we are looking at a resource allocation problem in which each member of a team has a privately known valuation of the resource. Coordination takes the form of a decision made by the “Center”, which could be one of the team members, and communication takes place in a series of discrete rounds. The information cumulates such that more has been revealed in later rounds, and the process stops as soon as the Center knows enough to allocate the resource. A code defines a nested sequence of one-bit messages aimed at describing a member's valuation with increasing precision. Because delays are costly, the team is looking for codes that minimize the expected number of rounds of communication. We abstract from incentive conflicts and assume that each member is looking for a code that helps the team, given the codes used by other members. We get two results.

(1) Members may gain compatibility advantages by using identical codes, and this supports the existence of several more or less efficient equilibria.

It is important that the codes make identical partitions between possible values. For example, if there are four possible values and “low” means “one or two” from one member, but “one, two, or three” from another, the Center cannot order the values based on the message pair “high”, “low”. It is better if the two members use the same codes. This preference for compatibility supports even very inefficient symmetric equilibria. In fact, any element of a very large set of codes can be supported in a symmetric equilibrium.

(2) Asymmetric equilibria may exist if coordination across different sets of members is of differing importance, and fewer symmetric equilibria exist if the member’s local environments are sufficiently heterogeneous.

This moderates the first result in two directions. Suppose first that the team has two resources and two pairs of members. In the extreme situation where the objective is to allocate one resource to each pair, the games are separable, and any pair of sub-game equilibria form an equilibrium for the entire team. In less extreme situations, it is possible that only some asymmetric equilibria exist. Suppose next that the players’ local environments are very different. In such cases, a specific code may be differentially efficient for two players. In particular, along certain branches it may reveal a lot of information from one member and very little from another. Some such codes cannot be supported in symmetric equilibria.

The first result contributes to the economic theory of languages by illustrating that decentrally constructed languages, found as equilibria, can be quite different from those found by central optimization. The moderating results are of more applied interest and

helps explain why firms experience problems with inter-functional communication. We will briefly discuss the literature on each topic.

Economic arguments about efficiency and equilibrium seem well suited to investigate aspects of communication and language (Marschak, 1965; Rubinstein, 1998), and have in fact been applied to at least three other classes of questions in the area:

The most closely related works are concerned with finding the most efficient language for transmitting information. Dow (1991), Kofman and Ratliff (1996), Meyer (1991), and Shannon and Weaver (1949) search a class of codes for those that transmit most information given a limit on bits, and Ramey and Watson (1999) can be interpreted as being concerned with alternative codes and the constraints they impose on renegotiation. The papers in this stream are extremely heterogeneous, but all differ from the present paper by looking at languages as results of optimization problems. Parikh (1990) does use game theory, but rather than applying it to the relationship between multiple senders, he uses it to understand how a listener can extract information from the context in which a coded message is sent. The present paper contributes to this literature in two ways. First, it makes the point that there are compatibility advantages (beyond learning advantages) associated with different player's use of the same code. Second, it shows that, even in the absence of incentive conflicts, *it may matter a great deal whether a language is found by central optimization or as an equilibrium of a team theory problem or a game.*

On a more fundamental level, Blume (1999) and Rubinstein (1996) have used economic tools to study the structure of language itself. These issues do not come up in the present paper since we are concerned with messages along a single dimension.

There are finally a number of papers that ask how incentive constraints influence what actors will, and can, communicate. This includes mainly the cheap-talk literature. Most work on this question, both theoretical (Crawford and Sobel, 1982; Farrell, 1993; and Rabin and Sobel, 1996) and experimental (Blume, DeJong, Kim, and Sprinkle, 1998;

and Crawford, 1998) have focussed on the multiplicity of equilibrium codes. This multiplicity is, essentially, due to the fact that almost any agreed-upon set of messages can serve as conventions and coordinate actions. The model analyzed in the present paper also exhibits multiple equilibria, but informativeness matters. The multiplicity is due to the advantages of compatibility.

The second result is consistent with the sociological literature on problems with inter-functional communication in organizations, for example in the context of new product development in firms (Barley, 1983; Dougherty, 1992; Tushman, 1978). The design of a new product typically depends on information from several departments of the firm, in particular marketing, manufacturing, and R&D. A common problem is that the employees in these departments have trouble communicating because specialization has led them to use different “thought worlds” (Douglas, 1987). “A certain thought world is likely to best understand certain issues, but also to ignore information that may be essential to the total task”. It will “selectively filter information and insights” (Dougherty, 1992, p.182). For example, marketers may have a very nuanced understanding of consumer needs, but a rather coarse view of different technologies. As a result, messages from a marketer will be well understood by other marketers, but less so by members of the R&D department. Dougherty (1992, p. 180) quotes a technical director as saying “there are little shadings of meaning that gets lost in the requirements statement from marketing”. The present paper contributes to this literature by providing a theoretical explanation for several widely accepted stylized facts.

In the next section, we describe the basic model and demonstrate the existence of several symmetric equilibria. In Section III, we explore the limits of the result along two dimensions. We first introduce two classes of members and look at the tension between more efficient “intra-class” and “inter-class” coordination. Not surprisingly, it turns out that the tradeoff depends on the relative importance of the two types of coordination. We

next allow the members' local environments to differ. In such cases, some linear codes cannot be supported in symmetric equilibria, because they are differentially efficient along certain branches. The paper closes with a discussion of several broader implications in Section IV.

II. BASIC RESULT

We look at a resource allocation problem in which a team M wants to allocate a set of resources to that or those members for whom they have the highest value. Each member knows how valuable the resource is for him or her, but it is not possible to communicate the exact value instantly. Instead, the members communicate in rounds. In each round, some or all members send one-bit messages to a Center, and the process ends when the Center can identify the complete set of members for whom the resource is worth the most. Because delays are costly, the team is looking for codes that minimize the expected number of rounds of communication. We abstract from incentive conflicts and assume that each member is trying to use that code and send those messages that most help the Center draw the correct conclusions as fast as possible

To better explain the nature of codes and the communication process, we look at several examples.

First Example. In this example, the team has two members, A and B , and the resource is worth 1, 2, 3, or 4 to each of them. We will analyze the performance of a particular pair of codes. Specifically, A 's code calls for the first round message "low" when the resource is worth 1 to her, and "high" when it is worth 2, 3, or 4. If she said "high" in the first round, "low" in the second round means 2, while "high" means 3 or 4. After "high" and "high" in the first two rounds, "low" in the third round means 3. In contrast, B says "low" in the first round when the resource is worth 1 or 2 to him, and "high" when it is worth 3 or 4. After "low" in the first round, a second "low" means 1, while a "high"

means 2. After an initial “high”, “low” in the second round means 3. We will walk through several scenarios.

Scenario One: In the first round, *A* says “high” while *B* says “low”, so the Center knows that *A*’s value is 2, 3, or 4, while *B*’s is 1 or 2. Suppose now that *A*’s second round message is “low”, meaning 2 when *she* says it after a “high” in round one, and *B*’s second round message is “high”, meaning 2 when *he* says it after a “low” in round one. The Center now knows that the resource is worth the same to both members and the process can stop.

Scenario Two: Suppose that *A* and *B* say “low” and “high” respectively, in the first round. Under the assumed codes this means that the resource is worth 1 to *A* and 3 or 4 to *B*. So in this case the process can stop after one round.

Scenario Three: Suppose finally that both players say “low” in the first round, such that the Center can conclude that the resource is worth 1 to *A* and 1 or 2 to *B*. In the second round, *A* has nothing more to add. However, if *B* says “high”, meaning 2 when *he* says it after a “low” in the first round, the Center knows that the resource is worth more to *B* and the process can stop after two rounds.

Summary: As mentioned above, the performance of a set of codes is defined as the expected number of rounds the team needs to communicate before the Center has received enough information to identify that or those members for whom the resource is worth the most. To take the expectation, we need an assumption about the probabilities of the sixteen possible value realizations. Keeping things simple, we assume that all are equally likely. If, as in Scenario Two, *A* and *B*’s first round messages are “low” and “high”, respectively, the Center knows enough and the process stops after one round. There are two realizations in which this happens, corresponding to a probability of 2/16. In two other realizations, both initial messages are “low” and the process can stop after two rounds. There are six realizations in which the first round messages are “high” and “low”, and in all these the Center will know enough after the second round. The final six

realizations lead to “high”, high” in the first round, such that the Center knows that A ’s value is 2, 3, or 4, while B ’s value is 3 or 4. If both second round messages are “high”, the Center knows that B ’s value is 4 and that A ’s value is 3 or 4, necessitating a third round. In the other four realizations, the process can end after two rounds. In sum, the two codes in question yield a one round process with probability $2/16$, a two round process with probability $12/16$, and a three round process with probability $2/16$, for an expected performance index of 2.

Second Example. We continue to look at the same two members and the same sixteen equally likely realizations. However, we now assume that both A and B use the code employed by A in the First Example. That is, the code calls for the first round message “low” when the resource is worth 1 to the sender, and “high” when it is worth 2, 3, or 4. If the sender said “high” in the first round, “low” in the second round means 2, while “high” means 3 or 4. After “high” and “high” in the first two rounds, “low” in the third round means 3. As long as at least one of the members says “low” in the first round, the process can finish then. There are seven such realizations. Of the nine realizations where both say “high” in the first round, five can be terminated after two rounds, and four require a fourth round. So this combination of codes leads to an average of $25/16$ rounds of communication.

Third Example. Suppose finally that A and B both use the code employed by B in the First Example. That is, “low” means 1 or 2 in the first round, two “low”s mean 1, and two “high”s mean 4. Given this combination of codes, the process can end after one round in the eight realizations where the members start with different messages, and in the other eight it can end after two rounds. So this combination of codes leads to an average of $3/2$ rounds of communication.

Comparison. The examples illustrate the main result of the paper. In the Second and the Third Example, both members use the same code and that in the Third Example is more

efficient. However, as illustrated by the First Example, the team performs very poorly when the members use different codes.

Returning to the general analysis, we assume that the resource may have one of a finite number V possible values, $v_m \in \Omega = \{1, 2, \dots, V\}$, to each member. We initially assume that the values are distributed iid across members. A member's code can be represented by a sequence of nested bisections of Ω . A code is said to be *linear* if when $x_1 < x_2 < x_3$, and it sends the same message for x_1 and x_3 , then it also sends that message for x_2 . The Center knows the codes used by each player, and a set of $|M|$ codes is then said to be in *equilibrium* if no unilateral deviation gives the team higher expected performance. In a *symmetric equilibrium* all members use the same code.

Armed with these assumptions, we will show that any linear code can be sustained in symmetric equilibrium, and that no asymmetric equilibria exist.

Proposition: *When values are distributed iid across members, (i) any linear code can be sustained in a symmetric, strict equilibrium, and (ii) no asymmetric equilibria exist.*

Proof: (i). It suffices to look at a two-member team and consider a deviation by member B given that A uses the candidate equilibrium code C^* . We look at a branch in the last possible round of communication on which A is going to tell the Center whether v_a equals s or $s-1$. (If there is more than one such branch, the argument applies to each of them.) Since we have reached this branch, the Center already knows that v_a is neither greater than s nor smaller than $s-1$. The relevant question about the design of B 's code is what information is best delayed to this round. Given that we have reached this branch, there are three scenarios. (1) The Center knows that $v_b \leq s-1$, but not if v_b equals $s-1$ or $s-2$. Given that A plays C^* , the team can do better if B instead delays information about whether v_b equals s or $s-1$. The reason is that communication could have ended in the prior round if the Center had known that $v_b < s-1$. So the deviation leading to this scenario

decreases expected performance. (2) There is the analog case in which the Center knows that $v_b \geq s$, but not if v_b equals s or $s+1$. Given that A plays C^* , the team can do better if B instead delays information about whether v_b equals $s-1$ or s . The reason is again that communication could have ended in the prior round if the Center had known that $v_b > s$. So also the deviation leading to this scenario decreases expected performance. (3) There is finally the case in which the Center does not know if v_b equals $s-1$ or s , but this just means that B 's code is equivalent to C^* on this branch. So the team does strictly better if B 's code is equivalent to C^* in the last round.

We can then go to the second-to-last round and apply the same arguments as follows: Since we know that the best candidate deviation is equivalent to C^* in the last round, we can collapse a pair of states distinguished there to an individual state. So we define $S \equiv \{s-1, s\}$ and apply the argument to a problem with $\mathcal{Q}' = \{1, 2, \dots, s-2, S, s+1, \dots, V\}$. Continuing backwards, we find that any deviation that is not equivalent to C^* in all rounds is dominated by it.

(ii). If we flip the labels of B 's "candidate deviations" and "candidate equilibrium strategies", the above argument also proves that no asymmetric equilibria exist in teams with two members. For teams with more members, we again go to the last possible round of communication. Consider a scenario in which a number $a \geq 1$ members are going to tell the Center whether their values are s or $s-1$, while $b \geq 1$ members are going to tell the Center whether their values are s or $s+1$. If $a \geq b$, any one of the b members can improve payoffs by deviating to the strategy followed by the a , and if $a \leq b$, any one of the a members can do so. Also this argument then cascades backwards.

Q.E.D.

The implication of the Proposition is that the team prefers that all pairs of members use identical codes, even if decoding is not a problem. This then suggests a very strong

preference for compatibility over informativeness. There is an equilibrium in which all members use C^* , even if C^* is very uninformative.

III. EXTENSIONS

To explore the limits of parts (i) and (ii) of the Proposition, we extend the previous model in two different directions. We first look at situations in which both local and global maxima matter, and then at cases in which the probability distributions over values are not iid across members.

Existence of Asymmetric Equilibria When Both Local and Global Maxima Matter.

Unlike the team analyzed in Section II, many organizations are structured into subsets, divisions, and it is generally believed that there is more coordination inside a division than across divisional boundaries. In our context of resource allocation, one could imagine that two sets of resources mostly are earmarked for two different subgroups, corresponding perhaps to different classes of projects (such as new products versus cost reduction), and that the team only sometimes puts all resources in one subset. It seems reasonable to conjecture that the tendency to use identical codes will be weaker in such circumstances.

To look at this, we split the team into two subsets, N and $M \setminus N$, and use $R(X)$ to denote the expected number of rounds of communication required to find the highest valuing members in X . If α and β be nonnegative real numbers summing to at most 1, we assume that the team's objective is to minimize

$$\alpha R(N) + \beta R(M \setminus N) + (1 - \alpha - \beta) R(M).$$

With this formulation, it is easy to evaluate the implications of different relative importance of local and global maxima. If only global maxima matters

($\alpha=\beta=0$), the Proposition applies and all linear codes can be supported in symmetric equilibria. At the other end of the continuum, if only local maxima matters ($\alpha+\beta=1$), the problem decomposes and any pair of linear codes C^* , D^* can be sustained in an asymmetric, strict equilibrium in which members in N use C^* , while members in $M\setminus N$ use D^* . Perhaps more interestingly, *more weight on global maxima reduces the amount of asymmetry supportable in equilibrium*. We show this by Example.

Fourth Example. Suppose that the team has four members, A_1 and A_2 in N , and B_1 and B_2 in $M\setminus N$. Assuming that the resource is worth 1, 2, 3, or 4 to each of them, and that all realizations are equally likely, we look at two candidate equilibria.

First Candidate. A_1 and A_2 's code calls for the first round message "low" when the resource is worth 1 to them, and "high" when it is worth 2, 3, or 4. After "high" in the first round, "low" in the second round means 2, while "high" means 3 or 4. After "high" and "high" in the first two rounds, "low" in the third round means 3. Conversely, B_1 and B_2 's code calls for the first round message "high" when the resource is worth 4 to them, and "low" when it is worth 1, 2, or 3. After "low" in the first round, "high" in the second round means 3, while "low" means 1 or 2. After "low" and "low" in the first two rounds, "high" in the third round means 2. Given these codes, $R(N) = R(M\setminus N) = 29/16$, and $R(M) = 682/256$. As a possible deviation, suppose that A_2 deviates to the strategy pursued by B_1 and B_2 . In this case, $R(N) = 39/16$, $R(M\setminus N) = 29/16$, and $R(M) = 597/256$. So global

coordination is improved, but local coordination in N is less good. Depending on the values of α and β , this deviation may or may not be attractive.

Second Candidate. In this candidate, A_1 and A_2 follow the same code as above, but B_1 and B_2 's code calls for the first round message “high” when the resource is worth 3 or 4 to them, and “low” when it is worth 1, or 2. After “low” in the first round, “high” in the second round means 2, while “high” after “high” means 4. Given these codes, $R(N) = 29/16$, $R(M|N) = 24/16$, and $R(M) = 664/256$. As a possible deviation, suppose again that A_2 deviates to the strategy pursued by B_1 and B_2 . In this case, $R(N) = 34/16$, $R(M|N) = 24/16$, and $R(M) = 600/256$. So also here, global coordination is improved, but local coordination in N is less good. Furthermore, the values of α and β for which this deviation is attractive are different from those that rule out the first candidate equilibrium.

The example shows that the extent to which asymmetric equilibria exist depends on the relative importance of identifying both local and global maxima.

Non-Existence of Some Symmetric Equilibria With Heterogeneous Environments.

The model in Section II assumed that all members face probabilistically identical environments, but because of division of labor, this is clearly not the case in many real organizations. Heterogeneity of the members' environments can be expected to affect the relative efficiency of different codes, because little is gained by using rounds/bits on very unlikely realizations. In such cases some very inefficient linear codes cannot be supported in equilibrium. We also show this by example.

Fifth Example. There are two members, A and B , and the resource is worth 1, 2, 3, or 5 to A , and 1, 3, 4, or 5 to B , with all realizations being equally likely. Consider a candidate equilibrium in which both members say “low” in the first round when the resource is worth 1 to him or her, and other wise “high”. After “high” in the first round, “high” in the second round means 3 or more - implying that B ’s second round message is wasted. After “high” and “high” in the first two rounds, “high” in the third round means 4 or more. Finally, after three “high”s, a “high” in the fourth round means 5- implying that A ’s fourth round message is wasted. With these symmetric strategies, the expected number of rounds of communication is $33/16$. However, suppose that B changes his strategy as follows: If a “high” in the second round comes after a “high” in the first round, it means 4 or more; if it comes after a “low”, it means 3; and three “high”s in a row mean 5. In this case the expected number of rounds of communication is $31/16$, so the symmetric equilibrium proposed does not exist.

IV. CONCLUSION

We saw that an individual’s choice of code depends on a tradeoff between compatibility with the individual’s personal environment and the codes and environments of those with whom the individual wishes to communicate. This tradeoff can typically support the use of several more or less efficient sets of codes, and it means that teams in very heterogeneous environments may choose codes that prevent them from communicating.

The extensions present organizational languages as functions of the importance of inter-group coordination and the heterogeneity of local environments. Groups in different local environments may find it efficient to use different codes, even though this will hurt

coordination between the groups. If inter-group coordination is not too important, and the local environments are sufficiently different, the language barriers can be so large that meaningful communication is very costly. On the other hand, if inter-group coordination is important, the groups may facilitate communication by using the same code, although this may come at some expense to their local adaptation.

The importance of the results depends to a large extent on whether we can interpret firms as examples of the teams. Fortunately, a lot of literature supports the claim that there is more communication within, than between, firms. Most models in the information processing literature (Bolton and Dewatripont, 1994; Radner, 1992; Van Zandt and Radner, 2001) implicitly or explicitly define the firm by the flow of messages, and Wernerfelt (1997, 2001) provides a theoretical rationale for it. In particular, the latter paper compares game forms in which two players negotiate before and after possible communication. In the latter case, “the market”, players may refrain from communication because it can hurt their bargaining position. Finally, Simester and Knez (2002) and Tushman (1978) offer empirical evidence showing that there is more communication in firms than in markets.

If we therefore interpret the model as describing firms, the results are consistent with Arrow (1974, p. 56), Nelson and Winter (1982, p. 102) and Williamson (1975, p. 25), who argue that the use of different internal languages may be a source of long-lived differences between firms in the same industry. The fact that we found some very inefficient equilibria suggests the possibility of taking this argument further, linking the differences to enduring competitive advantages. (Of course, many other intra-firm coordination games will yield similar predictions and it is not clear that the code game is that most important factor.)

Another set of interesting implications follow from an interpretation of divisions of firms as examples of teams whose members face heterogeneous environments. The results seem to be consistent with a lot of common beliefs about the difficulties

associated with inter-functional coordination. One could imagine that these issues are particularly acute when two firms merge. Indeed, when the popular business press is discussing mergers, it often raises concerns about the ability of the merged entity to preserve the “cultures” of its constituent parts (Lewis, 1998). It may be possible to take this further and argue that difficulty of communicating about different environments can be a source of organizational diseconomies and thus play a role in determining the optimal scope of the firm.

A promising extension may be to look at models in which the team members have different roles. For example, one could more explicitly model coordination by assuming that all messages go to a central member, who then processes them and sends back instructions. If endowed with such features, the model could be used to compare alternative organizational designs in terms of the number of layers of management, spans of control, and the grouping of members. It would finally be interesting to imbed the model in a dynamic analysis of change from one equilibrium to another. What happens in a merger, and what can management do to implement, or move a firm to, more efficient sets of codes?

Direct empirical tests of the present model are likely to be difficult. A weakness of the language explanation is that it relies on a large number of small effects. For any given communication, the cost of saying more is very low and no single “misunderstanding” should have large expected economic consequences. The force of the theory rests on the premise that a very large number of very small effects may matter in the aggregate. On the other hand, it seems reasonable to conjecture that the model, with minor adjustments, could be interpreted as describing non-linguistic aspects of coordination. It could be seen as a very abstract model of what has been called “organizational culture” (Kreps, 1990) or “conventions” (Young, 1993). In these interpretations, the model may be easier to test and have a more compelling link to organizational performance.

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