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Understanding Leadership: A Coordination Theory

by
Nicolai J. Foss
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Nicolai Foss
RESPECT
Department of Industrial Economics and Strategy
Copenhagen Business School
Nansensgade 19,6
1366 Copenhagen K
Denmark
esnjf@cbs.dk

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Abstract
Important aspects of leadership behavior can be rendered intelligible through a focus on coordination games. The concept of common knowledge is shown to be particularly important to understanding leadership. Thus, leaders may establish common knowledge conditions and assist the coordination of strategies in this way, or make decisions in situations where coordination problems persist in spite of common knowledge.

Keywords
Game theory, management, organization

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M10, M12, M13

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Contents

Why are new strategic initiatives in organizations often communicated through large-scale gatherings where top-management through face-to-face contact addresses employees instead of relying on, for example, electronic mail? Why do many corporations spend enormous amounts of Dollars on an annual basis on flying in, for example, managers from foreign subsidiaries to tell them things in personal meetings with top-management that they could easily be told over the telephone, fax or e-mail? The answer that I provide in this paper is that these phenomena are representative of *leadership* designed to *coordinate* the interlocking actions of many people through the creation of what game theorists refer to as "*common knowledge*". Indeed, my overall claim is that leadership, coordination, and common knowledge are three closely related phenomena.

Leadership is an issue that is characterized by considerable terminological soup, differing interpretations, and lack of precision. Part of the confusion has to do with the fact that many disciplines have contributed to the study of leadership and that leadership behavior is manifest in many diverse social settings. It is therefore advisable to make explicit one's starting points with respect to what is meant by leadership. In this paper I define leadership as *the ability to resolve social dilemmas by influencing beliefs*. For some reasons, possibly having to do with his psychological make-up, the leader is able to spot and resolve social dilemmas by influencing beliefs more effectively than other people. This overall conceptualization arguably grasps much, if certainly not all, of what is meant by leadership, both in common parlance and in the scholarly literature.

In making explicit this insight, I use some simple, albeit abstract, ideas from game theory on how the *coordination* of beliefs (e.g., of people in an organization) may be accomplished. My aim is to apply, rather than develop, existing game theory ideas heuristically, rather than formally. Specifically, the overall claim that I shall develop is that a particular type of games – namely coordination games – are non-trivial, basic, but overlooked parables that are very useful for understanding leadership. Moreover, I claim that the notion of common knowledge is particularly helpful for understanding how leadership can make a difference with respect to the coordination of beliefs. An event is common knowledge among a group of players if each player knows it, each one knows that the other players know it, each player knows that other players know that the other players know it and so on.[1]

[1] For splendid non-technical discussions of common knowledge, see Geanakoplos (1992) and Bicchieri (1993). Common knowledge was introduced by Lewis (1969) and formalized by Aumann (1976).

Whether common knowledge obtains or not may make a crucial difference. In particular, this will be the case in organizations where there are interdependencies between people's actions (or "strategies", in game theory parlance) and where some concerted action needs to be undertaken, for example, in connection with a new strategic initiative. Generating common knowledge about the new strategic initiative through, for example, a big gathering produces a level of commitment and trust that cannot be easily produced through communicating individually over the e-mail or phone. In other words, it may make a difference that Jones knows that Smith knows that Jones knows ….. that X obtains, rather than simply having Jones and Smith knowing about X but not knowing that each other knows, etc.

In a setting in which there are interdependencies among strategies and obtaining common knowledge is important, the role of leaders is very much an *epistemic* one. Leaders may create a common knowledge condition where none existed previously. Alternatively, they may solve coordination problems that persist even in the presence of common knowledge. They do so through their superior ability to grasp and see through problems of social dilemmas, and they further coordination through symbolic and charismatic leadership that, in analytic terms, are often tantamount to creating a condition of common knowledge.

The design of the paper is the following. I begin with some rather basic game theory ideas. Even on an elementary level we can make the basic point that coordination games aren't trivial and that they are likely to capture the essence of a larger number of real-world situations than we normally acknowledge. Among other things, they are likely to help us gain an improved understanding of important aspects of leadership. I end with some discussion of issues, such as what is the relevance of the concept of common knowledge, what is the practical relevance of the distinction between cooperation and coordination games, etc.

SOME BASIC GAME THEORY IDEAS

Social Dilemmas in Social Science Research

That social dilemmas and leadership are somehow connected is not really a new recognition in social science research. At least, political scientists have often made the link explicit (Calvert 1992). Although they have had much to say about social dilemmas, economists have had less to say about leadership. In fact, in a recent contribution, political scientist Gary Miller (1992) urges economists of organization to take a closer look at what political scientists have to say about leadership. This is because much of the literature on political economy may serve both as an important bridge between the behavioral and the economics views of hierarchy and as a source of new insights. In spite of this, it is noteworthy that Miller's own treatment is strikingly economistic. Thus, he only discusses leadership in the context of the incentive conflict problems that are the main focus of interest in the mainstream economics literature on organization.[2]

The basic thrust of the economics of organization is to cast virtually *any* issue related to economic organization in terms of solving incentive-conflicts, presumably because it is believed that conflicts of interest are *necessary* ingredients in any sound theory of economic organization (Hart 1995; Williamson 1996).[3] To illustrate, the very few economic contributions that explicitly relate to leadership behavior are entirely consistent with this heuristic (Kreps 1990a; Miller 1992): Leaders exist because they resolve incentive conflicts. An example of the prevalence of this mindset is provided by a recent contribution to an organizational behavior journal (Murnighan 1994). The author provides rich references to, and summaries of, organizational behavior theory, but then goes on to argue that virtually all of the insights that he distills from this literature can be interpreted in terms of solving incentive conflicts of various types. One way of describing this mindset (rather, heuristic) is to say that the dominant gameform that economists of organization consider is some sort of

[2] The basic point in Miller (1992) is that hierarchies suffer from the same inefficiencies (though arguably to a smaller degree for some classes of transactions) that characterize markets, although – seemingly paradoxically – they arise to remedy market failure. Leadership in firms can make a difference by fostering play of "good" equilibria.

[3] "Any" should be taken quite literally. See Foss (1998) and Langlois and Foss (1998) for discussion and critiques of this heuristic in the context of strategy research and economics, respectively.

cooperation game. I consider this type of game next, and then turn to a brief description of coordination games.

Cooperation and Coordination Games

In a cooperation game the pay-off space of the game is such that at the efficient equilibrium any player has an incentive to change his behavior, given other players' behavior. Because of this feature, for any Nash equilibrium, there will be a combination of pure strategies that is (Pareto) superior. The key problem that such a game leads one to ponder is how to avoid the Pareto-inferior outcome. Matrix 1 is the paradigmatic example of a cooperation game, the famous prisoners' dilemma game.

Matrix 1

		B	
		Defect	Cooperate
A	Defect	2, 2	5, -2
	Cooperate	-2, 5	4, 4

Cooperation games are important – even dominant – ways of representing social interaction, particularly in economics and political science.[4] Indeed, economists – and certainly economists of organization – have until only taken an interest in cooperation problems to the exclusion of other types of games.

A manifestation of this is the lack of interest shown in *coordination games*. A coordination game is a game in which the pay-off space is such that at the equilibrium point(s), not only does no player have any incentive to (unilaterally) change his behavior (given the behavior of other players), but no players wishes any other player to (unilaterally) change his strategy as well. For example, the game in matrix 2 is a simple pure, symmetric coordination game,

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[4] As mentioned earlier, Miller's (1992) whole discussion of "managerial dilemmas" revolve around these, thus arguably only capturing a subset of the set of possible managerial dilemmas. In fact, a reviewer took Miller to task for failing to consider "... issues of communication, coordination, and decision costs ... In fact, coordination – even in teams with shared goals – is far from free and automatic, and managers spend large amounts of time attempting to achieve and maintain it ... The economic theory of organizations ought to reflect this" (Roberts 1994: 160).

[5] which illustrates, for example, issues such as which side of the road to drive in (or, which standard (among equally efficient ones) to choose, etc.).

Matrix 2

		B: Right	B: Left
A	Right	1, 1	0, 0
A	Left	0, 0	1, 1

Although there are no conflicts of interest in such a game, there is still a social dilemma: Should A and B play strategies (left, left) or (right, right)? Thus, the main problem that such a game leads one to ponder is how to coordinate on an equilibrium.

The Neglect of Coordination Problems

Much recent work in game theory has consisted in refining various equilibrium concepts (Fudenberg and Tirole 1995). In contrast, the basic issue of how players actually home in on a coordinated state has been offered less attention, although it may clearly often be problematical, as we have just seen. The neglect of the process of actually achieving equilibrium has for a long time been a standard charge against economics. Game theory seemingly "solves" this problem by appealing to pure ratiocination: Agents simply reason their way to equilibrium, as it were – a procedure expounded already by von Neumann and Morgenstern (1944: 146-148).[6] For example, they may successively eliminate those

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[5] In what is sometimes called an "impure" coordination game, the players do not have identical preferences over outcomes. An example is the so-called "battle of the sexes" game, which may be obtained, for example, by substituting the (1,1), (1,1) diagonal outcomes in matrix 2 with the outcomes (2,1), (1,2).

[6] Some justification for this was provided by Aumann (1974). He argued that if pre-play communication was allowed, but players couldn't commit to certain actions, they would only consider self-enforcing outcomes, that is, Nash equilibria, the basic reason being that no external enforcement was available. However, the basic justification for focusing on outcomes that are Nash still mostly proceeds in terms of pure ratiocination; there is an underlying assumption that players can coordinate their strategy choices on any desired equilibrium. See also Aumann and Brandenburger (1995) for a recent discussion of the "epistemic conditions for Nash equilibrium". The exception to this rationalistic approach is, of course, constituted by evolutionary

strategies that are "dominated" by other strategies (both for themselves and for other players), and in this way deduce what will be the equilibrium, provided that this elimination process is common knowledge among the agents.

The problem is that such a rationalistic approach often won't do. Thus, we may question the soundness of beginning from what is basically an existence claim, namely that *if* rational players have commonly known and identical beliefs about all other players' strategies, *then* those beliefs are consistent with some equilibrium in the game (cf. Hayek 1937). A problem is that nothing is said about the origin and formation of beliefs, and it is in principle possible that although there is an equilibrium in players' strategies, they may never be able to realize that equilibrium.[7] Nevertheless, most of today's game-theoretical analysis or organizational phenomena proceed on the assumption that players can choose the efficient game-form for regulating their trade and can also choose any desired equilibrium thereof.[8] Of course, this is a shortcut to what these writers want to do, namely to conceptualize various contractual arrangements as equilibria of some properly specified underlying games. Since it is the properties of these equilibria that are the focus of attention, the coordination issue is suppressed; agents are simply assumed to be able to directly choose and implement the desired equilibrium.

However, suppose a basic rationale of, for example, leadership or the firm is to make it *possible* for agents to coordinate on a preferred equilibrium that they were not able to reach (in a cost-effective manner) without the leader or the firm. This situation is not really conceivable in the modern economics of organization, essentially because it is defined away. Moreover, the portrayal of organizational phenomena in the game-theoretical economics of organization is surprisingly ill-defined. For example, in the work of Hart (1995), organization simply refers to the allocation of residual (ownership) rights to control -- and that's it. In the work of Williamson (1985, 1996), on the other hand, organization also

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game theory, which, in some interpretations, provide a justification for focusing on Nash equilibria (Weibull 1995).

[7] Clearly, simply proceeding by eliminating equilibria by means of various refinement procedures will not do; we still need to rationalize the emergence of beliefs that can sustain the final equilibrium.

[8] This is the case of the standard principal-agent type analysis of compensation schemes (Salanié 1997), for the analysis of implicit contracts in long-term relationships, and also for the incomplete contract type of concern with the sharing of joint surplus and how this influences the choice of ownership arrangements (Grossman and Hart 1986).

serves the role of alleviating bounds on rationality, and this is more like the direction in which I want to move in the following.

THE UBIQUITY OF COORDINATION PROBLEMS

The implicit attitude among most social scientists so far appear to have been that coordination games are inherently uninteresting.[9] The sources of this attitude are hard to trace, but the verdict issued in R. Duncan Luce and Howard Raiffa's (1957: 59) very influential book, *Games and Decisions* that at least in pure coordination games "everything is trivial" seems to be a likely source. In contrast to what may be called "the Luce and Raiffa legacy", I assert that coordination games – even pure ones –are not so trivial as they may appear at first glance. This is because the problems they portray, namely coordination problems, are both fundamental and ubiquitious. As we shall see, the attributes of non-triviality and fundamentality are interrelated.

Coordination Games are Non-Trivial

Coordination games are non-trivial in the sense that they may be seen as highlighting what players believe, in particular about each other, and how such beliefs may change. Such interactive epistemology can be quite complicated business (Lewis 1969; Kreps 1990b; Bicchieri 1993; Gilbert 1992; Colman 1998; Colman and Bacharach 1998). For example, questions such as, How do players come to know the structure of the game they are playing? Other players' strategies? Do players think other players will collaborate? What equilibrium will the other players play, if several equilibria are possible (as in matrix 1)? etc.[10] are not trivial ones. Some of them can't even be satisfactorily addressed within the confines of game theory. To illustrate, the "eliminating your way to equilibrium" procedure that was briefly mentioned above runs into problems in the case of symmetric coordination games. This is because in such games there are at least two equilibria where a player's strategy

[9] For example, it is only within the last decade that economists have begun to take an interest, notably in connection with learning behavior (Crawford and Haller 1990), the economics of conventions (e.g., Young 1996) and the adoption of standards (e.g., Witt 1997). Philosophers have taken an interest for a long time (Lewis 1969; Gilbert 1992).

[10] This does not mean that issues of belief dynamics, etc. are neglected in cooperation games; only that coordination games tend to more explicitly draw our attention to these issues. One may perhaps say that the basic question in cooperation games rather has to do with preferences (do players like to cooperate? Is this particular player a "sucker" or will he defect? Etc.).

choice is a unique best reply, provided that the other player anticipates it. To put it flatly, analyzing such games is challenging (Schelling 1960; Lewis 1969; Gilbert 1992).

Coordination Games Are Fundamental

In addition to being non-trivial, coordination games are fundamental, and they are so in different ways. This is because of the importance of coordination problems.

First, coordination problems are more *common* in social life – including organizational life – than arguably is commonly recognized. They are so, of course, in a commonsense way (where should we meet if he haven't agreed upon this already and aren't able to communicate? Who will call up again if we are cut off on the telephone? Etc.). But recent work in game theory has also revealed that coordination games emerge under a number of conditions, as soon as theorists begin to relax assumptions about what players know about each other and make games dynamic. In essence, there are at least three types of (interrelated) coordination problems that coordination games may give rise to, namely

1. The problem of coordinating on an equilibrium.
2. The problem of selecting among multiple equilibria.
3. The problem of moving away from an inferior equilibrium.

In the following I briefly discuss these three problems.

Coordinating on an equilibrium. This is the problem of rationalizing the formation of those beliefs that will make it possible for agents to realize an equilibrium. For example, how do agents come to hold beliefs that will sustain the (right, right) equilibrium in matrix 2? Until rather recently, this problem has been sidestepped, but some recent work on learning in games has explicitly addressed it. Thus, in an important paper, Crawford and Haller (1990) study how agents may learn to cooperate in the context of a repeated coordination game with imperfect information. The imperfection of information in the game they consider is a matter of strategic uncertainty, stemming from the presence of symmetric equilibria and the complete absence of any focal points. More specifically, how strategies are labeled, who may be a leader and who a follower, and the graphical structure of the pay-off matrix are not common knowledge. This implies that it becomes possible to completely eliminate any possible focal points based on the description of the game. In this setting, the only way in which players can communicate is through actually playing the

game. For example, players may (will) through play establish and use precedents to coordinate actions.[11]

Selecting among multiple equilibria. In game theory terms, social life is likely to instantiate multiple equilibria and selecting among equilibria is often a coordination problem. In fact, this equilibrium is often the fundamental problem that has to be resolved before the players can consider other problems on lower-levels, as it were. To make this poetry a little bit more specific, consider the game in matrix 3, where player A and B both have four available strategies (we don't have to bother about what exact they mean in the present context).

Matrix 3

		B			
		1	2	3	4
A	1	**4,4**	**1,5**	0,0	0,0
	2	**5,1**	**2,2**	0,0	0,0
	3	0,0	0,0	*4,4*	*1,5*
	4	0,0	0,0	*5,1*	*2,2*

This is a 4 x 4 coordination game which is basically composed of two identical 2 x 2 prisoners' dilemma sub-games (indicated by bold and italicized pay-offs, respectively). In order to home in on an equilibrium in this game (possibly through repeated plays), the players appear to have to somehow solve the coordination game first and afterwards communicate about which PD subgame to play. The problem is that classical game theory is not terribly helpful with respect to telling us how they will solve this problem.[12]

[11] However, as Crawford and Haller (1990: 584) conclude, this may also mean that "... it is sometimes optimal to forsake an efficient strategy combination forever in favor of an inefficient one that is less costly to locate; that it is sometimes optimal to use one coordination problem as a 'trial run' for another whose solution has a higher pay-off but is more costly to locate ... and that it is sometimes optimal to play dominated stage-game actions in early stages in the hope of generating a useful precedent".

[12] Theory tells us that when a (one-shot) game has multiple Nash equilibria in pure strategies, it often has a unique mixed strategy equilibrium (Nash 1951), so that there is not really a problem of equilibrium selection. But the basic problem why players should play mixed strategies, and why they come to

Moreover, the suggestions that the problem should be solved sequentially and that players should communicate are rather outside the normal static interpretation of a normal form game, such as the one in matrix 3, where the players make their choices simultaneously and there is no explicitly modeled stage in which they can communicate.

Moving away from an inferior equilibrium. If there are multiple equilibria, it may be possible to rank these, according to various criteria. Thus, let us suppose that for some reason or another, the players portrayed in the game in matrix 4 play the (1, 1) equilibrium (from now on I will simply label strategies with numbers).

Matrix 4

		B	
		1	2
A	1	1,1	0,0
	2	0,0	2,2

But isn't this against intuition? Isn't it obvious that rational players must coordinate on the (2,2) equilibrium, the "pay-off (and Pareto) dominant" outcome?. Closer inspection of the problem reveals that it is not necessarily so simple (Farrell 1988; Colman 1998; Colman and Bacharach 1998). The basic problem is that A appears to have no rational grounds for choosing the 2 strategy *in lieu* of grounds for believing that B will choose the 2 strategy, because if A would choose the 1 strategy, B would do better by also choosing the 1 strategy. Of course, B is in the same epistemic situation, and the reasoning process winds up in infinite regress. Pre-play communication (á la Aumann 1974) doesn't necessarily help, for how can one player be sure that the other player understood him? There still seems to be a problem of justifying beliefs. So how can we justify everybody's strong intuition – that the pay-off dominant outcome will in fact be chosen?

In a recent paper, Colman and Bacharach (1998) suggest that players may solve the problem by using something they call the "Stackelberg heuristic". Essentially, this heuristic works by

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randomize in particular ways (i.e. choose certain probabilities rather than other) is not really addressed. Moreover, if the players can somehow condition their strategies on outside information, such as conventions, the resulting Nash equilibria will Pareto-dominate the mixed strategy equilibrium.

letting agents mentally transform a normal form game to an extensive form game. Thus, they know that they will choose simultaneously but think *as if* they will choose sequentially. Specifically, player A will simulate the game by thinking of himself as moving first. Then B has to move with knowledge of A's choice, choosing a best reply meta-strategy, namely strategy 1 if A also chooses 1 and strategy 2 if A also chooses 2. Of course, the latter choice is best for A. Having performed this simulation, A, returning to the real game, chooses what is (in the mental simulation) the utility maximizing strategy provided that B responds with a best reply (namely strategy 2). Player B, performing the same simulation – *and this being common knowledge* –, makes the same choice.

Hierarchical Relations Among Interaction Problems

Coordination problems, such as the ones in the above, are a nuisance in the context of classic game theory. Nevertheless, they have a number of interesting implications. Notably, as a burgeoning literature has clarified they are very helpful indeed for understanding the nature of conventions (Lewis 1969; Young 1996). The suggestion I shall make is that they are also useful for understanding leadership, because leadership may often be a low cost alternative to costly and lengthy convention formation. Before we can develop this point, it is instructive to look into a feature suggested by the above analysis, namely the hierarchical relations that often obtain between interaction problems.

To begin with, note that coordination problems are often more fundamental than cooperation problems, in the sense that they often, in a loose sense, come prior to cooperation games.[13] For example, people engaged in a business relationship have to solve the basic coordination problem of how to communicate before they can engage in the various conflicts that so enamor organizational economists. Such a hierarchical relation is indicated by the game in matrix 3: In a sense, there is a hierarchical quality to the process of interaction among A and B in this game. Although there is common knowledge, the players somehow – through

[13] In an often quoted critique of game theory explanations of the emergence of conventions and norms from an institution'less "state of nature" (as in Schotter 1981), Field (1984) argued that a basic problem with these stories is that they already implicitly presuppose the existence of all sorts of backgrounds institutions (e.g., some shared ways of categorizing events, i.e. languages). While entering this debate may appear rather unproductive – since the focus on the temporal aspects of institution formation can lead the whole discussion to unwind in infinite regress – a more constructive angle may be obtained by shifting the focus somewhat from the temporal sequence of institutions to their *hierarchical* relations. Thus, one recognizes that some institutions are simply more fundamental than others and define the interstices within which other institutions emerge, change and possibly disappear.

communication, mediation or repeated plays – have to agree on which sub-game to play. We may say that the overall coordination game is more fundamental than the cooperation sub-games.

A somewhat related example occurs in connection with iterated games with incomplete information. Such games are likely to have multiple equilibria. This means that there will be many different ways of motivating cooperation. Notably there may be many different ways of structuring retaliation schemes. However, the problem of choosing one such way – that is, make players coordinate on a specific equilibrium – is fundamentally a coordination problem.[14]

As a third example, consider the Crawford and Haller (1990) paper that was mentioned earlier. The bottomline of their analysis is that some sort of convention -- or focal point – has to be in place before successful coordination can take place, but that it will (in their analysis) nevertheless emerge from repeated play and produce optimal subgame perfect equilibria. Players must, as it were, coordinate on something on a higher level before they can coordinate on a lower level.

Summing Up

The preceding discussion suggests, even if it doesn't prove, the ubiquity of coordination problems as well as their fundamental nature. Alhough I don't want to put this forward as a general proposition, coordination problems often appear to be more fundamental in the sense that solutions to high-level coordination problem appear to select lower-level games, strategies or equilibria in a large number of situations.[15] For example, the phenomenon of framing, or focal points, or salience, essentially means that some higher-level conventions constitute a shared language that help to select, for example, certain equilibria, whose selection may not be readily apparent to an uninformed observer. We may say that such

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[14] Along related lines Calvert (1995: 243) argues that "... a well-developed theory of coordination games is necessary not just to understand institutions that function primarily to organize effort or to set standards, but more importantly to help us understand the emergence and design of institutions, and the conduct and maintenance of nearly any institution to foster cooperative behavior".

[15] The idea in the evolutionary theory of the firm (Nelson and Winter 1982) that "routines" and "capabilities" are hierarchically layered express a closely related idea. Thus, a hierarchy of routines may be seen as a hierarchy of conventions that solve hierarchically arranged coordination problems.

conventions solve fundamental coordination problems that logically have to be solved before less fundamental problems of interaction can be solved.

In such a reading, the class of less fundamental problems of interaction may include the set of cooperation problems conventionally studied in the economics of organization. These often involve some sort of cooperation game in an extremely stylized setting with perfectly defined sets of strategies and players, well-defined pay-offs, unique equilibria, etc. The fundamental interaction problems – such as finding out what are the available strategies and who are the players and agreeing on this[16] – have already been solved. In the view taken here, sidestepping fundamental coordination problems means that only some part of the leadership phenomenon is comprehensible.

LEADERSHIP: A COORDINATION PERSPECTIVE

A fundamental claim in this paper is that the phenomenon of leadership is intimately connected to coordination problems and that leadership is a higher level coordinative mechanism that allows coordination on lower levels to take place.[17] For example, leadership may effectively establish a situation of common knowledge that assists the coordination of strategies, or it may break the stalemate in situations where a coordination problem persists even in the presence of common knowledge. It is this overall claim that will be developed in the following.

The Need for Leadership

In much of the organization theory literature, it is held that the essence of organization is coordinated response to volatility, for example, in technologies or preferences (Thompson 1967). Obviously, management and leadership have key roles here, for some volatility cannot be handled by organizational routine but requires judgment and decision. In terms of game theory, players need to change strategies; old conventions for how to play a given game may become obsolete; or the whole game may have to be redefined. This is perhaps not completely neglected, but certainly not offered much attention in the game theoretic

[16] In practice, this may amount to communicating and making sure that other players agree on a business conception. See Witt (1998) for an analysis of this.

[17] I shall neglect various problems of weakness of will, the control of procastination, etc. as bases for understanding leadership and management (these are treated by Lippman and Rumelt 1992 and Rumelt 1995).

economics of organization, where leadership (and management) usually reduces to sophisticated versions of establishing incentive-alignment (Kreps 1990a; Miller 1992).[18] But surely there is much more to it than this. With respect to management, a classic work on the nature of managerial work, Mintzberg (1973: 5), lists six

> ... basic reasons why organizations need managers: 1. The prime purpose of the manager is to ensure that his organization serves its basic purpose ... 2. The manager must design and maintain the stability of his organization's operations ... 3. The manager must take charge of his organization's strategy-making system, and therein adapt his organization in a controlled way to its changing environment ... 4. The manager must ensure that his organization serves the ends of those persons who control it ... 5. The manager must serve as the key informational link between his organization and its environment ... 6. As formal authority, the manager is responsible for the operating of his organization's status system.

On the face of it, much of this sounds largely consistent with the basic thrust of the economics of organization: It is indeed possible to cast virtually all of the above six points in terms of monitoring and the alignment of incentives. However, if one reads Mintzberg's own further detailing of what the six points actually mean and imply, the economistic interpretation seems rather misplaced. For the production of "values" and "atmosphere" through "directing", disseminating information, and acting as "spokesman", "negotiator", and "figurehead" are what lies behind the above managerial roles.

These more symbolic and cognitive aspects become even more pronounced if one turns to the large and confusing literature on leadership in organizations (e.g., Vecchio 1997; Conger and Canungo 1998). Much of this literature insists on a categorial distinction between management and leadership. If one considers some of the usual understandings of leadership, this seems to be misplaced; rather, the distinction between management and leadership is one of degree than of kind. Thus, in the context of firms, the leader is conventionally seen as planning strategy, changing standard practice, creating vision and meaning for the organization, and inducing changes in values, attitudes and behavior, for

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[18] However, the emphasis in the incomplete contracts literature on residual rights as rights to decide asset use under contractually unspecified circumstances may open a window for a (limited) theory of management. For example, ownership rights may be though of as conventions with respect to who should decide in situtions that would otherwise introduce coordination problems.

example, using his own personal example, etc. (e.g., Vecchio 1997; Conger and Kanungo 1997). While it is certainly possible to provide interpretations of the managerial role from the point of view of economics, it would seem to be hard to come to grips with the cognitive and entrepreneurial aspects of leadership in particular. What is meant, for example, by "creating vision and meaning", "changing standard practice", etc.? In the following, I suggest that the basic game theory ideas that I have just discussed may be helpful for conceptualizing and understanding such questions and may provide some answers.

Leadership Behavior and Coordination Problems: Some Hints

More specifically, the claim here is that we can use basic ideas from work on coordination games to cast some light over the phenomena of leadership and management. This was actually anticipated in the classic work of Schelling (1960), whose idea of focal points has been widely appreciated and utilized in the analysis of institutional and cultural phenomena (notably by Kreps 1990a). However, much less notice has been paid to his discussion of the "mediator" (Schelling 1960: 144), and the observation that

> … a mediator can do more than simply constrain communications – putting limits on the order of offers, counter-offers, and so forth – since he can invent contextual material of his own and make potent suggestions. That is, he can influence … expectations on his own initiative … When there is no apparent point for agreement, he can create one by his power to make a dramatic suggestion.

Acting as a "mediator" (perhaps too weak a word) in the way described by Schelling certainly captures an aspect of what leadership means, and arguably an important one.

Another hint can be found in the equally classic work of Polanyi (1958). As he pointed out (1958: 224), submitting to leadership may itself be a coordination problem:

> If, in a group of men each believes that all the others will obey the commands of a person claiming to be their common superior, all will obey this person as their superior … [A]ll are forced to obey by the mere supposition of the others' continued obedience, without any voluntary support being given to the superior by any member of the group.

In order to influence the sub-ordinates' beliefs and thus ease the process of obeying to his authority, the leader must establish the knowledge among his subordinates that they all expect each other to obey and that they all know this – in short, he must establish a condition of *common knowledge*. In practice, this takes the form of numerous social practices -- such as morning meetings, rituals and ceremonies of various types, story-telling and much else – which typically require that all concerned players are involved and that direct interaction and observation are made possible.

A third hint is supplied by Farrell's (1988) discussion of pre-play communication in connection with coordination games, and his introduction of a "speaker". This is an agent who

> ... can make a *suggestion* about what players should do in the second stage [after communication]. A suggestion is a list specifying, for each player i, a non-empty subset T_i of i's (mixed) strategy space S_i. We can interpret this as a 'speech' proposing (precisely or vaguely) how everyone should behave in G [the second stage game]. If this speech is credible, we want to assume that everyone believes it; this is the link between words and action (p.210-11).

The reason why such a speaker may be necessary is that otherwise the players may run into the dilemmas associated with the analyses of matrix 2, 3 and 4 above. Is it too far-fetched to associate the making of "suggestions" in the first-stage game with the role of leadership? Perhaps; but the point here is that *somebody* has to "lead"– even in extremely simplified settings.[19] Notice also the point Farrell makes that "… [i]f this speech is credible, we want to assume that everyone believes it". Effectively, this is again a matter of establishing a condition of common knowledge. It is time to go somewhat more into the apparent relation between leadership and common knowledge.

Leadership and Common Knowledge

Why do we need leadership in coordination problem situations? Obviously, it may be objected that agents can simply communicate about which strategies to choose, also in larger-scale settings. Apart from the obvious counter-argument that it is costly to communicate and that leadership may be a low-cost method of coordination, this argument

[19] So that the relevant coordination game may be a three-stage game, with an additional "picking the communicator" first stage. In actuality, a part of the role of organizations is to provide solutions to this first stage of the game.

runs into deeper problems relating to common knowledge. For example, one agent may send an e-mail message to other agents, saying "Let us all coordinate on strategy x!". But obviously, this is not sufficient to make that message common knowledge – and full common knowledge is sometimes necessary to guarantee coordination.

The electronic mail game. To see this, consider the modified version of Rubinstein's (1989) "electronic mail game" in matrix 5a and 5b below:

Matrix 5a

		B	
		1	2
A	1	4, 4	0, -2
	2	-2, 0	2, 2

Matrix 5b

		B	
		1	2
A	1	2,2	0, -2
	2	-2, 0	4, 4

In this setting agents A and B have to choose between two strategies, 1 and 2 (the latter being risky because of its possible negative pay-offs). There are two possible states of nature, a, occurring with probability 1-p (matrix 5a), and b, occurring with probability p (matrix 5b). Of course, if the state of nature is common knowledge, coordinating on the desired equilibrium (4,4) would seem to be straightforward.[20] Not so if what Rubinstein calls "almost common knowledge" obtains, that is, if only a finite (but possibly very large) number of propositions of the sort "A knows that B knows that A knows ... that the state x (a or b) obtains" are true. Effectively, this situation implies that the game becomes one of incomplete information, *although* the players are allowed to communicate.[21]

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[20] As we have seen even, this intuition is in fact not so obvious.

[21] To illustrate the game, Rubinstein imagines two players that are physically separate, but can communicate over electronic mail. However, there is a small probability that a given message may never receive one of the players (this means that the number of exchanged messages is finite, so that common knowledge doesn't obtain) . On the other hand, if indeed a message is received, the receiving computer confirms to the sending computer that the message has been received, in a way so that confirmations are also confirmed,etc. More specifically, it is assumed that the state of nature is known initially only to player A, and that if this state is b, A will communite this to B (whose computer will confirm, leading A's computer to confirm, etc.). Of course, if a message doesn't arrive, there cannot be any communication. Also, if the state of nature is a, no message is sent from A to B. After communication, the players face uncertainty in their strategy choice. For example, given that A sent n messages, he does not know whether B got the n'th message or whether B got it, but the n'th confirmation got lost.

Rubinstein now proves that the uncertainty caused by incomplete information implies that under almost common knowledge, there is actually only *one* Nash equilibrium in the game, namely where the players play strategy 1 independently of the number of messages sent. Thus, there is no "convergence" to the common knowledge situation, where the players will play 2 if state b obtains. Clearly, the agents would have preferred a common knowledge situation to obtain, since this would have allowed them to coordinate on better equilibria (choose strategy 2 instead of 1 when state b obtains). They would have been better off if some mechanism could somehow throw a condition of common knowledge into their game.

Electronic mail games in organizations. In organizations, that mechanism is likely to take the form of leadership. Situations that are reminiscent of the electronic mail game may be represented by problems of coordinating in an administrative hierarchy: If senior management's strategic plan calls for new initiatives if certain conditions obtain and these new initiatives require inter-departmental coordination, what should division managers do? Moving first may be costly, but communication regarding concerted action will not lead to common knowledge. Depending on specific assumptions about the probabilities of other division managers moving first, the character of the communication channels, etc. all sorts of equilibria may be generated, including the equilibrium where nobody moves at all. Top-management may circumvent these processes simply by ordering *all* division managers to show up at a particular place and date, communicate their new initiatives and make sure that all division managers publicly and explicitly agree on coordinating their actions. This helps establishing the required condition of common knowledge. This suggest a first proposition about leadership:

Proposition 1: *Leadership is a method of transforming "almost common knowledge" conditions to "common knowledge" conditions.*

Thus, leadership is not here taken to be a matter of influencing preferences (as in Miller 1992), but a matter of influencing beliefs. In terms of the distinction made earlier between the sub-problems of 1) coordinating on an equilibrium, 2) selecting among multiple equilibria, and 3) moving away from an inferior equilibrium, leadership according to proposition 1 may alleviate problems of the third type, since it is precisely the change in common knowledge conditions that allow the players to avoid getting stuck with an inferior

equilibrium. It is also possible to link the analysis of leadership with the other sub-problems.

Leadership and equilibrium selection. As a starting point we may observe that common knowledge does not necessarily solve all problems. For example, if the relevant coordination problem can be portrayed as a symmetric coordination game (as in matrix 2), common knowledge does not necessarily help much. There is a problem of equilibrium selection. Of course, the world of managers and leaders is not a world of simple two-strategies, two-players coordination games without state-dependent uncertainty. The ongoing interactions of real life cannot be generally thought of as simple repeated games. Very little is actually known from a scientific point of view about realistic large-scale games with, for example, imperfect recall, state-contingent uncertainty, the occurrence of novelties (new strategies may for some reason become available, new players may unexpectedly join the game(s), etc.), costly communication, etc.

What *is* known is simply that it is likely to be a mess: players have incomplete information (or none at all) about other players, available strategies, previous plays, etc., and games will have to be re-defined and played anew. In a large scale game, the identity and reputation of players are likely to matter relatively little, so that – if the game is a large scale PD game – defection is likely not to be noticed and have consequences.[22] Individual belief formation can only proceed from simply extrapolating the current aggregate behavior of the population. There is not likely to be an exact (if any) correspondence between players, strategies and outcomes in various "repetitions" of "the game". More specifically, there are likely to be multiple equilibria. The problem is that, unfortunately, behavior that is appropriate for play in one equilibrium may be inappropriate for another equilibrium; equilibrium strategies are (generally) not interchangeable. The problem of selecting the right equilibrium is clearly a higher-order coordination problem – one that provides ample room for communication, leadership and other ways of influencing beliefs.

Proposition 2: *Leadership is a method of equilibrium selection. It may be a preferred method, even under common knowledge conditions.*

Leadership and reaching an equilibrium. A third coordination problem may be represented as the problem of reaching an equilibrium point in a coordination games. As we

[22] However, it is not clear how much this matters in reality, since people don't always defect in one-shot PD situations with anonymous others.

have seen, this is often not trivial. For example, Colman and Bacharach (1998) argue that complicated reasoning processes on the part of players are involved. And Crawford and Haller (1990) point out that coordination in simple symmetric coordination games will indeed take place, but only after false starts, trials and errors, etc. Finally, the classic work of Schelling (1960) suggests that the presence of focal points may help reaching an equilibrium. These contributions, too, make clear the connection between coordination and common knowledge. For example, it is because the Stackelberg heuristic of Colman and Bacharach (1998) (more about which in a second), or the focal points of Schelling (1960) and Crawford and Haller (1990) are common knowledge that the players can coordinate on an equilibrium. However, these contributions may also point to a need for leadership. Consider, for example, the Colman and Bacharach (1998) model.

Stackelberg games are often thought of as games with leadership, and in the Colman and Bacharach model no player is, strictly speaking, a leader; the Stackelberg element is introduced by thinking of oneself as a Stackelberg leader. However, we may find room for genuine leadership if we provide a realistic *interpretation* of the fundamental *assumption* in the model that any conclusion about which strategy to play reached by player A will be perfectly anticipated by player B, and *vice versa*. This assumption may make sense for small groups characterized by a long time of interaction. But in larger scale settings with less of a history of interaction, players may not have such an easy time performing the Stackelberg heuristic.[23] In such situations, it may make sense to condition one's strategy choices on the choices of one particular player – who will be, in a sense, a leader. Of course, this involves the problem of how that particular agent acquired his leadership status, but sometimes this is unimportant; what matters is simply that somebody for whatever reason is ascribed leadership status. This leads to our third proposition.

Proposition 3: *Leadership may be a method of reaching equilibrium that is less costly than complicated mental reasoning processes (á la the Stackelberg heuristic) or the formation of conventions (focal points).*

[23] Also, the Stackelberg heuristic will obviously not be helpful to players that are caught in symmetric coordination games.

DISCUSSION

There are many unsettled issues that emerge from or are relevant to the preceding discussion. For example, how practically relevant is the theoretically important notion of common knowledge? How does this relate to the understanding of strategy and organization? In this section, I briefly discuss a few pertinent issues.

Common Knowledge

The theory of leadership that has been sketched in the preceding pages relies on the notion of common knowledge But since common knowledge involves infinite sentences of the type "A knows that B knows that A knows ….. that X", aren't we dealing here with an utterly unrealistic assumption? Already Lewis (1969: 52) discussed this problem and there is a small literature on it.[24] The solution to the problem is to not actually think of common knowledge as involving ever-ascending processes of reasoning, but rather as something that players recognize heuristically.[25] For example, if players have a history of interaction, this may be sufficient to allow them to circumvent the infinite processes of reasoning involved in the common knowledge assumptions. Specifically, from the body language of the other players or through eye contact, etc., they may conclude on the basis of their earlier history of interaction that common knowledge is being formed. Hence, the importance of face to face contact in the examples with which I began this paper.

Game Theory's Extreme Assumptions

Admittedly, common knowledge may be an extreme assumption, if only because it is hard to connect to real life thought processes. But game theory makes other extreme assumptions. For example, bounded rationality is (largely) neglected and game theory generally proceeds on an assumption of ultra-rationality, a fact which has caused Radner (1996) (among others) to question whether game theory is useful at all for the study of management.

The critical angle here is somewhat different from the bounded rationality point. The claim is that the inability to come to grips with leadership and management in much of the

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[24] For example, see the symposium on common knowledge in *Journal of Economic Perspectives*, vol. 6, no. 4.

[25] More precisely, this is one possible solution. Aumann (1976) presents a formal solution to the problem that an infinite number of conditions must be checked to verify that an event is common knowledge. In essence, he shows that there is a definition of common knowledge that can be verified in a finite number of steps, provided that the set of states ofthe world is finite.

economics of organization literature is not so much caused by the reliance on game theory's strong claims about the epistemic powers of individuals (which anyway doesn't eliminate all coordination problem). The point is rather that this is caused by the fact that the literature not only neglects coordination games in favor of a near-exclusive concern with cooperation games, but also neglects what I have loosely talked about as the hierarchical character of various types of interaction problems.

Cooperation and Coordination, or Preferences and Beliefs

In this paper, the focus is on beliefs rather than on preferences, and on the leader as somebody who influences the formation of beliefs. Nevertheless, the two views are clearly rated. The so-called "Folk Theorem" tells us that multiple equilibria may arise from repeated cooperation games. This suggests that there may be a need for some agent to pick some equilibrium for the rest. A somewhat different angle is by taking seriously the idea that the leader influences preferences *first*, and *then* influences beliefs so that a coordinated outcome can be realized (i.e., again we have a hierarchy of interaction problems). Thus, suppose that at the outset, the leader confronts a combined coordination-PD game (such as in matrix 3). Focus on the PD subgame, and assume that it can be represented as in matrix 6a.

Matrix 6a

		B	
		1	2
A	1	α, α	δ, θ
	2	θ, δ	β, β

Matrix 6b

		B	
		1	2
A	1	α, α	$\delta + y\theta, \theta$
	2	$\theta, \delta + y\theta$	$\beta + y\beta, \beta + y\beta$

In this game, $\theta < \alpha < \beta < \delta$. Suppose now that charismatic leadership (Conger and Canungo 1998) somehow succeeds in influencing preferences towards generalized "niceness" in the organization (i.e., player A and B), so that the players get utility from reciprocating niceness (captured by the $y\beta$ term), as in matrix 4b.[26] In this setting,

[26] They also get utility from reciprocating meanness (represented by $y\theta$).

cooperation will be chosen when $y > (\delta + \beta) / (\beta - \theta)$ (Rabin 1993). Then the game is basically a coordination game, possibly with the same need for (further) leadership action that has been discussed in this paper.

Practical Relevance

The modern economics of organization may arguably have had an impact on managerial practice already. For example, Milgrom and Roberts (1992), a basic organizational economics textbook, enjoys great use in many business school. From a managerial point of view, organizational economists' neglect of coordination problems is problematic. For while managing may be about monitoring and changing preferences, so that "nice" equilibria of cooperation games can be reached, management – and leadership even more markedly – is surely also about influencing agents' beliefs. The practical management and leadership issue may often not be so much a matter of realizing the Pareto dominant equilibrium in PD games through incentive schemes and monitoring, as it is a matter of influencing what agents' think about each others' capabilities, plan, expectations, etc. – the issues under consideration in this paper. Furthermore, the practical importance of the distinction between cooperation and coordination problems is that it may be much harder to solve the former than to solver the latter. Thus, much psychological research suggests that incentive compensation and monitoring in some work contexts may have perverse effects (Frey 1997) – but we can be pretty certain that coordinating actions, plans, expectations, etc. lead to better results.[27]

Grown Conventions and Conscious Leadership

One final issue that warrants some further speculation is the distinction between spontaneously grown conventions as solutions to coordination games (Schotter 1981; Hayek 1973) and some sort of direct intervention, in the form of the exercise of leadership. In fact, since a now standard way to approach the emergence of conventions is through repeated coordination games (Young 1996), it may appear somewhat paradoxical to find a rationale for a phenomenon that is directly opposed to spontaneous coordination, namely leadership, in the very same type of problems that conventions are conventionally taken solve.

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[27] Indeed, economists routinely tend to *define* coordination as "an improvement in resource allocation".

I have earlier argued that it often makes sense to think of social interaction problems as hierarchically arranged, and that the corresponding solutions to such interaction problems may also have a hierarchical relation. This suggests one way of partly resolving the paradox. Thus, conventions and directions may form complex hierarchical relations, where, for example, managerial direction is bound by conventions that can be seen as having been established in earlier games between management and employees. Or, top-management may act so as to break sub-optimal lower-level conventions, and move the game to a better equilibrium.

This can, however, only be a partial solution to the spontaneous convention vs direction paradox, for problems that were once best solved through explicit direction may become familiar problems that are best solved through conventions. This is part of the idea behind "routinization" in organizations (Nelson and Winter 1982). Similarly, once-efficient conventions may become organizational liabilities, as preferences and technologies change, and managerial action may be required to break these sort of organizational rigidities. So we need to consider what will determine whether a given coordination problem is solved by means of spontaneous formation of conventions or through conscious leadership. Several circumstances appear to influence this.

The number of players. Intuitively, the larger this number becomes the more likely is the convention solution to succeed relative to the direction solution (Hayek 1973), although even here it is not possible to generalize completely (cf. war effort).

The number of plays of the game. Most models of convention formation build on a large number of repetitions of very simple games (Young 1996). As I have argued, in real life games are not that simple and the same game is unlikely to be played for a long time. However, because of their relative social closure (so that players are not anonymous), repetitions of the same game are more likely to take place inside firms than in market relations.

The leader/manager's understanding of the game. For example, does he know which equilibria can be reached? Is he able to identify the efficient equilibrium(bria)? In most of the preceding discussion, it has implicitly been assumed that the leader has at least the same knowledge of the game and sometimes more. This is not so unrealistic as it may sound. In fact, the ability to glimpse or intuitively judge what is the "true" structure of a situation (say, an ongoing battle) and take action on the basis of that judgment is traditionally how great political and military leadership is characterized.

The costs of communicating. If communication is very costly, conventions may be a low cost method of achieving coordination. Thus, one may conjecture that as the size of the group grows, conventions will increasingly substitute for leadership *ceteris paribus*. However, to my knowledge this has not been thoroughly reseached.

The leader's motivation. So far, I have tacitly assumed that the leader is a sort of benevolent *deus ex machina*, who spots and resolves social dilemmas in the form of coordination problems. But leaders, too, need to be motivated and awarded. One obvious take on this issue is that the leader's activities are value-creating: By making players change their strategies, he moves them towards better equilibria and in this way creates value. He can be paid out of this extra value, and this entrepreneurial return may be seen as his material rewards. Of course, many leaders are likely to be motivated by much less materially oriented rewards; for example, the exercise of leadership may be what counts for the leader.

The importance of quickly solving the coordination problem. If solving the coordination problem quickly is a major issue, the slow process of convention formation may be inferior relative to direct intervention. In many business contexts, the opportunity costs of convention formation are likely to be prohibitive.

CONCLUSIONS

This paper has had an explorative, yet ambitious agenda. On the overall level, it has been suggested that coordination games carries important lessons for the study of organizational phenomena, particularly the leadership. Thus, coordination games appear to be emerge under a number of circumstances, and, contrary to widespread belief, the study of coordination games is neither trivial nor unimportant.

Admittedly, the ideas that have been loosely sketched in the preceding pages only capture some aspects of leadership behavior. But it is often productive to tell admittedly partial stories, simply because they have not been told earlier. Thus, the application of basic game theory ideas of the sort sketched out here is, I believe, novel. Note also that the story in this paper is quite different from the main thrust of today's economics of organization, since they break with the dominant heuristic of reducing all phenomena to issues turning on the efficient alignment of incentives. It is perhaps more related to ideas in team-theory (Casson

1994; Radner 1996) and to recent ideas in the evolutionary/capabilities/ressource-based theory of the firm (e.g., Nelson and Winter 1982; Demsetz 1988; Foss 1993).

Combining the ideas in this paper with issues relating to the theory of the firm requires much additional work, for example, on communication costs (Segal 1996). Also, the connections between psychological work on leadership and the coordination perspective need to be made more explicit. Finally, and most importantly, much more work is needed to find out how far a game theory approach can really take us with respect to understanding leadership. Can we get a predictive game theory-based story? How much will such a story tell us about the subtler aspects of leadership behavior? Applications of game theory to new areas have traditionally begun surrounded by extreme enthusiasm. Not all of this enthusiasm has admittedly been justified (Kreps 1990b). The point in this paper has merely been that game theory is helpful for providing a new basic conceptualization of leadership.

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Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

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There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
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DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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96-1 **Lundvall, Bengt-Åke:** The Social Dimension of the Learning Economy. (ISBN 87-7873-000-7)

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