Optimal Communication*

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1. Introduction

Communication rests on shared understanding. Words or numbers have significance only to the extent that the communicating parties share a common framework that gives meaning to such words or numbers. An influential school in the philosophy of language offers an analysis of meaning in language in terms of common knowledge of intentions in an equilibrium of the coordination game among users of the language (Lewis (1968)). This analysis, in turn, builds on the Gricean tradition of analyzing meaning in terms of iterated intentions (Grice (1957)).[1]

Shared understanding and communication figure prominently in many areas of economic life. The conduct of monetary policy by a central bank and the debates on central bank transparency is intimately tied with the nature of common understanding and the best policies that would foster such common understanding (Morris and Shin (2005)). Accounting standards are another instance of the importance of shared understanding. In a frictionless world, accounting standards would not matter, since accounting in such a world would simply be a veil.

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[1] See Blackburn (1984) for an overview of the work of Grice, Lewis and others.

However, in a second-best world with differential information and incentive problems accounting standards take on huge significance. They provide the basis for contractual arrangements among diverse parties, provide the basis for incentive contracts, and allow outside scrutiny of insiders. As such, the accounting system performs a similar role to language in its ability to coordinate the actions of disparate individuals within a shared framework of understanding. Accounting numbers have meaning only to the extent that they can be given a common interpretation within such a shared framework.

However, the imperative for common understanding can sometimes detract from the precision of accounting numbers. Common understanding is predicated on the lowest common denominator - the coarsest shared framework among a set of disparate individuals. So, the coarser is the information, the greater is the chance that the information can be understood by all. However, coarse information is also imprecise information. The flip-side of "common understanding" is "unsophisticated". When communication is based on the coarsest individual information, there will be many individuals who are capable of handling more finely nuanced, and complex usage. There may be welfare losses that result from the fact that the opportunity to utilize the greater sophistication is foregone in favour of simplicity. However, simplicity is a great virtue in its ability to generate common understanding. There is a trade-off here. The setting of optimal accounting standards is like finding an optimal language. The task is to find the language (the accounting system) that will enable fine discrimination of the states of the world, while at the same time preserving, as much as possible, the common understanding of the numbers that are generated by the system.

A possible interpretation of the debates surrounding the well-publicised series of accounting scandals of recent years is that the increased complexity of accounting numbers and the prescriptive rules have attempted to keep pace with the rapid changes in business practices have made accounting numbers more remote from the common knowledge benchmark, depriving them of wider meaning. When meaning is fragmented for want of a common understanding, the bare numbers themselves take on added significance, for no other reason that such numbers are taken note of by other observers. When the bare numbers take on such significance, there is the potential for abuse. The potential (and temptation) for manipulation and abuse is symptomatic of the erosion of a common understanding of the accounting numbers themselves. In an ideal world, accounting numbers are just a veil and would not matter. The fact that they matter so much is indicative of the imperfections that pervade financial markets.

In emphasizing the importance of common understanding, we depart from the orthodox view in the accounting literature (as typified by Demski's (1973) classic piece), that looks at the information value of accounting systems purely from a single-person decision perspective. Demski views the accounting system as a mapping from the states of the world to the observed messages, in the manner of Blackwell's (1951) analysis of information systems. As in Blackwell's analysis of information systems, Demski argues that accounting systems cannot, in general, be ordered in a linear way. When two information systems are non-comparable in that neither dominates the other in generating sufficient statistics, then the ranking of information systems depends on the decision problem at hand. This was Demski's argument for the impossibility of a normative theory of accounting systems.

In contrast, our argument emphasizes the tradeoffs between the total quantity of information and the shared nature of that information. When common understanding is important, it is possible that greater precision of information can be detrimental to welfare if the greater precision comes at the expense of greater fragmentation, or if the greater precision of information leads to the exacerbation of externalities in the use of information that detracts from overall welfare.[2]

The importance of shared knowledge extends to other areas of economic life, such as the communication policies pursued by central banks.[3] Even when most market participants are sophisticated players able to digest complex messages, and hence receive the full message intended by the central bank, achieving common knowledge of the central bank's intentions is far from guaranteed when the communication channels are fragmented. When a central bank relies on a myriad of speeches and testimonies given possibly by a number of different officials at different points in time, achieving common knowledge can become difficult. Even if the collection of speeches taken together convey a coherent message, the fragmented nature of the communication leaves open the possibility that some market observers (possibly a very small minority) fail to capture the intended picture, with its subtle emphases and qualifications. Even if the proportion of market participants who miss the full picture is small, the overall consequence may be much larger, since even those market participants who have understood the full picture may harbour doubts as to the extent of slippage in addressing the full audience. To the extent market participants' actions have an element of coordination, the reactions of less than fully informed agents affect the actions of better informed agents, also. Overall, there is the possibility that the market outcome may be driven by the lowest common denominator - i.e. the less than fully informed parties - and not by the fully informed agents.

In what follows, we illustrate the important distinction between the *quantity* of information and the *shared nature* of that information. If more information

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[2] Accountants make the important distinction between *disclosure* of information (e.g., reporting of numbers in a footnote) and *recognition* (e.g., inclusion in profit and loss statement) and observe that the latter has a larger empirical impact than the former (Barth, Clinch and Shibano (2003), Espahbodi, Espahbodi, Rezaee and Tehreanian (2002)). The greater impact of recognized numbers presumably reflects greater common understanding of that information.

[3] See Morris and Shin (2005) for a more detailed discussion.

comes at the expense of the greater *fragmentation* of information, then overall welfare will reflect the costs.

2. A Model

We examine a team decision problem (Radner (1961)) which is a variant of the "beauty contest" model that we examined in an earlier paper.[4] There is a continuum of agents of unit mass indexed by the unit interval $[0, 1]$. The fundamental θ has an improper uniform distribution over the real line. There is a public signal y that is normal with mean zero and precision α. Everyone observes the realization of the public signal. In an accounting context, we can think of θ as the value of an individual firm that would rule in a frictionless world. The density over θ is the incidence in the population of firms that have the value θ. By assuming an (improper) uniform density over the population, we assume that any value of the firm in the real line is equally likely. This extreme assumption can be relaxed without affecting the main thrust of our argument. However, we adopt it for reasons of economy of the argument. The public signal y is the basic, publicly available signal of the value of the firm that is common knowledge among all agents.

We assume that all agents share the same loss function,

$$L = (1-r)\int (a_k - \theta)^2 \, dk + \frac{1}{2} r \int\int (a_j - a_k)^2 \, dj dk \tag{2.1}$$

where a_i can be interpreted as as agent i's estimate of θ, and r is a positive constant that lies between zero and one. Each individual comes to an estimate a_i of θ based on the information available (on which more below), but the loss consists of two components. The first term in (2.1) is the loss arising from the accuracy of each a_i as an estimate of θ. The second term is the loss arising from the disagreements across individuals on the estimates of θ. The parameter r measures

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[4] Morris and Shin (2002).

the weight given to the two components of loss. When r is high (close to one), the disagreements with others take on large weight in the overall loss. The idea is that a high r puts greater emphasis on the shared nature of the assessment of the value of the firm. Large discrepancies between individuals result in economic costs due to failure to achievement coordination.

Given this objective function, each agent's optimal decision rule is given by

$$a_i = (1 - r) E_i(\theta) + r E_i(\bar{a}) \tag{2.2}$$

where $E_i(.)$ is the expectations operator of individual i, and $\bar{a}$ is the average action across all agents, defined as $\int a_i di$. Given the identical interests of agents in this problem, this is also the decision rule that a planner would recommend to players in Radner's team problem. Ui (2004) and Angeletos and Pavan (2005) discuss how this case of common interests can be used as a useful benchmark in analyzing the welfare effects of different information structures, and it will allow us to to derive a simple model illustrating the trade-off between precision and fragmentation of information. If we allow coordination problems where equilibrium strategies entail *less* coordination than the social optimum (as in Angeletos and Pavan (2004) and Hellwig (2004)), then we can construct examples where more fragmentation is socially desirable at the margin (because it makes players put less weight on fragmented signals). Cornand and Heinemann (2006) have observed that if equilibrium strategies entail *more* coordination than than the social optimum (as in Morris and Shin (2002)), a form of fragmentation is desirable because it reduces overeliance on public signals.

3. Semi-public signals

To address the tradeoffs between precision of information and the fragmentation of that information, we introduce the following information structure. There are

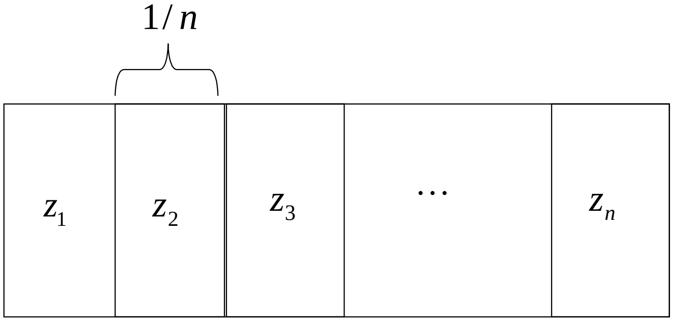

Figure 3.1: Semi-public signals

n signals

$$\{z_1, z_2, \cdots, z_n\}$$

and each individual observes precisely one of these signals. Each signal is observed by proportion $1/n$ of the population. In this sense, each signal z_i is a "semi-public" signal in the sense that the signal z_i is common knowledge among the individuals who observe it. The ith semi-public signal z_i is given by

$$z_i = \theta + \eta_i$$

where η_i is normal with mean zero and precision γ, and independent of all other random variables.

Denote by a_i the action of an agent who observes the ith semi-public signal. The information set of this agent is $\{y, z_i\}$. The equilibrium can be solved by the "guess and solve" method. Thus, let us hypothesize that the equilibrium strategies take the form:

$$a_i = \lambda z_i + (1 - \lambda)\, y \tag{3.1}$$

where λ is a positive constant. Then the average action $\bar{a}$ is given by

$$\begin{aligned}\bar{a} &= \frac{(a_1 + \cdots + a_n)}{n} \\ &= \frac{\lambda}{n}(z_1 + \cdots + z_n) + (1-\lambda)\,y\end{aligned}$$

so that

$$\begin{aligned}a_i &= (1-r)\,E_i(\theta) + rE_i(\bar{a}) \\ &= \left(\frac{r\lambda}{n} + \frac{\gamma}{\alpha+\gamma}\left(1 - r + r\lambda\left(\tfrac{n-1}{n}\right)\right)\right) z_i \\ &\quad + \left(1 - \left(\frac{r\lambda}{n} + \frac{\gamma}{\alpha+\gamma}\left(1 - r + r\lambda\left(\tfrac{n-1}{n}\right)\right)\right)\right) y\end{aligned} \tag{3.2}$$

Equating the coefficients in (3.1) and (3.2), we can solve for λ as follows.

$$\lambda = \frac{\gamma}{\gamma + \left(\frac{1-r/n}{1-r}\right)\alpha} \tag{3.3}$$

The weight given to the semi-public signal is decreasing in n. The intuition is that n is a measure of the *fragmentation* of information. As information becomes more fragmented in the population, the semi-public signals become less useful for the coordination of actions. To the extent that the agents care about coordination, they attach less weight to their semi-public signals. Note that the limiting case where $n \to \infty$ leads to the same decision function as in Morris and Shin's (2002) paper where each agent has an individual private signal.

The fragmentation loss associated with the pair of groups i and j is the cost arising from the discrepancy in the semi-public signals between the two groups, which feeds into coordination losses. It is defined as

$$F(i,j) = E\,(z_j - z_i)^2$$

For our information structure, it can be illustrated as in figure 3.2. When $i =$

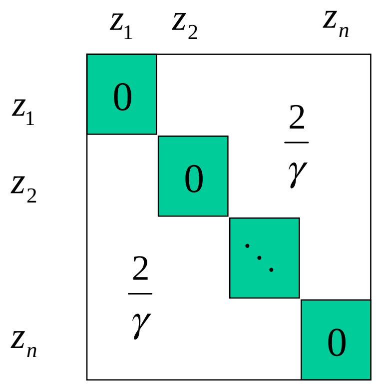

Figure 3.2: Fragmentation Loss

j, then the fragmentation loss is zero. When $i \neq j$, the fragmentation loss is $E\left(\left(\eta_i - \eta_j\right)^2\right) = \frac{2}{\gamma}$. The average fragmentation loss across all pairs of individuals can be seen from figure 3.2 to be

$$\frac{2}{\gamma}\left(1 - \frac{1}{n}\right)$$

The overall loss is given by the sum of the individual agents' loss functions that takes into account both the loss from deviations of individual actions from θ, and also the fragmentation loss. Overall loss is given by

$$L = (1-r)\int E\left(a_i - \theta\right)^2 di + \frac{1}{2}r\int\int E\left(a_j - a_i\right)^2 dj di$$

Letting $a_i = \lambda z_i + (1-\lambda)\,y$, we can write the overall loss as

$$\begin{aligned} L &= (1-r)\left(\frac{\lambda^2}{\gamma} + \frac{(1-\lambda)^2}{\alpha}\right) + r\lambda^2\left(\frac{1}{\gamma}\left(1 - \frac{1}{n}\right)\right) \\ &= \left(1 - \frac{r}{n}\right)\frac{\lambda^2}{\gamma} + (1-r)\,\frac{(1-\lambda)^2}{\alpha} \end{aligned}$$

where, re-writing (3.3),

$$\lambda = \frac{\gamma\,(1-r)}{\gamma\,(1-r) + \left(1 - \frac{r}{n}\right)\alpha}.$$

Thus

$$\begin{aligned} L &= \frac{\left(1-\frac{r}{n}\right)\gamma\left(1-r\right)^2+\left(1-r\right)\alpha\left(1-\frac{r}{n}\right)^2}{\left(\gamma\left(1-r\right)+\left(1-\frac{r}{n}\right)\alpha\right)^2} \\ &= \frac{\left(1-\frac{r}{n}\right)\left(1-r\right)}{\gamma\left(1-r\right)+\left(1-\frac{r}{n}\right)\alpha} \\ &= \frac{1}{\frac{\gamma}{1-\frac{r}{n}}+\frac{\alpha}{1-r}}. \end{aligned} \tag{3.4}$$

4. Precision versus Fragmentation

Expression (3.4) shows that losses are always increasing in fragmentation and decreasing in precision. Figure 4.1 shows the "iso-loss" lines for this problem, when $\alpha = 1$ and $r = \frac{1}{2}$, with losses decreasing up and to the left (i.e., as precision rises and fragmentation falls).

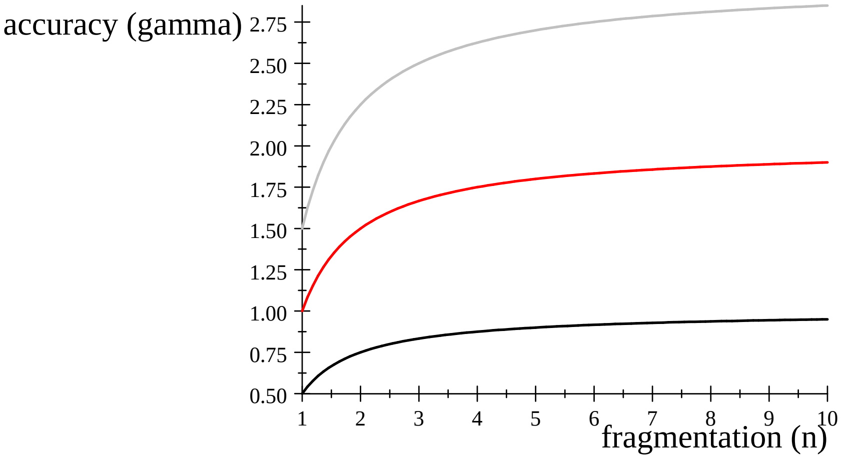

Figure 4.1: Iso-Loss Lines

A simple example will illustrate the comparative statics of the trade-off between precision and fragmentation. Suppose that the planner has a binary choice between one or two (semi-)public signals with accuracy $\gamma_1 < \gamma_2$ respectively. Inaccurate transparent communication (1 signal) is preferred if

$$\frac{\gamma_1}{1-r} > \frac{\gamma_2}{1-\frac{r}{2}}$$

i.e., if

$$\frac{\gamma_2}{\gamma_1} < \frac{1-\frac{r}{2}}{1-r} = 1 + \frac{1}{2\left(\frac{1}{r}-1\right)} \tag{4.1}$$

Recall that a low value of r means that it is important that agents choose actions close to θ, while a high value of r means that it is valuable for agents to choose actions close to each other. Now observe that for $r = 0$, condition (4.1) will not be satisfied. But as r becomes bigger, i.e., more value to coordination, the expression on the right hand side gets bigger. For any given $\frac{\gamma_2}{\gamma_1}$, if r is big enough, inaccurate transparent communication is optimal.

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