DISCUSSION PAPER NO. 456

# DESIGN OF INCENTIVE SCHEMES AND THE NEW SOVIET INCENTIVE MODEL

by
Bengt Holmstrom

October 1979

Revised January 1981

Department of Managerial Economics
and Decision Sciences
J.L. Kellogg Graduate School of Management
Northwestern University
Evanston, Illinois 60201

## ABSTRACT

The paper investigates the New Soviet Incentive Scheme and managerial target setting in a more general framework of incentive scheme design. The New Soviet Incentive Scheme is an example of delegation of decision-making responsibility due to asymmetrically informed agents. Its superiority to a system, where targets are set by the planner, is established. The new scheme is furthermore compared to the old system where targets are revised based on passed performance. The ratchet effect of the old revision system is argued to have desirable properties, in contrast to earlier views in the literature. Yet, circumstances are described under which the old revision prodecure is dominated by the new scheme. This establishes a social value for the suggested reform and more generally for the use of managerial discretion in setting their own goals.

# DESIGN OF INCENTIVE SCHEMES AND THE NEW SOVIET INCENTIVE MODEL*

## 1. Introduction

Information has played little or no role in the development of classical economics. Generally, economic agents have been assumed to possess complete information about the relevant characteristics of the economy and where uncertainty has been explicitly brought into the picture, agents have still had full information about the terms of trade; in particular, there has never been any difficulty assumed in validating that contracts are honored or in checking that contracts are favorable for parties involved. The Walrasian general equilibrium theory is but one manisfestation of this pervading principle.

For the purpose of studying economic organizations this neglectful attitude to information leaves little scope for interesting conclusions, since information is the soul of organizations; indeed, asymmetric information among the members of an organization is what gives it potential to operate in a more powerful and efficient manner than could a single individual. I am referring here to the concept of bounded rationality. For this reason, the recent invention and development of the economics of information, which explicitly allows agents to have limited and different information and attempts to study the ramifications of this thesis, has opened new and exciting possibilities for the analysis of organizational design and structure. In particular, by admitting differences in information one is naturally led into the intricacies of incentive problems, which permeate organizations.

Problems of motivation appear most prominently in centralized economies. In Western economies competition helps keep incentives in check, though it is vaguely understood exactly when and where it works as an efficient deterrent against informational externalities. In many circumstances the price system fails and has to be replaced by other forms of organization (partnerships, corporations, long-term implicit contracts, etc.) to achieve collective goals, and within these arise incentive problems of a similar kind to those in centralized economies.[1] Thus, the difference between the two systems is more in scale than in nature.

In both systems work is done to improve our understanding of incentive problems and how to combat them. Recently, a large reform was suggested in the Soviet planning process to improve the motivational aspects of the system. Rather than setting targets from above as before, the new scheme would allow plant managers to set their own goals. Rules for how this will affect the bonus are carefully defined and it is hoped that the reform will encourage managers to set higher targets and also achieve them.

This system is strongly reminiscent of management by objectives in Western economies, though it is more formally defined because lack of competition requires explicit rules. Consequently, the suggested Soviet reform has met with much interest in the West and several papers have recently attempted an economic analysis of the new scheme.[2] In so doing, the papers have largely ignored the basic question: is there an economic rationale for the reform? Authors have recognized that the new system can have both motivational and informational advantages (Weitzman (1976)), but rather than showing this to be the case, they seem to have taken the positive value of the reform as granted and proceeded to study more detailed features of the scheme, such as the conditions under which plant managers will report their information truthfully (in terms of setting targets equal to expected output) and the effects of changes in scheme parameters on managerial target setting behavior.

The purpose of this paper is to reflect on the New Soviet Incentive Model in the light of recent contributions to the incentive literature, and in particular, to go back to the basic question on the value of the reform and develop a better understanding for why it may be the case that the new system outperforms what was in its place before. No complete answers can be given, because the circumstances in which the new incentive structure operates are so wide and varying, but the analysis gives a strong indication that indeed the reform has motivational advantages. Delegating the choice of targets to plant managers allows managers to choose a final reward structure which will increase output to the benefit of society. However, a comparison to the old revision procedures is much more delicate than previous writings indicate. Most authors have only seen the negative effects of revision schemes--the ratchet effects--and thereby unnecessarily downgraded the old system. Here it is shown that judicious use of revision rules outperforms no revision, so in itself, revision is good rather than bad. It simply is a way of utilizing information about production potential for mutually beneficial adjustments in targets. However, under simplifying assumptions, delegation of target choice (the new system) is an even better means for cooperation under asymmetric information.

These results solely concern motivational benefits: those of finding a reward scheme that better matches production potential and thereby enhances output. Regarding informational advantages, it is clear that reporting a target will provide some information to the center that it does not get without reporting, and this can never hurt the system as this information always could be ignored. Yet, one point seems to have been overlooked in the previous literature, which has had a certain fixation on finding conditions under which reported targets will correspond to true (or best estimates of) production potential. Any scheme which leads the manager to give different reports depending on the content of his private information will provide valuable signals about production potential. Indeed, schemes with reporting of same dimension are equally good from a purely informational point of view and should be compared in terms of their implications on final production choices instead. For this reason, and also since it appears difficult to evaluate exactly how reported information will be used for coordination purposes, the issue of informational advantages is largely ignored in this paper.

The paper proceeds as follows. In the next section a relatively general formulation of the incentive problem in a two-level hierarchy with lower level agents possessing private information, is presented. The problem of organizational design is seen as a problem of constructing a non-cooperative mechanism or game to be played by the self-interested members of the organization. It is shown that among a multitude of conceivable games, there is a universal one that admits the same outcomes that are obtainable by all other possible games. This game has the simple structure that agents report their full information and the decision is made in one shot based on these inputs. Information may be coordinated in the process, but not arbitrarily since only certain decision rules are implementable, namely those which induce agents to report their information honestly in equilibrium. Thus, it is in principle an easy task to check what can be achieved with various mechanisms, and this simplifies the design task on a conceptual level.

In order to economize on information transmission costs, it may not always be desirable to try to coordinate subdivisions' information. In that case, the system of sending messages can be dispensed with, giving managers instead direct authority to make certain decisions under limited discretion. This is delegation and section 3 provides some results on when delegation is a desirable means for cooperation. As an example of delegation, the new Soviet scheme is analyzed in section 4 and compared to the old one in section 5. Section 6 contains some concluding remarks.

## 2. A General Model[3]

Look at a two-level organization with one center or principal and n subdivisions or agents. This organization functions by making decisions which have outcomes (production, sales, etc.) that are general stochastic. We are looking for simplicity at one decision instance only; a decision d has to be chosen from a set of feasible decisions D. Authority is vested with the center so that if it so desired it could choose a d by itself. However, due to imperfect information and the fact that subdivisions possess information of potential value to the center, the principal may rather let the agents participate in the decision-making process. This process could be a complex iterative exchange of information, which eventually would lead up to a final choice of d, but quite generally it can simply be described as a mapping $d: M \rightarrow D$, from inputs $m \in M$ to final decisions $d(m) \in D$. Moreover, m can be partitioned so that $m = (m_1, \ldots, m_n)$, where $m_i \in M_i$ is the input provided by agent i. The set $M_i$, called agent i's message space delineates the freedom agent i has in choosing his message. It is assumed that the principal can decide on this set too. A decision mechanism then is a pair $N = (d, M)$ with $M = \overset{m}{\underset{i=1}{X}} M_i$, and the task of the principal is to choose an N from a given set $\bar{N}$ of feasible mechanism.

The information structure is assumed to be as follows. There is a state of nature which prevails, denoted z. A probability space $G = (Z, F, P)$ describes uncertainty and is assumed to be known to all parties involved. The principal has observed the outcome of a random variable $y_o \in Y_o$ and agent i the outcome of a random variable $y_i \in Y_i$, all defined on G. These functions are common knowledge (but not their outcomes). The observations are made before the decision process starts and no new information is revealed before d is chosen.

As for preferences, the principal values d by the index function $F_o$: $D \times Z \to \mathbb{R}^1$, and agent i values d by the index function $F_i$: $D \times Z \to \mathbb{R}^1$. Thus, given z, the ranking of decisions by each party is clear. As long as z is not known, it is assumed that expected values of index functions describe preferences.

The model described above covers a wide range of situations. For instance, d could be a vector of capital allocations to subdivisions and the decision mechanism a formal investment budgeting routine, where agents' inputs correspond to information about production potential under different capital allotments. Or d could be a vector of reward schemes with agents' messages representing suggested parameter values in prespecified schemes. The latter case will be developed more fully later.

Certain limitations can be noted. Since it is assumed that d can be chosen by the principal alone, he cannot be uncertain about the possibility of its implementation. It would not be too difficult conceptually to introduce variables, which the principal cannot control due to non-observability or due to insufficient information about feasibility, but this extension will suggest itself in the course of the paper and need not concern us now.

Notice also that the specification of preferences is somewhat unorthodox as they are defined over decisions, not consequences. This again is a notational short-cut. One could derive preferences from more basic concepts like utility over consequences and a description of how decisions map into consequences for given z:s.[4]

The basic problem is how the principal should choose among different decision mechanisms N, that is, how the organization of decision-making should be designed. Given any N, agents will engage in a non-cooperative game of incomplete information with payoff functions $F_i$ (known to everybody) and information structure as earlier described. It is assumed that the appropriate solution concept that describes what will happen is a Nash equilibrium defined as a set of functions $\{\bar{m}_i\ (y_i;N)\}_{i=1}^{n}$, satisfying:

$$E\ \{F_i(d(\bar{m}(y;N)),z)\,|\,y_i\} \geq$$

(1) $$E\ \{F_i(d(\bar{m}^i(y;N),m_i),z)\,|\,y_i\},$$

for every $m_i \in M_i$, for every $y_i$,

and every $i = 1,..,n$.

Here, $\bar{m}\ (y;N) = (\bar{m}_1(y_i;N),\ldots,\bar{m}_n(y_n;N))$; a superscript i denotes a vector with the $i^{th}$ component deleted, e.g. $m^i = (m_1,\ldots,m_{i-1},m_{i+1},\ldots,m_n)$ and $m = (m^i,m_i)$.

The functions $\bar{m}_i\ (y_i,N)$ are the best response strategies of agents given the mechanism N. If randomized strategies were desired, they could be incorporated by augmenting the signals $y_i$ to include independently distributed random variables (more specifically uniformly distributed ones).

Assuming that a Nash equilibrium exists for each N, the principal's problem can be stated as follows:

Choose $N \varepsilon \mathcal{N}$, such that it maximizes:

(2) $$E \{F_o(d(\bar{m}(y;N)),z)|y_o\},$$

where $\bar{m}$ (y;N) is a Nash equilibrium as defined in (1).

There is another way of viewing the principal's problem, which is useful. Let $d_o(Y) = d(\bar{m}(y;N))$. This function is a mapping from agents' signals to decisions and is called the <u>outcome function</u>. It tells what decision will be taken given the information state y. Call an outcome function <u>attainable</u>, if there exists a mechanism $N \varepsilon \mathcal{N}$, which yields that particular outcome function at a Nash equilibrium, and denote the set of attainable outcome functions by $\mathcal{O}$ The principal's problem can then be stated equivalently as follows. Find the attainable outcome function $d_o(y) \varepsilon \mathcal{O}$ which maximizes:

$$E \{F_o(d_o(y),z)|y_o\},$$

or verbally find the best attainable outcome function.

A simple, but useful result is the following:

<u>Theorem 1</u>. An outcome function $d_o(y)$ is attainable if and only if the decision mechanism $N = (d_o,Y)$ has a Nash equilibrium such that $\bar{m}_i (y_i) = y_i$, $i = 1,\ldots,n$, where $Y = \overset{n}{\underset{i=1}{X}} Y_i$.

<u>Proof</u>: Sufficiency is obvious. To prove necessity let $N' = (d,M)$ be a mechanism with outcome function $d_o(y) = d(\bar{m}(y;N'))$, where $\bar{m}(y;N)$ is a Nash equilibrium. From (1) follows immediately that $d_o \equiv d\circ m$ and $M = Y$ constitute a mechanism with truth telling as equilibrium strategies.

Q.E.D.

The theorem shows that attainability can easily be checked at least in principle and that among all conceivable message spaces it suffices to restrict attention to full communication. Thus the search for optimal decision mechanisms can be restricted to decision functions alone.[5]

In the formulation above it is implicitly assumed that the decision function, i.e. the rule by which decisions are reached, is given to the agents before the play starts. If that is not the case, one would have to include the principal among the players and he could no longer choose decision rules arbitrarily; rather, the rule would be endogenously determined in a new equilibrium.

Above we have allowed the principal to exploit the agents as much as he can. A more natural economic analysis would follow a partial equilibrium approach, i.e. find efficient decision mechanism. However, with asymmetric information the notion of efficiency is not self-evident since information about what other parties know privately can be inferred from their expressed preferences. I do not want to go into the intricacies of this question; suffice it to say that there is now some consensus about how to define efficiency.[6] This could be expressed in technical terms as follows:

The outcome function $d_o(y)$ is efficient, if it is attainable and maximizes:

$$(3) \qquad E_o\{F_o(d_o(y),z)\,|\,y_o\},$$

$$\text{s.t.} \qquad E\,\{F_i(d_o(y),z)\,|\,y_i\} \geq U_i(y_i) \quad , \qquad \forall i \neq 1,$$

for some functions $U_i(y_i)$, $i = 2,\ldots,n$.

In other words, one could think of each agent as split up into as many agents as there are outcomes of his private signal and define a standard notion of efficiency for this enlarged set of agents within the space of attainable outcomes functions (see Wilson (1978) for the original idea of augmenting the space of agents in this way).

If randomized outcome functions are allowed, (3) could also be stated as a maximization over attainable outcome functions $d_o(y)$ of:

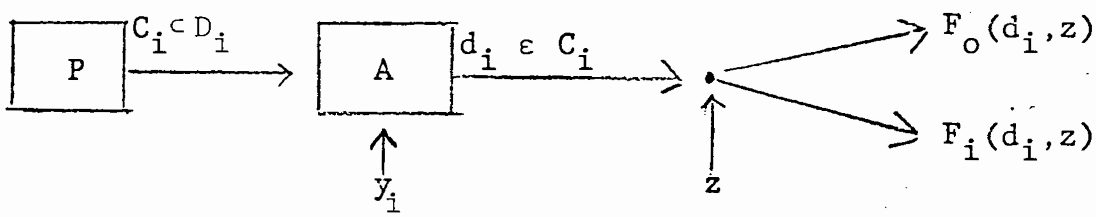
$$(4) \qquad \sum_{i=1}^{n} \lambda_i(y_i)\ E\ \{F_i(d_0(y),z)|y_i\}$$

for some positive functions $\lambda_i(y_i)$, $i = 1,\ldots,n$.[7] The weight functions are derived from the constraints in (3) that guarantee each agent a certain utility level in each information state $y_i$. This means that a Pareto move requires that no agent's expected utility, regardless of what information he happens to possess, can get smaller, which considerably enlarges the set of efficient outcomes. But this, of course, is only a consequence of the well known fact that releasing information before contracting, destroys insurance opportunities.

## 3. Delegation

For various reasons the costs of information coordination via a general function d(y) may be so high that it is not worthwhile. Instead, organizations often operate with independent decision making in the subdivisions. Such a restriction corresponds to a decision function of the form $d(y) = (d_1(m_1),\ldots,d_n(m_n))$, where each agent affects a separate part of the decision, and the decision-making procedure is thus decoupled.

Since the $d_i$:s are viewed as fixed functions prior to receiving the messages $m_i$, a decoupled decision process implies that, in fact, agent i may choose any decision he wants to from the set: $C_i = \{d_i \varepsilon D_i \mid \exists\, m_i \varepsilon M_i \text{ such that } d_i = d_i(m_i)\}$. In other words, rather than asking for the message $m_i$, and acting upon it according to $d_i(m_i)$, the principal could directly give agent i the freedom to choose any decision he wants to from the set $C_i$. This may at times greatly economize on information transmission costs, and corresponds to what we generally understand by delegation. The process can schematically be described as follows:




Despite its formal simplicity, delegation covers a wide range of possible mechanisms for cooperation under asymmetric information. Indeed, if the agent knows strictly more than the principal, the delegation covers all possible forms of cooperation as implied by theorem 1. Examples of delegation include all the screening models (though generally put in a market setting), optimal taxation, optimal regulation, optimal product differentiation and several others.[8] These models correspond to special interpretations of the decision variable d, and the information variables y and z. In the next section we will view the Soviet incentive model as another instance of delegation.

Since we are looking at the problem from the principal's point of view, it should be clear that unless the agent possesses some private information of potential value for the principal, delegation of decision-making responsibility will give no gains to the principal. At the other extreme, if preferences coincide ($F_o = F_i$), then full delegation is optimal. Apart from these extreme cases optimal use of the agent will in general entail some but not full degree of freedom of choice for him. Another immediate consequence of the formulation may be noted; the delegation set need never have a higher cardinality than the range of the agent's signal $y_i$.

A basic question of interest is: when will the agent be of any value at all, that is , when does it pay to delegate? The answer will generally depend on the problem's specific structure and little of general validity seems possible to say. One trivial sufficient condition, which nevertheless may be a practically useful test is the following. If d* would be the principal's choice if he acted alone, and there exists a d such that when this d is preferred to d* by the agent, it is also preferred by the principal given the information that the agent's preference for d will reveal to the principal, then letting the agent choose between d* and d will be preferred to having the principal act alone. Put another way: if the principal does not regret that he let the agent make the decision when he hears what the agent actually chose, then delegation is preferred.[9] Unfortunately, this test is not sufficient. There are cases where optimal delegation may lead the agent to a choice which the principal immediately afterwards regrets. But, of course, if the principal decided to enforce another decision after hearing the agent's choice then that would change the game; the agent would behave differently and the information revealed by his choice would also change.[10] Theorem 1 shows that the best the principal can do is to stick to his promise even if he occasionally regrets it.

At this point it may be helpful to go through a simple example to see how delegation works and also how enlarging the set of decisions may help to achieve mutual gains when more straightforward mechanisms are inoperative. The example is schematic.

Example

There are two states of nature z = 0 or z = 1 both equally likely ex ante. The agent knows which state prevails (i.e. $y_i = z$) the principal does not. There are two alternative decisions L = left or R = right. The situation can be described by the diagram:

A.

| | L | R | Prob. |
|---|---|---|---|
| z=0 | (1,5) | (10,6) | 1/2 |
| z=1 | (10,6) | (0,5) | 1/2 |

The numbers are dollars that will be received by each party; the first number in the parenthesis is the principal's reward, the second number is the agent's. For instance if z = 0 and L is chosen the principal gets 1, the agent 5. If the principal made the choice by himself he would choose L as it gives highest expected utility (5 1/2). However, it is evident that letting the agent decide will make both better off, since he will choose R when z = 0 and L when z = 1. Conditional on the agent's choice R, the principal knows z = 0 obtains and does not regret that he delegated the decision.

This is how delegation in its simplest form works.

Let us change numbers slightly so that the situation now looks like:

B.

| | L | R |
|---|---|---|
| z=0 | (1,5) | (10,10) |
| z=1 | (10,6) | (0,7) |

Evidently, delegation does no good. The agent would in each case choose R. whereas the principal would ideally see R chosen when z = 0 and L chosen when z = 1. Moreover, he prefers L to R if one of them has to be chosen for both states of nature. Thus, delegation appears inoperative. But the game can be redesigned for cooperative gains. The principal can promise to pay the agent $2 if he chooses L. This changes the game to:

| | L | R |
|---|---|---|
| z=0 | (-1,7) | (10,10) |
| z=1 | (8,8) | (0,7) |

In this new situation the agent will choose L if z = 1 and R if z = 0. This will make him better off, and also the principal, since he can now expect on the average $9 instead of $5 1/2 as in the non-delegation case.

Thus, we find that combining delegation with certain side-payments enlarges the scope for cooperation. What has effectively been done is enlarging the decision space from $D = \{L,R\}$ to $D = \{(L,\$_s),(R,\$_t)\}$: s t transfers from principal to agent.[11] This simple principle lies behind work on regulation (and screening) where specific payments are associated with agents' choices. Indeed, the problem of regulation and taxation is to choose the payment function optimally.

In certain situations payments as functions of the decisions alone will not help. The final case is an example of this. Let the game now look like:

C.

| | L | R |
|---|---|---|
| z=0 | (1,6) | (10,7) |
| z=1 | (10,6) | (0,8) |

Direct delegation does not work, nor does it help to tie choices to money transfers as in B. But suppose the principal could ex post observe a signal about z. Call it x with outcomes 0 or 1 and conditional probabilities $P(x=1|z=1) = 2/3$ and $P(x=0|z=0) = 2/3$. Payments can now be made both a function of choices L and R and of the outcome x. More specifically, pay the agent \$3 for choosing L if x = 1 and have him pay the same amount if he chose R and x = 1 came up. Do the reverse if x = 0. Assuming both are risk neutral this will transform the game to:

| | L | R |
|---|---|---|
| z=0 | (2,5) | (8,9) |
| z=1 | (8,8) | (1,7) |

In this table numbers are not certain outcomes but expected values taken over the distribution of x given z. We see that the agent will choose L when z = 1 and R when z = 0. The principal's expected payoff is \$8, which is better than he would get by acting on his own. The agent's welfare has also improved. If the principal does not use him he gets \$6 independent of z, now he gets either \$8 or \$9.

In this example the decision space D has been changed from {L,R} to a choice of lotteries associated with L and R.[12]

The last example is one where some verification of the agent's adequate choice is necessary for making coordinated decision-making feasible. An example of this could be a warranty for a product which backs up promises about quality. We will also see that the Soviet incentive model belongs to this category.

This sequence of variations on a schematic example is intended to illustrate on one hand how delegation works for mutual gains, how it requires a certain conformity of preferences in order to be feasible and how one may in the absence of such conformity change outcomes so that sufficient conformity is restored and cooperation becomes advantageous. It should also point towards the many ways in which incentive schemes can be designed to achieve common goals.[13]

No general results have been presented as to when various types of schemes work, and by and large this is an unexplored field. Results of some generality for more special structures can be found in Holmstrom (1977), (1980).

## 4. The Soviet Scheme

The incentive schemes used in the Soviet union are rather more intricate than the formalizations that have been adopted for analytical purposes. Nevertheless, I will follow previous writers and give a highly simplified model of how the incentive structure is set up, in order to focus on some central points I want to make regarding its delegation feature.

Before the recent reform, the incentive scheme for a plant manager could be described as follows. He had a basic guaranteed salary $\hat{B}$ which a bonus was added depending on plant performance. Say that performance is measured simply by output $x$; then the bonus $S(x)$ was determined according to the formula:

$$(6) \qquad S(x) = \begin{cases} \hat{B} + \alpha(x-\bar{t}) & , \text{ if } x \geq \bar{t}. \\ \hat{B} + \gamma(x-\bar{t}) & , \text{ if } x < \bar{t}. \end{cases}$$

whenever positive.
The constants $\alpha$ and $\gamma$ were set by the planners and so was $\bar{t}$, which has a natural interpretation as a target output. The constant $\alpha$ was obviously obviously dependent of the scale of operation and could instead be written $\alpha = \alpha'/\bar{t}$, with $\alpha'$ approximately equal for different plants. The parameter $\gamma$ was traditionally set equal to infinity so that no bonus at all was paid for an unfulfilled target.

The target itself was based in an imprecise way on past performance and negotiations. Since good performance induced a higher target, this had the much discussed ratchet effect as a consequence: managers were not eager to exceed the target by too much (or maybe rather miss it) in order not to be pressured in future periods by a higher target. This may have been one reason for the 1970reform and we will return to this point later.

The proposed reform would change the incentive in many ways, but the principal innovation concerned the role of plant managers in setting targets. Earlier it had been indirect; via the ratchet effect and negotiations. Now it was made explicit, so that plant managers could set their own targets with clearly specified consequences on the bonus pool. Formally, the reform may be described as a two-phase scheme where the central planners first suggest a tentative target $\bar{t}$, which the manager may change freely to $\hat{t}$ and thereby determine an initial bonus fund:

(7) $$\bar{B} = \hat{B} + \beta(\hat{t}-\bar{t}).$$

Later, when actual performance is measured, final payment is based on (6) with $\bar{B}$ in (7) taking the place of $\hat{B}$ in (6). In other words, the second stage is as before, (with the minor exception that $\gamma$ is given a finite rather than infinite value, so that underfulfillment may still give a positive bonus).

For purposes of comparison, it is useful to rewrite the old scheme as a linear scheme with an added loss function, i.e.

(8) $$S_o(x) = \hat{B} + \beta(x-\bar{t}) - L(x-\bar{t}),$$

where,

(9) $$L(z) = \begin{cases} (\beta - \alpha)z & , \text{ if } z \geq 0, \\ (\beta - \gamma)z & , \text{ if } z < 0. \end{cases}$$

Notice that $\beta$ in (8) is intentionally the same as in (7), though it could be chosen anything else in general.

The new scheme can similarly be rewritten as:

(10) $$S(x) = \hat{B} + \beta(x-\bar{t}) - L(x-\hat{t}).$$

If $\hat{t} = \bar{t}$, then (10) reduces to (8). Thus (8) and (10), the old and the new scheme, are equivalent with the exception that in (8) $\hat{t} = \bar{t}$ is imposed, whereas in (10) the manager is free to choose $\hat{t}$ as he wants. This clearly is an incidence of delegation of the kind described in the previous section. If we want to compare it to the earlier presented schematic example it is of type C, since there is a side payment related to the choice variable $\hat{t}$ (namely (7)) and the ultimate outcome will depend on a stochastic signal x, in this case the realized output of the firm.

Geometrically the comparison is given in figure 1. Delegating the target choice implies that the firm may move its loss function along a line with slope $\beta$, in order to determine its final payment schedule.

Insert Figure 1

One may immediately notice that $\gamma > \beta > \alpha$ is required or else it would pay the firm either to move the target to infinity or to zero due to a dominance over the whole range of x. As it is in the figure, a higher target leads to a higher total bonus when the target is actually attained or surpassed, whereas it leads to a lower total bonus if the target is underscored sufficiently. Thus, there is a tradeoff.

What is of interest here is to see why the center may want to delegate the target decision. What good does it do and is it an improvement from the old scheme?

Against the background developed in the previous section it is clear that with delegation central planners hope to capitalize on some private information that firms have. Evidently, this information concerns production potential and the cost of production. If these data were known to the center at the outset, it could by itself design a remuneration scheme which would consider the welfare of both parties and trade off risk-sharing against work incentives in an optimal way (cf. Holmstrom (1979)). However, when such information is not available to the center, any scheme that the center designs without the cooperations of the manager could be dominated in a Pareto sense by some other scheme if only the appropriate information about the firm were available.

Why not ask the firm? That is possible, but the problem lies in receiving reliable information. As was seen in section 3, asking for information and acting upon it was equivalent to just delegating the decision to the firm directly, so that it may choose from a menu of schedules the one it finds best. Of course, if the manager's welfare does not depend on plant output directly, but only via the reward scheme that is designed, then this scheme could simply give him a fixed wage, and there would be no reason to expect him to falsify reports under such an arrangement. Thus, the Soviet system is meaningful only in a context where there are either managerial costs to production (in terms of effort) and/or some private benefits to certain outcomes. A casual look at earlier problems in the planning routine indicate that effort costs are the key obstacle that needs special attention from scheme design.[14] Proper effort will only be provided against proper rewards and proper rewards will depend on production potential and production costs which constititute the information gap. The conclusion is that the Soviet reform must be primarily concerned with managerial motivation, since for reasons other than that, simpler arrangements would work.

Before analyzing whether the reform brings motivational improvements, one needs to specify the center's objective. There are (at least) three considerations that enter this objective. First, the center values output. Second, it values information about what the output will be so that it may coordinate the plans of other plants better; this is especially important if the firm produces primary products. Finally, it is concerned about firm costs, both psychic and real. A crude formalization of these components would lead to a social objective function of the form,

$$W(x) = G(x) - H(x-\tilde{t}) - V(x), \tag{11}$$

with

$G(x)$ = value of output gross of information benefits and production costs; known by center;

$H(x-\tilde{t})$ = cost of missed expected output $\tilde{t}$;

$V(x)$ = firm cost of production; known to the firm alone.

What is crude about this statement is the second term $H(\cdot)$, but the problem is that a rather more elaborate specification would be necessary if one would like to model the information value appropriately. This would depend on the delegation scheme employed and what information thereby is released, as well as on how this information is intended to be used.

One point needs emphasis. I have intentionally used the symbol $\tilde{t}$ as if it were a target, but avoided to use $\hat{t}$, which is the value for the target set by the firm in the new scheme (see (10)). The reason is that given the target set by the firm the center may well reason that the actual expected output will be either higher or lower than $\hat{t}$ depending on how the parameter values of the system have been designed. What this means, is that there has been in the literature a somewhat misdirected emphasis on analyzing whether or not the new scheme leads the firm to reveal its production potential honestly; i.e. is $\hat{t}$ set equal to expected output. That is not essential since even if $\hat{t}$ is set according to a different rule, the center can be expected to infer or learn this rule and revise the target projection $\tilde{t}$ accordingly. By and large, one should separate the information value of the target setting procedure from its incentive effects on action. This is very much the content of theorem 1.

For this reason, I will in fact drop the H-term from the analysis with the knowledge that any system that induces communication of information will improve on one that does not have communication as far as the H-term is concerned, and with the understanding that comparing the information value of two systems with essentially the same dimension of communication is intricate and presumably leads to small differences in value in any case. However, one should keep in mind that the reason for introducing a loss function L in the scheme in the first place, ultimately derives from the presence of a loss function H in the social objective, and this is an important consideration when thinking about optimal design of parameter values.[15]

So let us now see if there is any value in letting the firm decide on the target level in a one period setting with $H(\cdot) \equiv 0$. For simplicity, the information structure is taken to be such that the firm knows $V(x)$ completely, and can decide $x$ with certainty. The planner does not know $V(x)$. For our purposes there is no need to be explicit about the planner's beliefs about $V(x)$, so no random variable will be introduced into $V(x)$.

Theorem 2. Assume $G(x)$ and $V(x)$ are differentiable and $G' > 0$, $V' > 0$, $V'' > 0$. Then there is an interval $(t_1, t_2)$ and a $\beta > 0$ such that letting the firm choose its target from this interval according to the new Soviet scheme (10) will make both the firm and the society better off than with an optimal old scheme (8).

Proof: Let the parameters of the old scheme be fixed. Recall, however, that the old scheme is independent of $\beta$. Set $\beta$ in the new scheme according to:

$$(12) \qquad \beta = \frac{\alpha + G'(\bar{t})}{2}$$

Choose $t_1 = \bar{t}$ and $t_2 = G'^{-1}(\beta)$. We may assume $\alpha < G'(\bar{t})$, since it is easily seen that otherwise the old scheme could be improved by decreasing $\alpha$. Thus, $\beta < G'(\bar{t})$, and since $G' < 0$, $t_2 > t_1$.

The claim is that regardless of $V(x)$, the new scheme will lead to a better choice of $x$ than the old both from society's and the firm's point of view. The latter is obvious, since $t_1 = \bar{t}$ so the firm may, if it so wishes, remain with the old scheme. To prove that society is better off, consider the three possible cases:

Case 1: The firm sets $\hat{t} = t_1 = \bar{t}$. The choice of x will be the same as with the old scheme.

Case II: The firm sets $\hat{t} = t_2$. Again the choice must be the same as with the old scheme, since if $x < t_2$ then it would pay to lower $\hat{t}$.

Case III: The firm sets $\hat{t}$ between $t_1$ and $t_2$. It is easily seen that then $x = \hat{t}$ is chosen.

In fact, $\hat{t}$ is chosen so that $V'(x) = \beta$. Society would ideally like x chosen according to $V'(x) = G'(x)$. Let $x_1$ be what the firm chooses with the old scheme, $x_2$ what it does with the new scheme, and $x_3$ what society ideally would like. Since $x_2 = \hat{t} \varepsilon (t_1, t_2)$, $G'(x_2) > \beta$ and hence by $G'' < 0$, $x_3 > x_2$. On the other hand $\beta > \alpha$ implies $x_2 > x_1$. By concavity of G, then, society prefers $x_2$ to $x_1$.

We get equal outcome in the first two cases and a strict improvement in the third. If the range of possible V-functions that the firms may face is such that Case III can occur, the claim is proved. But this must be the case since in an optimal old scheme the target is set so that overfulfillment occurs some of the time.

Q.E.D.

With a more realistic informational set up, say such that the firm first receives a signal about V and only after setting the target, gets to know it fully, essentially the same line of reasoning applies. Parameters can be chosen so that when the firm desires to increase its target, society approves the move.

One the other hand, the restriction to a certain range of targets is necessary. In general full freedom need not dominate a fixed target. For an understanding why this may be the case, see Weitzman (1974).

## 5. Revision

In the discussion of the Soviet incentive scheme, the ratchet principle, that is, the habit of planners to revise targets based on previous performance, has been evaluated in a rather negative light by focussing only on its discouraging effect on high performance. But revision is a form of delegation and if properly administered it can dominate a fixed target as will be shown below. What seems to have been wrong with the old system was the principle not to pay a reward in conjunction with moving the target up. In the delegation scheme this is done according to (7). The old system corresponds to setting $\bar{\beta} = 0$ in which case, of course, it does not pay to increase the target, but to do the opposite and try to lower it instead.

To elaborate, assume that production takes place in two periods and V(x) is the same in both. In that case there is potential to use the firm's first period choice of x as a signal about $\bar{V}$, and revise the target accordingly in the second period. To make it work, however, compensation in some other form must accompany revision as noted above. One obvious procedure would be to make linear changes:

(13) $$t_2(x_1) = \xi(x_1 - \bar{t}) + \bar{t}$$

(14) $$B_2(t_2) = B_1 + \delta(t_2 - \bar{t}).$$

Here $x_1$ is first period output, $t_2(x_1)$ is the second period target as a function of the first period performance and $B_2(t_2)$ the second period constant in the bonus scheme given as a function of $t_2$.[16]

Assume the manager is risk neutral and has no time preference for payments. Then if one sets $\delta = B$ and $\xi = 1$ and adds to (13) that $\bar{t}_2$ will never be set below $t_1$ and above $t_2$ as they appear in the proof of theorem 2, then a slight variation of the proof of theorem 2 shows the following:

Theorem 3. Under the assumptions of theorem 2, there is a revision procedure which dominates (in the Pareto sense) a fixed target scheme.[17]

Thus what has been shown so far is that both direct delegation and revision will be better than just keeping the reward schedule unchanged. These results are certainly robust under a variety of changes in the informational assumptions. All that really is needed is that parameters are set so that society desires increases in the target whenever the firm does. A more intricate question is whether delegation dominates revision or not. Intuition suggests that since delegation allows an immediate move to the jointly preferred reward structure without the cost of signalling production potential through the choice of $x_1$, it should be better than revision in which signalling is mixed up with the choice of production levels.

To support this intuition I will make a comparison of the two procedures under the same informational assumptions as above, though this time one has to admit robustness of the result is not as apparent as in the previous theorems. For analytical purpose it is more convenient to work with a slight variant of the previous model; rather than having a linear loss function I will use a quadratic one. With this change the new Soviet model becomes (dropping constant terms):

$$(15) \qquad S(x) = \beta x - \lambda(x - \hat{t})^2,$$

for both periods. Similarly, a revision scheme becomes,

$$(16) \qquad S_1(x_1) = \beta x - \lambda(x_1 - \bar{t})^2,$$

for the first period, and,

$$(17) \qquad S_2(x_2) = \delta(t_2 - \bar{t}) + \beta x_2 - \lambda(x_2 - t)^2,$$

for the second period, with $t_2(x_1)$ given by (13). By redefining $\bar{t}$ and $\beta$ if necessary, (16) and (17) can equivalently be written:

$$(18) \qquad S_1(x_1) = \beta' x_2 - \lambda(x_1 - \bar{t}')^2,$$

$$(19) \qquad S_2(x_2) = \beta' x_2 - \lambda(x_2 - t_2)^2.$$

Thus revision and delegation look the same except that with delegation the target can be changed freely, whereas with revision the first period target cannot be changed at all and the second period target changes with output $x_1$.

<u>Theorem 4</u>. A linear revision scheme in which the target only may increase can be dominated by a delegation scheme with this same restriction

Proof: Let the revision scheme be given by (18) and (19) and the revision rule $t_2(x_1) = \max(\bar{t}', \xi(x_1 - \bar{t}') + \bar{t}')$, which prevents targets from being lowered. I will show that taking $\beta = \beta'$ in the delegation scheme (15) and restricting $\hat{t}$ to be at least equal to $\bar{t}'$ will give a mutually prefered outcome. For the firm, the preference is clear, since with the delegation scheme described above it could imitate the revision outcome if desired. Thus, what needs to be shown is that society is better off as well.

Assume first $\xi \leq 1$. Let $\tilde{x}_1, \tilde{x}_2$ be first and second period decisions in the revision procedure and $\bar{x}$ be the production decision under delegation (the same in both periods). It is readily seen that $\bar{x} > \max(\tilde{x}_1, \tilde{x}_2)$. Thus output will be higher in both periods under delegation, and society will be better off as long as $G'(\bar{x}) > V'(\bar{x})$, which can be guaranteed, if necessary, by putting an upper limit on the target at the point where $G'(x) = \beta^1$(cf. theorem 2).

In the other case, $\xi > 1$. Solving the two-period maximization problem under revision gives first-order conditions:

$$\beta' - 2\lambda(\tilde{x}_1 - \bar{t}') - V'(\tilde{x}_1) + 2\lambda\xi(\tilde{x}_2 - \bar{t}' - \xi(\tilde{x}_1 - \bar{t}')) = 0,$$

$$\beta' - 2\lambda(\tilde{x}_2 - \bar{t}' - \xi(\tilde{x}_1 - \bar{t}')) - V'(\tilde{x}_2) = 0 .$$

Combining then, yields:

(20) $$\beta' - 2\lambda(\tilde{x}_1 - \bar{t}) - V'(\tilde{x}_1) + \beta'\xi - V'(\tilde{x}_2)\xi = 0.$$

Substituting $\tilde{x}_1 = \tilde{x}_2 = \bar{x}$ makes (20) negative, since $\beta' = V'(\bar{x})$. So will any other combination of $\tilde{x}_1, \tilde{x}_2$, for which $\tilde{x}_1 + \tilde{x}_2 \geq 2\bar{x}$, $\tilde{x}_1 \geq \bar{t}$, $\tilde{x}_1 < \bar{x}$, as can readily be verified. Since $\xi > 1$, $\tilde{x}_1 < \bar{x}$, and if $\tilde{x}_1 < \bar{t}$, we have no revision, in which case the outcome is the same as in delegation. Hence, if revisions are made

$\tilde{x}_1 + \tilde{x}_2 < 2\bar{x}$, and total production will again be below that of delegation. Moreover, it will be less efficient than taking $\bar{\bar{x}} = (\tilde{x}_1 + \tilde{x}_2)/2$ in both periods because V is convex. Since $\bar{x}$ is preferred to $\bar{\bar{x}}$ by society, this shows that revision does worse than delegation also when $\xi > 1$.

Q.E.D.

As mentioned above, this result is not general at all, but I think it demonstrates the basic idea that with revision, efficiency losses are incurred in the first period since signalling is not given sufficient rewards (rather, costs are incurred). In the two-party set-up discussed above, it is also evident that if one were to consider informational values, delegation would have an additional advantage in that revision schemes do not communicate anything in the first period, and more importantly, their signals for the second period are presumably more noisy. In times of rapid change of production potential, this would be particularly harmful. At an extreme, if production potential in consecutive periods were independent of each other (or maybe more realistically, the general dependence was fully known to the center with independently distributed noise as the only unknown factor), then there would be no place for revision, whereas delegation would still be meaningful.

## 6. Concluding remarks

Many authors have observed that the ratchet effect is not completely removed in the new scheme either, because most likely the parameters of the system will be revised periodically albeit less frequently than before, and these changes will be functions of past performance. But again the emphasis of the discussions seem to me wrongly placed; namely on the negative side effects of such a procedure. The previous section should have made it clear that despite certain costs, revision schemes imply in general improvements and what should be studied is how they can be used optimally.

The reason there are gains from revision even in the new scheme is that reporting a single target is a very narrow channel for communication. It cannot contain all the relevant information and so some of what is left out can be signalled via performance instead and be used as a base for revisions. Secondly, the objective of the planners, i.e., the G(x) function, is likely to change over time and give reason to revisions, but these will, of course, not relate to the firm's performance and should not lead to ratchet effects in themselves.

I do not intend to propose specific rules for how revisions of the parameters should be undertaken in the new scheme, but a principle could be mentioned. If one wants to secure that the managers do not get worse off by the changes, one could effect them by offering new alternatives without removing the old ones. For instance, one could propose a new set of parameter values and leave it to the firm to stick to the old ones or choose the new ones. This amounts to superimposed delegation.

Alternatively, one could within the 5-year planning period allow firms to change not only targets, but also parameter values. For instance, an additional bonus could be paid for setting targets very tightly via the $\alpha$ and $\lambda$ values. This woudl give additional information about the expected variance of the output as well as leave room for improved risk sharing, which here has been ignored.

This paper has focussed on the motivational gains that can be achieved via target delegation in the present Soviet planning process and thereby give one economic rationale for the reform as well as an economic, rather than psychological, rationale for management by objectives in Western firms. The other main source for potential gains was the information value of target reporting. This was not studied mainly because it seems hard to model in a satisfactory way, and also because it is unclear to me exactly how coordination is undertaken with the help of targets. Are firms' outputs planned in a sequential manner, starting with primary products and are all firms subject to the new system?

If all firms are incorporated in the new plannning process and the alleged fact that the parameters of the new system will be fixed for five years (the planning cycle) is correct, then a further confusion about coordination benefits arises. Namely, no coordination can take place at all for five years; all firms are left to go by themselves completely! This can hardly be the case, so somewhere revisions and feedback must enter even in the new system, but until we know how, the coordination aspect cannot be properly understood.

FOOTNOTES

* This paper was supported by a grant from Neste Saatio, Helsinki, Finland. It was presented at the Third Finnish-Soviet Symposium on Economics, Tampere, Finland, November 20-22, 1979. I would like to thank Dave Baron for comments on an earlier draft.

1. See Arrow (1974).
2. See, for instance, Weitzman (1976), Fan (1975), Ekern (1979), Snowberger (1977), Bonin (1976), Loeb and Magat (1978), and Miller and Thornton (1978).
3. This description is based on Holmstrom (1977), Chapter 1.
4. As an example, let $d_i$ be the investment in division i and let the financial outcome be $x_i(d_i,z)$ (for simplicity, one number only). Let agent i's preferences over money be given by $U_i(w)$, and suppose his reward has been tied to $x_i$ via a linear share $a_i x_i + b_i$. Then $F_i(d,z) = U_i(a_i x_i(d_i,z) + b_i)$.
5. It may be noted that an equilibrium in a finite move extensive form game with explicit description of the sequencing of information exchange and decision-making will always correspond to some equilibrium in a one shot-game with suitably augmented message spaces. And this one shot game can again be reduced to a game where truthful information is passed as theorem 1 states. Furthermore, randomization in the possibly very complex extensive form game with still be captured by simple draws from a uniform distribution (honestly reported in equilibrium). The benefits of theorem 1, which has been noted by several authors, have been ingeniously exploited in Myerson (1978).

FOOTNOTES (Cont'd)

6. The same notion of efficiency was independently proposed by Harris and Townsend (1977), Holmstrom (1977), and Myerson (1979).

7. Randomization guarantees converxity in expected utility space; see Myerson (1979).

8. For screening, see Rothschild and Stiglitz (1976), for optimal taxation, Mirrlees (1971), and for optimal regulation, Spence (1977). In Holmstrom (1980) I look at these models in a delegation perspective.

9. This is very much akin to the issue of winner's curse in bidding models; see for instance Capen, Clapp and Campbell (1971).

10. In technical terms, optimal delegation generally corresponds to an imperfect equilibrium; see Selten (1974) for a rigorous discussion and Kydland and Prescott (1977) for an interesting economic application.

11. Alternatively, the agent could have paid the principal $2 if R was chosen. Sometimes it is beneficial for the agent to punish himself to make his behavior credible (see Moulin (1976)). Warranties are good examples. (Grossman (1980)).

12. With risk neutral principal and agent, it turns out that any signal received ex post, which discriminates between z:s (likelihoods of z:s differ conditional on signal outcomes), can be used to achieve a first-best optimum.

FOOTNOTES (Cont'd.)

13. One means for improving cooperation which has not been mentioned is randomization. Somewhat surprisingly, randomized taxes for instance, may be desirable; see Weiss (1976).

14. It is hard to believe that managers would get any specific joy from low outcomes per se.

15. Weitzman's (1976) discussion of coordination benefits recognizes that one may want target to equal expected output not so much because one is interested in expected output per se, but because then the kink in the reward schedule will be placed at a point where reward is most closely aligned with social benefit. Though I agree with the basic idea, I think it is subtle to analyze whether it is desirable to have expected output equal target, particularly, given the motivational aspects of the scheme.

16. See Weitzman (1980) for an analysis of how revision schemes influence the behavior of the manager. Note, however, that there is no obvious reason for revisions in his model, as uncertainties across periods are unrelated.

17. Stiglitz (1975) discusses revision as a form of signalling, in a similar spirit, but in a different context.

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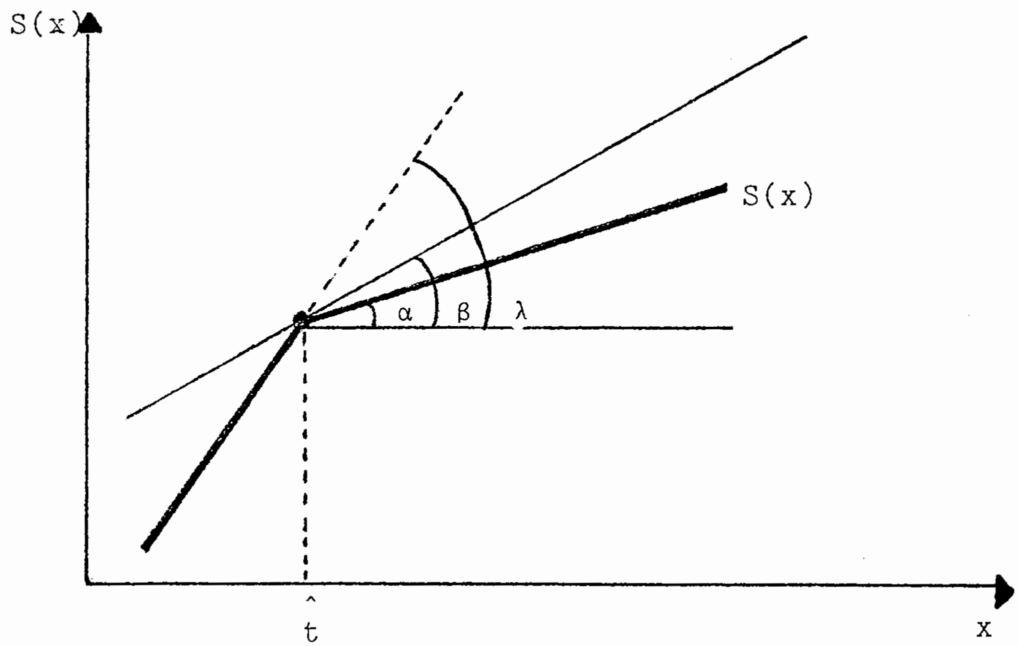


FIGURE 1.