LONG–TERM CONTRACTS, THE PRISONER'S DILEMMA

AND X-EFFICIENCY

by

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Dilemma and X-Efficiency

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Introduction

The phenomenon of long-term contracts has recently received much
attention in the literature, especially in monetary theory, where the length
of labor contracts is associated with the efficiency of monetary policy.[1]
Also, the relationship between productivity and the wage rate was much
investigated, and it was frequently argued that in labor markets marginal
conditions are not fulfilled.[2]

This study examines these issues within the framework of the well-known
non-zero-sum-game called the Prisoner's Dilemma. Today in the economic litera-
ture long-term contracts seem to be explained either by employers being less
risk-averse than their employees or by imperfect labor markets and so forth.[3]
The application of the Prisoner's Dilemma shows that these assumptions are
unnecessary: even if both employers and employees have linear utility functions,
and disregarding mobility costs, long-term contracts are shown to be efficient.
This same model also questions the meaning of marginal productivity not being
equal to the wage rate: if "trust" (just one firm-specific human or information
capital) is included in the definition of marginal productivity, doubts are
raised on the validity of these discussions. In addition to these issues it
is shown that the same model which explains the rationale for long-term contracts
in labor markets explains the various forms of long-term arrangements among
buyers and sellers of services other than labor. Then the relationship between
this model and (a) Akerlof's "market of lemons" and Leibenstein's "X-efficiency"
theory,[4] (b) mobility and productivity, (c) fiscal and monetary policies and
productivity, are briefly discussed. Although when dealing with these issues

I refer to relevant empirical work that has come to my attention, it should be pointed out that no testing of the implications of the model discussed here have yet been attempted.

In the first section the interpretation of the Prisoner's Dilemma for these issues is presented, and in the second section the various implications are discussed. The conclusions follow.

I. The Prisoner's Dilemma, the Single and the Repeated Game

The Prisoner's Dilemma is a non-zero sum game characterized by the following type of payoff matrix:[5]

Prisoner 2

$$
\begin{array}{cc}
 & \begin{array}{cc} \beta_1 & \beta_2 \end{array} \\
(1) \qquad \text{Prisoner 1} \quad \begin{array}{c} \alpha_1 \\ \alpha_2 \end{array} & \begin{pmatrix} (5,\ 5) & (-4,\ 6) \\ (6,-4) & (-3,-3) \end{pmatrix}
\end{array}
$$

The lines and the columns represent the payoffs in monetary terms (which can be transformed without any loss of generality to represent utilities) for the two strategies α_i, β_i, $i = 1, 2$ that each prisoner may choose. The conditions of the game are such that each prisoner chooses his strategy without knowing what strategy is being played by the other. It can then be shown that if the players expect the game to be played only <u>once</u>, the outcome of rationale utility maximization are the strategies α_2, β_2 or the $(-3, -3)$ payoff. But if this game is expected to be repeated many times in the future, Luce and Raiffa [1966] show that if (a) the discount rate of future games is not too small (so that the sum of the payoffs converges), or (b) the repeat probability of facing the same game in the future is not too small, or (c) the number of trials is a random variable of the exponential type (i.e. the conditional probability of playing exactly "n" more trials given that "k" have already been played is independent of "k") then the equilibrium pair is the repeated use of the first strategies by both players and the outcome of the game is then $(5, 5)$.

Luce and Raiffa also note that there is an alternative strategy for this supergame: for one player it is profitable to play initially as if he does not know the long-run equilibrium of the game and let the opponent teach him. In this way, one player can temporarily obtain the benefits of playing the second strategy while the other plays the first. This becomes particularly

tempting when the payoff matrix is:

(2)
$$\begin{pmatrix} (5,\ 5) & (-50,\ 50) \\ (50,-50) & (-3,-3) \end{pmatrix}$$

In the long run also this repeated game converges to the first strategies when the conditions mentioned above are fulfilled.[6]

First, the conditions of the game must be clarified: it refers to situations where one player faces information costs in discovering the strategy (or intentions) chosen by the other player. This game cannot refer to either perfectly competitive markets or monopolies, since in these markets the sellers have only one strategy.[7] Markets which can be characterized by this game are those where the buyer's ability to evaluate a service is limited without additional costly information. For, let the two players of the game be an employer and an employee, and assume that the job is such that the employee's effort (or productivity) cannot be assessed without additional costs. The employee is then able to make either a small or a great effort.[8] The meaning of the payoff matrix becomes this: let W_1 be the wage rate paid for a greater productivity and W_0 the rate for a lower one. The outcome (5, 5) means that the employee makes a greater effort and receives the appropriate wage, W_1. (6, -4) means that the worker made a great effort but only received W_0, because his efforts were not recognized. (-4, 6) means that the employee made only a small effort and received the wage W_1, while (-3, -3) means that the employee made a small effort and received the appropriate lower wage. That this is the equilibrium in the market when the game is expected to be played only once stems from the following argument: both the employer and the employee are rational, i.e. they know the game and take its consequences into consideration. When the game is expected to be played only once the employee knows that his employer will be unable to measure his productivity (or effort), expects to be fired and thus independent

from this employer's evaluation eventually, he responds rationally by making

a small effort. The employer also knows what human nature is, pays the appro-

priate wage, and the outcome (-3, -3) results in the market. "Effort" being

an unmeasurable decision variable in the short run and the high information

costs in discovering individual intentions lead to this outcome. It is straight-

forward to interpret the game for buyers and sellers of services other than

labor. When the buyers' ability to evaluate the quality of the service (like

auto repairs, medical services, punctuality in delivery and so forth) is limited

without additional costly information the meaning of the payoff matrix becomes

this: the seller is viewed as being able to play two strategies, i.e. providing

a low or a high quality service. There are two strategies available to the

buyer: either to pay W_1 for a high quality or W_0 for a low quality service.

When the game is only expected to be played once, the same arguments as before

lead to the (-3, -3) equilibrium outcome, i.e. a low price is paid for a low

quality good.

However, knowing the (5, 5) outcome of the supergame implies that there

are incentives in the market to find arrangements which would permit it being

arrived at, since this outcome makes both buyers and sellers better off. There

are various strategies which permit this outcome: (a) to sign long-term contracts,

(b) employers demanding information on their employees' performance from their

previous employers and employees being aware of this fact; (c) service contracts,

leasing arrangements, extensive warranties, or some more informal "client

relationship" in the market for services other than labor.[9] All these arrange-

ments indicate to either buyers or sellers of services or goods that the game

will be played more than once, i.e. that the strategy chosen by the seller is

α_1. Thus, the various forms of long-term arrangements in both the labor market

and the market for goods can be viewed as a "technological innovation" which

economizes on information costs and allows an efficient allocation of resources. Risk aversion is not necessary to explain the existence of long-term contracts, the utility functions of both employers and employees may be linear in the payoffs and still these contracts are preferred by both sides when there are information costs in discovering individuals' intentions.[10] While models justifying the efficiency of long-term contracts were appropriate only for the labor market the approach presented here, besides having the advantage of being simple, also explains long-term contracts in markets other than labor, and with testable implications indicated later.

The different equilibrium solutions for the game which is expected to be played only once and for the repeated game allow the following additional observations to be made:

1) The incentives to enter into a long-term contract depend on expectations to repeat the same game many times in the future. The meaning of "the same game" is that both the buyer and the seller expect to face the same relative prices in the future, i.e. the expected payoffs are relatively stable. Frequent changes in relative prices imply that each game is perceived to be played for only a short period of time. Therefore, the incentives to enter into a long-term contract decrease, and market participants lose their confidence or "trust" one in the other and productivity and real wages decrease. The cost of breaking a contract in this model is clear: information capital is lost when this happens. Thus, fluctuations in relative scarcities perceived as temporary will not lead to breaking long-term contracts.[11]

2) When a group in the population moves more often in and out of
the labor force the model predicts that members of this group
will earn lower wages than equally qualified members of less
mobile groups. Since there are high information costs to discover
what individual's intentions are, the employer will use as a proxy
for his information the characteristics of the group (and efficient
discrimination results). If an employee is a member of a relatively
more mobile group, the employer, expecting a short game with this
employee and knowing that he will be less dependent on employer
evaluation should he leave the labor force, expects a smaller effort
than from an identically qualified member of a less mobile group.
This argument fits the situation of women in the labor force, and
I shall return in the next section to the existing evidence which
supports this prediction of the model.[12]

3) An additional aspect of mobility should be mentioned: when the popu-
lation becomes relatively more mobile both buyers and sellers of
goods are expected to have a one play orientation. However, knowing
that (5, 5) is the equilibrium outcome of a repeated game gives
incentive for national chains or brand names or other alternative
forms of long-term "contracts" to develop. For, once a firm succeeds
in building up a local reputation it becomes cheaper for customers
to look for the same firm when they move to another location. In
particular this demand exists in industries characterized by the
production of goods which have "credence qualities," qualities
which although worthwhile either cannot be evaluated in normal use
or their assessment requires additional costly information. Cars
or other durable goods, fast food chains, department stores, etc.
are some examples.[13]

4) As indicated above, the players arrive at the (5, 5) equilibrium
   outcome either through an efficient arrangement or through a
   learning process. In particular, when the payoff matrix is of
   type (2), a long run strategy may be such that initially one
   player teaches the other the rules of the game and a transfer
   occurs (in the short run) from one player to another. Such a
   process may happen voluntarily when the investing player expects
   a long-term relationship with the other player. The rationale for
   this outcome is clear: investing in the other player for a while
   is profitable when this investment permits the (5, 5) outcome in
   the long run instead of $(-3, -3)$. Specific training in firms provide
   one such example: the firm has the incentive to teach the employee
   a firm-specific skill, and the worker learning it signals that he
   does not have a one-play orientation.[14] Another example is advertising,
   where a seller tries to establish a brand name to signal a long-term
   relationship.

5) This model raises several questions as to the meaning of fraud or
   discrimination in the market. When a high price is paid for a low
   quality good, i.e. the monetary payoff (6, -4) results, we define
   it as "fraud." The meaning of the payoff is clear: "-4" is the
   buyer's payoff and "6" the seller's, which is higher than "5" since
   to produce a low quality good is cheaper. When the seller sells a
   high quality good for a low price, i.e. the outcome (-4, 6), we only
   hear about it when the seller happens to be an employee. Then he
   will claim to be exploited or discriminated against. There is,
   however, a difference between "fraud" and "discrimination": when
   a good is exchanged its quality can later be assessed by specialists,

in contrast to an employee's past performance. From our previous discussion it follows that different wages for "equally" qualified members of the population is not by itself a sign of discrimination. If one group moves more frequently in and out of the labor force, the lower wages they receive are not due to discrimination but to the lower level of effort expected from members of this group. The term "equal" becomes meaningless, and whether there is discrimination or not becomes hard to measure since it depends on the employee's intentions and his level of effort.[15]

In conclusion, the approach presented here combines in one simple model both the buyer's and the seller's optimization problem, and the equilibrium outcomes for both the short-run and the long-run are obtained. This equilibrium is based on rational expectations, i.e. both sides of the market derive the expected outcome from the same model which describes the behavior in the economy. In the next section additional implications of the model are discussed in detail and the explanations this approach gives to some phenomena are compared with alternative explanations that were suggested.

II. The Market for Lemons, X-Efficiency,
     Wages of Women and Some Macro Implications of the Game

Akerlof [1970] showed that under conditions in which sellers of a commodity are better informed about it than the buyers, a self-selection mechanism exists in which the commodities of worst quality become traded. This is exactly the implication of the Prisoner's Dilemma when a game is only expected to be played once. The fact that the game is expected to be played once must not, however, be confused with perfect competition. While it is true that the present value of any future relationship with a buyer or a seller is in this case zero, perfectly competitive markets do not fit the game, since the sellers only play one strategy and all the information on the quality of the good is provided through the price mechanism. Also, if the market is not perfectly competitive the approach in this paper suggests the various solutions found in the market which avoid the (-3, -3) type outcome. The long-term contracts indicated in the previous section permit the (5, 5) outcome to be arrived at, since they signal to the buyer that the strategy α_1 was chosen by the seller, and they also allow avoidance of the outcome suggested in Akerlof's study. Sears, Roebuck and Co.'s renewable service contract on a variety of home appliances, the "Kaiser Plan" for medical care, leasing of automobiles and other durable goods from firms which handle future servicing and extensive warranties are just some of the forms these long-term contracts take in practice.[16]

While Akerlof's paper dealt with the (-3, -3) equilibrium solution (in terms of the game) Darby and Karni [   ] analyzed the relationship between fraud and free competition. Their analysis can be viewed as part of the Prisoner's Dilemma: as shown in the previous section the meaning of fraud in terms of the game is the (6, -4) type outcome. Darby and Karni showed that fraud is more likely to occur when no repeated exchanges are expected (or in terms of their model, the present value of future client relationship is small), which is

also the prediction this model makes. The frequent, unnecessary repairs
tourists face provide just one empirical evidence which fits the empirical
evidence of these theories.[17]

In a series of articles Leibenstein[18] presented his X-efficiency theory.
The idea behind it is thus defined:

> "Suppose that certain inputs have been allocated to a firm. These
> inputs can be used with various degrees of effectiveness within a
> firm. The more effectively they are used the greater the output.
> When an input is not used effectively, the difference between the
> actual output and the maximum output attributable to that input is
> a measure of the degree of X-efficiency."[19]

The Prisoner's Dilemma defines this outcome precisely: it is the (-3, -3) equi-
librium outcome instead of the (5, 5) one. According to Leibenstein the difference
between his and the general economic approach is that while neoclassical theory is
based on maximization with no interpersonal interactions, effort being assumed
as given, his theory is based on "rational selectivity," some interpersonal
interaction and effort being a decision variable.[20] But as shown in the pre-
vious section the existence of low quality goods, low levels of effort and long
term contracts do not require a change in the basis of economic theory. Rational
utility maximization explains them; the Prisoner's Dilemma is based on utility
maximization of both market participants (whether buyers/sellers, or employers/
employees); the interaction between market participants is taken into consideration,
and the level of effort is endogenous. Hence it fulfills all Leibenstein's objec-
tions against economic theory; moreover it leads to predictions consistent with
facts, like explaining the rationale behind various long-term contracts found in
the economy or tourists being cheated, and sheds light on the differences between
the wages of men and women presented below.

Several researches were carried out to explain male-female wage differ-
entials. In both Polachek's [1975] and Niemi's [1975] studies the major explanatory
variable was the continuity in labor force participation. Niemi's study showed

that the fact that women have relatively little specific training has only
a small effect in explaining male-female unemployment rate differentials--it
is the high inter-labor force turnover of women which accounts for most of the
sex differential in unemployment rates. In Polachek's study the female worker
who achieves the same experience more continuously has higher earnings and he
found that "a high continuous labor force participation has the greatest impact
on raising female wages" (p. 107). These two evidences were unrelated in the
literature; but if effort is a major variable explaining productivity then both
evidences are exactly the predictions that the Prisoner's Dilemma makes, for
there is a major difference between intra and inter labor force participation
in terms of this model. Women, having a greater inter labor force mobility,
are less dependent on evaluations by previous employers than males who stay
more permanently in the labor force. Employers, knowing this, expect a smaller
level of effort from women. This leads to both wage differentials with equally
qualified males and to longer search periods when re-entering the labor force[21]
for women. At the same time women with continuous experience in the labor force
signal their intentions of long term relationships, and a smaller wage differen-
tial between these women and males should then result. This explains why in
spite of the empirical evidence of women changing jobs less frequently than men,
and when they do change jobs tending to stay within the same occupation[22] which
would suggest that firms have greater incentives to invest in specific training
for females, a wage differential in favor of equally qualified males results.[23]

Finally, a macroeconomic implication of the model should be pointed out.
Most discussions in macroeconomics do not pay much attention to changes in rela-
tive prices.[24] When they do, then the change in relative prices is either due to
confusion between nominal and real shifts in the economy or to the existence of
long-term contracts.[25] It is an implication of these latter approaches that I

discuss here: fiscal and monetary policies change the relative prices in the economy. For example, keeping the nominal rate of interest constant changes the prices in the housing market and subsidies for agriculture change the price of farm outputs. The meaning of random and unpredictable policies in terms of the Prisoner's Dilemma is a frequent change in the payoff matrix. Thus the incentives to enter into long-term contracts in either the labor market, the market for goods or the financial markets decreases. Consider now that output can be produced by two inputs, labor and physical capital. When frequent changes in policies are expected, the demand for inputs with more cheaply adjustable contracts will increase. If the adjustment of the optimal amounts of labor are lower than those of optimal amounts of capital (as the evidence suggests)[26] frequent changes in policy lead to a change in the optimal method of production. The output will be produced by a more labor-intensive method, and ceteris paribus (i.e. no technological innovations) real wages will *increase*.[27]

III. Conclusions

An attempt was made in this paper to explain long-term contracts in the economy within a simple framework which has, however, testable implications. Long-term contracts are a feature not only of labor markets but also of the market for goods. The advantage of this model is that it explains the presence of long-term contracts in both markets, in contrast to the existing models which only concentrate on the labor market. Moreover, these models cannot be applied to the market of goods since it is arbitrarily assumed that one participant in the contract is more risk-averse than the other.[28]

The model gives an explanation for the fact that low quality goods are found in the market, and like in Akerlof's model they may eliminate higher quality goods. But this is a short-run effect in this model, since in the long run both buyers and sellers have the incentive to arrive at the (5, 5) outcome. This is however, not instantaneous: the market participants must learn the appropriate strategies. Warranties, leases and so forth require the parallel development of the legal system enforcing such contracts.

One implication of the model will be subject for further research: the model suggests than when the population becomes relatively more mobile there are incentives for national chains to develop: McDonalds, Lord and Taylor's[23] and so forth seem to be evidence for this trend. It is however a puzzle why for some goods with credence qualities the private sector responded in developing these chains but for others, like schools, hospitals and law firms, it has not (so far). But it is also clear that if my hypothesis on mobility is correct and the private sector has not responded, the demand for national chains in these cases will be directed toward the government.

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FOOTNOTES

[1]See Azariadis [1975], Baily [1974], Fischer [1977], Brenner [1979a].

[2]See, for example, Lazear [1979].

[3]See, for example, Baily [1974], and for implicit criticism of this approach Stigler [1962].

[4]See Leibenstein [1966, 1973 and 1978] and Akerlof [1970].

[5]See Luce and Raiffa [1966], pp. 94-102, Davis [1973], pp. 93-103, and Brenner 1979b, c] for two further applications of the game to the subject of discrimination and inheritance.

[6]See Luce and Raiffa, op. cit.

[7]Since in both perfectly competitive markets and monopolies the price gives all the information on the qualities of the good. In monopolistic competition goods differ in their characteristics, thus the sellers play more than one strategy. Also, in the context of this paper the assumption of perfect information in these two markets is crucial for the analysis.

[8]Becker [1977] discussed the allocation of effort in a different framework, without relating it to short-term and long-term commitments, which are the foci of my analysis.

[9]See Darby and Karni [   ]. They have analyzed the problem of optimal amounts of fraud in the market, and they argued that these arrangements in the market of goods decreases the probability of fraud. In terms of my approach the definition of fraud would be the outcome (6, -4) or (-4, 6), discussed later in the text.

[10]See Baily [1974] and Jovanovic [1978], where risk-aversion is crucial in the model either explaining long-term contracts or the existence of low-quality goods.

[11]See Becker [1971], lecture 17, where a similar point is made.

[12]See Phelps [1972]. The subject of discrimination within the framework of the Prisoner's Dilemma is discussed in detail in Brenner [1979b].

[13]This is also a conclusion in Darby and Karni, op. cit.

[14]Otherwise to learn firm-specific skills would be a waste of time.

[15]Again, see Darby and Karni, op. cit.

[16]See Darby and Karni, op. cit., p. 80 for these and similar examples.

[17]See Darby and Karni, op. cit. Another example of low quality service might be the case of illegal abortions, where the issue, however, is more complicated since the demanded service is illegal.

[18]See works quoted in footnote 4.

[19]See Leibenstein [1978], p. 17.

[20]These are some of the differences Leibenstein [1978] emphasizes in chapter 2. Although it must be noted that none of his terms are very clearly defined: selective rationality depends on "personality" (which is left undefined), what determines the level of effort is unclear, and the exact nature of inter-personal interactions is also left open.

[21]Since it is more costly (in particular more time consuming) to the firm to find out information on females and makes it more profitable to wait. Also see Alchian [1970].

[22]See Niemi [1975], Table 3.4.

[23]That from the firm's viewpoint males and females may have the _same_ job turnover was shown by Mincer, as quoted in Niemi [1975]. What is important, however, in terms of the model suggested here is the difference between inter and intra-labor force mobility.

[24]See the IS-LM model, for example.

[25]See Fischer [1977], Phelps and Taylor [1977] and Lucas [1976].

[26]Firms respond to fluctuations in demand by either lay-offs or more hours supplied by existing workers, rather than adjusting their physical capital.

[27]The elaboration of this point is beyond the scope of this paper and it will be the subject for further study. It is useful to notice, however, the endogeneity of long-term contracts in contrast to the assumptions in some macro-models, like Fischer [1977].

[28]See works quoted in footnote 1.

[29]And recently Montgomery Ward's started to offer "Law Stores" in San Diego for a flat $10 consultation fee.

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