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# INTERPRETING REAL WORLD CONTRACTS: AN INVESTIGATION OF EX POST MUTUALLY BENEFICIAL AGREEMENTS

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## I. Introduction

The existence of contracting is an integral factor in a wide range of economic settings, and has recently become a popular topic of analysis. Studies in this area have generally modeled contracts by utilizing one of two approaches. First, some studies assume away the existence of transaction costs. This typically results in complex contingent claims contracts which are restricted only by the information structure in the economy (see e.g., Myerson 1979, Harris and Townsend 1981, and Townsend 1982). Second, other studies impose a contract form, where the imposition is based on descriptive realism. The rationale for this approach is that the existence of transaction costs precludes the types of complex contingent claims contracts which characterize the first approach (see e.g., Stiglitz 1974, 1975, Shavell 1980, and Hall and Lazear 1982). This paper looks at studies which fall into the second category, and proposes a new way to interpret the imposed contract forms.

One issue which does not arise in the zero transaction costs approach is how should ex post mutually beneficial agreements be treated. By ex post mutually beneficial agreements we mean feasible agreements occurring at some date after the initial contract signing, which, given the then existing position of the parties, make the contracting parties better off. This is not an issue in the zero transaction costs approach because the initial contract will necessarily exhaust any opportunities for ex post agreements which improve ex ante welfare, while at the same time prohibiting any such agreements which worsen ex ante welfare. When we are dealing with imposed contract forms, on the other hand, the existence of ex post mutually beneficial agreements is an issue. That is, with an imposed contract form the initial contract might not have enough flexibility to either exhaust all opportunities for desirable ex post agreements, or prohibit all ex post agreements which might be objectionable. Thus, with imposed contract forms one must decide first, when to allow ex post mutually beneficial agreements, and second, what specific form these agreements should take.

Most previous studies which have used an imposed contract form have dealt with the above issue by simply assuming that no ex post agreements are ever made. The argument underlying this approach is that the transaction costs associated with reopening negotiations are too high to make any such agreements feasible.[1] The position we take in the present paper is that this standard approach is not discriminating enough in terms of the renegotiation costs assigned to different types of ex post mutually beneficial agreements. In particular, we identify and investigate the ramifications of a family of ex post agreements which likely have zero, or at most very small, renegotiation costs.

Consider the following hypothetical situation. Mr. X has just signed a contract which gives Mr. X the option to purchase from some Mr. Y a fixed set of services at a price of $100. Now suppose that previous to the date at which Mr. X has to decide whether or not to purchase the services, Mr. Y finds out that he would actually be better off if the prespecified price was $90. We conjecture that there are zero (or very small) renegotiation costs associated with having the contract changed such that the new prespecified price is $90. That is, Mr. Y could simply offer to have the contract changed in the specified manner, and given the nature of the proposed change it seems likely that the change would be immediately accepted. Or more generally, we conjecture there are zero renegotiation costs whenever one party to a contract finds it advantageous to offer a change in a prespecified contract term, e.g., a price or a royalty rate, where the proposed change is in a direction the other party (or parties) could not possibly find objectionable.

Consideration of low renegotiation cost ex post agreements is of obvious importance given the substantial body of recent literature that has utilized imposed contract forms to explain observed economic behavior. An excellent example of this is the recent macroeconomics literature (see e.g., Fischer 1977, Taylor 1980, and Okun 1981) that utilizes imposed contract forms in the labor market to explain observed cyclical fluctuations in output and employment. The analysis in this paper suggests that one needs to be very careful in drawing inferences from a model with an imposed contract form. In particular, we argue that while transaction costs may prevent complex contingent claims contracts from developing, prohibiting all potential ex post agreements rather than discriminating between those that have low and those that have high renegotiation costs may yield misleading results.

The outline for this paper is as follows. Section II investigates the general ramifications of the existence of ex post mutually beneficial agreements which entail zero renegotiation costs. The main thrust of this section is that, given a contracting environment which satisfies a particular intertemporal independence condition, the existence of such agreements tends to increase the ex ante welfare of the contracting parties. In Section III we apply our conjecture concerning a specific family of ex post agreements which entail zero renegotiation costs to the analysis of three different contracting situations. Our goal in this section is to demonstrate how one can incorporate our conjecture concerning this family of ex post agreements into actual analyses of contracting. One of the contracting situations we analyze in this section is an example of the prespecified wage contract world analyzed by, among others, Kuratani (1973), Hashimoto (1979), Hashimoto and Yu (1980), Carmichael (1981), and Hall and Lazear (1982). Our analysis demonstrates that the incorporation of these simple ex post agreements leaves little rationale for the comparison of imposed contract forms contained in Hall and Lazear. Finally, in Section IV we present some concluding remarks.[2]

## II. General Ramifications

In this section we consider some of the general ramifications of the existence of ex post mutually beneficial agreements which entail zero renegotiation costs. It might at first seem that the existence of such agreements must necessarily make contracting parties better off. The intuition is simply that, by definition, mutually beneficial agreements make the parties to the agreements better off. This intuition is, however, incorrect. The key term here is that the agreements are ex post. That is, the agreements are not being reached at the date of the initial contract signing, and it is therefore possible for expectations of such future agreements to have deleterious effects on early stages of the execution of a contract. Below we present two theorems which delimit when this aspect of the problem can be ignored, and thus indicate when our initial intuition is valid.

Theorem 1 compares the performance of a given contract in two types of renegotiation cost environments. In the first type of environment all ex post mutually beneficial agreements entail prohibitively high renegotiation costs. This will be referred to as the standard renegotiation cost environment. In the second type of environment there is a subset of ex post mutually beneficial agreements which entail zero renegotiation costs, while all other ex post agreements entail prohibitively high renegotiation costs. This will be referred to as a partially discriminating renegotiation cost environment.[3]

<u>Theorem 1</u>: Consider a given contract, set of contracting parties, and particular partially discriminating renegotiation cost environment. All else

the same, if the following condition is satisfied, then each contracting party will be at least as well off in this partially discriminating renegotiation cost environment as in the standard renegotiation cost environment. Additionally, it is possible for contacting parties to be strictly better off in the partially discriminating renegotiation cost environment.

1) Given the absence of any ex post agreements, there exists no date at which the behavior of either a contracting party or a relevant third party depends, possibly indirectly, on expectations of future agreements consistent with this partially discriminating renegotiation cost environment.

Proof: We can prove part of Theorem 1 by demonstrating that for a randomly chosen contract, set of contracting parties, and partially discriminating renegotiation cost environment, no contracting party can be worse off in this partially discriminating renegotiation cost environment than in the standard renegotiation cost environment when the stated condition is satisfied. Suppose this is not so. Given as fixed the position of all the agents in the economy at the date a mutually beneficial agreement is reached, such an agreement by definition cannot make any of the contracting parties worse off. Thus, for some contracting party to be better off in the standard renegotiation cost environment, some agent must have his behavior at some prior date depend, possibly indirectly, on his expectations of future agreements consistent with this partially discriminating renegotiation cost environment. This violates our restriction. Finally, the idea that a contracting party can be strictly better off in the partially discriminating renegotiation cost environment is demonstrated by the first two examples of Section III. Q.E.D.

Theorem 1 states that, when a fairly strong intertemporal independence property is satisfied, our initially stated intuition is valid. One weakness with the Theorem, however, is that it does not treat the contract itself in an endogenous fashion. In Theorem 2 we attempt to extend Theorem 1 in this direction.

Theorem 2: Consider a given imposed contract form, set of contracting parties, and particular partially discriminating renegotiation cost environment. Allowing contracts to emerge endogenously in both environments and all else the same, if the following two conditions are satisfied, then this partially discriminating renegotiation cost environment may (may not) be Pareto superior (inferior) to the standard renegotiation cost environment, i.e., in terms of the welfare of the contracting parties.[4]

1) Given the constraints of the imposed contract form, the bargaining process always places the parties somewhere on the Pareto frontier.

2) For the contract which emerges under the standard renegotiation cost environment, the intertemporal independence property presented in Theorem 1 holds.

Proof: We can prove part of the Theorem by demonstrating that for any imposed contract form and set of contracting parties, a randomly chosen partially discriminating renegotiation cost environment cannot be Pareto inferior to the standard renegotiation cost environment when the stated conditions are satisfied. Denote the contract which emerges under the standard renegotiation cost environment as Contract S, and the contract which emerges under our randomly chosen partially discriminating renegotiation cost environment as Contract P. Condition 1) implies that under this partially discriminating renegotiation cost environment, Contract P cannot be Pareto inferior to Contract S. Condition 2) and Theorem 1 imply that for Contract S, this partially discriminating renegotiation cost environment cannot be Pareto inferior to the standard renegotiation cost environment. Taken together these two statements imply that when contracts are allowed to emerge endogenously in both environments, this partially discriminating renegotiation cost environment cannot be Pareto inferior to the standard renegotiation cost environment. Finally, the idea that a partially discriminating renegotiation cost environment may be Pareto superior to the standard renegotiation cost environment is demonstrated by the first two examples of of Section III.

Q.E.D.

## III. Three Examples

In this section we analyze three different imposed form contracting situations under the partially discriminating renegotiation cost environment which we refer to as the termwise flexible renegotiation cost environment. This environment is described in the following discussion. First, there are zero renegotiation costs whenever one party to a contract finds it advantageous to offer a change in a prespecified contract term, where the proposed change is in a direction the other party (or parties) could not possible find objectionable. For example, there are zero renegotiation costs when a firm finds that it is advantageous to offer a worker a wage higher than a wage that has been prespecified in an employment contract. Second, all other ex post agreements have prohibitively high renegotiation costs. The way we will assume renegotiations take place in this environment is as follows. When one party finds that it would prefer a contract change of the specified type, the party makes an offer of the change. Furthermore, given the nature of the proposed change, the other parties simply accept the offer. This assumption avoids one problem concerning how one analyzes this type of environment. That is, suppose one party finds that it would prefer any of a number of changes of a particular contract term, all of which could not possibly be objectionable to any of the other parties. Given our assumption concerning how renegotiations take place in this environment, the change which is implemented is simply the one which the offering party finds most desirable.

The first two situations we analyze in this section exhibit the intertemporal independence property of Section II. Thus, they are both situations for which the termwise flexible renegotiation cost environment cannot be Pareto inferior to the standard renegotiation cost environment. In both analyses we demonstrate that, under specific assumptions concerning distribution functions and utility functions, the parties to the contract will in fact be strictly better off under the termwise flexible renegotiation cost environment. The third situation we analyze does not exhibit the intertemporal independence property of Section II. Our goal with this example is to demonstrate how, given the absence of this property, the parties to a contract can in fact be strictly worse off under a partially discriminating renegotiation cost environment.

Example 1

We first look at an example consistent with the branch of the literature which might best be termed the prespecified wage contract literature (see e.g., Kuratani 1973, Hashimoto 1979, Hashimoto and Yu 1980, Carmichael 1981, and Hall and Lazear 1982). This literature looks at a two period worker-firm problem which is characterized by bilateral asymmetric information and no possibility of shirking behavior on the part of the worker. Bilateral asymmetric information in this context means that firms privately observe productivities, while workers privately observe their alternatives. Because of bargaining costs and the costs of bilateral monopoly negotiations, it is assumed that prior to the onset of the specified two period relationship the worker and firm agree to a contract of the following form. First, the contract specifies both a first period wage and a second period wage, where the second period wage is contingent on the worker remaining with his first period employer. Second, the contract does not allow either side to terminate employment during the first period, while a separation can be initiated by either side during the second period. Third, the prespecified second period wage is assumed to not be contingent either on the firm's private information concerning the worker's productivity, or on the worker's private information concerning his alternatives.

There are two types of ex post agreements in the prespecified wage contracting world which are consistent with a termwise flexible renegotiation cost environment. First, after observing his alternatives, the worker may find that he prefers a second period wage lower than the second period wage prespecified in the contract. Second, after observing the worker's productivity, the firm may find that it prefers a second period wage higher than the second period wage prespecified in the contract. Given this, it is easily seen that the prespecified wage contracting world exhibits the intertemporal independence property of Section II. That is, since the contract does not allow for any type of discretionary behavior in period one, there necessarily exists no date at which behavior depends on expectations of the type of ex post agreements specified above. Thus, this is a contracting world for which Theorems 1 and 2 are relevant. In what follows we set up an example consistent with the prespecified wage contracting literature, and derive the contract which emerges under the standard renegotiation cost environment. We then demonstrate that for the particular contract which emerges, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment. Finally, we demonstrate that even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto superior to the standard renegotiation cost environment.

Both the firm and the worker are assumed to be risk neutral. Let $W_1$ be the first period wage specified in the contract and $W_2$ the second period wage. The first period of employment is solely a training period, and thus no output is produced. Denote the value of the worker's marginal product at the firm in period two as $M$, and the value of the alternative use of the worker's time in period two as $R$. At the start of period two, the firm privately observes $M$ and the worker privately observes $R$. The specific nature of our example derives from the distributions of $M$ and $R$. It is assumed that $R$ is uniformly distributed over the range $[0,1]$. On the other hand, $M$ equals 3/4 with probability 1/3, 1 with probability 1/3, and 2 with probability 1/3.

It is assumed that the contract which emerges in this world is simply the one which maximizes the expected profits of the firm, given an expected utility constraint on the part of the worker.[5] Because the worker is risk neutral, this reduces to finding the second period wage which maximizes the second period expected joint value of the contract, i.e., the expected profits of the firm plus the expected normalized utility of the worker. We will now solve for $W_2^S$, the second period wage which emerges in the standard renegotiation cost environment. In the standard renegotiation cost environment, the firm will discharge the worker at the start of period two if $M < W_2$ and the worker will quit if $R > W_2$.[6] Given this, it is easily demonstrated that $W_2^S$ equals either 3/4 or 1. That is, $W_2^S = 3/4$ dominates any wage below 3/4, while $W_2^S = 1$ dominates any wage which is either above 1 or between 3/4 and 1. Now, direct computation yields that if $W_2^S = 3/4$ then the second period expected joint value of the contract equals 111/96, while if $W_2^S = 1$ the second period expected joint value of the contract equals 112/96. Thus, $W_2^S = 1$.

Our next step is to analyze this example under the termwise flexible renegotiation cost environment. We will first demonstrate that for the contract which emerged under the standard renegotiation cost environment, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment. As previously stated, possible ex post agreements in the termwise flexible renegotiation cost environment consist of offers by the worker to work for a lower wage than $W_2$, and offers by the firm to employ the worker at a higher wage than $W_2$. Consider first the firm. Because $W_2^S = 1$ the firm realizes that the worker will never quit. Thus, there is no private observation of M which would cause the firm to prefer a higher wage than $W_2^S$.

Consider now the worker. After privately observing R, the worker may prefer a sure wage of 3/4 over $W_2 = 1$ where with probability 1/3 the worker is fired. In fact, this is true whenever $R < 1/4$, in which case $W_2$ shifts from 1 to 3/4. The firm can obviously not be made worse off by such a shift, while by construction the worker is better off in an expected sense. Thus, for the contract which emerged under the standard renegotiation cost environment, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment.

We will now demonstrate that even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto superior to the standard renegotiation cost environment. We will do this by demonstrating that for the termwise flexible renegotiation cost environment, the second period expected joint value of the contract which emerges is higher than 112/96. This is a sufficient condition because of the following. First, the expected utility constraint on the part of the worker is necessarily satisfied as an equality in both environments. Second, because this constraint is always satisfied as an equality and because the worker is risk neutral, changes in this second period expected joint value will translate one for one into changes in expected profits.

Let $W_2^T$ denote the second period wage which emerges in the termwise flexible renegotiation cost environment. The same logic as before yields that $W_2^T$ must either equal 3/4 or 1. We first look at the case $W_2^T = 1$. As previously, ex post agreements here consist of $W_2$ shifting from 1 to 3/4 whenever $R < 1/4$. Taking this into account yields that if $W_2^T = 1$, the second period expected joint value of the contract equals 117/96. We now look at $W_2^T = 3/4$. Because the wage in this case never exceeds $M$, the worker realizes that there is no possibility he will ever be fired. Thus, there is no private observation of $R$ which would cause the worker to prefer a lower wage. Consider now the firm. After privately observing $M$, the firm's optimal value for $W_2$, denoted $W_2^F$, is defined by equation (1).

$$(1) \qquad W_2^F = \arg\max_{W_2} \, (M - W_2) \int_0^{W_2} dR$$

(1) yields $W_2^F = M/2$. Whenever $W_2^F > W_2^T$, the second period wage moves from $W_2^T$ to $W_2^F$. When $W_2^T = 3/4$ this occurs whenever $M = 2$, in which case $W_2$ shifts from 3/4 to 1. Taking this into account yields that if $W_2^T = 3/4$, the second period expected joint value of the contract equals 120/96. Thus,

$W_2^T = 3/4$. Furthermore, since $120/96 > 112/96$, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment even when the contract for the former environment is treated in an endogenous fashion.

One question which might be asked is how significant is the assumption concerning which type of environment holds. A measure of this is what proportion of the inefficiency attributable to the prespecified wage contract form is eliminated by assuming a termwise flexible rengotiation cost environment rather than a standard renegotiation cost environment. Placing no constraints on the contract form employed, it is possible to achieve a first best result in this example (see Hall and Lazear 1982). Furthermore, a contract which yields a first best result would have a second period expected joint value of 121/96. Thus, in this example almost 90% of the inefficiency attributable to the imposed contract form is eliminated by assuming termwise flexible renegotiation cost environment rather than a standard renegotiation cost environment.

One final point needs to be addressed. Hall and Lazear (1982) compare the prespecified wage contract with two other simple contracts. Specifically, they compare it with a contract where the worker decides on $W_2$ after privately observing $R$, and with a contract where the firm decides on $W_2$ after privately observing $M$. Their conclusion is that, depending on the distributions of $R$ and $M$, it is possible for any of the three contracts to dominate. Their comparison is made, however, under the assumption that a standard renegotiation cost environment holds. The question we address is how does this conclusion change when a termwise flexible renegotiation cost environment is assumed. The answer is that, under this alternative assumption, the prespecified wage contract always does at least as well as either of the other contracts. This is seen by noting that, in the termwise flexible renegotiation cost environment, each of the other contracts is simply a special case of the prespecified wage contract. That is, the contract where the firm decides on $W_2$ is the special case of the prespecified wage contract where $W_2$ is set equal to $\infty$, while the contract where the worker decides on $W_2$ is the special case of the prespecified wage contract where $W_2$ is set equal to $-\infty$. Thus, in a termwise flexible renegotiation cost environment there is little rationale for the comparison of imposed contract forms contained in Hall and Lazear, because in this environment each of the other contracts they consider is simply a special case of the prespecified wage contract.

Example 2

In our second example we look at a principal-agent problem with asymmetric information, where the output of the agent is distributed according to a linear share rule. Contracts which are restricted to linear share rules have previously been analyzed by Stiglitz (1974, 1975 and 1981). The example we analyze is in most respects typical of the principal-agent literature. First, output of the agent depends on both a random state of nature and an action of the agent. Second, both the realized state of nature and the action of the agent are unobservable to the principal. Third, the agent observes the realized state of nature before deciding on his action. There is, however, one distinctive aspect of our example. That is, just prior to the agent taking his action, the principal privately observes a "noisy" signal concerning the realized state of nature.[7]

For the above outlined example, there is one type of ex post agreement which is consistent with a termwise flexible renegotiation cost environment.

Specifically, after observing his signal, the principal may find it advantageous to increase the share received by the agent. Note that because of the single period specification, this example obviously satisfies the intertemporal independence property of Section II. In what follows we specify in detail the example outlined above, and derive the contract which emerges under the standard renegotiation cost environment. As in example 1, we then demonstrate that for the particular contract which emerges, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment. Finally, again as in example 1, we demonstrate that even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto superior to the standard renegotiation cost environment.

The principal is assumed to be risk neutral and the worker is assumed to be infinitely risk averse. The assumption of infinite risk aversion allows us to solve the model in an explicit fashion. Let $R$ be the share of the agent's output which is retained by the agent. Also, we denote the worker's action as $A$, and the state of nature as $S$. It is assumed that $S$ equals $0$ with probability 1/4, and $1$ with probability 3/4. The agent observes $S$ before deciding on his action, while the principal observes a signal of the state of nature, denoted $s$, before the agent decides on his action. The relationship between $S$ and $s$ is as follows. If $S = 0$, then the probability that $s = 0$ is 7/8 and the probability that $s = 1$ is 1/8. On the other hand, if $S = 1$, then the probability that $s = 0$ is 1/8 and the probability that $s = 1$ is 7/8. This implies that if the principal observes $s = 0$, he assigns a probability of 7/10 to $S = 0$ and a probability of 3/10 to $S = 1$. Alternatively, if the principal observes $s = 1$, he assigns a probability of 1/22 to $S = 0$ and a probability of 21/22 to $S = 1$.

The output of the agent, denoted as $\Pi(A,S)$, is assumed to take the following specific functional form.

$$\Pi(A,S) = \frac{S}{2} + A^{1/2} \tag{2}$$

The utility of the agent, on the other hand, is a function of the income of the agent and a disutility for effort. The specific functional form here is given by equation (3), where $Y$ denotes the income of the agent (note: money terms have been normalized such that the price of a unit of the agent's output equals one).[8]

$$U(Y - A), \quad \text{where} \quad U' > 0 \tag{3}$$

Because the agent is infinitely risk averse, when the agent faces uncertainty his expected utility equals the lowest possible realized value of $U(.)$. Note, however, since the agent chooses $A$ only after observing $S$, the choice of $A$ is not made in an uncertain environment. Thus, $A$ is chosen so as to maximize $U(.)$, given the values for both $R$ and $S$.[9] This in turn yields (4).

$$A = \max[0, R^2/4] \tag{4}$$

Notice that $A$ does not depend on the state of nature. This is because of the additively separable nature of our production technology.

It is assumed that the contract which emerges in this world is simply the one which maximizes the expected income of the principal, given an expected utility constraint on the part of the agent. We will now solve for the contract which emerges in the standard renegotiation cost environment. In the standard renegotiation cost environment, the value for $R$ specified in the contract, denoted $R^S$, determines how output is distributed in all states of nature. Thus, (5) describes the expected income of the principal in this environment (note: below $B$ denotes a lump sum transfer between the principal and the agent, and $K$ denotes the value of the expected utility constraint).

$$(5) \qquad \max_{R,B} \frac{(1-R)\ \max[0,R/2]}{4} + \frac{3(1-R)(\frac{1}{2} + \max[0,R/2])}{4} - B$$

$$\text{s.t. } B + R \max[0,R/2] - \max[0,R^2/4] > U^{-1}(K)$$

(5) yields that $R^S = 1/4$.

Our next step is to analyze this example under the termwise flexible renegotiation cost environment. We will first demonstrate that for the contract derived above, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment. As previously stated, possible ex post agreements in the termwise flexible renegotiation cost environment consist of offers by the principal to make $R$ higher than the $R$ specified in the contract. Consider first the case where $s$, the signal observed by the principal, equals one. It is easily demonstrated that when the principal receives this signal, the principal prefers $R = 1/4$ to any higher value for $R$. Thus, no ex post agreements occur when $s = 1$. Consider now the case where $s = 0$. Given the relationship between $s$ and $S$, the principal's optimal value for $R$ in this case, denoted as $R^F$, is given by (6).

$$(6) \qquad R^F = \arg\max_R \frac{7(1-R)\ \max[0,R/2]}{10} + \frac{3(1-R)(\frac{1}{2} + \max[0,R/2])}{10}$$

(6) yields that $R^F = 7/20$. This in turn implies that when $s = 0$, $R$ shifts from 1/4 to 7/20. The agent can obviously not be made worse off by such a shift, while by construction the principal is better off in an expected sense. Thus, for the contract which emerged under the standard renegotiation cost environment, the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment.

Our next step is to again compare the two environments, but this time treat the contract for the termwise flexible renegotiation cost environment in an endogenous fashion. Let $R^T$ denote the value for $R$ specified in the contract which emerges endogenously in the termwise flexible renegotiation cost environment. It is necessarily the case that $R^T < 7/20$,[10] which implies that when $s = 0$, $R$ shifts from $R^T$ to 7/20. This in turn yields (7) as the maximization problem faced by the principal.

$$(7) \qquad \max_{R,B} \frac{169}{2560} + \frac{(1-R)\ \max[0,R/2]}{32} + \frac{21(1-R)(\frac{1}{2} + \max[0,R/2])}{32} - B$$

$$\text{s.t. } B + R\max[0,R/2] - \max\ [0,R^2/4] \geq U^{-1}(K)$$

(7) yields $R^T = 1/12$.. Now, the expected utility constraint is satisfied as an equality in both (5) and (7). Therefore, to demonstrate that the termwise flexible renegotiation cost environment is Pareto superior to the standard renegotiation cost environment, all we need do is demonstrate that the maximized value of the objective function in (7) exceeds the maximized value of the objective function in (5). Substituting $R = 1/12$ into the expression

in (7) and $R = 1/4$ into the expression in (5) yields that this is indeed the case. Thus, even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto superior to the standard renegotiation cost environment.[11]

Example 3

We now look at a two period cartel problem, where the cartel consists of $n$ identical producers of a homogeneous commodity. There are two distinctive aspects of the particular model we analyze. First, prior to period one the members of the cartel are allowed to meet and agree on a contract which specifies both a first period cartel price and a second period cartel price. Second, consuming the good produced by the cartel requires an initial fixed investment. A real world good consistent with this second aspect is home heating oil, for which the initial fixed investment could be thought of as the purchase of an oil burning furnace.

For the above outlined model, there is one type of ex post agreement which is consistent with a termwise flexible renegotiation cost environment. Specifically, just prior to period two, the cartel members may find that they prefer a second period price different than the one specified in the initial contract. Given this, it is easily seen that this world does not exhibit the intertemporal independence property of Section II. That is, because of the required initial fixed investment, each consumer's purchase decisions in period one will depend on expectations of prices in period two. Thus, there does exist a date at which behavior depends on expectations of the type of ex post agreements which can occur in this world. In what follows we set up an example consistent with the model outlined above, and characterize the contract which emerges under the standard renegotiation cost environment. We then demonstrate that for the particular contract which emerges, the termwise flexible renegotiation cost environment is Pareto inferior to the standard renegotiation cost environment. Finally, we demonstrate that even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto inferior to the standard renegotiation cost environment.

We begin by characterizing the demand side of the model. Individuals in this model derive utility from the consumption of two goods. The first good, denoted as B, is produced by a perfectly competitive industry. It is assumed that the price of B is the same in each period, and to simplify the exposition we normalize this price to one. Additionally, the consumption of B is assumed to exhibit constant marginal utility. This assumption simplifies the analysis, while leaving the qualitative nature of the results unchanged. The second good, denoted as X, is produced by the cartel. The $i^{th}$ individual's consumption of goods B and X in period t are denoted as $b_i^t$ and $x_i^t$, respectively. As opposed to the consumption of B, the consumption of X is assumed to exhibit decreasing marginal utility. The distinctive characteristic of X, however, is that prior to or concurrent with the consumption of X it is necessary to make an initial fixed investment (note: if an individual makes the investment in period one, then to consume X in period two it is not necessary for him to make the investment again). Individuals are assumed to be perfectly identical except for the cost of this fixed investment. Specifically, denoting as $z_i$ individual i's cost of this fixed investment, we assume that $z_i$'s are distributed between 0 and $\infty$ according to a density function g(.). Furthermore, g(.) is assumed to be continuously differentiable and nonzero in the specified interval.

Formally, the $i^{th}$ individual's two period utility function, which is assumed to be additively separable over time, is given by equation (8).

$$(8) \qquad U_i = \sum_{t=1}^{2} b_i^t + x_i^t - a(x_i^t)^2$$

The interpretation of (8) is straightforward. $b_i^t$ represents the utility derived by individual $i$ in period $t$ from the consumption of B. $x_i^t - a(x_i^t)^2$ represents the utility derived by individual $i$ in period $t$ from the consumption of X.[12] Note, for purposes of exposition we are assuming that consumers have a zero rate of discount, and we also assume there is a zero rate of interest.

Each individual $i$ also faces the following two period budget constraint.

$$(9) \qquad b_i^1 + b_i^2 + P^1x_i^1 + P^2x_i^2 + L_i^1z_i + L_i^2z_i < Y$$

The interpretation of (9) is as follows. First, $b_i^1 + b_i^2$ represents individual $i$'s expenditure on good B. Second, $P^t$ denotes the price for good X in period $t$, and therefore $P^1x_i^1 + P^2x_i^2$ represents individual $i$'s expenditure on good X. Third, $L_i^t = 1$ if period $t$ is the first period consumer $i$ purchases a positive quantity of X, and equals zero otherwise. Thus, $L_i^1z_i + L_i^2z_i$ represents individual $i$'s expenditure on the fixed investment required to consume X. Fourth, each individual is assumed to have the same income, this income being denoted simply as Y. Now, it is easily demonstrated that (9) must hold as an equality, and therefore the budget constraint can be substituted directly into the utility function, i.e.,[13]

(10) $$U_i = Y + \sum_{t=1}^{2} (x_i^t - a(x_i^t)^2 - P^t x_i^t - L_i^t z_i).$$

Three aspects of the demand side of the model remain to be specified. First, each consumer $i$'s value for $z_i$ is unobservable to anyone but consumer $i$. Second, consumers have no way of storing $X$. Third, consumers have rational expectations concerning the price of $X$. This last assumption means that if consumers are in a standard renegotiation cost environment they anticipate that the second period cartel price will be the price specified in the initial contract, while if they are in a termwise flexible renegotiation cost environment they realize that the cartel has the ability to reset $P^2$ just prior to period two.

We can now derive some things concerning consumers' purchase decisions. (10) yields that if consumer $i$ makes the required fixed investment in or prior to period $t$, then (11) describes consumer $i$'s purchase of $X$ in period $t$.

(11) $$x_i^t = \max[0,(1-P^t)/2a]$$

Substituting (11) back into (10) yields that consumer $i$ will at some date make the required fixed investment if and only if equation (12) is satisfied.

(12) $$\frac{\max[0,1-P^1]^2 + \max[0,1-P^2]^2}{4a} - z_i > 0$$

Furthermore, let $Z(P^1,P^2) = (\max[0,1-P^1]^2 + \max[0,1-P^2]^2)/4a$. (12) implies that all consumers whose value for $z_i$ is above $Z(P^1,P^2)$ will never make the fixed investment, while all consumers whose value for $z_i$ is below $Z(P^1,P^2)$ will make the fixed investment. Note, also, if $P^1 < 1$, then each consumer who makes the fixed investment will make it in period one.

We will now characterize the contract which emerges under the standard renegotiation cost environment. It is assumed that each of the $n$ members of the cartel produce $X$ at a constant cost $c$ per unit, where $c < 1$. Thus, the two prices specified in the contract, i.e., the prices which maximize the cartel's profits, are the prices which solve (13).

$$\max_{P^1,P^2} \int_0^{Z(P^1,P^2)} (P^1-c)\max[0,(1-P^1)/2a]\, g(z_i)dz_i + \int_0^{Z(P^1,P^2)} (P^2-c)\max[0,(1-P^2)/2a]\, g(z_i)dz_i \tag{13}$$

It can be demonstrated that the solution to (13) has $P^1 = P^2 < 1$ (see the Appendix). Therefore, (13) reduces to (14).

$$\max_P \int_0^{Z(P,P)} \frac{(P-c)(1-P)}{a}\, g(z_i)dz_i \tag{14}$$

(14) implies that the price which holds in both periods under the standard renegotiation cost environment, denoted as $P^S$, satisfies the following first order condition.

$$\frac{dZ(P,P)}{dP}\,\frac{(P-c)(1-P)}{a}\, g(Z(P,P)) + \int_0^{Z(P,P)} \left(\frac{1-2P+c}{a}\right) g(z_i)dz_i = 0 \tag{15}$$

Our next step is to demonstrate that for the contract characterized above, the termwise flexible renegotiation cost environment is Pareto inferior to the standard renegotiation cost environment. In the termwise flexible renegotiation cost environment the value for $P^2$ specified in the contract is not necessarily the price which eventually holds on the market. That is, after period one the cartel will set $P^2$ so as to maximize profits, taking into account the actions of consumers in period one. We also know that because $P^S < 1$, each consumer $i$ who incurs the cost $z_i$ will incur it in period one. Thus, our rational expectations assumption implies that cartel profits are now described by (16).

$$(16) \qquad \max_{P^2} \int_0^{\hat{Z}} \frac{(P^S-c)(1-P^S)}{2a} g(z_i)dz_i + \int_0^{\hat{Z}} (P^2-c) \max[0,(1-P^2)/2a]\, g(z_i)dz_i,$$

where $\hat{Z} = Z(P^S,P^2)$. Notice, because of rational expectations, consumers' purchase decisions in period one must be consistent with the actual value for $P^2$ which prevails on the market, i.e., $\hat{Z} = Z(P^S,P^2)$. However, because the cartel's choice of $P^2$ comes after these period one purchase decisions are made, the cartel takes these decisions as fixed when choosing $P^2$.

A comparison of (13) and (16) yields that cartel profits will be lower under the termwise flexible renegotiation cost environment unless $P^2 = P^S$. This is because the maximization problem in (16) is simply a constrained version of the maximization problem in (13). Now, the first order condition for the maximization problem in (16) is,

$$(17) \qquad \int_0^{Z(P^S,P^2)} \left(\max[0,(1-P^2)/2a] + \frac{d\max[0,(1-P^2)/2a]}{dP^2}(P^2-c)\right) g(z_i)dz_i = 0.$$

Comparing (15) and (17) yields that $P^2 = P^S$ does not solve (17). Thus, profits for the cartel are lower under the termwise flexible renegotiation cost environment than under the standard renegotiation cost environment.[14]

We will now demonstrate that even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto inferior to the standard renegotiation cost environment. It is necessarily true that for the termwise flexible renegotiation cost environment, the contract which emerges endogenously has $P^1 < 1$ (see the Appendix). Thus, equation (18) describes the profits for the cartel in the endogenous case.

$$(18) \qquad \max_{P^1,P^2} \int_0^{Z(P^1,P^2)} (P^1-c)\max[0,(1-P^1)/2a]\, g(z_i)dz_i + \int_0^{Z(P^1,P^2)} (P^2-c)\max[0,(1-P^2)/2a]\, g(z_i)dz_i$$

$$\text{s.t. } P^2 = \arg\max_P \int_0^{\hat{Z}} (P-c)\max[0,(1-P)/2a]\, g(z_i)dz_i,$$

$$\text{where } \hat{Z} = Z(P^1,P^2)$$

A comparison of (13) and (18) immediately yields that cartel profits will be lower under the termwise flexible renegotiation cost environment unless $P^1 = P^2 = P^S$. Now, the first order condition for the maximization problem in the constraint in (18) is,

$$(19) \qquad \int_0^{Z(P^1,P^2)} \left(\frac{1-2P^2+c}{2a}\right) g(z_i)dz_i = 0.$$

Comparing (15) and (19) yields that $P^1 = P^2 = P^S$ does not solve (19). Thus, even treating the contract in the termwise flexible renegotiation cost environment in an endogenous fashion, this environment is Pareto inferior to the standard renegotiation cost environment.[15]

One final point needs to be mentioned. We have just demonstrated that producers can be made worse off by giving them the ability to respecify price after consumers have made sunk investments in a complementary good. In our demonstration we assumed the existence of a cartel, for which contracting over price is an available method of enforcing a collusive agreement. The basic idea, however, holds in a broader range of settings. For example, the idea is valid both for a cartel which does not have access to contracts, but still has the ability to collude on price, and for a monopolist.

## IV. Conclusion

Many studies concerned with contracting impose a contract form, rather than derive a contract form under an assumption of zero transaction costs. One issue which arises, when this approach is taken, is how should ex post mutually beneficial agreements be treated. By ex post mutually beneficial agreements we mean feasible agreements reached some date after the initial contract signing, which, given the then existing position of the parties, make the contracting parties better off. The standard way this issue has been dealt with previously is through an assumption that no ex post agreements are ever made. The rationale being that the transaction costs associated with reopening negotiations are too high to make any such agreements feasible. In the present paper we argued that this standard approach is not discriminating enough in terms of the renegotiation costs associated with different types of ex post mutually beneficial agreements, and then investigated the ramifications of this idea. We first demonstated that, given a contract situation which satisfies a particular intertemporal independence condition, an environment which contains some zero renegotiation cost agreements will tend to Pareto dominate an environment which doesn't. We then posited a particular set of agreements which seemingly have zero (or very small) renegotiation costs, and demonstrated, through the analysis of three examples, one method by which low renegotiation cost ex post agreements can be incorporated into actual analyses of contracting. In the first two examples, each of which exhibited the intertemporal independence condition mentioned above, the incorporation of these ex post agreements improved the welfare of the contracting parties. In the third example, which did not exhibit this condition, the incorporation of these agreements decreased the welfare of the contracting parties.

There are a number of different directions in which this research could be extended. Below we list some obvious candidates. First, it might be worthwhile searching for different types of low renegotiation cost ex post agreements, and investigating the ramifications of such agreements in common contracting situations. Second, in each of our three examples, there was never a date at which two or more of the contracting parties might offer changes in the same contract term which were in different directions. Under a termwise flexible renegotiation cost environment, this will not in general be the case. For example, such a situation might arise in the prespecified wage contract world under different assumptions concerning the distributions of $R$ and $M$. Thus, an interesting extension might be to construct such an example, and in the process devise a method of choosing among the conflicting offers. Third, Section II derives conditions which are sufficient to ensure that contracting parties will never be worse off in a partially discriminating renegotiation cost environment than in a standard renegotiation cost environment. An interesting extension, therefore, might be to pinpoint more precisely when this is and is not the case by deriving sufficient and necessary conditions.

## Footnotes

[1]One exception to this is Rogerson (1983). He analyzes a model under an assumption that ex post mutually beneficial agreements can always be reached costlessly. As with the standard approach, we feel this approach does not discriminate sufficiently between different types of ex post mutually beneficial agreements.

[2]Shavell (1980) discusses and demonstrates how breach of contract and damage measures can serve as substitutes for complex contingent claims contracts. One can interpret our paper as saying that, when the intertemporal independence condition mentioned above is satisfied, low renegotiation cost ex post mutually beneficial agreements will tend to serve this same function. Note, to keep our analysis tractable we have not incorporated the possibility of breach into our paper. However, we are in general sympathetic to its incorporation in analyses of contracting.

[3]There are two qualifications to Theorems 1 and 2. First, the preferences or utility functions of the contracting parties are being assumed to not vary over time., Second, we are employing a partial equilibrium analysis. That is, when we look at a particular contract situation and vary the renegotiation cost environment, we are not considering how this change in the renegotiation cost environment will affect other contract situations in the economy, and through this route indirectly affect the contract situation under analysis.

[4]When we state that one environment is Pareto superior (inferior) to another, we mean that in the former (latter) environment each party is at least as well off as in the latter (former) environment, and at least one party is strictly better off.

[5]This method of solving the bargaining problem satisfies condition 1) of Theorem 2.

[6]We are assuming that if $M = W_2$ the firm does not fire the worker, and that if $R = W_2$ the worker does not quit.

[7]It is assumed that the market for agents clears before the principal observes this signal.

[8]Hart (1983) has previously used a specification where a disutility for effort term subtracts directly off an income term.

[9]One might question whether this is the appropriate manner of having the agent behave, since, if the choice of action is not being made in the worst state of nature, within a range his choice will not have an effect on his expected utility. It can be demonstrated, however, that as an agent approaches infinite risk aversion, this is how he would behave.

[10]If $R^T > 3/8$, then the type of environment assumed does not affect the execution of the contract. This combined with the fact that $R^S = 1/4$ implies $R^T < 3/8$.

[11]Theoretically, it should be possible, as in example 1, to check what proportion of the inefficiency attributable to the imposed contract form is eliminated by assuming a termwise flexible renegotiation cost environment rather than a standard renegotiation cost environment. However, deriving the optimal contract for this example in the absence of an imposed contract form is beyond the scope of this paper.

[12]This specification violates free disposal. We could have instead assumed that if $x_i^t$ exceeds 1/2a, then the utility derived by individual i in period t from the consumption of X equals 1/4a. This specification yields exactly the same results as the specification actually employed, and it does not violate free disposal.

[13]We are assuming $Y$ is large enough such that the constraint, $b_i^1 + b_i^2 > 0$, is never binding.

[14]Because of the rational expectations nature of the problem, one might question whether or not a solution to the maximization problem in (16) exists. However, inspection of (17) yields that $P^2 = (1+c)/2$ is the unique solution to (16).

[15]As with equation (16) (see footnote 14), one might question whether or not a solution to the maximization problem in (18) exists. However, (19) yields that the constraint in (18) can be rewritten as $P^2 = (1+c)/2$, which in turn implies that existence is not an issue.

## Appendix

Proof that in example 3, $P^1 = P^2 < 1$ in the standard renegotiation cost environment: Suppose first that $P^t > 1$. This strategy yields the cartel zero profits in period t. Obviously the cartel can do better by setting $P^t$ less than one and greater than c. Thus, it cannot be the case that either $P^1$ or $P^2$ is greater than or equal to one.

Suppose now $P^1 \neq P^2$, but that each of the prices is less than one. Consider a consumer whose value for the fixed investment equals zero. Also, denote as $S(P)$ the consumer surplus this consumer derives from the consumption of X in a period when the price of X equals P. (11) yields $S(P^t) = a(x_i^t)^2$. Now let $x^*$ be such that $S(P^1) + S(P^2) = 2S(P^*)$, where $x^* = (1 - P^*)/2a$. Solving for $x^*$ yields $x^* = (((x_i^1)^2 + (x_i^2)^2)/2)^{1/2}$. Note, each consumer's decision as to whether or not to make the fixed investment depends only on $S(P^1) + S(P^2)$. Furthermore, this implies that if in each period the price of X was $P^*$, then the number of consumers who would make the fixed investment would be the same as for the prices $P^1$ and $P^2$.

Let $\pi(P)$ be the cartel's profit per purchaser in a period when the price of X equals P. $\pi(P^t)$ is given by $(P^t - c)x_i^t$ or $(1-2ax_i^t-c)x_i^t$. Utilizing the expression for $x^*$ derived above yields $\pi(P^1) + \pi(P^2) < 2\pi(P^*)$. Moreover, since the number of consumers who make the fixed investment is the same for the price sequence $(P^*,P^*)$ as for the sequence $(P^1,P^2)$, aggregate profits for the cartel is strictly greater for the sequence $(P^*,P^*)$ than for the sequence $(P^1,P^2)$. Thus, $P^1 \neq P^2$ (such that each of the prices is less than one), cannot be profit maximizing. Q.E.D.

Proof that in example 3, $P^1 < 1$ in the termwise flexible renegotiation cost environment: For any given $P^2$, $P^1 \geq 1$ yields the cartel zero profits in period 1. Obviously the cartel can do better by setting $P^1$ less than one and greater than c. Thus, setting $P^1 \geq 1$ cannot be part of an optimal strategy for the cartel. Q.E.D.

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