Institutional Underpinnings of Trustworthiness in Infrastructure Contracts: Trust and Trust Perceptions*

Xeni Dassiou and Jon Stern
Dept. of Economics, City University,
Northampton Square, London EC1V 0HB, U.K.
CCRP, City University
x.dassiou@city.ac.uk and jon.stern.1@city.ac.uk†

March 7, 2008

Abstract

This paper discusses trust and trust perceptions in infrastructure contracts. We focus on perceptions of the trustworthiness of the government purchasers of infrastructure services (a) by supplying companies and (b) by governments. In particular, we allow for trust misalignments which may give rise to 'undertrusting' and 'overtrusting'. The core of the paper sets out a game theoretic model of contracts which we use to explore the impact of trust misalignment both on economic efficiency and on investment levels, taking account both of asset specificity issues and maladaptation costs. We explore flexible contracts with and without pre-payments, rigid contracts (which do not allow for post-investment renegotiation) and hybrid contracts. Their efficiency is compared to an incentive compatible benchmark contract. The model is also used to shed light on current issues on the sustainability of private investment infrastructure contracts both in OECD countries (e.g. PPPs) and in developing countries.

*The authors wish to thank Chris Bolt, Stephen Littlechild, Francesc Trillas, Chris Walters and the January 2008 CCRP Workshop participants for many useful and constructive comments on earlier versions of this paper. The usual disclaimer applies.

†Corresponding author.

1 INTRODUCTION

Investment and maintenance in infrastructure industries raise well-known issues of contract commitment, which are nowadays typically resolved by governments establishing an independent regulatory agency[1] . However, that solution requires both governments and supplying companies to trust that the regulator will act fairly and impartially - and by no means all regulators do so, or at least are able to do so. Underlying the regulatory debate are issues about the viability and commitment to long-term contracts that involve governments, which again raise major concerns about trust. In this paper, we investigate trust issues in the financing of infrastructure, the viability of contracts and the role of regulation. More specifically, we focus on how well aligned are trust perceptions between buyers and sellers of infrastructure services, as well as on absolute levels of trust. It turns out from our analysis, that the mutual alignment and evolution of trust perceptions are both of major importance. Infrastructure assets are very long-lived, sunk assets and the services that they provide are typically highly politically sensitive (electricity, water, transport, etc.). In consequence, the critical issue for effective and sustained delivery is how to ensure adequate trust between the supplying entity and the government which is purchasing the output and providing the legal underpinnings, including possible regulatory arrangements. These issues are always important for private infrastructure investment in general, but are particularly important, firstly, for riskier investments; and, secondly, for infrastructure investment in difficult institutional environments as are frequently found in developing and transition countries.

In practice,we typically observe two main approaches to private investment infrastructure: (i) concession contracts and (ii) regulation by agency. The economic literature focuses on these two – and, on the whole, treats them separately. In particular, the literature on PPPs (public-private partnerships) in the UK, the EU and elsewhere focuses on a concession contract approach. However, the distinction between the two is often far from clear-cut since, firstly, concession contracts and PPPs almost always include sizeable amounts of "regulatory content" material in the contract; and, secondly, regulatory authorities monitor and enforce contracts, including concession contracts.

A wide range of institutional arrangements is observed in practice to support private investment in infrastructure. This range includes, at one extreme licensed suppliers operating on infinite length contracts supervised by a regulator (classic electricity, water and telecom regulation) through to, at the other end of the spectrum, fixed length concession contracts with no external supervisory body other than the courts (e.g. many toll road contracts). There are also many hybrid models which combine contracts with regulatory or other forms of external regulation/arbitration etc. in various ways (e.g. UK railways, the London Underground and many others). As argued elsewhere, contracts and regulation are better regarded as complements rather than substitutes[2]. It

[1] See, for instance, Levine, Stern and Trillas (2005).

[2] See Stern (2003), Bolt (2003 and 2007). These both discuss the issues arising from the perspective of a regulated industry. Athias and Saussier (2006) discuss these issues arising

is worth pointing out that infrastructure contracts – like long-term contracts between companies - can be found with various degrees of external contract resolution and with varying degrees of renegotiating flexibility both in terms of tariff and similar changes and for post-investment renegotiation[3].

In this paper, we present and report the results of a game theoretic model which includes not just the choice or contract versus external regulation and the relevant institutional framework, but also the potential for renegotiation (including regulatory review). Hence, following Menard and Saussier (2002), we consider the relative merits of different types of contractual arrangements. In addition, we explicitly consider the role of term revision and renegotiation clauses, following the evidence of Athias and Saussier (2006) on the way that they are used (and not used) in toll road concession contracts. But, we integrate the discussion of contracts with that of regulation on the basis that external regulators can allow simpler contracts, easier dispute resolution and, in particular, more readily agreed contract renegotiation. This perspective arises from Laffont (2005), Guasch and Straub (2006) as well as Stern (2003).

We adopt a game theoretic approach to these issues starting from a consideration of alternative types of contract. We first develop a typology of contracts building on Athias and Saussier (2006) who distinguished between:

(a) *Flexible contracts* (which explicitly allow for contract renegotiations after investments have been made); and

(b) *Rigid contracts* (which set fixed contract terms before the investments are made and do not allow for subsequent term changes or renegotiation.

We then develop hybrid models which are constructed by introducing a variable for the probability of renegotiating a fixed contract after the investment has taken place. This variable depends on the quality of the institutional arrangements in the country. Following Athias and Saussier, this a proxy for the institutional and regulatory conditions that prevail in the environment where the contract is to be implemented. Hence, it is a variable that covers the aspects of country governance that most directly impact on the likelihood that the contract will be fairly administered and any contract disputes resolved in an impartial manner. This most obviously concerns issues to do with the rule of law, the reliability and timeliness of law courts, and levels of probity (and corruption) in public life[4].

The measure of trustworthiness on which we focus is the probability that the contract between the buyer and the seller can be enforced. We explore a range of

---

from the perspective of concession contract design.

[3]See Athias and Saussier (2006) for evidence on this for toll road concessions and Menard and Saussier (2002) for water supply arrangements.

[4]Specialist regulatory or similar external agencies may be given some of the responsibilities for these issues, but within a legal framework under which appeals and possibly implementation would be done by the local courts. Of course, countries may decide to establish independent regulatory or similar agencies as a way of *signalling* to investors their commitment to fair dealing on infrastructure contracts and investment. Such policy signalling devices were advocated by the World Bank and others in the 1990s but actually go back to medieval times for trade courts, as shown in Greif (2006).

contractual and institutional arrangements that can reduce this perception gap and/or help guarantee payment. These may take a variety of forms from (a) insurance type of arrangements (for example World Bank guarantees against regulatory risk) to (b) some form of explicit pre-payment contracts (see, for instance, Braynov and Sandholm (2002). Essentially in our model, the term 'prepayment' is interpreted broadly and can mean any facility that provides an almost "as good as in your pocket money" to the buyer and/or the seller.

The paper sets out the formal modeling relationship between trust perceptions and different contractual arrangements, including 'prepayments'. A bargaining model between the buyer and the seller is developed using a framework based on Nash bargaining. We compare the welfare implications of each of these models with those from an incentive-compatible benchmark contract and use the welfare comparisons to evaluate the appropriateness in different circumstances of different contract forms, or external regulator and pre-payment/guarantee arrangements.

Note that in this paper, the term 'regulator' is applied to any external agency that can investigate contract violations, impose sanctions as well as adjudicate disputes. A critical issue is whether or not the agency has the power to devise and, even more, to impose contract modifications. The efficiency and reliability of such an external body is an important determinant of the actual – and perceived - value of the trustworthiness of the buyer. However, the establishment of external regulatory agencies inevitably raises the issue of *regulatory risk* so that it is not the case that having an external regulatory agency in place necessarily increases trustworthiness of the buyer government.

In section 2 we address the question of whether concession contracts are substitutes or complements. This is followed by section 3 where the framework for our model is set out. We attempt to tackle the problem of misalignment of trust perceptions regarding the buyer by using alternative forms of flexible contracts, followed by an analysis of rigid contracts. Then the welfare implications of rigid contracts with no commitment not to renegotiate are compared to those of flexible contracts. In section 4 the issue of trust and trust perceptions is discussed in more depth in the light of the results derived from the model in section 3. Finally, we draw our conclusions in section 5.

2 CONCESSION CONTRACTS AND REGULATION: SUBSTITUTES OR COMPLEMENTS?

From around the mid-1980s, there was a strong push towards developing regulatory agencies as the key way in which trust could be established for countries privatising their utilities or wishing to expand private investment. This policy was heavily influenced by developments in the 1980s in the UK and in Chile as well as some other countries. Indeed, World Bank policy advice suggested that for developing countries, establishing an independent regulator would signal that they were trustworthy for supporting private investment (including allowing a reasonable rate of return). Hence, it was suggested that establishing such agencies was a way of assuring infrastructure investors that countries were now trustworthy i.e. eliminating the 'undertrusting' problem.

Proponents of this view failed to give sufficient weight to:

(i) the degree to which governments would intervene into regulatory decisions;

(ii) the degree to which regulatory laws and institutions provided discretionary powers (which enabled governments to intervene arbitrarily); and

(iii) the time it takes to establish regulators and the volume of specialist resources required.

In consequence, by the late 1990s, the optimistic view of regulators was seriously battered by major regulatory failures, in particular after the Asian financial crisis in 1997-98 when new regulators were effectively discarded and many investments (or at least debt contracts for the investments) became unviable.

Spiller (2004) argues that concession contracts provide individualized regulation with contracts that are rigid by origin rather than 'relational' as typically found in long-term contracts between private sector entities.

The problem with this argument is that, as is now well-known, tight contracts are very brittle in the face of shocks and renegotiation can be difficult. Renegotiation rates are typically very high for developing country concession contracts - particularly for toll road and water concessions which Guasch (2004) report at (respectively) 55% and 74% for Latin America over the period 1989-2000. Of course, far from all renegotiations lead to project collapse. Nevertheless, according to the World Bank PPI database, over the period 1990-2004, 160 infrastructure projects accounting for 9% of investment flows were canceled or in distress. For water, 7% of projects accounting for 37% of investment flows in the sector were canceled or became distressed, i.e. a disproportionate number of high value concession projects.

The counter-argument to the case for rigid contracts in Stern (2005) is that, where country governance is sufficiently supportive, trust is better achieved for infrastructure investment by establishing a separate regulatory entity, which has been assigned legal powers to act of its own volition. This agency has the authority, in consultation with regulated companies and their consumers, to modify existing regulatory obligations (for example, tariffs and quality of service) and to establish new regulatory rights and obligations. In particular, it has the right to review and revise regulatory obligations according to some defined process. Hence, it operates as a full regulator, including a degree of *bounded and accountable discretion.*

Such a mechanism provides a way in which contracts can be reappraised and revised in the light of changing circumstances according to a pre-agreed and impartial process. Hence it allows simpler and more transparent initial contracts and better enforcement. Of course, although regulators may behave in the way recommended, there is no guarantee that they *will actually* do so. Hence, the search for other mechanisms to help establish regulatory capacity and reputation like initial regulatory risk guarantees, etc. to help underpin agreements and induce more trust earlier i.e. what we have described as 'pre-payment' agreements.

While contracts without external regulatory support may work well in some circumstances, in many cases, the contracts will at best require major renegotiation and in many cases will fail. However, there are also cases where contracts with little or no regulatory support may well be sufficient. The difference depends firstly on the nature of the contracted service and its associated investment (e.g. whether it is a straightforward and/or previously successfully delivered investment); and, secondly, on the degree of trust between the purchaser and the seller. The latter again raises issues as to whether the parties do or do not have a previous history of successfully managing such contracts. We will discuss this further in Section 4 in the light of the results from our bargaining model.

In the model, we consider long-term concession contracts, contract renegotiations and external "regulatory" arrangements as alternative potential institutional choices. They represent alternative ways not just of creating trust between supplying infrastructure companies and governments; but also as alternative ways of aligning perceptions of trust – or at least providing protection against major differences in perception. Some will be more appropriate in some circumstances; others in different ones – as with the choice between PPPs, direct management and concessions in French water supply. Not only do both buyers and sellers have a spectrum of quality on their past trustworthiness; but, in addition, there are major uncertainties over future performance.

In this context, we introduce the concepts of 'undertrusting' and 'overtrusting'. These can be understood as follows:

Consider the typical case where the government is the buyer of infrastructure services via some type of long duration contract or equivalent[5] and the seller is a private company, typically an infrastructure company. We define "undertrusting" as the existence of a gap between the subjective estimates of the trustworthiness of the buyer as perceived by the seller and as perceived by the buyer himself i.e. where the seller believes that the probability of full payment under the contract by the buyer is less than the buyer believes it to be. Similarly, we define "overtrusting" as the case where the subjective estimate of the seller that they will receive full payment under the contract is higher than the seller believes it to be.

With undertrusting, the key problem is how to motivate and sustain ongoing and agreed levels of investment in the face of unforeseen developments and incomplete contracts. Conversely with overtrusting, the key problem is whether or not companies, having made particular investments, will receive payments that they think they are owed under the contract when unanticipated changes are needed and/or unforeseen developments occur. Hence, one would expect contracts with undertrusting to break down relatively slowly but contracts with overtrusting to collapse rapidly.

[5] A fixed period UK-style infrastructure regulatory licence and an infinite US utility authorisation would both be included in this categorisation.

Trust alignment occurs when the subjective perceptions of seller and buyer are the same. Of course, this may be at a high level of trust (as in countries in the top 5% of country governance scores) or at a very low level of trust (as in countries with very low country governance scores). In what follows, we show that, while the best outcome – particularly for consumers – involves contracts at high levels of mutual trust; infrastructure contracts involving quite large amounts of privately financed investment may be sustainable in circumstances of low trust (e.g. Paraguay in the 1960s and '70s, some central African states).

Note that this paper is primarily concerned with welfare comparisons arising from objective and perceived trust variations of the buyer government. In consequence, we consider neither (a) government perceptions of the trustworthiness of sellers; nor (b) welfare issues arising because buyer governments may not be maximizing consumers' welfare (either because of a corruption tax or because of agreeing protected monopoly provision which jointly increases buyer and seller incomes). Including the second of these effects into the model should be relatively straightforward. We leave these for subsequent work.

Similar trust and trust perception issues exist over the commitment of the seller (i.e. the infrastructure company). We do not explicitly discuss such issues in what follows but the analysis should be similar, albeit this time referring to the probability of investment rather than the probability of full payment. We leave this for future research - as well as combining buyer and seller trust and trust perception issues. The combination could lead to a highly complex model.

3 THE MODEL

In this Section we set out our formal model of infrastructure contracting, trust and trust perceptions.

The model draws on game-theoretic bargaining models that have been developed in related contexts. In particular, we draw attention to McMillan and Waxman (2007) which explores the importance of trust in terms of the way it influences the bargaining power of governments and multi-national companies. We also draw attention to the paper by Braynov and Sandholm (2002) which has a technical discussion of how trust can be integrated and dealt within different types of Nash bargaining solution modelling environments. The general issue of government and company reputation in infrastructure concession contracts is discussed in Guasch and Straub (2006) paper on concession contract renegotiation.

For the infrastructure contracts that we discuss, within the context of contractual arrangements, agreed payments to the seller are primarily affected by:

- the degree of asset specificity
- the trust perceptions that each party has of the buyer government
- the cost of renegotiating flexible contracts

- the size of maladaptation costs caused by the inability of the investor to fully predict the investment outcomes in a rigid contract.

Following Athias and Saussier (2006), the last one is caused by the inability of the investor in a rigid contract to reliably predict investment outcomes (both investment costs and revenues arising). Major forecasting errors and/or major shocks cause significant maladaptation costs, which can be positive (e.g. where demand is much higher than predicted for a toll road) as well as negative (e.g. in substantive investment cost overruns or unexpectedly low demand).

We have explicitly integrated into the model the issue of the reliability of the purchasing government by inserting two trustworthiness parameters, a and b. The first parameter, a, denotes the selling firm's estimate of the trustworthiness of the buying government; while the second parameter, b, denotes how the buyer government estimates its own trustworthiness. The buyer will pay the firm with some probability γ that measures its actual trustworthiness. It is also the case that $0 \leq a, b, \gamma \leq 1$. In formal terms we postulate that a and b are the firm's and the purchasing government's estimates of γ respectively[6].

The explanation of why a might be less than 1 – and sometimes considerably less - is relatively straightforward. Governments have different histories and reputations over whether they have good or bad records at sustaining long duration infrastructure and similar contracts as well as for prompt/delayed payment, etc. However, the explanation of why b might be less than 1 is less obvious. One example is where governments know that they have foreign indebtedness and foreign exchange problems which mean that they may not be able to pay out or may even need to suspend such contracts. However, this is likely to be more of a crisis situation than a chronic, underlying issue.

A country where b is markedly less than 1 is most likely to arise in circumstances where governments have entered into arrangements with private (particularly foreign) investors but without total commitment. For instance, they may have done so because of insufficient tax revenue to fund preferred public sector options, as a result of political and economic pressure from a higher level of government or as a condition for international lending or aid assistance. Another case is where there is a clear possibility that a change of regime/government would probably lead to a major renegotiation or suspension of the contract (viz. Venezuela pre and post the Chavez presidency and the Chad government's actions to suspend the Future Generations Fund to collect earmarked savings from oil sales). A further possibility is where political opposition to private investment in infrastructure increases over time so that the political costs to the government of maintaining the private investment contracts gradually increase so that they have an incentive to reduce payment commitments.

Of course, the key point of our paper is that a and b may not only be significantly less than one, but also may differ significantly from one another i.e. a significantly greater or less than b – and this may be at higher or lower absolute values of a and b. As the implications of this play a major role in the formal modeling, it is useful to provide a little intuition at this stage.

[6] This is in line with the discussion found in Braynov and Sandholm.

Consider an electricity generating company that wishes to build a greenfield plant to sell electricity in a developing country that has a mixed past reputation on the degree of - but for which there is some evidence that it is committed to - infrastructure contract observance. Let us also assume that the company in question has not previously invested in the country. In that case, the 20-25 year power purchase agreement is likely to be negotiated where a is relatively low – and markedly lower than b. But, there will be significant confidence limits around each party's estimate. The contract will only be concluded if the range of the confidence interval estimates of a and b overlap sufficiently; if not, no contract will be concluded. Experience under the contract will reduce the uncertainty – either the contract will go well and further contracts can be negotiated with a converging on b or the contract will go badly and a and b will diverge. In the latter case, there will clearly be no repeat contract and the first contract may well not be sustainable.

The impact of any external regulatory entity will be, firstly, on whether and how far it helps (or hinders) in achieving a successful negotiation of a sustainable original contract; and, secondly on whether and how far it helps (or hinders) the resolution of problems that arise over the life of the contract.

Returning to γ, we suggest that this be considered as the probability of the enforcement of the contract by the country as indicated, for instance, by past history as well as by the reliability of contract enforcement through the local courts, or by the degree of international indebtness of the country concerned. Alternatively it can be considered as an indicator of the probability that contract violations will be detected and punished, as well as whether or not there are effective adjudicating procedures for disputes. These latter concerns are likely to be determined by whether or not there is some type of external regulatory agency in place, including agencies whose role is to monitor and enforce such contracts, or an external body arbitration agency/facility. The efficiency of such a body will determine the actual value of trustworthiness, γ.[7]

Alternatively, we may adopt a stochastic approach where we set $\gamma = b = x$, where x, the probability of enforcement (payment) by the government, is a random variable following the uniform distribution over $[0, 1]$. Assuming that $f(x)$ and $F(x)$ are the density and cumulative distribution functions respectively, we consider as $F(a)$ and $1 - F(a)$ the probability of overtrusting and undertrusting respectively. Under this formulation, b is an objective measure whose actual value is realised at some point in time; it is not a subjective perception as elsewhere in this paper.

Our paper considers flexible contracts, rigid contracts and hybrid contracts. We denote the flexibility of the contract by η. We define fully flexible contracts (i.e. contracts where a post-investment change in contract terms and/or a renegotiation is certain) as those where $\eta = 0$. For fully rigid contracts (i.e. those where post-investment changes in contract terms and/or renegotiations are fully excluded), $\eta = 1$. We also consider *hybrid* contracts, i.e. those where there is some positive expectation of post-investment changes in contract terms and/or

[7] We thank Chris Walters from the OFT for suggesting to us this alternative specification.

renegotiations. For such contracts, $0 < \eta < 1$, with a greater degree of rigidity as $\eta \to 1$.

In what follows, we first consider three types of fully flexible contracts. We then look at rigid contracts and finally, at the hybrid contract, where there is a positive probability of ex post renegotiation. The three types of flexible contracts that we consider are:

1. The Athias and Saussier flexible contract model, but including our trustworthiness parameters a and b.
2. The same model with a guaranteed pre-payment mechanism.
3. A benchmark, incentive compatible "F-contract" model with prepayments.

We show that the third model sets such prepayment terms, that the total surplus split between the infrastructure company and the government is identical to the one found in A&S where trustworthiness terms were not included in the model. We conclude by comparing the efficiency of the hybrid model to the first flexible contract model.

Note that prepayments, as incorporated in models (2) and (3) above play an important role in the analysis. They can take the form of an NPV contract or similar (as in the endogenous contract duration for the Dartford bridge). These pre-payment arrangements can be exogenous (as in the 2006 Athias and Saussier paper, henceforth referred to as A&S) or they can form part of the Nash bargaining process taking the form of a guaranteed payments (viz. prepayments in the Braynov and Sandholm paper). We shall comment in more detail on prepayment contracts in section 3.2.

We now turn to the formal analysis where, in each of the subsequent discussions we analyse the bargaining model that corresponds to each of the above models.

3.1 Flexible contracts

Let us start with the flexible contracts as discussed in A&S, where we also include in the payoff functions the parameters a and b which respectively represent the trustworthiness of the buyer (government) as estimated (i) by the seller (the supplying firm) and (ii) by the buyer (government).

As mentioned, the fact that the buyer estimates its own trustworthiness is either a reflection of the fact that its ability to pay is affected by circumstances outside its control, or is a function of other institutional and/or political issues. Of course such circumstances are also observed by the seller, but the two agents, as discussed above, may well have different estimates of the trustworthiness of the person on the paying side.

The firm's profit function and the consumer surplus[8] are given by the fol-

[8] Here we assume that the government fully represents the interests of the consumers. If this full alignment hypothesis is dropped, then this can be easily reflected by the model by assigning appropriate weights to the consumer and producer surplus within the government's objective function.

lowing functions respectively:

$$\Pi^f = P_0 - C_0 + at - i$$
$$CS^f = B_0 - P_0 + \overline{f}R(i) - bt$$

where B_0 and C_0 are positive constants representing, firstly, the social benefits and, secondly, the costs of providing the basic service without any investment. t denotes the amount of payment going to the firm following renegotiation between the company and the government on how the ex post surplus $R(i)$ $(R' > 0, R'' < 0, R''' < 0)$ created by the investment i undertaken by the firm will be shared between the two parties. $\overline{f}$ and α are inverse measures of the cost of renegotiation and of the degree of asset specificity respectively. If $\alpha = 0$ then the investment is wholly sunk and hence has no opportunity cost. Therefore, $r(i) = \alpha R(i)$ is the proportion of the surplus $R(i)$ which is not sunk and hence has an opportunity cost. For infrastructure contracts $r(i)$ is likely to have a low value.

The Nash Bargaining solution will be used in the flexible framework to determine the payment going to the firm

$$(\overline{f}R(i) - bt)(at - r(i))$$

The first parenthesis shows the net gain of the investment to the buyer, while the second parenthesis shows the yield to the seller after subtracting from the expected payment the opportunity cost of its investment (assuming that the investment will only take place if $at \geq r(i)$). This gives a payment solution[9]:

$$t = \frac{a\overline{f}R(i) + b\alpha R(i)}{2ab} = \frac{\overline{f}R(i)}{2b} + \frac{\alpha R(i)}{2a} \tag{1}$$

The equation above suggests that the lower a and b are, the higher is t, the value of the payment to the firm.

Conclusion 1 *Better trustworthiness of the government buyer as perceived by both the seller as well as the government itself will lead to a lower t paid, and hence a better deal for the country in terms of its share of the revenue from the project.*

This result is confirmed econometrically in a recent paper by McMillan and Waxman (2007), where their evidence indicates that higher quality of institutions will lead to a larger share of the revenues from the investment accruing to the country. In a sense an increase in a and/or b corresponds to a reduction in the political risk premium and the cost of capital for a firm to accept a long duration contract with the government of a particular country. *It is also possible that this reduction may also increase the government's bargaining power (as*

[9] As both expressions in the product are positive we can apply a monotonic transformation of the expression into logarithms and easily check that both the FOC as well as the SOC are satisfied.

McMillan and Waxman argue), rather than just its share in the rents. (This case is studied later, through the F-contract analysis.)

Substituting the above result back into the profit function and consumer surplus function gives:

$$\Pi^f = P_0 - C_0 + \tfrac{a\overline{f}R(i)}{2b} + \tfrac{\alpha R(i)}{2} - i$$
$$CS^f = B_0 - P_0 + \tfrac{\overline{f}R(i)}{2} - \tfrac{b}{a}\tfrac{\alpha R(i)}{2}$$

Hence the lower are sunk costs (i.e. the higher is α) the higher are profits and the lower is consumer surplus. The profit maximising level of investment for the firm is:

$$i^f \mid R'(i^f) = \frac{2b}{a\overline{f} + b\alpha} \tag{2}$$

It follows that as $R'' < 0$, $\frac{\partial i^f}{\partial b} < 0$ while $\frac{\partial i^f}{\partial \alpha}$, $\frac{\partial i^f}{\partial a}$, $\frac{\partial i^f}{\partial \overline{f}} > 0$. Total welfare is:

$$W^f = \Pi + CS = B_0 - C_0 + \left(\frac{a+b}{2b}\right)\overline{f}R(i^f) + \left(\frac{a-b}{2a}\right)\alpha R(i^f) - i^f \tag{3}$$

If $b > a$ (i.e. undertrusting) then by inspection of (3), as b is reduced $\frac{a+b}{2b}$ reaches a maximum (becomes 1) when $b = a$, whereas $\frac{a-b}{2a}$ (which is ≤ 0) also reaches a maximum (it becomes 0). Moreover, from (2) if $b > a$, then:

$$i^f \mid R'(i^f)_{b>a} = \tfrac{2b}{a\overline{f}+b\alpha} > \tfrac{2b}{b\overline{f}+b\alpha} = \tfrac{2}{\overline{f}+\alpha} = i^f \mid R'(i^f)_{b=a<1} = i^f \mid R'(i^f)_{b=a=1}$$

Since $R' = \frac{2b}{a\overline{f}+b\alpha}$, it is easy to conclude that R' is an increasing function of b and a decreasing function of a. As R' is an inverse function of investment (since $R'' < 0$), this means that investment is a decreasing function of b and an increasing function of a. Interestingly, the above results indicate that $W^f_{b=a<1} = W^f_{b=a=1}$, i.e. the above results hold as long as $b = a$ irrespective of whether absolute trustworthiness levels are high or low. This implies that complete trustworthiness ($b = a = 1$) is not required, rather just matching values of b and a. (In the A&S model, implicitly $a = b = 1$.)

Conclusion 2 *Untrustworthy agents can transact as efficiently as trustworthy agents provided that they hold similar estimates of the buyer's commitment to the payment agreement in the contract. What matters is that the buyer is trusted to the degree that it deserves to be trusted, rather than whether the buyer government is per se a trustworthy contracting party.*

Conclusion 2 explains why some countries which are ruled by a tight and corrupt elite where a and b are both low but matching, can still sustain private investment in sunk assets through renegotiation with a monopoly supplier (as in the case of some sub-Saharan African countries). Note that this model of matching expectations only works in flexible contracts as it depends on continuous renegotiation, or within a relational contract arrangement.

Another very interesting issue rises from the fact that undertrusting ($a < b$) *adds a deadweight loss* by making the welfare function directly dependent on α as indicated in (3); the higher α is (the lower sunk costs are) then the higher this deadweight loss is. Moreover the surplus following renegotiation is now multiplied by a factor $\frac{a+b}{2b}$ less than one, that measures the degree of undertrusting.

Hence undertrusting reduces welfare in two ways: (i) through the inability of the purchasing government to fully reclaim the surplus from sunk investment lost to the supplying firm and (ii) by a reduction in the amount of surplus accruing to the society following renegotiation. This translates into the next two conclusions below.

Conclusion 3 *In the presence of undertrusting, the smaller the proportion of sunk assets (i.e. the higher is α) the greater the deadweight loss resulting from the existence of a given level of undertrusting.*

In other words, an implication of undertrusting is that a decrease in the degree of asset specificity (an increase in α) will reduce CS by more than it will increase Π, while in the Athias and Saussier paper these two effects exactly offset each other so that, in their model, there is no direct impact of the sunk costs parameter on the welfare function - it only affects investment levels.

In simple terms the purchasing government is hit by a lower asset specificity to a greater extent than the investor benefits from it. Hence, an increase in asset specificity (a reduction in α), directly increases welfare by reducing the importance of this lack of ability by the buyer to fully capture what is lost to the seller. The reverse situation applies in the case of overtrusting; low sunk costs increase welfare as the direct effect is now a positive function of the value of α.

Note that the indirect effect of sunk costs on welfare is always negative as an increase in asset specificity (a reduction in α) depresses investment. *Hence, in the case of overtrusting, the existence of the direct effect reinforces the impact of the indirect effect; while in the case of undertrusting, the former offsets the latter and finally in the case where $a = b$ the direct effect is zero.*

As already mentioned earlier, in the presence of undertrusting the society's surplus retention following renegotiation is reduced. This arises because the retention parameter, $\overline{f}$, is multiplied by $\left(\frac{a+b}{2b}\right)$, which is smaller than 1 for $a < b$, because the firm investing in the country receives a smaller part of the surplus following renegotiation than it did in the A&S model.

Conclusion 4 *The existence of undertrusting reduces the society's ability to benefit from the investment induced surplus by lowering the overall coefficient of surplus retention.*

Again, the opposite conclusion holds for overtrusting. Note that overtrusting directly increases welfare in the two ways mentioned above. This means that contracts where overtrusting is present will lead to big welfare gains in the short run. However they are likely to end in rapid contract collapse as soon as there is a realignment of expectations held by the investing companies to more realistic values (viz. Argentina in the late 1990s).

Theorem 1 *When renegotiation costs are sufficiently low and asset specificity sufficiently high, welfare is a decreasing function of the government's (seller's) perception of the government's trustworthiness and an increasing function of the selling firm's perception of the government's trustworthiness.*

This holds when $\frac{\overline{f}}{\alpha} > \frac{b}{a} > 1$. *In other words for* $a\overline{f} > b\alpha$ $(b > a)$, b (a) *has a negative (positive) indirect impact on* W, *reinforcing the negative (positive) direct impact of the same parameter on the welfare function.*

Proof. Please refer to the appendix. ■

As was shown earlier, if $b > a$ then W^f is smaller than it would be if b was reduced to equal a (and vice versa). *Hence undertrusting reduces welfare, just as overtrusting increases welfare (albeit temporarily as mentioned earlier).* Interestingly, market efficiency in terms of increasing welfare using as a starting position $b > a$ does not require complete trustworthiness, but rather only that $b = a$. We now turn out attention to an attempt to tackle the problem of undertrusting with the use of prepayment contracts.

3.2 Prepayment contracts

In this section we model flexible contracts with prepayments following the Braynov and Sandholm approach outlined above. In our context prepayments are used in the wider sense to cover any form of contractual or institutional arrangement that effectively guarantees payments to the investor in the form of NPV contracts, political or regulatory risk guarantees and any other 'as good as in your pocket money' payment arrangement.

Whether or not a regulatory agency counts as a pre-payment arrangement is an interesting and difficult question. It seems reasonable to argue that established regulators that have been in place for 5-10 years or more, that were created by a primary law and which operate in a country with a strong rule of law can be considered as a type of pre-payment arrangement. This would apply to the UK infrastructure regulators (Ofgem, Ofcom, Ofwat,etc.) as well as, for French water supply, the Conseil d'Etat. It would most obviously apply to US utilities operating under the protection of the Supreme Court judgment of the Hope Gas case of 1944. However, even in such circumstances, regulatory opportunism is not unknown and, unless clearly and rapidly corrected, removes the implicit pre-payment trust protection.

Conversely, it makes little sense to make the same case for a six month old regulator created by presidential decree and operating in a country with weak rule of law. Indeed, we have a number of examples of cases where companies have indulged in 'over-trusting' because an infrastructure regulator was in place but the investing company placed too much reliance on the government allowing the regulator to operate according to the letter of the law. The classic example of this is Argentina in the 1990s but several Asian regulators and others were also, post-1997, found not to provide the anticipated payment protection. Hence, the development of (temporary) regulatory risk guarantees and other issues to buy pre-payment protection while the regulatory agency establishes its credentials as an effective pre-payment entity.

For flexible contracts with prepayments, the Nash bargaining problem is:

$$(\overline{f}R(i) - P_0 - bt)(P_0 + at - r(i))$$

which gives a payment solution:

$$t = \frac{a\overline{f}R(i) + b\alpha R(i) - (a+b)P_0}{2ab} \tag{4}$$

Substituting this back into the profit function and consumer surplus function gives:

$$\Pi^{P_0} = P_0 - C_0 + \tfrac{a\overline{f}R(i)+b\alpha R(i)-(a+b)P_0}{2b} - i = \tfrac{(b-a)P_0}{2b} + \tfrac{a\overline{f}}{2b}R(i) + \tfrac{b\alpha}{2b}R(i) - C_0 - i$$

$$\begin{aligned} CS^{P_0} &= B_0 - P_0 - \tfrac{a\overline{f}R(i)+b\alpha R(i)-(a+b)P_0}{2a} + \overline{f}R(i) = \\ &= B_0 + \tfrac{(b-a)P_0}{2a} + \tfrac{a\overline{f}}{2a}R(i) - \tfrac{b\alpha}{2a}R(i) \end{aligned}$$

As both of the above functions are increasing functions of the prepayment this can be set at a maximum when there is an issue of undertrusting $(b > a)$:

$$P_0 = \tfrac{a\overline{f}R(i)+b\alpha R(i)}{a+b}$$

which if replaced into the above functions they become

$$\begin{aligned} \Pi^{P_0} &= \tfrac{a\overline{f}R(i)+b\alpha R(i)}{a+b} - C_0 - i \\ CS^{P_0} &= B_0 + \tfrac{b\overline{f}R(i)-b\alpha R(i)}{a+b} \end{aligned}$$

Hence we see that in the case of a prepayment contract the surplus division between the buyer and the seller is in proportion to each party's trustworthiness estimate of the buyer after adjusting for the non-sunk element of investment in favour of the investor. The profit maximising level of investment is:

$$i^{P_0} \mid R'(i^{P_0}) = \frac{a+b}{a\overline{f} + b\alpha} \tag{5}$$

$$W^{P_0} = B_0 - C_0 + \overline{f}R(i) - i^{P_0} \tag{6}$$

Hence welfare in this case is only affected by the values of the trustworthiness parameters indirectly through the impact of any changes on these parameters on the level of investment. Clearly as $R' > 0$, $R'' < 0$ and $R'' < 0$, then since for $b > a$:

$$R'(i^{P_0}) = \frac{a+b}{a\overline{f}+b\alpha} < R'(i^f) = \frac{2b}{a\overline{f}+b\alpha},$$

it follows that $i^{P_0} > i^f$ and $R(i^{P_0}) > R(i^f)$.

We next calculate the impact of b on W^{P_0}, again through the split of the total derivative into a direct and an indirect effect. As the direct effect on welfare is clearly equal to zero, we get:

$$\frac{dW^{P_0}}{db} = \frac{\partial W^{P_0}}{\partial i^{P_0}}\frac{\partial i^{P_0}}{\partial b} = \frac{b(\overline{f}-\alpha)}{(a\overline{f}+b\alpha)}\frac{a(\overline{f}-\alpha)}{(a\overline{f}+b\alpha)^2 R''(i^{P_0})} = \frac{ba(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3 R''(i^{P_0})}$$

which clearly is negative as $R''(i^{P_0}) < 0$. Hence again b has a negative impact on welfare in the case of a prepayment contract.

Similarly,

$$\frac{\partial W^{P_0}}{\partial a} = \frac{\partial W^{P_0}}{\partial i^{P_0}}\frac{\partial i^{P_0}}{\partial a} = \frac{b(\overline{f}-\alpha)}{(a\overline{f}+b\alpha)}\frac{b(a-\overline{f})}{(a\overline{f}+b\alpha)^2 R''(i^{P_0})} = \frac{-b^2(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3 R''(i^{P_0})} > 0$$

Conclusion 5 *Under prepayment contracts, welfare is a decreasing function of the buying state's own perception of its trustworthiness, and an increasing function of the seller's perception of the trustworthiness of the buying state. However the impact of both is only limited to the indirect effect of the trustworthiness parameters via their impact on the level of investment and neither affects the welfare function directly.*

Theorem 2 *The higher the degree of undertrusting, the more efficient are prepayment contracts compared to a flexible contracts.*

Proof. Please refer to the appendix. ■

Issues of incentive compatibility may exist in flexible contracts. In particular, it may be beneficial for the buyer to declare an overestimate of his own trustworthiness given that this will reduce the share of the payment that goes to the firm. Even with the context of a prepayment contract the buyer may still have an incentive to overstate his trustworthiness.

Theorem 3 *Both the flexible payment contracts and the flexible prepayment contracts are not always incentive compatible as buyer governments have an incentive to exaggerate their trustworthiness to a considerable extent.*

Proof. Please refer to the appendix. ■

Therefore in both types of contracts the buyer has an incentive to overstate his trustworthiness as long as the adverse impact that an inflated b has on investment is not so detrimental for it to more than offset any direct gains accruing to the buyer by overstating his trustworthiness.

3.3 F-contracts[10]

If we drop the assumption that the buyer will always honestly declare its estimate of its own trustworthiness, then in this case it will be more appropriate to use an F-prepayment contract of the form:

$$F = (\overline{f}R(i) - P_0 - bt)^a (P_0 + at - r(i))^b$$

Such a contract allows the trustworthiness declared by each party affect the payoff of the other party. *This approach coupled up with prepayments makes the payoffs going to both parties independent of the trustworthiness parameters.* As we will show below, the impact of undertrusting on investment and welfare can be eliminated by establishing an F-contract.

The relevance of this model is not as a real world possible contract but in its role as a benchmark. As we have seen flexible contracts become more difficult to agree and sustain as $\frac{b}{a}$ increases, because such contracts are no longer incentive compatible. The level of efficiency as measured by welfare, achieved by the benchmark F-contract model is only possible in the pure flexible and flexible prepayment contracts when $a = b$.

For F-contracts, the payment solution is determined by maximising F with respect to t:

$$t = \frac{\overline{f}R(i) + \alpha R(i) - 2P_0}{a + b} \tag{7}$$

$$\Pi^{PF} = P_0 - C_0 + a\frac{\overline{f}R(i)+\alpha R(i)-2P_0}{a+b} - i = \frac{(b-a)P_0 + a\overline{f}R(i) + a\alpha R(i)}{a+b} - C_0 - i$$
$$CS^{PF} = B_0 - P_0 - b\frac{\overline{f}R(i)+\alpha R(i)-2P_0}{a+b} + \overline{f}R(i) = B_0 + \frac{(b-a)P_0 + a\overline{f}R(i) - b\alpha R(i)}{a+b}$$

As both of the above functions are increasing functions of the prepayment amount, the latter needs to be increased as the level of undertrusting ($b > a$) increases. This eliminates the incentive for the state to announce a trustworthiness higher than its true one in order to improve its share of consumer surplus as the prepayment is:

$$P_0 = \frac{\overline{f}R(i) + \alpha R(i)}{2}$$

which is independent of both a and b. If replaced into the profit and consumer surplus functions these become respectively,

$$\Pi^{PF} = \frac{(a+b)(\overline{f}R(i)+\alpha R(i))}{2(a+b)} - C_0 - i = \frac{\overline{f}R(i)}{2} + \frac{\alpha R(i)}{2} - C_0 - i$$
$$CS^{PF} = B_0 + \frac{(a+b)\overline{f}R(i) - (a+b)\alpha R(i)}{2(a+b)} = B_0 + \frac{\overline{f}R(i)}{2} - \frac{\alpha R(i)}{2}$$

The prepayment profit maximising level of investment is:

$$i^{PF} \mid R'(i^{PF}) = \frac{2}{\overline{f} + \alpha} \tag{8}$$

[10] A full definition and discussion of this incentive compatible category of contracts can be found in Braynov and Sandholm.

$$W^{PF} = B_0 - C_0 + \overline{f}R(i^{PF}) - i^{PF} \tag{9}$$

We see that the investment decision within an F-contract is identical to the one in the A&S model, and similarly the payments to the seller and the buyer are independent of the trustworthiness parameters. *The F-contracts fully avoid the implications of trustworthiness by introducing a system of prepayments such that both the direct as well as the indirect effects of such parameters are eliminated.* The key point is that the payments in the A&S model have now become prepayments in the F-contracts.

Theorem 4 *The higher the degree of undertrusting, the more efficient an F-contract compared to a flexible one and to a flexible prepayment one.*

Proof. Please refer to the appendix. ■

For undertrusting, an F-contract will lead to a welfare higher than the one experienced in the other two types of flexible contracts. Obviously, for overtrusting F-contracts will result into lower welfare, but would prevent the collapse of flexible contacts once a and b were realigned by converging into γ.

3.4 Rigid contracts

We use the terminology found in A&S, adding into the model the trustworthiness parameters. In the A&S model, rigid contracts are those where the contract specifies the main contract terms (e.g. prices, payments, etc.) in advance of the investment – and for the duration of the contract. In addition, the contract specifies the level of the investments to be made.

Renegotiation is excluded from the theoretical model. However, in practice, renegotiation cannot be excluded and is common – not least to rescue projects where one or both parties finds emerging outcomes becoming unacceptable. Hence, the pure model is, to some extent, a hypothetical reference model.

The model incorporates some of this via the introduction of 'maladaptation' costs, which are defined as the difference between expected surplus levels and actual (outcome) surplus levels. The impact of maladaptation costs, $\underline{f}$, falls on investment levels; the way in which this happens is explained directly below. However, higher than expected maladaptation costs will inevitability increase the probability to renegotiate a rigid contract. This latter issue is discussed in the 3.5, while in this section we temporarily assume that such a probability is equal to zero.

In this model, the payoffs are:

$$\Pi^r = P_0 - C_0 + a\underline{f}R(i) - i$$
$$CS^r = B_0 - P_0 + (1 - \underline{f}b)R(i)$$

The value of the maladaptation parameter, $\underline{f} < 1$, is an inverse measure of the potential size of the investor's loss over the distribution of outcomes; e.g.

actual versus expected traffic flows for toll roads. This parameter in our model is multiplied by the investor's expectation a that the buyer will pay him the surplus agreed in the contract. Correspondingly, the surplus received by the purchasing government is increased by this investor's loss. This is because the government is a residual claimant to any surplus over and above that paid the investor as agreed in the contract - subject to b, the probability (as assessed by the government) that the contractor will be paid the agreed amount.

The firm will choose an investment level i^r such that:

$$i^r \mid R'(i^r) = \frac{1}{a\underline{f}} \tag{10}$$

So in this case the level of investment *only depends on the trustworthiness of the buyer as perceived by the seller (a), and not at all by the buyer's own trustworthiness perception, b.*

In this model, total welfare is:

$$W^r = \Pi^r + CS^r = B_0 - C_0 + \left[1 + (a-b)\underline{f}\right] R(i^r) - i^r \tag{11}$$

As in the case of flexible uncertain contracts, W^r is a decreasing function of b, and an increasing function of a. For the case of $a = b$, the maladaptation costs only influence welfare indirectly (through their impact on investment). If $b > a$ (undertrusting) then the direct impact of $\underline{f}$ is negative and constitutes a deadweight loss, while in the reverse case of overtrusting its direct impact on welfare is positive.

As we have seen earlier, in the case of flexible contracts undertrusting made welfare directly dependent on the level of asset specificity, thus reducing welfare in the case of flexible contracts by adding a deadweight loss (this loss in welfare is higher the lower the level of asset specificity is). Here undertrusting makes the maladaptation parameter feature explicitly in the welfare function as a direct deadweight loss. This stems from the buyer's inability to fully capture the part of the surplus lost to the seller. Again this direct impact of $\underline{f}$ on welfare moves in the opposite direction to that of its indirect impact (via the level of investment) when $b > a$. Obviously, in the case of overtrusting ($b < a$) the direct impact of $\underline{f}$ on welfare moves in the same direction to that of its indirect impact.

The government's own perception of its trustworthiness only has a direct effect on welfare, as investment is not affected by b. Hence:

$$\tfrac{dW^r}{db} = -\underline{f}R(i^r) < 0$$

The impact of a on welfare still retains both a direct and an indirect effect:

$$\tfrac{dW^r}{da} = \tfrac{\partial W^f}{\partial a} + \tfrac{\partial W^r}{\partial i^r}\tfrac{\partial i^r}{\partial a} = \underline{f}R(i^f) + \left[\tfrac{1+(a-b)\underline{f}}{a\underline{f}} - 1\right]\tfrac{\partial i^r}{\partial a} \Leftrightarrow$$
$$\tfrac{dW^r}{da} = \underline{f}R(i^f) + \tfrac{1-b\underline{f}}{a\underline{f}}\tfrac{\partial i^r}{\partial a} > 0$$

In other words, under undertrusting W^r is an increasing function of a, i.e. an increasing function of the seller's perception of the trustworthiness of the buying state.

However unlike the flexible uncertain payment contracts, here the *actual* size of the parameter a does matter on investment since if $a = b < 1$:

$$i^r \mid R'(i^r)_{b=a<1} = \frac{1}{a\underline{f}} > i^r \mid R'(i^r)_{b=a=1} = \frac{1}{\underline{f}} \Leftrightarrow i^r_{a=b<1} < i^r_{a=b=1}$$

and

$$W^r_{b=a<1} = B_0 - C_0 + R(i^r)_{b=a<1} - i^r_{b=a<1} > W^r_{b=a=1} = B_0 - C_0 + R(i^r)_{b=a<1} - i^r_{a=b=1} \tag{12}$$

Hence the gap between these two is the difference in the investment level, i.e. $W^r_{b=a=1} < W^r_{b=a<1}$ and the difference between these two depends on a.

In summary, for rigid contracts matching estimates of trustworthiness are still important, but in this case, unlike the flexible contract case, the absolute level of a is important and needs to be high. Good outcomes on efficiency and investment require a to be close to one.

3.5 Hybrid contracts

We finally analyse the hybrid model, where there is always the probability that subsequent to investment taking place, rigid contracts will be renegotiated, and/or key terms reset. Following this, the key issues we explore in this section is the relative efficiency (in terms of welfare) between flexible to hybrid models in terms of the values key parameters: a) maladaptation costs, b) the probability of renegotiation of an *ex ante* rigid contract, c) sunk costs and d) renegotiation costs.

We follow the terminology of A&S and denote by $(1-\eta)$ the probability to see an *ex ante* rigid contract renegotiated. We calculate the profit function of the firm:

$$\Pi^H = \eta \Pi^r + (1-\eta)\Pi^f =$$

$$= \eta\left(P_0 - C_0 + a\underline{f}R(i) - i\right) + (1-\eta)\left(P_0 - C_0 + \tfrac{a\overline{f}R(i)}{2b} + \tfrac{\alpha R(i)}{2} - i\right) \Leftrightarrow$$

$$\Pi^H = P_0 - C_0 + aR(i)\left(\eta\underline{f} + \frac{(1-\eta)\overline{f}}{2b} + \frac{(1-\eta)\alpha}{2a}\right) - i \tag{13}$$

$$i^H \mid R'(i^H) = \frac{2}{\eta(2a\underline{f} - \frac{a}{b}\overline{f} - \alpha) + \frac{a}{b}\overline{f} + \alpha} = \frac{2b}{2\eta ab\underline{f} + (1-\eta)(a\overline{f} + b\alpha)} \tag{14}$$

So when $\eta = 1$, the results are identical to those of a rigid contract as the government can credibly commit not to renegotiate the contract, while for $\eta = 0$ they coincide with those in the flexible model discussed in the beginning of this paper. We focus on the hybrid case where $0 < \eta < 1$.

Calculating the difference between the hybrid and the flexible contracts,

$$CS^H = \eta CS^r + (1-\eta)CS^f = \eta\left(B_0 - P_0 + (1-\underline{f}b)R(i)\right) + \\ +(1-\eta)\left(B_0 - P_0 + \frac{\overline{f}R(i)}{2} - \frac{b}{a}\frac{\alpha R(i)}{2}\right) = \\ B_0 - P_0 + \left(\eta(1-\underline{f}b) + (1-\eta)\frac{\overline{f}}{2} - (1-\eta)\frac{b}{a}\frac{\alpha}{2}\right)R(i)$$

Hence the welfare outcome in the hybrid contract, W^H is,

$$W^H = B_0 - C_0 + \left[\eta + \eta\underline{f}(a-b)\right]R(i^H) + (1-\eta)\alpha\frac{a-b}{2a}R(i^H) + \\ +(1-\eta)\overline{f}\frac{a+b}{2b}R(i^H) - i^H$$

If we calculate the difference between the welfare in a hybrid contract and welfare in a flexible contract we get:

$$W^H - W^f = \eta + \eta\underline{f}(a-b)R(i^H) + \left[\overline{f}\frac{a+b}{2b} + \alpha\frac{a-b}{2a}\right]\left[(1-\eta)R(i^H) - R(i^f)\right] + \\ +i^H - i^f \tag{15}$$

We next calculate the impact on this difference of all the parameters, namely $\overline{f}, \underline{f}, \alpha$ and η. We present the direct and indirect effects (through investment) of all these parameters in the appendix. The results lead us to the following conclusions:

Proposition 1 *For $a\overline{f} > b\alpha$ and $\eta > 0$, the lower are maladaptation costs (the higher is $\underline{f}$), the more efficient is the hybrid model relative to the flexible one. But if the negative direct (welfare) effect comes to dominate the positive indirect one (on investment), then the flexible model is more efficient relative to the hybrid one.*

Proof. Please refer to the appendix. ■

Notice how the existence of undertrusting gives rise to the requirement that sunk costs are sufficiently high and renegotiation costs sufficiently low for $a\overline{f} > b\alpha$ to hold; a condition more demanding than in corresponding proposition in the A&S paper, where the necessary condition was that $\overline{f} > \alpha$. Our analysis in the appendix shows that the assumption $a\overline{f} > b\alpha$ implies that the impact of investment on welfare is positive for both types of contracts $\left(\frac{\partial W^H}{\partial i^H}, \frac{\partial W^f}{\partial i^f} > 0\right)$.

Specifically, the gap between $\overline{f}$ and α needs to be sufficiently high so that when the former is multiplied by a lower number (a) and the latter by a higher number (b) the inequality does not change its direction. The more pronounced undertrusting becomes (the higher the gap between b and a is), the higher the difference between $\overline{f}$ and α needs to be for the proposition to hold.

In other words, the higher the level of undertrusting, the less likely is the hybrid contract to be more efficient. This is because an increase in the gap between b and a will make the inequality $a\overline{f} > b\alpha$ increasingly more difficult to sustain. If it becomes unsustainable and $a\overline{f} < b\alpha$, then the positive impact of $\underline{f}$ on welfare will be far smaller and, possibly, even negative.

A&S concluded that low maladaptation costs make a hybrid rigid contract preferable to a flexible contract in terms of welfare. While our proposition (1) supports this result, it also establishes (for $a < b$) the existence of a negative direct effect of the maladaptation parameter $\underline{f}$ on welfare (deadweight loss). This means that for sufficiently large differences between the two trustworthiness parameters, the results found in this proposition may be reversed. This happens when this direct (deadweight loss) effect more than offsets the indirect impact of $\underline{f}$ on welfare. Hence substantial undertrusting may turn the tables in favour of the flexible contract!

The next three propositions are all formally set out, proved and analysed in the appendix. Here we only summarise these and compare them to the corresponding propositions 2-4 in A&S. Proposition 2 argues that the lower the probability to renegotiate is, the more efficient a hybrid contract compared to a flexible one. On the other hand, the lower the asset specificity the more efficient a flexible contract compared to a hybrid one according to proposition 3. Finally, proposition 4 sets that the lower the renegotiation costs, the more efficient a flexible model is compared to a hybrid one.

As stated all these propositions are similar to those found in A&S. The common cause behind any differences between all of the above four propositions to propositions (1)-(4) found in A&S is the existence of undertrusting: this results to the creation of a direct effect of the parameters on welfare. In simpler terms, a major implication of our paper is that undertrusting not only reduces the level of infrastructure investment undertaken by firms; it also leads to a failure from the side of the buyer to fully capture those parts of the (now reduced) investment-induced surplus that the investor fails to appropriate because of asset specificity (in the flexible model), or because of maladaptation (in the rigid model). Each of these effects results in a deadweight loss with a direct adverse impact on welfare. Moreover, in the flexible model undertrusting further reduces the surplus that goes to the seller (and therefore to the society) as a result of renegotiation costs.

As a result, in proposition 2, undertrusting lessens the positive impact of η on the welfare superiority of the hybrid contract. The direct effect of η may be negative; if this is the case it will reduce or even dominate the positive indirect effect of η on welfare. So extensive undertrusting reduces the strength of this proposition and may even come to reverse it. Proposition (3) is also affected by the direct reverse effect of a higher α on the superiority of the flexible contract relative to the rigid one unless we restrict (by assuming a sufficiently low η) this negative direct effect to be smaller in absolute terms for the flexible contract rather than the hybrid contract. This means that the direct effect reinforces the welfare superiority of the flexible contract as established in terms of the indirect effect. Finally, proposition (4) is not affected as $\overline{f}$ already has a direct effect on welfare even when $a = b = 1$. Provided that η is sufficiently high for the positive direct effect of $\overline{f}$ on welfare to be larger under a flexible rather than hybrid contract, the direct effect will reinforce the indirect effect in supporting the argument that the welfare superiority of the flexible model will increase as $\overline{f}$ increases.

4 DISCUSSION AND IMPLICATIONS OF THE MODEL

In the literature to date, there is no distinction between trust levels between investors and (buyer) governments and the subjective perceptions of the government by the investor (and vice-versa). Indeed, the implicit assumption is that there is no misalignment. However, this may be an unfortunate simplification.

The reality is not only that contracts are most likely to break down when there is such misalignment, but also that as we have shown it is unlikely to achieve incentive compatible contracts unless perceptions can be aligned. That, in turn, may help explain whether infrastructure contracts that run into difficulties can be renegotiated between the parties. Our conjecture is that in circumstances where the seller's perception of the reliability of the buyer is much lower than the buyer's own perception (undertrusting), the contract is most likely to break down irrevocably. For contracts where the seller's perception of the buyer reliability is higher than justified (overtrusting), contracts may continue satisfactorily until the misalignment is revealed at which point they are likely to fall apart rapidly. Conversely, contracts can survive where the levels of trust are low but perceptions are correctly aligned.

Most of the discussion on trust and most of the theoretical models in this field accept that a and b can be high or low depending on the country or project but, implicitly or explicitly assume that $a = b$. However, there are circumstances where a and b are both low (e.g. under 0.5) but both parties have the same perspective and hence private investment in infrastructure may be sustainable. Conversely, there may be circumstances where a and b are both relatively high (e.g. above 0.5) but a is sufficiently less than b so as to create a significant degree of mistrust.

These issues were fully explored in the theoretical model set out in the previous sections. We can summarise these by setting out a simple typology, based on a 4 quadrant table as in Table 1 below; we then set out and discuss some illustrative examples on each case as set in Table 1. The table and the discussion focuses primarily on undertrusting, but we will say something further on overtrusting afterwards.

Table 1
Perceptions of Trustworthiness

Case (A)	Case (C)
Repeat project and/or contract	New type of project or contract
Country with strong institutions	Country with strong institutions
and high trustworthiness reputation	and high trustworthiness reputation
$a = b, \ \ a, b \longrightarrow 1$ (*large*)	$a < b, \ \ a, b \gtrsim 0.5$ (*moderate*)
Case (B)	Case (D)
Repeat project and/or contract	New type of project or contract
Country with weak and/or	Country with past history of weak
corrupt institutions	and/or corrupt institutions but trying to
	establish reputation for trustworthiness
$a = b, \ \ a, b \longrightarrow 0$	$a < b, \ \ a, b < 0.5$ (*small*)

The key point behind the table is that mistrust is most likely in circumstances of high uncertainty. When is project/contract uncertainty likely to be highest?

The answer is:

(i) for new types of project, particularly with high construction, technological or political risk; and

(ii) for countries where they are trying to change from having a low trustworthiness reputation to having a high trustworthiness reputation.

In both these cases, a is likely to be significantly lower than b. Conversely, for repeat projects based on a history of reasonable success it is likely that $a = b$, whether at a high or a low level.

Let us briefly consider each quadrant in turn.

Case (A) represents well-established types of project in high reputation countries. For many types of infrastructure concession contract or PPP, trust is likely to be high and the contracting parties may well be able to monitor, enforce and revise their contracts straightforwardly, without a need for external assistance (other than occasionally for arbitration/dispute resolution or similar) or for 'pre-payment' arrangements. Hence, private investment is readily forthcoming and at a reasonable cost of capital as perceived risk is low. Examples include repeat water supply management contracts in easy to access and process water (as in Menard and Saussier), repeat UK PPP contracts in politically uncontentious sectors, electricity distribution in Chile. This is a sustainable and efficient process that is potentially welfare maximising.

Case (B) represents infrastructure contracts in countries with low quality institutions. Supplying companies can and do have supply contracts with governments in Latin America, Sub-Saharan Africa and elsewhere where government is arbitrary and/or corrupt – and liable to change on the replacement of the current autocrat. These contracts can support investment.

The key point is that they are *relational* contracts where the monitoring, enforcement and revision is done between the two parties who know one another well. The contracts will only be sustainable if the supplier can expect to receive a return adjusted for higher risks and for any (potentially large) corruption payments – both buyer and seller may receive returns from corrupt practices. Clearly, these contracts are far from optimal for the consumers or taxpayers in the countries concerned and are likely to be monopoly contracts that do not allow any competitive entry (e.g. no independent power producers or competing telecom operators). But, given aligned beliefs on each party's trustworthiness of the regime over the life of the contract, they do allow a low-level, incentive compatible equilibrium with positive private investment and without the need for a 'pre-payment' arrangement. This process is sustainable (at least while the current parties continue) but it is highly inefficient and far from welfare maximizing.

Case (C) represents early and potentially difficult contracts in high reputation countries. In the UK, the London Underground PPPs were in this category (and one – the Tube Line PPP - appears to be progressing well, even if the Metronet PPP has failed) as were the NATS air traffic control contract and early PPPs in hospitals and prisons. In these cases, to sustain the contract, it helps to have an external regulator – the PPP Arbiter for the London Underground, the Civil Aviation Authority for NATS.

Note that in most of these cases, there has been an explicit or implicit government guarantee providing a 'pre-payment' facility. There clearly are potential incentive compatibility problems so that breakdown is likely in the case of major disputes. But, provided the first contract (or first few years of the contract) go well and any major problems are addressed by successful renegotiation (as with NATS), subsequent contracts or periods should go well. This is because experience under the contract has realigned initial trust concerns so that a becomes equal to or close to b.

Most of these contracts faced not only significant political risk, but most also had serious construction, technology, demand and/or demand risks. The London Underground contracts also had major issues of ongoing rather than front-loaded investment. Interestingly, an early major success for UK PPPs was the Dartford bridge crossing of the River Thames. For that project, an effective and robust 'pre-payment' mechanism was put in place through allowing the duration of the concession to correspond to that necessary for the contractor to recover his principal and earn an agreed rate of return (i.e. an NPV contract).

Finally, Case (D) represents countries that start with poor reputations but are trying hard to obtain private investment into infrastructure e.g. into roads, power generation, sometimes water. To attract that investment, governments may pass concession laws, introduce independent regulators or allow external arbitration or similar. Examples of such countries include Uganda, Nigeria, Mozambique and Romania.

However, supplying companies are likely to want a demonstrable record of achievement for those institutions before reducing their cost of capital risk premia. Hence, the private investment may not be possible – at least not at a cost that would be acceptable in terms of the final tariff. In these circumstances, private investment will only be forthcoming and sustainable if there is external support in place e.g. from an effective 'pre-payment' agreement. That is where transitional regulatory risk guarantees and other forms of external underpinning (e.g. on-demand guarantees, bilateral investment treaties, comprehensive credit insurance, etc.) can help align perceptions or relative trustworthiness.

If this process is successful and the country floats away from the (hopefully unused) pre-payment support, the result is an efficient equilibrium with realigned trust perceptions.

The table omits overtrusting. The latter raises more difficult issues and seems to be much more difficult to anticipate. The non-alignment of trust perceptions is only revealed after some time. Typically it is not only some period after pre-agreed investments have been made, but later when unanticipated problems have arisen which require an increase in the revenue requirement if the supplying entity under the contract is not to be forced into bankruptcy. Sometimes, as in the Argentinian case, the misperception is on the powers of any regulatory agency, particularly at times of crisis.

Note that sometimes trust perception problems clearly exist, but it is unclear whether we are observing undertrusting or overtrusting. The collapse of the London Underground Metronet PPPs initially looks like an example of undertrusting – and certainly some of the features of the contract reflect undertrusting via the political risks from the hostility of the London authorities to a PPP model. However, it is also possible to argue that the failure is a case of overtrusting where the investor believed that the contract was closer to a cost-plus contract than was actually the case. This example points to the need, in future work, to extend the model to encompass perceptions of sellers as well as of buyers.

5 CONCLUSIONS

The key conclusions of this paper are:

(i) How far governments and investors share the same perceptions of government trustworthiness in contract enforcement is at least as important for the sustainability of infrastructure contracts and investment as whether absolute levels of trust are high or low.

(ii) Undertrusting (i.e. where the company has a lower perception of government trustworthiness than the government has) is the more frequently observed case. This occurs when investing infrastructure firms have a lower expectation of full payment under the contract than the government has ex ante e.g. at the time of initially negotiating the contract.

(iii) The negative effects of undertrusting increase the higher the proportion of assets that are sunk and the higher the degree of trust misalignment.

(iv) In our model, undertrusting leads to direct negative effects on total welfare as well as indirect negative effects on welfare via the level of investment. This is in contrast to the Athias and Saussier model where, in the absence of trust misalignment, only indirect effects occur via the level of investment. In our model, the direct effects are deadweight losses inversely related to the degree of asset specificity and the degree of maladaptation costs and directly related to the degree of trust misalignment.

(v) Undertrusting is a transitional state of imbalance, primarily associated with innovative contracts or first-time contracting parties. To rectify it, requires the use of external measures such as pre-payment arrangements, regulatory and/or other guarantees, or other specific actions to realign initially different perceptions.

(vi) Overtrusting is theoretically less likely and is also less frequently observed in practice. It is not easy to rectify, and when revealed is likely to lead to rapid contract breakdown. The revelation is likely to arise when the buyer approaches the seller for a post-investment revenue increase relative to what was expected and/or specified in the original contract .

(vii) Rigid contracts appear particularly unattractive in our model as they are dependent for sustainability not only on closely aligned trust perceptions, but also on high absolute levels of trust, whereas flexible relational infrastructure concession contracts are potentially sustainable with low but aligned levels of trust, typically on a relational basis.

(viii) Under conditions of undertrusting, flexible contracts are not incentive compatible so that successful renegotiation in situations of serious problems is likely to be very difficult.

(ix) Hybrid contracts tend to be more efficient than either pure rigid or flexible contracts except at higher levels of undertrusting when flexible contracts dominate – assuming they are sustainable.

(x) The potential for trust misalignments e.g. over future investment requirements and costs, technology uncertainties, political sensitivities, etc. provides additional support for the role of external regulatory or similar agencies, guarantees and similar mechanisms. These also support the use of hybrid contracts (rigid contracts but with a strictly positive probability of renegotiation.)

The work reported here is, as far as we are aware, a first attempt to seriously model the role of potential trust misalignments on welfare and investment in infrastructure contracts. Such an analysis helps bring out the potential role of regulatory agencies, of external guarantee mechanisms and of contract features that reduce uncertainty (e.g. NPV contracts). We see this as a useful extension to the Athias and Saussier model which has been very clearly set out and empirically tested for toll road concessions.

We look forward to seeing whether our proposed framework and approach can be usefully extended. More importantly, we would like to be able to test its predictions using real world data on infrastructure contracts in developing as well as in OECD countries.

6 REFERENCES

Athias, L. and Saussier, S. (2006), ‘Contractual Design of Toll Adjustment Provisions in Infrastructure Contracts’, Atom-U, Paris-Sorbonne,
http://ssrn.com/abstract=828944

Bolt, C. (2003), ‘Regulating the London Underground, Beesley Lecture, www.ppparbiter.org.uk

Bolt, C. (2007), ‘Regulating by Contract and by Licence – The Relationship between Regulatory Form and its Effectiveness’, CRI Bath and
www.ppparbiter.org.uk

Braynov, S. and Sandholm, T. (2002), ‘Contracting with Uncertain Level of Trust’, Computational Intelligence, Vol.18, No. 4.

Greif, A. (2006), Institutions and the Path to the Modern Economy: Lessons from Mediaeval Trade, Cambridge University Press.

Guasch, J.L. (2004), ’Granting and Renegotiating Concession Contracts: Doing It Right’, World Bank Institute.

Guasch, J.L. and Straub, S. (2006), ’Renegotiation of Infrastructure Concessions: An Overview’, Annals of Public and Cooperative Economics, Vol. 77, No 4.

Laffont, J.J. (2005), Regulation and Development, Cambridge University Press.

Levine, P., Stern, J. and Trillas, F. (2005), ’Utility Price Regulation and Time Inconsistency: Comparisons with Monetary Policy’, Oxford Economic Papers, Vol. 57, pp 447-478.

McMillan, M.S. and Waxman, A. (2007), ’Profit Sharing Between Host Countries and Multinationals in Natural Resource Extraction: An Empirical Investigation’, Brookings Trade Forum.

Menard, C. and Saussier, S. (2002), ’Contractual Choice and Performance: Water Supply in France’, in E. Brousseau and J.M. Glachant (eds.) The Economics of Contracts: Theories and Applications, Cambridge University Press.

Spiller, P. (2004), ’An Institutional Theory of Public Contracts’, ISNIE Conference 2004.

Stern, J. (2005), ’Regulation and Contracts: The Inevitability of Discretion’, CCRP Workshop, Barcelona, Spain.

Stern, J. (2003), ’Regulation and Contracts: Substitutes or Complements? Lessons from UK Historical Experience’, Journal of Policy Reform, Vol. 6, No 4, December 2003.

7 APPENDIX

Proof of Theorem 1

We first show that W^f is a decreasing function of b. To calculate the impact of b on W^f we split this into a direct and an indirect effect; the latter evaluates the impact of b on W^f via the impact of b on the level of investment. Hence:

$$\begin{aligned}\tfrac{dW^f}{db} &= \tfrac{\partial W^f}{\partial b} + \tfrac{\partial W^f}{\partial i^f}\tfrac{\partial i^f}{\partial b} = -\tfrac{2a}{(2b)^2}\overline{f}R(i^f) - \tfrac{1}{2a}\alpha R(i^f) + \\ &\left[\tfrac{a+b}{2b}\overline{f}\tfrac{2b}{a\overline{f}+b\alpha} + \tfrac{a-b}{2a}\alpha\tfrac{2b}{a\overline{f}+b\alpha} - 1\right]\tfrac{\partial i^f}{\partial b} = \\ &-\tfrac{2a}{(2b)^2}\overline{f}R(i^f) - \tfrac{1}{2a}\alpha R(i^f) + \tfrac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)}\tfrac{\partial i^f}{\partial b} = \\ &= -\tfrac{2a}{(2b)^2}\overline{f}R(i^f) - \tfrac{1}{2a}\alpha R(i^f) + \tfrac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)}\tfrac{\frac{2a\overline{f}}{(a\overline{f}+b\alpha)^2}}{R''(i^f)} \Leftrightarrow\end{aligned}$$

$$\frac{dW^f}{db} = -\frac{2a}{(2b)^2}\overline{f}R(i^f) - \frac{1}{2a}\alpha R(i^f) + \frac{2\overline{f}b(a\overline{f}-b\alpha)}{(a\overline{f}+b\alpha)^3 R''(i^f)} \tag{16}$$

If $b > a$ (undertrusting) and $\frac{\overline{f}}{\alpha} > \frac{b}{a} > 1$, $\frac{\partial W^f}{\partial i^f} = \frac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)} > 0$, and $\frac{\partial R'(i^f)}{\partial b} = \frac{2a\overline{f}}{\left(a\overline{f}+b\alpha\right)^2} > 0$. The latter implies a negative impact of b on the level of investment i^f since $\frac{\partial i^f}{\partial b} = \frac{\partial i^f}{\partial R'(i^f)}\frac{\partial R'(i^f)}{\partial b} = \frac{\frac{\partial R'(i^f)}{\partial b}}{R''(i^f)} < 0$. Therefore, b has a negative indirect impact on W, reinforcing the negative direct impact.

Similarly, we calculate the impact of a on W^f:

$$\begin{aligned}\tfrac{dW^f}{da} &= \tfrac{\partial W^f}{\partial a} + \tfrac{\partial W^f}{\partial i^f}\tfrac{\partial i^f}{\partial a} = \tfrac{1}{2b}\overline{f}R(i^f) + \tfrac{2b}{(2a)^2}\alpha R(i^f) + \\ &\left[\tfrac{a+b}{2b}\overline{f}\tfrac{2b}{a\overline{f}+b\alpha} + \tfrac{a-b}{2a}\alpha\tfrac{2b}{a\overline{f}+b\alpha} - 1\right]\tfrac{\partial i^f}{\partial a} = \\ &\tfrac{1}{2b}\overline{f}R(i^f) + \tfrac{2b}{(2a)^2}\alpha R(i^f) + \tfrac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)}\tfrac{\partial i^f}{\partial a}\end{aligned}$$

As $\frac{\partial R'(i^f)}{\partial a} = \frac{-2b\overline{f}}{\left(a\overline{f}+b\alpha\right)^2} < 0$, this implies a positive impact of a on the level of investment i^f since $\frac{\partial i^f}{\partial a} = \frac{\partial i^f}{\partial R'(i^f)}\frac{\partial R'(i^f)}{\partial a} = \frac{\frac{\partial R'(i^f)}{\partial a}}{R''(i^f)} > 0$.

Proof of Theorem 2

Taking the difference between $W^{P_0} - W^f$ and differentiating with respect to b gives:

$$\begin{aligned}\tfrac{\partial(W^{P_0}-W^f)}{\partial b} &= \tfrac{2a}{(2b)^2}\overline{f}R(i^f) + \tfrac{1}{2a}\alpha R(i^f) - \tfrac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)}\tfrac{\partial i^f}{\partial b} + \tfrac{b(\overline{f}-\alpha)}{(a\overline{f}+b\alpha)}\tfrac{\partial i^{P_0}}{\partial b} = \\ &\tfrac{2a}{(2b)^2}\overline{f}R(i^f) + \tfrac{1}{2a}\alpha R(i^f) - \tfrac{2\overline{f}b(a\overline{f}-b\alpha)}{(a\overline{f}+b\alpha)^3 R''(i^f)} + \tfrac{ba(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3 R''(i^{P_0})} = \\ &= \tfrac{2a}{(2b)^2}\overline{f}R(i^f) + \tfrac{1}{2a}\alpha R(i^f) + \tfrac{b}{(a\overline{f}+b\alpha)^3}\tfrac{a(\overline{f}-\alpha)^2 R''(i^f) - 2\overline{f}(a\overline{f}-b\alpha)R''(i^{P_0})}{R''(i^f)R''(i^{P_0})}\end{aligned}$$

where since $R'', R''' < 0$ and $i^{P_0} > i^f$ we have that $R''(i^{P_0}) < R''(i^f) < 0$. Analogously,

$$\frac{\partial(W^{P_0}-W^f)}{\partial a} = \frac{-b^2(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3 R''(i^{P_0})} - \frac{1}{2b}\overline{f}R(i^f) - \frac{2b}{(2a)^2}\alpha R(i^f) + \frac{2\overline{f}b^2(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)^3 R''(i^f)} =$$
$$= -\frac{1}{2b}\overline{f}R(i^f) - \frac{2b}{(2a)^2}\alpha R(i^f) - \frac{b^2}{a(a\overline{f}+b\alpha)^3}\frac{a(\overline{f}-\alpha)^2 R''(i^f) - 2\overline{f}(a\overline{f}-b\alpha)R''(i^{P_0})}{R''(i^f)R''(i^{P_0})}$$

Hence unless $\frac{\overline{f}^2-\alpha^2}{2\overline{f}\alpha} < \frac{b}{a} - 1$[11] and $-\frac{b^2}{a(a\overline{f}+b\alpha)^3}\frac{a(\overline{f}-\alpha)^2 R''(i^f) - 2\overline{f}(a\overline{f}-b\alpha)R''(i^{P_0})}{R''(i^f)R''(i^{P_0})} > \frac{1}{2b}\overline{f}R(i^f) + \frac{2b}{(2a)^2}\alpha R(i^f)$, we will have that $\frac{\partial(W^{P_0}-W^f)}{\partial b}$ is positive and $\frac{\partial(W^{P_0}-W^f)}{\partial a}$ negative. Hence as undertrusting increases because a decreases and/or b decreases, a prepayment contract becomes more efficient in relation to a flexible contract.

Proof of Theorem 3

Let us assume a falsely declared beta (say b^{dl}) higher that the true beta (say b^{tr}). By totally differentiating the payment solution in (1) we get that:

$$\frac{dt}{db^{dl}} = \frac{\partial t}{\partial b^{dl}} + \frac{\partial t}{\partial i^f}\frac{\partial i^f}{\partial b^{dl}} = \frac{-\overline{f}R(i)}{2(b^{dl})^2} + \left(\frac{1}{a}\right)\frac{\partial i^f}{\partial b^{dl}} < 0$$

Hence as

$$CS^f = B_0 - P_0 + \overline{f}R(i) - b^{tr}t \Leftrightarrow$$
$$\frac{dCS^f}{db^{dl}} = \overline{f}\frac{2b^{dl}}{a\overline{f}+b^{dl}\alpha}\frac{\partial i^f}{\partial b^{dl}} - b^{tr}\frac{dt}{db^{dl}} \Leftrightarrow$$

$$\frac{dCS^f}{db^{dl}} = b^{tr}\frac{\overline{f}R(i)}{2(b^{dl})^2} + \frac{1}{a\overline{f}+b^{dl}\alpha}\frac{(2\overline{f}ab^{dl} - \overline{f}ab^{tr} - b^{tr}b^{dl}\alpha)}{a}\frac{\partial i^f}{\partial b^{dl}} \tag{17}$$

As $\overline{f} > \alpha$ and $1 \geqslant b^{dl} > b^{tr}$, the term in the brackets is positive and hence the overall indirect effect is negative. Hence the buyer has an incentive to overstate his trustworthiness as long as the impact of an inflated b on investment is not so detrimental as to substantially reduce both i and hence R (which are determined by the firm given its profit maximising investment decision) to such an extent that more than offsets any direct gains for the buyer.

Similarly, for the case of prepayments, by totally differentiating $P_0 = \frac{a\overline{f}R(i)+b^{dl}\alpha R(i)}{a+b^{dl}}$, we get that:

$$\frac{dP_0}{db^{dl}} = \frac{\partial P_0}{\partial b^{dl}} + \frac{\partial P_0}{\partial i^{P_0}}\frac{\partial i^{P_0}}{\partial b^{dl}} =$$
$$\frac{-a\overline{f}R(i)}{(a+b^{dl})^2} + \frac{\alpha R(i)(a+b^{dl}) - b^{dl}\alpha R(i)}{(a+b^{dl})^2} + \left(\frac{a+b^{dl}}{a\overline{f}+b^{dl}\alpha}\right)\frac{a\overline{f}+b^{dl}\alpha}{a+b^{dl}}\frac{\partial i^{P_0}}{\partial b^{dl}} \Leftrightarrow$$
$$\frac{dP_0}{db^{dl}} = \frac{a(\alpha-\overline{f})R(i)}{(a+b^{dl})^2} + \frac{\partial i^{P_0}}{\partial b^{dl}} < 0$$

[11] This is rather unlikely: clearly $\frac{\overline{f}^2-\alpha^2}{2\overline{f}\alpha}$ is an increasing function of $\overline{f}$ and a decreasing function of α, hence unless the former is small and the latter large this inequality is unlikely to hold. We already know that $\frac{\overline{f}}{\alpha} > \frac{b}{a} > 1$ so it is more likely than not that $\frac{\overline{f}^2-\alpha^2}{2\overline{f}\alpha} > \frac{b-a}{a}$ rather than the other way round.

Hence as

$$CS^{P_0} = B_0 - P_0 + \overline{f}R(i) - 0b^{tr} \Leftrightarrow$$
$$\tfrac{dCS^{P_0}}{db^{dl}} = \overline{f}\tfrac{a+b^{dl}}{a\overline{f}+b^{dl}\alpha}\tfrac{\partial i^{P_0}}{\partial b^{dl}} - \tfrac{dP_0}{db^{dl}} \Leftrightarrow$$

$$\frac{dCS^{P_0}}{db^{dl}} = \frac{a(\overline{f}-\alpha)R(i)}{(a+b^{dl})^2} + \frac{b^{dl}(\overline{f}-\alpha)}{a\overline{f}+b^{dl}\alpha}\frac{\partial i^{P_0}}{\partial b^{dl}} \tag{18}$$

Hence again the buyer has an incentive to overstate his trustworthiness provided that the impact of an inflated b on investment is not so detrimental that the reduction in investment as denoted by the second term in the relation above more than offsets any direct gains to the buyer (as denoted by the first term). However, unlike $\frac{dCS^f}{db^{dl}}$, $\frac{dCS^{P_0}}{db^{dl}}$ does not depend on the magnitude of the true value of b, b^{dl}.

Proof of Theorem 4

Comparing the PF solution (prepayment F-contracts) to those of pure flexibility contracts f and the prepayment ones we get that for $b > a$

$$R'(i^{PF}) = \tfrac{2}{\overline{f}+\alpha} \leqslant R'(i^f) = \tfrac{2b}{a\overline{f}+b\alpha}$$

it follows that $i^{PF} > i^{P_0} > i^f$ and $R(i^{PF}) > R(i^{P_0}) > R(i^f)$.

As $\frac{\partial W^{PF}}{\partial i^{PF}} = \overline{f}R'(i^{PF}) - 1 = \frac{2\overline{f}-\overline{f}-\alpha}{\overline{f}+\alpha} = \frac{\overline{f}-\alpha}{\overline{f}+\alpha}$, $\frac{\partial i^{PF}}{\partial b} = \frac{\partial i^{PF}}{\partial R'(i^{PF})}\frac{\partial R'(i^{PF})}{\partial b} = \frac{\frac{\partial R'(i^{PF})}{\partial b}}{R''(i^{PF})} = 0$ and $\frac{\partial R'(i^{PF})}{\partial b} = 0$, both the direct as well as the indirect effects of b on welfare are zero. Hence taking the difference between $W^{PF} - W^f$ and differentiating with respect to b gives:

$$\tfrac{\partial\left(W^{PF}-W^f\right)}{\partial b} = \tfrac{2a}{(2b)^2}\overline{f}R(i^f) + \tfrac{1}{2a}\alpha R(i^f) - \tfrac{b(a\overline{f}-b\alpha)}{a(a\overline{f}+b\alpha)}\tfrac{\partial i^f}{\partial b} > 0$$

Hence the higher b is, the more efficient if the F- prepayment contract is as compared to the pure flexible contract of A&S.

Similarly both the direct as well as the indirect effect of a on W^{PF} is zero, and hence the lower a is, the more efficient an F- prepayment contract as compared to a flexible contract.

In an analogous manner, we compare the welfare implications of an F-contract to that of a prepayment contract. Calculating:

$$W^{PF} - W^{P_0} = \overline{f}R(i^{PF}) - i^{PF} - \overline{f}R(i^{P_0}) + i^{P_0}$$

and differentiating with respect to b gives:

$$\frac{\overline{f}-\alpha}{\overline{f}+\alpha}\frac{\partial i^{PF}}{\partial b}-\frac{b(\overline{f}-\alpha)}{a\overline{f}+b\alpha}\frac{\partial i^{P_0}}{\partial b}=\frac{\overline{f}-\alpha}{\overline{f}+\alpha}0-\frac{b(\overline{f}-\alpha)}{a\overline{f}+b\alpha}\frac{a(\overline{f}-\alpha)}{(a\overline{f}+b\alpha)^2R''(i^{P_0})}\Leftrightarrow$$
$$\frac{\partial\left(W^{PF}-W^{P_0}\right)}{\partial b}=-\frac{ab(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3R''(i^{P_0})}>0$$

Hence the higher b is, the more efficient the F-prepayment contract as compared to the prepayment contract. An opposite result will hold for a as $\frac{\partial(W^{PF}-W^{P_0})}{\partial a}=0+\frac{b^2(\overline{f}-\alpha)^2}{(a\overline{f}+b\alpha)^3R''(i^{P_0})}>0$.

Next, we set out in detail the proofs for the four propositions referred to in section 3.5.

For $\eta>0$, $i^H>i^f$, $R(i^H)>R(i^f)$ we require that $R'(i^H)<R'(i^f)$, which holds if:

$$(2b\underline{f}-\overline{f})a>b\alpha \tag{19}$$

It then follows that $R^{''}(i^H)<R^{''}(i^f)<0$.

We now look at the impact of parameters on investment. First we look at **the impact of** α **:**

$$\frac{\partial i^f}{\partial\alpha}=\frac{\frac{\partial R'(i^f)}{\partial\alpha}}{R''(i^f)}=\frac{\frac{-2b^2}{(a\overline{f}+b\alpha)^2}}{R''(i^f)}>0$$
$$\frac{\partial i^H}{\partial\alpha}=\frac{\frac{\partial R'(i^H)}{\partial\alpha}}{R''(i^H)}=\frac{\frac{-2b^2(1-\eta)}{\left(2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right)^2}}{R''(i^H)}>0$$
$$2b^2>2b^2(1-\eta),\ \frac{1}{(a\overline{f}+b\alpha)^2}>\frac{1}{\left(2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right)^2}$$

and

$$0<R''(i^f)>R''(i^H)\Leftrightarrow-\frac{1}{R''(i^f)}>-\frac{1}{R''(i^H)}>0,$$

it follows that

$$\frac{\partial i^H}{\partial\alpha}<\frac{\partial i^f}{\partial\alpha} \tag{20}$$

Also, for the **impact on investment of renegotiation costs,** $\overline{f}$ **:**

$$\frac{\partial i^f}{\partial\overline{f}}=\frac{\frac{\partial R'(i^f)}{\partial\overline{f}}}{R''(i^f)}=\frac{\frac{-2ba}{(a\overline{f}+b\alpha)^2}}{R''(i^f)}>0$$
$$\frac{\partial i^H}{\partial\overline{f}}=\frac{\frac{\partial R'(i^H)}{\partial\overline{f}}}{R''(i^H)}=\frac{\frac{-2ba(1-\eta)}{\left(2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right)^2}}{R''(i^H)}>0$$

Hence as above,

$$\frac{\partial i^H}{\partial\overline{f}}<\frac{\partial i^f}{\partial\overline{f}} \tag{21}$$

The **impact of the maladaptation parameter,** $\underline{f}$ is:

$$\frac{\partial i^f}{\partial \underline{f}} = 0$$

$$\frac{\partial i^H}{\partial \underline{f}} = \frac{\frac{\partial R'(i^H)}{\partial \underline{f}}}{R''(i^H)} = \frac{\frac{-4\eta ab^2}{\left(2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right)^2}}{R''(i^H)} > 0$$

Therefore:

$$\frac{\partial i^H}{\partial \underline{f}} > \frac{\partial i^f}{\partial \underline{f}} = 0 \tag{22}$$

The impact of b :

$$\frac{\partial i^f}{\partial b} = \frac{\frac{\partial R'(i^f)}{\partial b}}{R''(i^f)} = \frac{\frac{2a\overline{f}}{(a\overline{f}+b\alpha)^2}}{R''(i^H)} < 0$$

$$\frac{\partial i^H}{\partial b} = \frac{\frac{\partial R'(i^H)}{\partial b}}{R''(i^H)} = \frac{\frac{2(1-\eta)a\overline{f}}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}}{R''(i^H)} < 0$$

$$\frac{2a\overline{f}}{(a\overline{f}+b\alpha)^2} > \frac{2(1-\eta)a\overline{f}}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}$$

$$0 < R''(i^f) > R''(i^H) \Leftrightarrow -\frac{1}{R''(i^f)} > -\frac{1}{R''(i^H)} > 0$$

$$-\frac{\frac{2a\overline{f}}{(a\overline{f}+b\alpha)^2}}{R''(i^f)} > -\frac{\frac{2(1-\eta)a\overline{f}}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}}{R''(i^H)} \Leftrightarrow$$

$$0 > \frac{\partial i^H}{\partial b} > \frac{\partial i^f}{\partial b} \tag{23}$$

Also the impact of a:

$$\frac{\partial i^f}{\partial a} = \frac{\frac{\partial R'(i^f)}{\partial b}}{R''(i^f)} = \frac{\frac{-2b\overline{f}}{(a\overline{f}+b\alpha)^2}}{R''(i^H)} > 0$$

$$\frac{\partial i^H}{\partial a} = \frac{\frac{\partial R'(i^H)}{\partial a}}{R''(i^H)} = \frac{\frac{-2b(1-\eta)\overline{f}-4b^2\eta\underline{f}}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}}{R''(i^H)} > 0$$

We have that,

$$2b\overline{f} < 2b(1-\eta)\overline{f} + (2b)^2\eta\underline{f} \Leftrightarrow 2b\underline{f} - \overline{f} > 0$$

and,

$$\frac{1}{(a\overline{f}+b\alpha)^2} > \frac{1}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}$$

Moreover,

$$0 > R''(i^f) > R''(i^H) \Leftrightarrow -\frac{1}{R''(i^f)} > -\frac{1}{R''(i^H)} > 0$$

Therefore,

$$-\frac{\frac{-2b\overline{f}}{(a\overline{f}+b\alpha)^2}}{R''(i^f)} > -\frac{\frac{-2b(1-\eta)\overline{f}-4b^2\eta\underline{f}}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}}{R''(i^H)} \Leftrightarrow$$

$$\frac{\partial i^H}{\partial a} < \frac{\partial i^f}{\partial a} \tag{24}$$

Finally, we examine the **impact on investment of the probability or renegotiation, η:**

$$\frac{\partial i^f}{\partial \eta} = 0$$

and

$$\frac{\partial i^H}{\partial \eta} = \frac{\frac{\partial R'(i^H)}{\partial a}}{R''(i^H)} = \frac{\frac{-2b[a(2bf-f)-b\alpha]}{\left[2\eta ab\underline{f}+(1-\eta)(a\overline{f}+b\alpha)\right]^2}}{R''(i^H)} > 0$$

Hence,

$$\frac{\partial i^H}{\partial \eta} > \frac{\partial i^f}{\partial \eta} = 0 \tag{25}$$

To derive the indirect impact of the above parameters on welfare, we first need to calculate the investment derivatives $\frac{\partial W^H}{\partial i^H}$ and $\frac{\partial W^f}{\partial i^f}$ respectively.

When calculating the indirect effect on welfare in the flexible and hybrid rigid models we impose the condition:

$$0 < \frac{\partial W^H}{\partial i^H} = \frac{b}{a} \frac{2\eta a(1-\underline{f}b) + (1-\eta)(a\overline{f} - b\alpha)}{\left(2\eta ab\underline{f} + (1-\eta)(a\overline{f} + b\alpha)\right)} < \frac{\partial W^f}{\partial i^f} = \frac{b}{a} \frac{(a\overline{f} - b\alpha)}{(a\overline{f} + b\alpha)} \tag{26}$$

For the above to hold, it suffices to show that:

$$\begin{gathered}
\left[2\eta a(1-\underline{f}b) + (1-\eta)(a\overline{f} - b\alpha)\right](a\overline{f} + b\alpha) < \\
\left[\left(2\eta ab\underline{f} + (1-\eta)(a\overline{f} + b\alpha)\right)\right](a\overline{f} - b\alpha) \Leftrightarrow \\
2\eta a(1-\underline{f}b)(a\overline{f} + b\alpha) < 2\eta ab\underline{f}(a\overline{f} - b\alpha) \Leftrightarrow \\
(a\overline{f} + b\alpha) < b\underline{f}(a\overline{f} - b\alpha) + \underline{f}b(a\overline{f} + b\alpha) \Leftrightarrow \\
(1 - b\underline{f})(a\overline{f} + b\alpha) - b\underline{f}(a\overline{f} - b\alpha) < 0 \Leftrightarrow
\end{gathered}$$

$$b\alpha < a\overline{f}(2b\underline{f} - 1) \tag{27}$$

As clearly,

$$a\overline{f}(2b\underline{f} - 1) < a(2b\underline{f} - \overline{f}),$$

this means that inequality (27) implies inequality (19). Remember that what has been assumed so far is that $a\overline{f} > b\alpha$. (27) can be true provided that $2b\underline{f} - 1$ is positive and sufficiently close to one for the direction of the inequality to be retained. In other words we require that the maladaptation costs in the hybrid model are small. This is more restrictive than the existing boundary on maladaptation costs compared to renegotiation costs which requires that relation (19) is satisfied i.e., $(2b\underline{f} - \overline{f})a > b\alpha$; this in turn is more restrictive that the one in A&S which required that $(2\underline{f} - \overline{f}) > \alpha \Leftrightarrow \overline{f} >$ since $a > b$.

As we will see below, the above indicates that the presence of undertrusting requires that maladaptation costs need to be further bounded relative to renegotiation costs (e.g. $\underline{f} > \frac{a\overline{f}+b\alpha}{2ab\overline{f}}$ rather than just $\underline{f} > \frac{\overline{f}+\alpha}{2}$) for propositions 3 and 4 regarding the relative efficiency of flexible to hybrid contracts in relation to changes in asset specificity and renegotiation costs to hold.

Proof of Proposition 1

Obviously both the direct as well as the indirect effect of $\underline{f}$ on welfare under a flexible contract is zero. Hence $\frac{\partial i^H}{\partial \underline{f}} > \frac{\partial i^f}{\partial \underline{f}} = 0 \Leftrightarrow \frac{\partial W^H}{\partial i^H}\frac{\partial i^H}{\partial \underline{f}} > \frac{\partial W^f}{\partial i^f}\frac{\partial i^f}{\partial \underline{f}} = 0$. Moreover as the direct effect of $\underline{f}$ on W^H is equal to $\eta(a-b)R(i^H) < 0$ this means that the efficiency of the hybrid model relative to the flexible one is eroded by the existence of a deadweight loss in the case of undertrusting. If the negative direct effect on W^H is dominated by the positive indirect effect on W^H, then the higher $\underline{f}$ (i.e. the lower the misalignment cost is), the more efficient the hybrid contract compared to a flexible one. On the other hand, if the direct effect dominates the indirect effect the reverse will be the case. However the latter is unlikely to happen for as long as $\frac{\overline{f}}{\alpha} > \frac{b}{a} > 1$ as the gap in the value of b and a will be exceeded by the gap in the values of $\overline{f}$ and α.

For the next proposition, we shall add to the assumption $a\overline{f} > b\alpha$, the assumption that $[(2b\underline{f} - \overline{f})a] > b\alpha$. This latter inequality assumption implies that:

$$\begin{gathered} i^H > i^f, \\ R(i^H) > R(i^f), \\ R'(i^H) < R'(i^f), \\ R''(i^H) < R''(i^f). \end{gathered}$$

Proposition 2 *For* $a\overline{f} > b\alpha$, $\frac{2ab}{(b-a)} > \left[(2b\underline{f} - \overline{f})a - b\alpha\right] > 0$ *and* $\eta > 0$, *the lower the probability to renegotiate a rigid contract (the higher* η*), the more efficient a hybrid contract compared to a flexible one. This relies on sufficiently aligned values for the trustworthiness parameters as well as* $\underline{f} > \frac{a\overline{f}+b\alpha}{2ab}$ $(> \frac{\overline{f}+\alpha}{2}$, *i.e. a more restrictive lower boundary for* $\underline{f}$ *than in the A&S model, where* $a = b = 1$).

Proof. If $b\alpha < a(2b\underline{f} - \overline{f})$, then $\frac{\partial i^H}{\partial \eta} > \frac{\partial i^f}{\partial \eta} = 0$. This means that given (27):

$$\frac{\partial W^H}{\partial i^H}\frac{\partial i^H}{\partial \eta} > \frac{\partial W^f}{\partial i^f}\frac{\partial i^f}{\partial \eta} = 0$$

Moreover in the hybrid contract there is a direct effect of the same parameter equal to:

$$[1 + \underline{f}(a-b)]R(i^H) - \alpha\tfrac{a-b}{2a}R(i^H) - \overline{f}\tfrac{a+b}{2b}R(i^H) \Leftrightarrow$$

$$\tfrac{2R(i^H)}{4ab}[2ab - 2ab\underline{f}(a-b) - b(a-b)\alpha - a(a+b)\overline{f}]$$

For the direct effect to reinforce the indirect one, the former should be positive, which is the case if:

$$\tfrac{2ab}{b-a} > \left[\left(2b\underline{f} - \overline{f}\right)a - b\alpha\right] \;\blacksquare$$

In Proposition (2), if $a = b = 1$, the direct effect of η on welfare in the hybrid model becomes equal to $1 - \overline{f}$ which clearly is positive. However for $a < b$ we do need a more complex condition to ensure that this is the case, so that the indirect positive effect of η on welfare in the hybrid model is supported by the direct effect. This complex condition requires that both the gap in the values of the trustworthiness parameters as well as the size of the maladaptation costs are sufficiently small to ensure that this is the case.

For the remaining two propositions, we shall start from the requirement that the impact of investment on welfare in a hybrid contract is smaller that the impact of investment on welfare in a flexible model ($0 < \frac{\partial W^H}{\partial i^H} < \frac{\partial W^f}{\partial i^f}$). As already shown, this requires inequality (27), which is re-written below, to hold:

$$a\overline{f}(2b\underline{f} - 1) > b\alpha$$

Inequality (27) is a sufficient condition for the following three inequalities to hold:

1. $a\overline{f} > b\alpha$,
2. $[(2b\underline{f} - \overline{f})a] > b\alpha$
3. $b\alpha < a\overline{f}(2b\underline{f} - 1) \Longleftrightarrow \underline{f} > \frac{a\overline{f}+b\alpha}{2ab\overline{f}} \left(> \frac{a\overline{f}+b\alpha}{2ab} = \frac{\overline{f}}{2b} + \frac{\alpha}{2a} > \frac{\overline{f}+\alpha}{2}\right)$

Assumption 1 is shared by all propositions, while assumption 2 is shared by the last three propositions. Assumption 3 imposes further size boundaries for $\overline{f}$, $\underline{f}$ and α. In particular, the lower boundary for the value of $\underline{f}$, which is an inverse measure of the misalignment costs, becomes even more restrictive than in Proposition 2. More simply, the maladaptation costs are smaller (i.e. $\underline{f}$ is higher) than the level needed to ensure that as the probability of renegotiation decreases, the hybrid contract becomes more efficient relative to the flexible one.

If (27) holds, then the impact of the size of renegotiation and sunk costs on the efficiency (in welfare terms) of the flexible contract relative to the hybrid contract is determined by the following two propositions:

Proposition 3 *For* $0 < \frac{\partial W^H}{\partial i^H} < \frac{\partial W^f}{\partial i^f}$ *and* $0 < \eta < \frac{R(i^H)-R(i^f)}{R(i^H)}$*, the lower the level of asset specificity (i.e. the higher* α*), the more efficient the flexible contract compared to the hybrid one.*

Proof. Concerning the indirect effects, given that $0 < \frac{\partial i^H}{\partial \alpha} < \frac{\partial i^f}{\partial \alpha} \Leftrightarrow$

$$\frac{\partial W^H}{\partial i^H}\frac{\partial i^H}{\partial \alpha} < \frac{\partial W^f}{\partial i^f}\frac{\partial i^f}{\partial \alpha},$$

if (27) is satisfied which means that (26) holds. As already discussed the direct effect of α on welfare is negative in both models given the introduction of a deadweight loss if $a < b$. Hence for this negative impact to be of a smaller absolute size for the flexible compared to the hybrid one, so that the above inequality is preserved, the condition is that

$$(1-\eta)R(i^H) > R(i^f) \Leftrightarrow \eta < \frac{R(i^H)-R(i^f)}{R(i^H)}$$

The upper boundary set for η reflects the requirement that the direct effect (deadweight loss) of α on welfare is (in absolute terms) smaller in the flexible contract than in hybrid one. This combined with the indirect effect of α will imply that $\frac{d(W^H-W^f)}{d\alpha} < 0$, and therefore proposition 3 applies. ■

Proposition 4 *For* $0 < \frac{\partial W^H}{\partial i^H} < \frac{\partial W^f}{\partial i^f}$ *and* $\eta > \frac{R(i^H)-R(i^f)}{R(i^H)}$*, the lower the renegotiation costs (i.e. the higher* $\overline{f}$*), the more efficient a flexible contract compared to a hybrid one.*

Proof. Given that $0 < \frac{\partial i^H}{\partial \overline{f}} < \frac{\partial i^f}{\partial \overline{f}} \Leftrightarrow$

$$\frac{\partial W^H}{\partial i^H}\frac{\partial i^H}{\partial \overline{f}} < \frac{\partial W^f}{\partial i^f}\frac{\partial i^f}{\partial \overline{f}},$$

if (27) is satisfied which means that (26) holds. Therefore there is a larger indirect effect for the flexible as compared to the hybrid model. This will be strengthened by the direct effect if $(1-\eta)R(i^H) < R(i^f) \Leftrightarrow \eta > \frac{R(i^H)-R(i^f)}{R(i^H)}$ as then $\frac{\partial W^H}{\partial \overline{f}} < \frac{\partial W^f}{\partial \overline{f}}$. In other words, the lower boundary for η reflects the requirement that the direct positive effect of $\overline{f}$ on welfare is greater in the flexible contract than in hybrid rigid one. Given this boundary, proposition 4 of the A&S paper, that the lower the renegotiation costs (the higher $\overline{f}$), the more efficient the flexible contract relative to the hybrid model (i.e. $\frac{d(W^H-W^f)}{d\overline{f}} < 0$), is reinforced under conditions of undertrusting. ■

The actual size of the commitment not to renegotiate matters in both propositions (3) and (4). This is once more the result of the existence of the direct effect that both parameters α and $\overline{f}$ have on welfare, but in an opposite manner. As far as proposition (4) is concerned, the higher η is (the higher the commitment not to renegotiate) the more similar the hybrid model becomes to the pure rigid one. All other things being equal, the higher $\overline{f}$ is (the lower renegotiation costs are), the more advantageous the flexible contract is. This result is the same as the A&S proposition (4). On the other hand, the lower η is (the higher the probability to renegotiate), then the hybrid model becomes increasingly similar to the flexible one. Hence the latter contract loses some of its advantage in terms of low renegotiation costs, but gains an advantage in terms of low asset specificity terms, as it further strengthens the argument that a flexible contract is to be preferred if sunk costs are low, as proposition (3) indicates.