MIT LIBRARIES

DUPL

3 9080 01917 5865

Digitized by the Internet Archive
in 2011 with funding from
Boston Library Consortium Member Libraries

<http://www.archive.org/details/reputationeffect00bane>

331
1415
.99-14

DEWEY

**working paper
department
of economics**

***Reputation Effects and the Limits of Contracting:
A Study of the Indian Software Industry***

**Abhijit Banerjee
Esther Duflo**

No. 99-14

July 1999

**massachusetts
institute of
technology
50 memorial drive
cambridge, mass. 02139**

WORKING PAPER
DEPARTMENT
OF ECONOMICS

*Reputation Effects and the Limits of Contracting:
A Study of the Indian Software Industry*

Abhijit Banerjee
Esther Duflo

No. 99-14

July 1999

MASSACHUSETTS
INSTITUTE OF
TECHNOLOGY

50 MEMORIAL DRIVE
CAMBRIDGE, MASS. 02142

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

NOV 26 1999

LIBRARIES

Reputation Effects and the Limits of Contracting: A Study of the Indian Software Industry

Abhijit V. Banerjee* and Esther Dufo[†]

First Draft: November, 1998 - This version June 11, 1999[‡]

Abstract

This paper examines evidence of the role that reputation plays in determining contractual outcomes. We conduct an empirical analysis of the Indian customized software industry. We analyze a data set containing detailed information about 230 projects carried out by 125 software firms that we had previously collected. The evidence supports the view that reputation matters. Ex ante contracts as well as the outcome after ex-post renegotiation vary with firms' characteristics plausibly associated with reputation. We argue that this pattern is not consistent with optimal risk sharing and propose a model of the industry where reputation determines contractual outcomes, whose predictions are consistent with several facts observed in the data. We argue that there is no obvious alternative explanation to the patterns present in the data.

*Massachusetts Institute of Technology. Email: banerjee@mit.edu

[†]Massachusetts Institute of Technology. Email: eduflo@mit.edu

[‡]We thank Daron Acemoglu, Philippe Aghion, Roland Benabou, Mathias Dewatripont, David Genesove, Jonathan Guryan, Oliver Hart, Doug Miller, Dilip Mookherjee, Ashok Rai, Emmanuel Saez, Andrei Shleifer, Jean Tirole, and Richard Zeckhauser for helpful conversations and Paul Joskow for encouragement and support. We acknowledge financial support from the the National Science Foundation, Alfred P. Sloan Foundation, the Shultz Fund and the John D. and Catherine MacArthur Foundation. We are especially grateful to the software professionals in India, who patiently answered our many questions, and in particular to Mr N. R. Narayana Murthy, from Infosys Technologies Limited, whose help and insights were crucial throughout this project.

1 Introduction

The idea that there are severe limits to what can be achieved through contracting has had an enormous impact on the way economists now think about firms, markets and governments. Correspondingly, there has been a growing emphasis on the role of reputation as a way of counteracting the problems created by the limitations of contracting.¹ While less often emphasized, a view of the world which gives central importance to issues of contracting, reputation and trust, also has important consequences for the process of growth and development. Most importantly, it suggests that the lack of a proper infrastructure for contract enforcement (which makes contracting less effective) and the difficulty of building a secure reputation² are potentially important determinants of success in getting out of poverty, along with the more conventional determinants such as human capital and physical infrastructure.

This paper attempts to quantitatively assess the importance of reputation and, by implication, the seriousness of the limits on contracting in the context of the Indian customized software industry. Customized software is an obvious place to study such effects since the desired end-product tends to be extremely complex and difficult to describe ahead of time in a way that a third party (such as a court) would understand. In fact, typically the parties to the contract themselves do not fully understand what they want until well into the production process. Therefore, it seems naive to expect that they could write a contract enforceable by the courts that would fully cover all contingencies that could arise in the production process. Moreover, software production does not require very much fixed capital: indeed most firms nowadays simply own a number of PCs (which are cheap and getting cheaper). The rest, including the premises, access to a mainframe and links to a satellite, can all be rented.³ This limits the possibility of the reputation effects that interest us being confounded with the effects of differential access to capital or the lack of real competition.

The Indian software industry is suitable for such a study for a number of reasons: First, it is an industry which is quite large (employing 140,000 people with a turnover of \$1.75 billion in

¹See for example Greif (1994), Baker, Gibbons and Murphy (1997).

²Stemming from prejudice, or a history of bad performance, as emphasized by Tirole (1996).

³In India, the government has actually invested heavily, and by all accounts fruitfully, to make sure that firms have the option of renting expensive fixed inputs (such as expensive computers, building space and equipment for satellite telecommunication) in virtual "Software Technology Parks" (STPI, 1997).

1997-98) and growing fast (at an average annual growth rate of 54% over the past six years). Second, its main focus is on exports (more than 60% of its revenue comes from exports) and a large (over 30%) and fast-growing share of the exports is customized software. Moreover, the industry's current focus is on expanding the export of customized software relative to its other businesses on the grounds that this is likely to be its best bet for the near future (NASSCOM, 1997).⁴ Consequently, the limits of contracting are a major issue in this industry and one that everyone is clearly concerned about. Finally, the fact that the contracts are typically across long distances makes contracting more complicated both by making monitoring somewhat harder and, perhaps more importantly, because of the inherent difficulties of international litigation (combined with the deficiencies of the Indian court system). The data we use in this paper comes from interviews of 125 software companies in three major software development centers in India (Bangalore, Hyderabad and Pune)⁵. We collected detailed data on the company and on the two last projects they have completed, including what kinds of contracts were initially arranged between them and how the contract got renegotiated as the project evolved (we have a total of 236 contracts in our data set).

Prima facie, the data supports both the view that contracting is very limited and the view that reputation is important. All contracts in our sample are either fixed-price contracts or time and material contracts. In fixed-price contracts the software firm - henceforth, the firm - gets a fixed price and is supposed to pay for all realized costs. In time and material contracts the software buyer - henceforth, the client - is supposed to pay for all realized costs. A large fraction of the contracts do however get renegotiated *ex post*: the buyer does not pay the entire cost in almost half the fixed contracts and the client pays less than the full amount in about a quarter of the time and material contracts. There is also a simple pattern in both the kind of contract that gets chosen and the sharing of the costs which is a result of the renegotiation. It is shown in Figures 1 and 2. Figure 1 shows the fraction of fixed-price projects as a function

⁴In the past, export of software services was almost exclusively on-site services (or "body-shopping"), cf. Hecks (1996).

⁵In each city, we interviewed half of the firms who belong to the software technology park (all exporters do). We selected the firms randomly, but we oversampled the firms that are not fully-owned subsidiaries. No firm refused to meet with us and answer the questionnaire. Some appointments could not be arranged due to the CEO's unavailability at the moment we were interviewing, and these firms were replaced.

of the foundation date of the software firm, and Figure 2 shows the share of overrun⁶ paid for by the firm as a function of the age of the software firm.⁷ Both are sharply increasing with the starting date of the firm. In particular, firms created in 1994 or after (half of the sample) bear a substantially larger share of the overrun than older firms on average, and the share of overrun they bear is increasing more sharply with age over this range. Measured both in terms of the *ex ante* contract and in terms of *ex post* outcome, young firms bear a larger share of the ‘risk’ of each software project.

This effect of age is perhaps the main empirical finding of the paper. We interpret this as an effect of reputation on the grounds that the firms that started in the industry a long time ago and have survived are more likely to be the kinds of firms that clients can trust - the older firms that cannot be trusted are likely to have already gone out of business (since eventually people would have got to know about them).

To provide further support for our interpretation of the age effect as a reputation effect, in Section 5 we show that a similar pattern exists when we use other potential measures of reputation such as whether there has been a previous transaction between the firm and the client, whether it is an internal project (i.e., with a client who either owns the firm or has a long-term arrangement with the firm)⁸, etc. Further, we show that different kinds of reputation are to some extent substitutes. For example, the difference between young and old firms disappears among firms that work for an internal client.

In sections 3 and 4 of the paper we develop a simple model based on our observation of the industry which explains why reputation would have the observed effect on contractual outcomes. The basic idea of the model is that in most cases by the end of the project the firm and the client know who was responsible for cost overruns. While this is not contractible, firms and clients could nevertheless benefit from it if they could commit to always follow a certain norm. The norm we emphasize here - clearly there can be other norms that will also work - is that of being reliable: reliable firms always try very hard to ensure that they do not exceed the cost overrun that they had implicitly promised, and pay for any extra overrun when they fail to do so. The problem is that this is typically not consistent with short-run profit maximization by the firm or

⁶The amount of the project cost that goes beyond the initial prediction.

⁷Because the number of firms per year in the sample is small for firms created before 1988, we have grouped all these firms together.

⁸We will describe this type of structure below.

the client, and can only be sustained if the firms and clients are either innately reliable or, more conventionally, if the particular equilibrium that they are playing induces them to put some value on their reputation. We look at equilibria where a certain fraction of firms and clients are reliable and the rest are not and investigate the implications of a change in the fraction of those who are reliable (interpreted as a change in the average reputation of the firms). The basic trade-off that governs what happens is that fixed-price contracts are best for protecting reliable buyers from unreliable sellers while the reverse is true of time and material contracts. Therefore there should be more fixed-price contracts if the share of buyers who are likely to be reliable is smaller, which is consistent with the evidence we describe above. We also argue that a number of other predictions from this model are consistent with what we observe.

While we do provide some evidence supporting the broad premises of our model, it is clear that we cannot provide sharp enough evidence to rule out alternative reputation models: it is possible, for example, that the relevant reputation is for honesty or for a different form of reliability. The objective of this paper is not to distinguish among different kinds of reputation. However our reputation-based story does rule out many alternative explanations. In particular it rules out models where there are no agency problems as well as models of agency problems where there is no learning about the firm's type.

Of course, this is all conditional on establishing that we are in fact correctly interpreting the data when we impose the reputation model on it. In other words, it still remains possible that what we are picking up here is the effect of some other variable which happens to be correlated with these measures of reputation. In Section 6, we consider some of these explanations. They fall broadly in two classes.

First, there is a class of alternative explanations which rule out agency problems: the differences in the contracts is then explained either by differences in risk-sharing or by differences in the production technology available to the firm. Against this view, we first argue that it is very implausible that the contractual variations that we observe are a result of optimal risk-sharing. The basic point is that in our data set, *firms are usually much smaller than their clients and young firms are especially small*. It is therefore very hard to understand why firms bear so much of the risk (57% on average) and why especially the smallest and youngest firms bear the most.⁹ In response to the view that there are differences in the production technology (essentially that

⁹There are of course other determinants of the sharing of the risk. We discuss these issues in section 6.

young firms are more incompetent) we point out that the natural effect of such incompetence should be to *lower the price* the young firms gets paid *rather than to make them bear a lot of risk* that they can ill afford. Moreover the evidence does not support the view that the differences in competence between the firms is of a magnitude that can explain the differences in the contracts. For example, we present in Figure 3 the average overrun as a function of firm's foundation date. If the high shares of overrun paid by young firms were a way to make them pay for higher overrun, we should see average overrun falling with age. If anything, the opposite seems to be true.

The second class of competing theories posits that there are agency problems but no learning about the firm: we point out that this conflicts with the evidence on the effects of sources of reputation other than age. These and related issues are discussed at some length in Section 6.

As a final piece of evidence, we emphasize the fact that the necessity to build reputation and trust is recognized and is emphasized repeatedly at the industry level as well as by individual firms. For example, the National Association of Software Services Companies (NASSCOM) directory of the Indian Software industry has a large section on "quality" (NASSCOM, 1997). The main element they stress is the number of Indian firms that have ISO 9000 certification or are in the process of acquiring it (ISO-certified firms have proven that their software development processes follow approved routines, which is a way for firms to establish a reputation). The association provides technical consulting to any member who wants to get ISO certification. The Indian government provides financial incentives for firms who acquire it. At the individual level, efforts to develop a reputation are also obvious.¹⁰

This paper is a part of a small but growing number of papers that study the empirics of contractual choice.¹¹ Among recent papers Crocker and Reynolds (1993) is most closely related to this work. They examine the determinants of the choice between fixed-price contracts and more flexible contracts in U.S. Air Force engine procurement. In their view, the key trade-off is the following: fixed-price contracts protect the government against *ex post* opportunism (in particular it makes it useless for the contractors to claim higher costs) but they require the

¹⁰20% of the firms in our sample already have ISO certification. 13% are in the process of getting it.

¹¹Monteverde and Teece (1982), Masten and Crocker (1985), Joskow (1987) and Pittman (1991) are important early papers on this subject. These papers differ from ours in studying settings where there are huge relationship-specific investments and very long term relationships are the norm and where the key trade-off is between tightness of contract (or control) and flexibility.

ability to draft an exhaustive list of requirements (a complete contract), which is possible, but costly. Time and material contracts do not require a truly complete agreement *ex ante*, but open the room for opportunistic behavior by the contractor.¹² Contracts will tend to be fixed-price if the nature of the engine makes them easy to draft (if the engine is well known or the production cycle is short), and if the contractor is more likely to behave opportunistically. Their empirical analysis of a panel of 44 contracts between the government and two contractors confirms these predictions. Their work shares therefore a central intuition with ours: the reputation of the contractor does matter for the choice of contracts.¹³ The more reputed a firm is, the less likely it is that the contract will be fixed-price. The central difference is that fixed-price contracts are not associated with any *ex post* cost for the contractor, since fixed-price contracts are “truly complete agreements”. In contrast, we recognize the fact that in the software industry the contract is never complete. Fixed-price contracts need not be more precisely drafted than time and material contracts. Overrun happens in both types of contracts. The central trade-off is between containing opportunism by the client and opportunism by the firm.

Lafontaine and Shaw (1996) is another paper that looks at the effect of a firm’s age on contracts (in the context of franchising) and finds that the franchiser’s age has no effect on the contract. However as they point out, by changing the franchise contract over time a franchiser runs the risk of hurting its early franchisees (who are locked into one contract while their competitors get a different contract that perhaps allows them to be more aggressive). Because of this cross-contract externality, contracts may not change very much over time, even if the market over time becomes more knowledgeable about the franchiser.¹⁴

The rest of the paper is organized as follows: In Section 2, we describe the institutional

¹²Bajari and Tadelis (1999) emphasize a related trade-off in the private sector building industry (in a model where there are no unobserved difference among contractors). Time and material contracts give the contractor little incentive to control the costs, but do not require complete drafts. Fixed price contracts give the contractor strong incentives to control cost, but require more precise design to avoid costly bargaining if changes are needed during the completion of the project. The time scale and the complexity of the project will determine which contract is chosen.

¹³In their paper, they measure the reputation by the number of litigation conflicts that the contractors had in the past.

¹⁴This paper is also related to papers such as Barron and Umbeck (1984), Shepard (1993) and Genesove (1993) which test the implications of theories based on asymmetric information in industrial contexts (but not the implications for the choice of the contract).

settings in more detail and present a number of basic facts about the production of customized software. The model is presented in Section 3 and its predictions about how reputation shapes the contractual forms as well as the *ex post* outcome are described in Section 4. In Section 5, we provide evidence which, in our view, clearly supports the implications of this model. In Section 6, we discuss alternative explanations of the pattern observed in the data. Section 7 concludes.

2 Institutions and Basic Facts

We begin by describing the sequence of events leading to the off-shore production of a piece of software.¹⁵ The project begins when the client sends a request for proposal to one or more firms. Each interested firm studies the request (this costs the firm 1.25% of the total project cost for the median external project¹⁶), and submits a proposal, which includes, among other things, a proposed mode of payment and an estimate of how much the client would have to pay. The client chooses a firm, and the firm and the client agree on a contract. The contract specifies an estimate of effort needed to complete the project, a mode of payment, financial details (price, etc.) and a projected schedule for deliverables (which are specific milestones - corresponding to phases of the software development process or to modules of the software - that will be reached in the course of completing the project). The work then starts. The first phase is the writing of specifications. The firm, in collaboration with the user at the client's end, writes the set of functions that the software will execute. For the median project, it takes 10% of the total project effort to complete this phase.¹⁷ At the end of this part of the project, what the client wants and what it would cost is usually clearer to both the client and the firm and the schedule of deliverables is sometimes amended or clarified.

The second phase of the work is the lower level design, coding and testing of the software. When a specified milestone is reached, the firm sends the deliverable to the client. Each time this happens the client can either acknowledge that it has been delivered (by signing off) or request changes. The firms also send regular status reports to the clients (a little less than once

¹⁵Table 1 shows the descriptive statistics mentioned in this paragraph.

¹⁶Those projects where the client does not own the firm or does not effectively control the part of the firm which is working towards the completion of the project (see below).

¹⁷For some projects, specifications writing and subsequent work are decoupled. One firm – or the client itself – writes the specifications, and another firm completes the project.

a week on average), keeping the clients up-to-date about the progress of the project.

In terms of project outcomes our main focus will be on overrun: overrun in industry parlance is the difference between the amount of effort actually needed to complete the project and the estimated effort given in the contract. It is therefore important to be clear about what firms mean by an estimate. A standard textbook on software management (Pressman (1997)), has an entire chapter on estimation. He describes the process as follows:

‘The project planner begins with a bounded statement of software scope and from this statement attempts to decompose software into problem functions that can each be estimated individually. Line of Code or function points (the estimation variable) is then estimated for each function. Alternatively, the planner may choose another component for sizing, such as classes or objects, changes or business processes impacted. Baseline productivity metrics (i.e., line of code per person-month or function point per person months) are then applied to the appropriate estimation variable and cost or effort for the function is derived. Function estimates are combined to produce an overall estimate for the entire project.’ (Pressman (1997))

Our interpretation of this and other material in this book (which is also consistent with what we have learned from industry sources) is that the estimate is the firm’s best guess about how much effort will be needed to complete the project, *assuming that the firm’s current understanding of the project is correct and that the firm adheres to its own productivity norms.*¹⁸ The estimate is therefore clearly not meant to be an unbiased estimate of how much effort the project will actually take. This is important because it tells us that overrun represents the extent of deviation from the firm’s initial plan of action.

This also tells us that overruns ought to be quite common: first, because the needs of the client are typically not very clear at the very beginning of a relationship - even to the client himself. Moreover the client may not put enough effort into understanding and explaining what he wants. Not surprisingly then, the firm often does not understand what the client really wants. When, in the course of the project, the needs of the client eventually become clear, changes have to be made and these are costly. Second, the amount of time and effort needed to design and

¹⁸In other words, the presumption behind the estimate is that the firm has understood perfectly what the client wants and that the firm implements the project at its normal level of productivity.

code a piece of software is difficult to evaluate *ex ante*, even when the set of functions is well-defined (both for the client and for the firm), and will depend on the type of technology being used, the ability and the experience of the staff of the two companies. Third, with the best of staff and the clearest of goals there is also the risk that some unexpected problem arises and delays or destroys the project. Finally, not all firms try their hardest to control costs and delays and one would expect that some projects will end up costing much more than they ought to.

Table 1 shows evidence from our interviews confirming that overruns are indeed common: it turns out that 74% of the projects are completed with a positive overrun. The average overrun amounts to 24% of the initial estimate, and varies a lot (its standard deviation is 34%, and the maximum overrun in the sample is 250%). According to the firms, overruns are due mostly to changes required by the client (these changes cause 48% of the overrun on average). Another 20% of the overrun is due to initial ambiguity in the specifications (i.e., to cases where the firm did not understand what the client really wanted), 8% is due to internal difficulties in the firm (the most frequent one being the loss of the project manager in the middle of the way) and 13% to delays occasioned by the client. Very few projects (less than 5%) are completed with a negative overrun, and the mean overrun is clearly not zero.

Both firms and clients are, of course, aware of the possibility of overruns.¹⁹ Overruns, apart from being wasteful in themselves (in so much as they could have been avoided by both parties being more diligent), lead to delays which are costly²⁰ and are a potential source of conflict between the client and the firm (conflicts arise when each side blames the other for the overrun).

Vertical integration and contracts are two ways of limiting the waste due to overrun. Many foreign companies have set up 100% owned subsidiaries in India.²¹ These subsidiaries are 100% export oriented, and carry out work for their mother company and in some cases, for other clients as well. A number of Indian software firms have also entered into arrangements under

¹⁹For example, the template of a firm's contract specifies that "the effort estimates provided for the conversion and testing phases of this project have been provided by *the software firm* on a best estimate basis. If the scope of the effort changes as a result of discussions during the detailed design phase, *the software firm* will analyze the impact of changes on the project and may present revised schedules and costs. Changes in schedules and costs resulting from such changes will be reflected by an amendment to this contract."

²⁰Delays, while rarer than overrun, are far from uncommon in our sample: there are delays in 19% of the cases, and in 25% of the cases where there was an overrun.

²¹Including AT&T, IBM, Microsoft, INTEL, ORACLE, Fujitsu and Motorola.

which the firm dedicates a part of its employees, office space, and computers to a single foreign client. This is what is called an “Off-shore Software Development Center” (OSDC). The client sends a steady fraction of his software development needs to the firm, and is responsible for making use of the facilities devoted to him. This is in effect a type of vertical integration: the OSDC becomes virtually a unit of the client for whom it works regularly. In such cases the interests of the firm and the client are clearly better aligned and while there may be overrun, there is much less reason why the overrun should be wasteful.²²

Since we are interested in contracts rather than vertical integration our focus in this paper is mainly on external contracts (i.e., contracts that are performed neither within OSDC nor for the mother companies of the firm). We observe the following types of external contracts: Under *fixed-price contracts*, a fixed price is agreed upon up-front, before the specification analysis. These contracts are by far the most frequent: 58% of external contracts are fixed-price contracts. Under *mixed contracts* the price is fixed for the specification phase only at the beginning of the process. The price for the complete project is fixed only when specifications are written and more is known. Typically in such cases the requirement analysis is paid for on a time and material basis, though this is not necessarily the case. Under *time and material contracts*, the entire product is paid for on a time and material basis. These contracts are the least frequent among external contracts (15%). A striking fact is that there appears to be no “intermediate” contracts: all contracts belong to one of these three categories.²³ For example, there are no contracts where the client and the firm agree on sharing the costs.²⁴

While these contracts predict extreme outcomes in terms of cost-sharing, we actually do not always observe this. It turns out that a large fraction of contracts get renegotiated *ex post*. This is evident from Table 2, which shows the fraction of overrun paid for by the firm and the proportion of firms that pay all or nothing of the overrun for the three types of contracts. Even in fixed-price contracts, the actual overrun is often shared between the client and the firm (in 46% of the cases) while firms with time and material contracts sometimes pay for overrun (in

²²Indeed there may be more overrun in such cases than in general precisely because overrun entails less waste. For example, the client may not need to be very precise about what he wants since he knows that the firm will be happy to do whatever is asked of it.

²³Or their variants: in some cases property rights in the product substitutes for cash payments.

²⁴Such contracts are observed, albeit rarely, among the procurement contracts for airplane engines studied by Crocker and Reynolds (1993).

22% of the cases). However it is also clear from the figures in Table 2 that the initial contract has an clear influence on which party bears the risk of the project: in fixed-price contracts, firms bear on average 63% of the overrun, while they bear on average 51.5% in mixed contracts and 15.5% in time and material contracts. Since fixed-price contracts dominate our sample, this evidence also implies that firms bear a lion's share of the overrun (57% on average for external projects, 76% for the median external project). Since firms are typically much smaller than their clients, this is at least somewhat surprising.

There are several potential explanations for the pervasiveness of renegotiation. First, even when a firm faces a fixed-price contract it may have some bargaining power because it usually has the option of walking off the job. If it does, it will not get paid for work that it has already done, but it will also avoid the overrun and, at least at early stages of the job, the second effect may dominate. Second, the court system in India is extremely inefficient and going to court is very costly. Firms and clients will therefore prefer to make some concessions in order to avoid going to court. In fact, there is no project in our sample where the firm and the client went to arbitrage court (even though in some occasions the firm reports a conflict with the client). More generally, from our conversations with industry people we have the impression that people go to court very rarely and therefore we ought to expect some renegotiation.

Finally, firms and clients may voluntarily pay for any overrun that is of their own making, because they care about their reputation for being reliable. We had a number of conversations where the CEO of the firm told us 'it was our fault and we paid for it'. We also have some more indirect evidence that this is at least sometimes the case: as mentioned above, we asked firms questions about who was responsible for the overrun. In what follows, we assume that the firm is responsible for what it described as changes due to ambiguities and overrun caused by internal difficulties. Changes required by the client and delays coming from the client's side are taken to be caused by the client's responsibility. Table 3 shows the share of overrun paid by the firm when the overrun is entirely due to the client (column (1)), entirely due to the firm (column (3)), or due partly to both (column (2)). In column (4), we present the coefficient of an OLS regression of the share of overrun paid by the firm on the share of overrun which it caused. In all types of contracts, firms always pay more of the overruns entirely caused by their own mistakes compared to the overrun entirely due to the client. Moreover, in all cases but one, the share of overrun paid by the firm lies inbetween these two numbers when the overrun is partly

caused by each side. Furthermore, the OLS regressions indicate that, regardless of the initial contract, the larger the fraction of the overrun that a firm has caused, the larger the share it has to pay (if a firm causes one additional percent of the overrun, it bears approximately 0.20 percent more of it).

In the next section we present a model of the industry which is based on the picture that emerges from the above discussion. The main elements we wish to capture in our model are the following:

- the high levels of overrun,
- the fact that both sides are responsible for overrun,
- the use of simple *ex ante* contracts,
- the fact that the contracts get renegotiated *ex post*,
- the fact that the *ex ante* contract continues to influence the renegotiated outcome,
- the fact that firms and clients care about their reputation for being reliable and will often voluntarily pay for overrun that is of their own making.

3 A Model of the Software Industry

The model we propose in this section is an attempt to capture in as simple a way as possible what, on the basis of our experience in the industry, we see as the fundamental structures and conflicts in the Indian customized software industry. The contracting outcomes that will be predicted by the model will, as we shall see, match up reasonably well with what is observed in the data. However, one could come up with other models, or at least combinations of other models, which also explain the data. We will discuss some alternative explanations in Section 5. In the end, however, it remains plausible that elements of these other models could also be a part of any comprehensive story of the software industry in combination, perhaps, with the story we tell. In this sense, the model is meant to be illustrative rather than definitive.

The premise of the model is that software projects are prone to cost overruns and that the main conflicts are over the apportioning of these cost overruns. Overruns can happen for two reasons. First, the client could have been insufficiently diligent in delineating his requirements

or he could have made a mistake. As a result, when the firm comes up with a product he might realize that this is not what he wants and demands changes. The firm is, of course, happy to make the changes – since they are Pareto improving – but only if it is adequately compensated. The issue is whether the client will be willing to compensate it enough. Second, overruns could also happen because the firm was either lazy or unlucky in the way it carried out the project.

Since the overrun could come from either side, when there is an overrun, there is a real possibility that each side will blame the other for it. This need not be a problem if outsiders, and specifically the courts, can observe who was really responsible. Our assumption will be that this is not possible in most cases.

This is clearly something of a caricature of reality: firms and clients clearly do try to set up systems to ensure that it is clear, *ex post*, who was to blame for any overrun. The procedure of defining deliverables and having the client sign off on each deliverable is one such system. Once a client signs off on a deliverable, he is to a large extent committed to admit that at least up to that point the firm had done what it was supposed to do. This clearly limits the scope for future disagreements. Nevertheless, there seem to be lots of disagreements and this is presumably ascribable to the fact that even after many milestones have been reached, there remains substantial ambiguity about what exactly needs to be done.

3.1 Disagreements, Overrun and Contracts

We capture the possibility of this kind of disagreement as follows. The client (C) wants the firm (F) to build a piece of software that will be worth V to the client (we will assume risk-neutrality on both sides throughout, so this is best thought of as a money payoff and the costs as money costs). In a world where the client can describe the product it wants perfectly and the firm also understands this description perfectly, the project should cost $\bar{y}$ (i.e., the estimate is $\bar{y}$). We adopt the normalization that $\bar{y} = 0$.

However we assume that in every project the actual cost will be positive, i.e., there will be overrun: the client's description of the project will always be incomplete and the firm will never understand it perfectly. Total overrun will thus be the sum of overrun caused by the firm (y_F) and overrun caused by the client (y_C). Assume that all overrun is initially paid for the by the firm.

The amounts of the overrun, y_F and y_C , are determined, respectively, by the effort put in by the firm and the client in describing and understanding the project. Specifically we assume that firms face a choice between a high level of y_F , $\overline{y}_F$, and a low level, $\underline{y}_F$. Likewise, the client faces a choice between $\overline{y}_C$ and $\underline{y}_C$. Ceteris paribus, both firms and clients prefer high levels of overrun - this may be because controlling overrun takes effort or because the firm (or the client) gets to keep a part of the overrun it has generated (say the firm is lying about its costs). The extra private benefits to the client and the firm of a high level of overrun are, respectively, B_C and B_F . Assume that $\overline{y}_C - \underline{y}_C > B_C$ and $\overline{y}_F - \underline{y}_F > B_F$ so that it is always efficient to minimize overrun.

However, we will assume that both y_C and y_F are known only to the firm and its client: third parties such as the courts only observe total overrun ($y_C + y_F$).²⁵ Moreover, we restrict all contracts to being linear and in addition require that they do not involve throwing away any money. In other words, we only consider contracts where the client pays the firm an amount $P + (1 - s)(y_F + y_C)$ - where P is a pre-specified fixed payment and s is the share of the overrun borne by the firm ($s \in [0, 1]$) - and neither party makes any payments to anybody else. Of particular interest to us will be two extreme contracts: the contract with $s = 1$ (corresponding to a fixed-price contract) and the contract with $s = 0$ (which corresponds roughly to a time and material contract).²⁶ It will be key to our analysis that neither of these contracts obviously dominates the other. The fundamental trade-off comes from the fact that s is one number that is being used to give incentives to both parties: a high s will give good incentives to the firm but not to the client, while a low s contract does the reverse. As a result, it will typically not be possible to implement the first best.²⁷

To complete the description of the contracting process we need to say who proposes the contract. Our reading of the industry practice is that the contract is usually proposed by the

²⁵In other words, the fact that, say, two people were assigned to the project for 14 weeks is verifiable but not what they were actually doing - they could have been really working on a different project for most of that time.

²⁶The correspondence is not exact because a time and material contract typically pays a markup on the realized costs rather than a fixed payoff. Similar results hold for that case but the exposition is somewhat more cumbersome.

²⁷This basic tension is very general. Our restriction to linear contracts, while vital in the discrete case we have chosen here, can be relaxed if we are prepared to go to the model where overrun varies continuously: the impossibility of implementing the first best in that case is a consequence of the results in Holmstrom (1982).

firm. We will make this our maintained assumption, noting however that similar results would hold if we allowed the client to propose the contract.

3.2 Norms

When the first best cannot be achieved by contractual means, it is possible to improve on the outcome if the behavior of the firms and the clients is at least partly norm-governed. Specifically assume that there are two types of firms and two types of clients. Of these, one type of firm and one type of client observes a norm of being reliable, by which we mean that they always pay for any overrun that they themselves have generated, as long as the other side does the same. In particular, they will pay for the overrun that they have generated, even if the contract stipulates that the other side pays for it - in other words they do not necessarily maximize current profits. However, if the other side does not act reliably they do not act reliably either - they simply try to maximize current profits. Assume by contrast, unreliable firms and clients always act to maximize their current profits.

When a firm and a client are matched, they do not directly observe each other's types. Rather they assign probabilities to the other party being reliable, on the basis of what they know about them. The probability that the firm puts on the client's being reliable, θ_C , and the probability that the client puts on the firm's being likewise, θ_F , therefore summarize their respective reputations. We will return to the question of how these reputations are sustained and their evolution later in this section.

3.3 Contracts for Protection

In this setting, since the reliable firms and clients are going to be self-regulated, the function of the contract is to protect reliable clients against opportunism by unreliable firms and vice versa. The contract protects because it provides a fall-back option when the other party is being unreliable. If a firm, for example, generates a large amount of overrun and refuses to pay for it, it can be taken to court and forced to pay at least the share of the overrun it has contracted to bear.

However as we have already argued in Section 2, we expect these contracts to be renegotiated. We assume that the renegotiated outcome is a sharing of the overrun which is potentially different

from what is in the contract and is represented by the share of the overrun paid for by the firm when there is a dispute, $s^*(s, \theta_C, \theta_F)$. It is natural to assume that s^* is increasing in s . We would also expect that more reputed parties will have more bargaining power and therefore pay less (because, for example, the court will pay more attention to their complaints but also because other determinants of bargaining power such as creditworthiness tend to be correlated with reputation), i.e., $\frac{\partial s^*}{\partial \theta_C} > 0$ and $\frac{\partial s^*}{\partial \theta_F} < 0$. Assume also that s^* is bounded below by $\underline{s^*} > 0$ and above by $\overline{s^*} < 1$.²⁸

3.4 Firm Behavior

Reliable firms and clients always pay for any overrun that they generate. It follows that they always choose a low level of overrun - $\underline{y}_F$ for the firm and $\underline{y}_C$ for the client. At the end of the contracting period they observe the overrun generated by the other party and also whether or not they agree to pay for it. If the other party refuses to pay for the overrun it has generated there is a dispute: then the firm and the client end up splitting the overrun in the ratio $s^*/(1 - s^*)$.

Unreliable firms want to maximize their short run earnings. They have four options: to mimic the reliable firms and choose $\underline{y}_F$ and to pay for all of it as long as the client behaves reliably and to go to the dispute outcome otherwise; to choose $\overline{y}_F$ but to act reliably in all other respects (i.e., to pay for all of it as long as the client behaves reliably and to go to the dispute outcome otherwise); and to choose either $\underline{y}_F$ or $\overline{y}_F$ and to go directly to the dispute outcome.

Unreliable clients also want to maximize short run earnings and face a similar trade-off. The actual choice made by unreliable firms and clients will depend on the s that is written into the contract, as well as on what they expect the other side to do. The following proposition gives conditions under which unreliable firms and clients indeed are unreliable i.e., choose a high level of overrun and then get into a dispute:

Claim 1 *The unique equilibrium behavior of unreliable firms and clients is to choose $y_F = \overline{y}_F$ and $y_C = \overline{y}_C$ and go the dispute outcome subsequently, as long as the two following conditions hold:*

²⁸Given that we have assumed risk neutrality, the natural interpretation for s^* is that it is the *expected* share of the overrun borne by the firm in the event of a dispute. The actual share will presumably vary according to exact circumstances of the negotiation process, and, on occasion, may turn out to be 1 or 0.

- (i) $\overline{s^*}(\overline{y_F} - \underline{y_F}) < B_F$ and $(1 - \underline{s^*})(\overline{y_C} - \underline{y_C}) < B_C$
(ii) $\underline{y_F}$ and $\underline{y_C}$ are both sufficiently close to 0.

These conditions are not necessary for there to be an equilibrium with unreliable behavior but they have the advantage of being easy to interpret. The first condition essentially says that even if it were possible to give incentives separately on y_F and y_C , neither party could be induced to make their first best choice purely on the basis of those incentives - simply because in our setting renegotiation rules out the most extreme contracts ($s^* = 0$ or $s^* = 1$). The second condition illustrates an additional source of incentives that arises because of the specific structure we assume - by choosing to dispute, the disputant necessarily takes on responsibility for some part of the overrun generated by the other party. If the other party was reliable, he could have avoided this part of the overrun by behaving reliably himself. This might give him a reason to behave reliably. The second condition in effect rules out this particular source of incentives, since it says that if the other party is reliable his contribution to overrun is very small.

For most of this section we will assume that both these conditions hold and, consequently, unreliable firms and clients choose high levels of overrun and then go to the dispute outcome. We realize that the first of these conditions is actually quite stringent. However we will suggest later that our results on contractual choice do not really turn on this property: it is simply convenient, since it limits the number of possible cases.

3.5 Matching

For most of this section we assume that firms and clients are matched randomly with each other. This of course does not apply to the clients who are going back to a firm that they have already worked with - there the question is whether the original match was more or less random. Even in the more common case of first time matches, however, one may expect some selection, especially since - as will be pointed out later - there are benefits from matching appropriately. The possibility of selective matching is, however, limited by the fact that clients often have quite specific needs and the number of firms with the capacity to meet those needs at any point of time, may be quite small. Moreover, clients often rely on hearsay in selecting which firms to approach with a request for proposal and this may imply more or less random selection from

the point of view of everything that is publicly observable. In such cases, random matching may not be a bad approximation to the truth.

3.6 Reputation

Reputation in our model is reputation for being reliable. There are at least two possible interpretations of what makes a firm reliable. In one interpretation it is an intrinsic property of the firm (i.e., the owner of the firm genuinely prefers to be reliable rather than rich) and some firms have it and others do not.

In a second interpretation, all firms are greedy, but some are patient and therefore able to restrain their greed in favor of better long term outcome and the rest are impatient (or have more pressing immediate needs). In other words, reliable firms and clients play a strategy that corresponds to a good equilibrium of a repeated game while the unreliable play strategies that maximize short run profits. Clearly this would only work if there is some mechanism by which the history of past behaviors becomes public. We therefore posit that if a firm or a client has been unreliable in the past, with some probability it becomes public information at some point in the future.²⁹ The good equilibrium is sustained by the threat (say) that no firm will contract with a client who is known to have been unreliable in the past and vice versa.³⁰

Under either interpretation, there are several mechanisms by which reputation can evolve. First, in those cases where the firm and the client have contracted at least once before, the presumption is that both had behaved reliably so that they both now have a better reputation vis a vis the other.³¹ Forty-one percent of the contracts in our sample involved a client with whom the firm had worked already. This proportion is roughly the same among young and old firms.

Second, the age of the firm should be a source of reputation. We have already assumed that if a firm or a client has been unreliable, with some probability this becomes public information at some time in the future. Once that happens no one will want to contract with it any more since it is known to be unreliable and it will probably end up exiting from the industry.³² This

²⁹This might happen because a disgruntled employee reports what really happened or an incriminating document gets to the wrong hands.

³⁰This formulation closely follows Tirole (1996). See also Kandori (1992).

³¹For an explicit model of how reputation evolves within a specific relationship, see Rauch and Watson (1999).

³²Under our second interpretation above, the equilibrium strategies actually dictate that no one contracts with

selection process ensures that older firms (and clients) will typically be more reliable. This is reinforced by the fact that information is revealed over time and therefore a firm that has been in the industry a long time and does not have any black marks against it, is more likely to be reliable. Fifty-seven percent of the firms in our sample were created in 1993 or after.

Finally, firms may be able to establish a reputation by demonstrating that they follow processes which, in principle, should reduce overrun. Process certification by outside agencies, such as ISO 9000 certification, are therefore another potential source of reputation.³³ As we noted in the introduction, firms in the industry are currently very keen to acquire ISO certification, precisely because they think that it will improve their reputation. Nineteen percent of the external contracts in the sample were done by ISO-certified firms. ISO-certified firms tends to be older firms (only 9% of the young firms have ISO certification).

4 Theoretical Results

4.1 The Optimal Contract

Since we have assumed that it is the firm who proposes the contract, and the firm knows its own type, the proposed contract can be used as a signalling device - a firm that plans to be unreliable will prefer a contract where it pays very little of the overrun and therefore, by choosing to absorb most of the overrun a firm may be able to signal that it is reliable. Given that we are in a signalling environment, we will expect that there will be many equilibria. However all such equilibria will involve pooling since in a separating equilibrium all the unreliable firms and clients would be worse off than they would be pretending to be reliable.

Among the set of pooling equilibria we focus on contractual outcomes where the total joint a firm or a client that is known to have behaved unreliably. Under the first interpretation firms and clients that are known to be unreliable should still make less money and therefore should be more likely to exit.

³³ISO certification is awarded by international or Indian agencies, themselves accredited, which examine that the processes of software production in the firm follows some approved routines. In particular, the firm must follow specified procedures to report on the progress of the software and to perform the tests. Consequently, the software development process should be easier to monitor for ISO certified firms. Moreover, ISO certified firms are monitored every once in a while, and lose the certification if they cannot prove that they followed the approved methods. This should give strong incentive to the ISO certified firms to stick to standard procedures and report problems reliably.

surplus of a firm and a client who are both reliable is maximized. This is always a Bayesian-Nash equilibrium (sustained by the belief that only opportunists deviate). The fact that it is also Pareto optimal from the point of view of the reliable types makes it an obvious focal outcome.

This expression for joint surplus is:

$$W(s, \theta_C, \theta_F) = V - \theta_F \underline{y_C} - (1 - \theta_F)(1 - s^*(s, \theta_C, \theta_F))(\underline{y_C} + \overline{y_F}) \\ - \theta_C \underline{y_F} - (1 - \theta_C)s^*(s, \theta_C, \theta_F)(\underline{y_F} + \overline{y_C}).$$

The third term in this expression gives the total surplus that is lost because in a pooling equilibrium a reliable client must allow for the possibility that the firm is unreliable, while the fifth term is the surplus that is lost because the firm must allow for the possibility that the client is unreliable.

To find the optimal contract we need to maximize the above expression for W . Differentiating W with respect to s gives us the expression:

$$[(1 - \theta_F)(\overline{y_C} + \underline{y_F}) - (1 - \theta_C)(\overline{y_F} + \underline{y_C})] \frac{\partial s^*}{\partial s}$$

This expression is positive if and only if $[(1 - \theta_F)(\overline{y_C} + \underline{y_F}) - (1 - \theta_C)(\overline{y_F} + \underline{y_C})] > 0$. The fact that this last expression is independent of s , decreases in θ_F and increases in θ_C gives us:

Claim 2 *The optimal contract is always either a fixed price or a time and material contract (s is either 0 or 1). It is a fixed-price contract when most clients are reliable while firms are more likely to be opportunists, and a time and material contract in the reverse situation.*

This accords well with the fact, reported above, that these are the only two types of contracts.³⁴ It also confirms the intuition, given above, that fixed-price contracts are instituted to protect clients against opportunism, while time and material contracts protect firms. Firms that have a high reputation will get time and material contracts while the rest of the firms will not.

³⁴The reader may feel that the result that the contracts are always at one or other extreme is driven by the assumption of risk-neutrality. This is partly true, in the sense that if the two parties are sufficiently risk-averse a less extreme contract will be chosen. However note also that s^* is always strictly between zero and one - the effective contract is never very extreme. Therefore it may well be the case that the initial choice of an extreme contract is consistent with optimal risk-sharing.

4.2 The Sharing of Overrun

The expected share of the overrun paid by the average firm with reputation θ_F that works for a client of reputation θ_C , is:

$$\theta_F \theta_C \frac{\underline{y}_F}{\underline{y}_F + \underline{y}_C} + (1 - \theta_F \theta_C) (s^*(s, \theta_F, \theta_C))$$

In the previous section we showed that the optimal s is a decreasing function of θ_F . Therefore an increase in θ_F reduces the share of the overrun paid for by the firm both through its direct effect on s^* and through its effect on s . An increase in θ_F also shifts weight from the second term in the above expression to the first term. The effect of this shift depends on the relative sizes of s^* and $\frac{\underline{y}_F}{\underline{y}_F + \underline{y}_C}$. For firms with a relatively low reputation, the contract is likely to be a fixed-price contract and s^* will be high. Therefore this third effect is likely to also be negative or even if it is positive it should be small. For very reputed firms, however, this effect might be negative and could in principle be negative enough to counteract the two other effects: for such firms an increase in their reputation may actually increase their share of the overrun. To summarize:

Claim 3 *If two firms are matched with clients who have the same reputation, the firm with the higher reputation is likely to bear less of the overrun on average. The one case where this relation may not hold is for very reputed firms. With random matching, the negative relation between reputation and the share of overrun also holds without controlling for the reputation of the client.*

The mean overrun generated by a firm of reputation θ_F is given by the expression:

$$\theta_F \underline{y}_F + (1 - \theta_F) \overline{y}_F.$$

This is clearly decreasing in θ_F . Likewise, the overrun generated by a client is decreasing in the client's reputation. With random matching, since the reputations of the two parties are independent, it follows that the total overrun is also decreasing as a function of the reputation of the firm.

Claim 4 *The overrun generated by the firm (client) decreases with the firm's (client's) reputation. With random matching, the total overrun generated in a relationship is also decreasing in the firm's reputation.*

4.3 Extensions of the Model

4.3.1 Non-random Matching

The assumption that firms and clients match at random is clearly indefensible for the case where there is a repeat match. A repeat match clearly signals high levels of mutual respect - in other words compared to the initial match between them, both θ_C and θ_F ought to be higher. The direction in which the new contract will differ from the initial contract is therefore potentially ambiguous. However it may be reasonable to assume that since there are many more start-ups among firms than among the clients³⁵, the firm's reputation will improve by more than the client's reputation. In this case, the new contract will be more likely to be a time and material contract. The firm's share of the overrun should also go down.

The assumption of random matching is questionable even for first time matches. Firms with low reputations expect to get a fixed-price contract. Therefore, they have the most to lose from being matched with a client who has a low reputation. Formally this is captured by looking at the properties of the function

$$\begin{aligned} W^*(\theta_C, \theta_F) &= \max_s W(s, \theta_C, \theta_F) \\ &= V - \theta_F \underline{y}_C - (1 - \theta_F)(1 - s^*(s(\theta_C, \theta_F)), \theta_C, \theta_F)(\underline{y}_C + \overline{y}_F) \\ &\quad - \theta_C \underline{y}_F - (1 - \theta_C)s^*(s(\theta_C, \theta_F), \theta_C, \theta_F)(\underline{y}_F + \overline{y}_C). \end{aligned}$$

Now if θ_C is greater than θ'_C

$$\begin{aligned} W^*(\theta_C, \theta_F) - W^*(\theta'_C, \theta_F) &= (1 - \theta_F)(s^*(s(\theta_C, \theta_F)), \theta_C, \theta_F) \\ &\quad - s^*(s(\theta'_C, \theta_F), \theta'_C, \theta_F)(\underline{y}_C + \overline{y}_F) \\ &\quad - (\theta_C - \theta'_C)\underline{y}_F + (\theta_C - \theta'_C)s^*(s(\theta_C, \theta_F), \theta_C, \theta_F)(\underline{y}_F + \overline{y}_C) \\ &\quad + \theta'_C(s^*(s(\theta_C, \theta_F), \theta_C, \theta_F) - s^*(s(\theta'_C, \theta_F), \theta'_C, \theta_F)). \end{aligned}$$

Ignoring terms that depend on the second derivative of the $s^*(\cdot)$ function (the last term in the above expression), the effect of an increase in θ_F on $W^*(\theta_C, \theta_F) - W^*(\theta'_C, \theta_F)$ is unambiguously

³⁵ 57% of the firms were created before 1993, while more than half of the client are fortune 500 firms or equivalent.

negative.³⁶ An unreputed firm (client) benefits more from being matched with a reputed client (firm) than a more reputed firm (client).

While it is beyond the scope of this paper to explicitly model the matching process that leads to this outcome, the implication of this result is that firms with low reputations should be more likely to be matched with reputable clients and vice versa.³⁷ It is easy to see that this kind of matching will reinforce our results in Claim 2 about contractual choice - the effects of a higher θ_F and a lower θ_C always go in the same direction.

Turning next to the average share of the overrun borne by the firm, $\theta_F \theta_C \frac{y_F}{y_F + y_C} + (1 - \theta_F \theta_C) (s^*(s, \theta_F, \theta_C))$, we see that the fact that higher θ_F 's are now associated with lower θ_C 's reinforces the result given above in Claim 3, since s^* is increasing in θ_C .

The effect of an increase in θ_F on total overrun is however no longer unambiguous in this case. While a less reputed firm generates more overrun, its partner, the more reputed client, generates less, so the net effect may not be the one given in Claim 4.

We summarize these results in

Claim 5 *Less reputed firms will try to match with more reputed clients and vice versa. This will reinforce our previous results on the effect of firm reputation on contractual choice and the sharing of overrun. Clients who work with less reputed firms will generate less overrun than clients who work with more reputed firms. As a result, total overrun is no longer necessarily decreasing as function of the reputation of the firm.*

4.3.2 Choice of Projects

The fact that firms with low reputation pay for most of the overrun should clearly influence their choice of projects. This can be introduced into our model by making the plausible assumption that the most rewarding projects (the ones with the highest V) will also have the highest possibility of large overruns ($\overline{y_C}$ and $\overline{y_F}$ are going to be large). It is easy to show by introducing this assumption into the model of the previous section, that keeping the reputation of the client fixed, less reputed firms will be more willing to trade off a lower V for a lower $\overline{y_C}$ than more

³⁶This follows from the fact that $s^*(s(\theta_C, \theta_F), \theta_C, \theta_F) - s^*(s(\theta'_C, \theta_F), \theta'_C, \theta_F)$ is positive, while $s^*(s(\theta_C, \theta_F), \theta_C, \theta_F)$ goes down when θ_F goes up.

³⁷Since we do not have data on client reputation we cannot directly test this prediction. We do observe that client generated overrun is smaller for younger firms, which is consistent with this prediction.

reputable firms. Formally this is seen by differentiating the expression for $W^*(\theta_C, \theta_F)$ with respect to $\overline{y_C}$. This yields

$$-(1 - \theta_C)s^*(s(\theta_C, \theta_F), \theta_C, \theta_F),$$

which is clearly increasing in θ_F : less reputed firms benefit more from a low $\overline{y_C}$.

Here we have assumed that it is possible to reduce $\overline{y_C}$ without affecting $\overline{y_F}$. This is not especially implausible: Y2K projects are sufficiently simple and standardized that the scope for client side opportunism is probably very limited. On the other hand the firm always has the option of simply doing the job lackadaisically. It is interesting nonetheless to look at what happens when a reduction in $\overline{y_C}$ is always accompanied by an equal reduction in $\overline{y_F}$. Differentiating the expression for $W^*(\theta_C, \theta_F)$ with respect to $\overline{y_C}$ and $\overline{y_F}$ yields the expression

$$-(1 - \theta_F)(1 - s^*(s(\theta_C, \theta_F)), \theta_C, \theta_F)) - (1 - \theta_C)s^*(s(\theta_C, \theta_F), \theta_C, \theta_F).$$

Differentiating this expression with respect to θ_F , yields

$$(1 - s^*(s(\theta_C, \theta_F)), \theta_C, \theta_F)) + (\theta_C - \theta_F) \frac{ds^*(s(\theta_C, \theta_F)), \theta_C, \theta_F)}{d\theta_F}$$

which, for low reputation firms, should be positive (since $\theta_C - \theta_F$ should be positive). This tells us that even if $\overline{y_C}$ and $\overline{y_F}$ move together, the youngest firms will probably be among those who benefit most from choosing a low $\overline{y_C}$ (and $\overline{y_F}$) project.³⁸

Claim 6 *Low reputation firms will tend to be specialized in projects which have low potential for client-side opportunism.*

In terms of what we observe, this seems to suggest that low reputation firms will choose projects which are simple and well-understood so that the client does not have to do very much work to make clear what he wants. These projects can be either short projects³⁹, or projects where the main goal is easily defined. Y2K projects are typical in this respect.⁴⁰

³⁸Very reputable firms may also prefer projects with low $\overline{y_C}$ and $\overline{y_F}$ - the benefit in that case comes from the fact that these projects protect the clients, who in this case will be the vulnerable party.

³⁹The complexity of a software project increases sharply with its size, see Pressman (1997).

⁴⁰Other projects where the objectives are relatively easily defined include CAD projects and migration of an existing software from one platform to another.

The possibility of switching to a low $\overline{y_C}$ project should not affect the firm's share of the overrun in our model, since $\overline{y_C}$ never enters the expression for the firm's share of the overrun.⁴¹ It does however makes it more likely that the results on the relation between reputation and mean overrun will be ambiguous. Because firms with low reputation will choose projects so as to limit overrun, client generated overrun will be smaller when the firm has no reputation and therefore, total overrun may go up with reputation. Moreover, if these projects have also less scope for opportunism on the part of the firm, the mean overrun generated by the firm may not always fall with reputation.

4.3.3 Contracts for Incentives

Under the assumptions made so far, contracts only protect the contracting parties from opportunistic behavior on the other side. They have no direct incentive effects. We can add incentive effects to the model by assuming that when s is chosen to be high enough, the resulting s^* will be close enough to 1 that even unreliable firms will prefer to act reliably. We also allow for the symmetrical possibility of inducing an unreliable client to act reliably by setting s low enough. We still rule out the possibility of getting the first-best outcome by assuming that in order to give any one side the incentive to be reliable, the other side has to be given very weak incentives.

In this case, once s is high enough to induce reliable behavior from unreliable firms, there will be no reason to raise it further. In other words, the optimal contract may not be at the extremes. However it will still be the case that an increase in θ_F and a fall in θ_C will favor a contract with a lower s . On the other hand, since the least reputable firms in this world will never behave unreliably, it turns out that for a certain specific range of values of θ_F (those exactly around the value at which the contract switches from a high s to a low s) firms with lower θ_F will both generate less overrun and bear a smaller share of it, compared to firms with a higher θ_F .⁴²

⁴¹This is not strictly true. A lower $\overline{y_C}$ and $\overline{y_F}$ may affect the choice of the optimal contract and thereby affect the sharing of the overrun. However, since most low reputation firms almost always have fixed cost contracts, this effect may not be very important.

⁴²It should be noted that this perverse consequence of the incentive effect is most likely in model like ours where the firm (and the client) make discrete choices. With a smoother set of choices, the incentive effect is never quite as dramatic and hence it may never be the case that more reputable firms actually pay a higher share of the overrun.

5 Evidence

In this section, we document that the central implications of the model are consistent with the data, by showing that contractual forms as well as the actual sharing of the overrun vary with characteristics likely to be correlated with the reputation of the firm. We then examine how the other predictions of the model match with the software data. Finally, we consider some obvious alternative explanations of the patterns observed in the data.

5.1 Measures of Reputation

We have already suggested three alternative measures of a firm's reputation: its age, whether or not it is in a repeat contract and ISO certification.⁴³

We also make use of a fourth metric - we compare internal (projects for OSDC and mother companies) and external projects. We would expect the difference between external projects to be similar to the difference between first time and repeated relationships, for two reasons. First, there is clearly an element of reputation: much like in a repeat contract but even more strongly, the firm and the client must know much more about each other (and what they know must be positive) if they have decided to establish a long term relationship together.⁴⁴ Second, the scope for unreliable behavior in this type of relationship is much more limited, since both parties share the control rights. In other words, this kind of relationship is, in part, a substitute for reputation. However, we need to be sensitive to the fact that companies working for internal clients are potentially very different from other companies. In particular, OSDCs will be established only after the client has spent a very long time studying the firm. Fully-owned subsidiaries are often run by people who had been previously working in the US office of the firm. We therefore restrict the comparisons to firms that perform some internal projects (e.g. subsidiaries that works for

⁴³Note that we think of the reputation as being an attribute of the firm, more than of the individuals who compose it. It could be that an experienced professional leaving his job to create a software firm takes his individual reputation with him. It turns out that individual reputation seems difficult to transport (we asked what the past career of the person who founded the software firm was, and examined whether this was related with sharing of the overrun, but did not find that this was the case). The main reason is that the important input the CEO of a software firm has to provide is the management of the team, which may or may not be related to his ability as a software professional.

⁴⁴The internal/external comparison is therefore closer to a repeated/first-time comparison than to a young/old comparison - since the matching in an internal project is like that in a repeat project.

their mother company and also for external client). This insures that the selection of firms for internal projects does not invalidate the comparison (since all firms in this sub-sample have been selected for some internal work).

5.2 Choice of Contract and Sharing of the Overrun

5.2.1 Structure of the Contracts

An implication of the model is that contractual forms will be restricted to contracts where the *ex ante* rule is that firms will bear either all or nothing of the cost overruns. As pointed out, this implication rests on the particular assumptions we have made, but it matches well with the observed pattern.

As we describe in Section 2, there are three major types of contracts: fixed-price, time and material and “mixed” contracts. Fixed price contracts are linear contracts with $s = 1$. As we discuss above, time and material contracts are similar to such contracts, with $s = 0$. In mixed contracts, the initial agreement specifies a payment for the specifications only. At the end of the specification phase, another agreement is specified for the development and testing phases. This kind of contract effectively splits the projects into two sub-projects. For each of them, a separate sharing rule is chosen, which is either 1 or 0 (often, time and material for the specification phase and fixed-price for the subsequent work).

In other words, mixed contracts are a juxtaposition of fixed-price and time and material contracts. It is easy to understand why, when the project is broken into these two phases, specifications tend to be written on time and material and the rest of the work tends to be done using a fixed-price contract. In the specification phase, the potential for the client to generate an overrun is extremely large. In particular, when the firm first sends the specifications, he can pretend that the specifications written do not correspond to what he wanted. The whole effort of the firm until that point becomes in effect useless. Therefore, it is important to give the client higher powered incentive. On the other hand, at the time the second sub-contract is written, a large part of the uncertainty about what the client really wants is resolved, since he has agreed (in writing) to the specifications. Therefore a fixed-price contract, which give better incentives to the firm, can become optimal from that point on. In practice, the choice of the contract for the second phase of the project is often endogenous: if the firm feels that a substantial amount

of uncertainty remains, it can in general insist on getting a second time and material contract. Mixed contracts are therefore *ex ante* more constraining for the client than for the firm.

5.2.2 Reputation and the Choice of Contract

The reputation of the firm determines both which contract it will get (choice of s) and what share of the overrun it will end up paying (actual s^*). Firms without a reputation will be more likely to be have fixed-price contracts than time and material or mixed contracts. Firms in fixed-price contracts should bear more of the overrun than firms with other types of contracts. Finally, conditional on having any particular type of contract, firms without a reputation will bear more of the overrun than firms with a reputation. The combined effect of these is, of course, that firms without a reputation will bear a larger share of the overrun.⁴⁵

This sub-section presents data related to these implications.

We presented evidence that age does matter in the introduction, as a motivation for this project. The relationship is illustrated in Figures 1 and 2. The proportion of fixed-price contracts and the share of the overrun borne by the firm are increasing with the foundation date of the firm. Table 5 shows the means of the firm's share of the overrun for each type of firm, and the difference between low and high reputation firms. In column (1), we report the mean for the sample of external firms. In columns (2) to (4), we show the contrast between young firms (created in 1994 or after) and old firms (created in 1993 or before). Young firms are significantly more likely to have fixed-price contracts (the probability is 26% higher). They also bear substantially more of the overrun both on average (19%), and within the projects with fixed-price contracts (the difference is 13%).

The pattern is less clear for ISO certification: ISO-certified firms are not less likely to get fixed-price contracts and they do not pay for a lower fraction of the overrun in general. However, conditional on doing fixed-price contracts, they bear less of the overrun (20.4%).

A relationship with a client has the same effect as a general reputation. Firms engaged in a

⁴⁵It should be emphasized that the full effect of reputation potentially includes things that are not necessarily the effect of reputation *per se*. As pointed out above, the effect of reputation on the actual sharing of the overrun *conditional on any particular initial contract*, may include a bargaining power effect because the determinants of bargaining power will tend to be correlated with the determinants of reputation like age. In this sense, the evidence on the choice of the initial contract tends to be "cleaner". This kind of conflation of reputation effects and other effects is less likely to be the case when we are comparing internal and external contracts.

repeated relationship with their client are about as likely as other firms to have fixed contracts, but they pay significantly less of the overruns (20% less).

Finally, among firms who have internal contracts, firms pay for more of the overrun when they deal with external clients than when they deal with internal clients. Almost half of their external contracts are fixed-price contracts (a number close to the proportion of fixed-price contracts among old firms), whereas only 23% of the internal contracts are fixed-price contracts. They pay a much smaller share of the overrun (20% instead of 47%) in internal contracts than in external contracts. The difference conditional on doing fixed-price projects is not significant, but this is probably due to the small number of fixed-price contracts among internal projects.

In summary, it seems that young firms, firms working with a new client and firms working with an external client bear a larger share of the overrun compared respectively to older firms, firms engaged in a repeated relationship and firms working for an OSDC or their mother company. We interpret these results as showing that reputation does influence the way the overruns are shared between the client and the firm. We will address some alternative explanations below, but the first possible caveat to this interpretation is that these firms do different types of projects, which require different types of incentives or entail different types of risk. For example if old firms do mostly project where there is a possibility of very large overruns, they may refuse to do the project unless they know they will be covered in case this happens.⁴⁶ In particular, Table 4 shows that young firms, non ISO-certified firms, and firms working for external clients do on average smaller and simpler projects than old firms, ISO firms and firms working for internal clients. It is therefore important to check that the simple contrast between the groups is not an artifact of the different composition of their contracts.

In Table 6, we show the differences between the overrun paid for by each type of firm in project-size cells (panel B) and complexity cells (panel D).⁴⁷ The first panel reproduces the uncontrolled difference of Table 5. In panel C, we show the “controlled contrast”: this is simply a weighted average of the differences between the young and old firms in the project size cells, where the weights are given by the fraction of projects falling into this project size cell. This is a crude way to take into account the two facts that different types of firms choose different type of projects and that the differences across young and old firms are not necessarily the same for

⁴⁶We will comment more on the choice of project per se below.

⁴⁷We used the subjective complexity measure given by the firms.

all project sizes.

Firms tend to bear less of the overrun when they do complicated projects than when they do simple projects. There is also a weak relationship between the size of the project and the share of the overrun paid for by the firm. Young firms pay a larger share of the overrun than old firms for small and large projects, but not for medium-sized projects. The controlled contrast between young and old firms is slightly smaller than the simple difference, but still high. The controlled contrast becomes positive, though insignificant, for ISO-certified firms, mainly because the ISO-certified firms doing small projects do not pay any of the overrun.⁴⁸ Controlling for project size does not affect the difference between repeated and new clients and between internal and external contracts. Whatever the complexity of the project, young firms bear more overrun than old firms, firms working with a new client bear more overrun than firms working with a repeated client, and firms bear less overrun when they do internal projects. The evidence for ISO certification is, once again, mixed.

In summary, even after taking into account the size of the projects, firms with low reputation bear more of the overrun than other firms (although the evidence in favor of ISO certification remains less than overwhelming).

A final piece of evidence is presented in Table 7. In this table, we examine whether the different kinds of reputation are substitutes. Namely, we ask in panel A whether young firms still bear more of the overrun when they benefit from another kind of reputation. In the table, we present the difference between young and old firms in the proportion of fixed-price contracts (line 1) and in the share of overrun they pay (line 2) within groups of ISO-certified/non ISO-certified firms, repeated/new clients, internal/external contracts (for firms who do some jobs for internal firms). The contrasts are interesting. Non ISO-certified young firms bear 27% more of the overrun than non ISO-certified old firms, but among ISO-certified firms, there is no difference. Young firms are significantly more likely than old firms to have fixed-price contracts if they work with a new client, but not if they have already worked with this client. Among firms that do some internal contracts, the same contrast appears: young firms are more likely to have fixed-price contracts when they work with an external client and pay for more of the overrun, but not when they work with an internal client or an OSDC.⁴⁹ In panel B, we perform

⁴⁸This number should be taken with caution, as very few ISO firms do small projects.

⁴⁹Johnson, Mc Millan and Woodruff (1999) report comparable evidence in transition economies. Sellers are

the same exercise, but we look at how the difference between the share of the overrun paid for by firms working with a new rather than repeated client varies across different kind of firms. Interestingly, a very different pattern emerges. The difference between new and repeated clients persists for old firms and for ISO-certified firms, and does not decline. It suggests that the mechanism of reputation formation is rather inefficient: even after a firm has been in the market for some time, much remains to be learned about it.

We have documented systematic differences in the way cost overruns are shared across young and old firms, contracts with repeated and new clients, ISO-certified firms and other firms, and firms in internal and external contracts. This evidence is consistent with a model where reputation is an important determinant of the contracts and the sharing of the overrun. In the next subsection, we examine whether the other empirical predictions of the model also hold.

5.3 Further Results

5.3.1 Choice of Project

A simple extension to our model also predicts that the firms with a low reputation will tend to choose simpler projects where the objectives are easier to define, which will tend to limit the overrun generated by the client. We present evidence relating to the choice of project in Table 4, and Figures 5, 6 and 7. Young firms do smaller projects (Figure 6), which have smaller overrun (even expressed in proportion of predicted costs).⁵⁰ They also tend to carry more often “simple” projects (Y2K, CAD, data manipulation) (Figure 7), which generate lower overruns, are easily defined, and are easier to monitor. We have also asked them to subjectively rate the complexity of the project, and even according to this subjective measure, young firms do more simple projects (Figure 5). As a result of these two combined facts, the returns from each project (cost multiplied by markup) is smaller on average for young firms than old firms.

This could be at least partly explained by the fact that young firms are on average less competent (and that therefore clients do not want to entrust them with large or complex projects).

more willing to extend trade credit to a new customer if they have obtained information about him from a social or business network than if they have not, but the weight given to this information declines as the length of the relationship with this buyer increases.

⁵⁰Moreover, by doing that they keep the share of overrun accounted for by each project more or less similar across young and old firms: this could therefore be explained by adding risk aversion to the model.

However the same contrast holds between internal and external projects (Table 4), for project size and Y2K projects. Since we have restricted the comparison to firms that do at least some internal work, the difference between internal projects and external projects is not tainted by this bias. This confirms that part of this difference between young and old is due to difference in behavior.

5.3.2 Overrun generated by the firm and by the client

Our baseline model predicts that, on average, firms with a better reputation will generate less overrun (and therefore, total overrun will also tend to be smaller for their project). However, once we take into account non-random matching and the choice of projects, the prediction about the relationship between overrun generated by the firm and reputation are not unambiguous. On the other hand, these extensions predict that clients matched with firms with low reputation should generate less overrun.

Table 8 presents evidence on overruns generated by the firm and the client.⁵¹ There is no systematic relationship between total overrun and the reputation of the firm: total overrun is smaller for young firms, firms without ISO certification, and external projects; it is larger for firms dealing with a new client. None of these contrasts is close to being significant. Overrun generated by the firm is slightly larger for young firms and firms dealing with a new client, but larger for ISO-certified firms and firms dealing with an internal client.⁵² Finally, overrun generated by the client is smaller in all cases for less reputed firms, which is consistent with our argument that less reputed firms try to protect themselves from absorbing large overruns by dealing with reliable clients or by choosing projects where the scope for client generated overrun is smaller.

The data seems consistent with our model of how reputation determines contractual outcomes. In the next section, we examine the most obvious alternative explanation to the observed pattern.

⁵¹Overrun generated by the firm and overrun generated by the client do not necessarily add up to total overrun: among sources of overruns proposed to the firms, there was an ‘other’ category, which we left unattributed.

⁵²These results could be consistent with the idea that overrun is slightly lower when firms have a good reputation. First, there is in general no compelling evidence that ISO certification really gives a firm a reputation. Second, as we have noticed already, overruns are less costly for internal projects, so they tend to be larger.

6 Alternative Interpretations of the Data

This section reviews alternative explanations to the pattern observed in the data (in particular to the main result that young firms bear a larger share of the overrun than old firms).

6.1 Pure Risk Sharing

One possible interpretation of what is going on in this industry is pure risk sharing. However, as explained in much greater detail in a previous version of this paper, this interpretation very quickly runs into trouble. In the case where we assume CRRA preferences (which is standard in cases like this where there is substantial variation in the size of the contracting parties) we showed in the previous version of this paper that

Claim 7 *If the firm and the client have CRRA preferences, for a fixed project size, the share of the risk that they each bear will be approximately in the inverse proportion of their coefficients of relative risk-aversion, keeping fixed the ratio of their total revenues. It will also be approximately in the direct proportion of their total revenues, keeping fixed the ratio of their risk-aversions.*

Given that the client's revenues are much bigger than that of the firm,⁵³ an implication of this proposition is that the client should bear most of the risk unless the client is much more risk averse than the firm. In fact, the firm bears on average more than half of the cost overrun, suggesting that the client's coefficient of risk-aversion must be very large relative to the firm's. It is however difficult to think of a basis for such differences in risk aversion. Moreover, this result has systematic predictions about the relationship between firm size and the share of the risk that it bears, controlling for client size and project size. Table 9 presents the share of overrun paid by the firm by client size, project size and firm age. In all project size-client size cells, old firms bear less of the overrun than young firms. Since old firms are on average larger (this is shown in Figure 4 and in columns 2 to 4 in Table 4: old firm's turnover is larger by \$3.7 million,

⁵³More than half of the contracts in the sample are with "large" clients, 26% are with medium sized client, and 19% are with small clients. Large clients are in general fortune 500 companies or equivalent. Small clients are firms with turnover below \$10 million. In contrast, the median turnover of the software companies in the sample is only \$1.2 million, and the largest firm had a turnover of \$47 million. Only 27% of the firms have a turnover above \$ 10 million. Among the firms engaged in contracts with small clients, the median firm has a turnover of \$0.5 million.

or more than 100%, than young firms), this contradicts the basic implication of the risk-sharing model.

One might also speculate that old and new firms generate different risk profiles and that this explains why old firms bear less risk: perhaps old firms simply generate less risk. However, the evidence on the standard deviation of total overrun presented in Table 8 shows that this is not the case. The standard deviations of total project overrun are very similar across all types of firms. There is therefore no evidence to support the view that young firms are systematically more risky to deal with. Another possibility, however, would be that the underlying distribution of overrun is different for young and old firms (despite the fact that mean and standard deviation are not different), and that the particular form of the risk faced by old firms made this particular risk sharing rule optimal. We examined the entire distribution of overrun generated for both young and old firms (Figure 8). The two distributions are very similar, except for four old firms which generated very large overrun (150% and higher). These four old firms are however not driving the results, since all of them paid 100% of the overrun. Moreover, as we have shown above, the difference between old and young firms is maintained when we control for project type (complexity or size), which are presumably good indicators of project-specific risk.

The evidence we give above strictly only applies to the case of CRRA preferences. There are, of course, many classes of risk preferences which do not fall into this category. However, there are two basic intuitions which suggest that these other preferences will not work particularly well either: on the one side, if the coefficient of *absolute* risk aversion falls faster than a CRRA, it is very hard to explain why the firm bears any risk at all. On the other side, if the coefficient falls slower than a CRRA (so that the preferences approach the CARA model), it can be shown that project size and client size effects also become smaller and this leaves very little to explain the inter-firm differences.⁵⁴

6.2 Varying Levels of Competence

Our model has assumed that both clients and firms are risk-neutral. Suppose we now assume that firms and clients make mistakes which lead to overrun but that these mistakes can be contracted upon. In this case, one possible first best contract is one in which firms take the

⁵⁴In the extreme case of CARA preferences neither project size nor client size affects risk-sharing.

full responsibility of any mistake that they make.⁵⁵ Now if young firms⁵⁶ are on average less competent, then it is to be expected that they would pay on average for more of the overrun.

The first point against this explanation is simply that risk-neutrality is a very extreme assumption. If the firm was at all risk-averse then the optimal contract would try to insure the firm against all sources of risk that are beyond its control. Therefore, since young firms do not choose to be incompetent, they should be insured against overrun that results from their mistakes. Of course, the extent of such insurance may well be limited by the client's willingness to bear risk, but as we have already argued, the client is in a much better position to bear risk than the firm, and in particular small firms should only bear a small part of the risk. Of course, this assumes that the mistakes are not made deliberately. The case of varying levels of moral hazard will be examined below.

There are also some simple empirical arguments against this view: first (and most importantly), firms pay much more of the overrun than the share for which they are responsible: as shown in Table 3, even when the client is fully responsible for the overrun, the firms still pay on average 51% of it. Second, to explain the differences in the share of overrun paid by the firms entirely by differences in the share of overrun that is caused by the firm, it would have to be the case that young firms cause substantially more overrun than old firms do. Recall that the total overrun is, if anything, larger for old firms than young firms. The difference between the share of overrun due to young firms and the share of overrun due to old firms is clearly not large enough to explain the difference in the sharing of these additional costs. Differences in sources of the overrun are shown in Table 8. The difference between the fraction of overrun due to young firms and that due to old firms is only 1.18%, but they pay 20% more of the overruns. Finally, even within firms that do some internal work (and are therefore more homogeneous), it is the case that firms bear more of the overrun in external contracts than in internal contracts. Therefore it does not seem to be the case that the differences in the share of the overrun borne by young firms can be explained by systematic differences in competence between young and old firms.

⁵⁵Of course the actual contracts do not say anything about dividing the overrun. Therefore what we are referring to here is a fully efficient implicit contract.

⁵⁶Or more generally, firms that we have called so far "low reputation" firms.

6.2.1 Underbidding by Young Firms

One could imagine that even in a world where contracts are effectively complete, young firms might systematically underbid (quote a price based on intentionally low estimates) to win the project. Of course the client knows this, and in the optimal contract corrects for it by holding them responsible for the extra overrun resulting from the underbidding.⁵⁷ Young firms therefore end up paying for a higher share of the overrun. However it should be easy to see that the same objections that we list above to the competence-based explanation also apply in this case.

6.2.2 Varying Level of Moral Hazard

The arguments against the two previous alternatives are based on the assumption that the mistakes (or prediction errors) are deliberate. Once we allow for such moral hazard, the client may well not be willing to insure the firm. Old firms could be less prone to moral hazard than young firms, and therefore bear less risk than young firms. The evidence we have presented on mean and variance of the overrun cannot respond to this kind of criticism, since they are endogenous: young firms could be generating the same level of overruns as old firms, precisely because they face higher punishments. Note however that this would be a real alternative to our view only if the levels of moral hazard were common knowledge (i.e., if there was no learning about the type of the firm or the client - if there was learning, it would just be a variant of our reputation model). Moreover, it is not clear why, in this alternative scenario, it should make any difference that a firm is working with a repeated client. The level of moral hazard is unlikely to change very much between the first and the second contracts for a specific client. The fact that firms are treated differently the second time around must therefore indicate that there is learning going on about the characteristics of the firm.

6.2.3 Dynamic Moral Hazard

The fact that repeat contracts are different from first time contracts could perhaps be explained in terms of the evolution of a dynamic incentive contract, in the absence of any learning. However this would not explain the contrast between the first-time contracts faced by young and old firms. Moreover it is not easy to see why, in this view, the age effect would be smaller when it is a

⁵⁷ Again we are referring here to a fully efficient implicit contract.

repeated contract.

6.2.4 Varying Levels of Honesty

Young firms could also differ from old firms in their propensity to report costs honestly. They could be more prone to try to report inflated costs, or to pretend that changes due to their own incompetence are due to the client changing his mind. If the client could not tell the cheaters apart, then the analysis of such a model would be similar to the analysis of the model we propose, and lead to the same conclusion (the reputation of old firms would be a reputation for honesty instead of a reputation for reliability). As we mentioned earlier, our modeling choice was to model a reputation for reliability, but it is clear that the analysis could be carried out with a different reason for the importance of reputation.

Note however that if clients could tell apart cheaters and honest firms, and punish cheaters by imposing them to pay more of the overrun, then we would also observe that young firms would pay on average more of the overrun (but this would not result in any social cost, unlike in our model or a version of the model with a reputation for honesty). Assuming that firms report in the questionnaire what they have reported to the client, then the evidence that young firms pay more often than old firms overruns reportedly caused by the client would simply reflect the fact that they are lying more often than old firms. Because this argument rests on the fact that firms are lying in what they report to us as well as in what they say to their client, it is not easily verified or invalidated in the data. Note however that this argument implies that the clients never make any mistake in telling apart cheaters and honest firms. It is therefore self-defeating: why would firms cheat in the first place if they know that they are going to be found out? Moreover three facts are difficult to reconcile with this explanation: First, firms pay on average 50% of the overrun when they report that the client is fully responsible for it. The suggested explanation would therefore imply an implausibly high fraction of cheaters among Indian software companies (young and old).

Moreover, if the client has perfect information and can enforce any sharing *ex post*, there should be no variation in the contractual form, or at least it should not be related to the final outcome. However, firms pay more of the overrun when they have fixed-price contracts than when they have time and material contracts. Furthermore, young firms have more often fixed-price contracts. Therefore the *ex ante* contracts seem both to be relevant and to be used by the

clients, which is not consistent with the world we just described.

Finally, note that such a model would not explain the difference between contracts with repeated and new clients, or the difference between internal and external contracts: if the client has perfect information, then it is not easy to explain why firms would behave differently when dealing with different types of clients.

7 Conclusion

We set out in this paper to look for evidence that reputation plays an important role in determining contractual outcomes. We find that the evidence seems to strongly support this view, though given that the evidence is indirect (we do not actually observe people looking at reputation when deciding on contracts) and there are important firm characteristics that are potentially correlated with our measures of reputation, some doubts clearly remain.

The conclusion that reputation matters is of course important in itself: it gives support to a range of theories that are based on limitations of contracting. Moreover, it might suggest an explanation of why the Indian software industry is not much larger (Indian software exports were only worth 3.4% of the 1995 worldwide outsourcing business) given its obvious labor-cost advantage⁵⁸ and the fact that this is a very labor-intensive industry. Or, to state the same point differently, why is it an equilibrium for software professionals in India to get paid so much less than their U.S. counterparts? Reputation at the firm level is one possible explanation: most Indian firms are simply not trusted enough to be given important contracts. While our evidence cannot directly substantiate this view, the fact that reputation is important within the Indian industry suggests that it also ought to be important when an American client is deciding whether to go to a firm in India or to one in the U.S.

To add support to this view, our results also suggest that the process of reputation formation is rather inefficient. This is reflected in the fact that after controlling for age, whether or not a firm is dealing with a repeat buyer still makes a substantial difference to the contract. In other words, repeat buyers clearly know much more about the firm than the market does. In other words, the fact that a firm performed well in the past vis a vis one firm takes time to become

⁵⁸The U.S. imports a very large number of Indian software professionals for short-term assignments at a cost of more than twice what they would earn in India.

public information. This is of course consistent with rational behavior on the part of the client but it clearly hurts the firm.

The policy implication of this view is that a credible system for rating firms modeled on credit rating systems may play an important role in the evolution of industries such as the software industry where contracting is inherently problematic, by making it possible for the market to efficiently aggregate all that is known about each firm.

References

- [1] Bajari, Patrick and Steven Tadelis (1999), "Procurement Contracts: Fixed Price vs. Cost Plus", Mimeo, Stanford University.
- [2] Baker G., R. Gibbons and K. Murphy (1997) "Implicit contracts and the theory of the firm" NBER Working Paper #6177.
- [3] Barron J. and John Umbeck (1984) "The effect of different contractual arrangements: the case of retail gasoline market" *Journal of Law and Economics* 27:313-328.
- [4] Crocker K. and K. Reynolds (1993) "The efficiency of incomplete contracts: an empirical analysis of air force engine procurement" *RAND Journal of Economics* 24-1:127-146.
- [5] Genesove D. (1993) "Adverse selection in the wholesale used car market" *Journal of Political Economy* 101-4:644-665.
- [6] Greif A. (1994) "Cultural beliefs and the organization of society: A historical and theoretical reflection on collectivist and individualist societies" *Journal of Political Economy* 102-5:912-950.
- [7] Hecks R. (1996) *India's Software Industry. State Policy, Liberalisation and Industrial Development*, Sage Publication, New Delhi, Thousand Oaks, London.
- [8] Holmstrom, Bengt (1982) "Moral Hazard in Teams" *Bell Journal of Economics* 13-2:324-40.
- [9] Johnson, S., J. McMillan and C. Woodruff, (1999) "Contract Enforcement in Transition", Mimeo, MIT.

- [10] Joskow, P., (1987) "Contract duration and relationship specific investment: empirical evidence from coal markets" *American Economic Review* 77-1:168-185.
- [11] Kandori, M. (1992) "Social norms and community enforcement" *Review of Economics Studies* 59:63-80.
- [12] Lafontaine F. and K. Shaw (1996) "The dynamics of franchise contracting: evidence from panel data" NBER Working Paper #5585.
- [13] Masten S. and K. Crocker (1985) "Efficient adaptation in long-term contracts: Take-or-pay provisions for natural gas" *American Economic Review* 75-5:1083-1093.
- [14] Monteverde K. and D.J. Teece (1982) "Supplier switching costs and vertical integration in the automobile industry" *Bell Journal of Economics* 13:206-213.
- [15] NASSCOM (1997) *Indian Software Directory*, CD-ROM.
- [16] Pittman R. (1991) "Specific investment, contracts and opportunism: the evolution of railroad sidetrack agreements" *Journal of Law and Economics* 34:565-589.
- [17] Pressman, Roger S. (1997) *Software Engineering, A Practitioner's Approach*, 4d edition, MacGraw Hill International editions, Software Engineering Series.
- [18] Rauch, James and Joel Watson, "Starting Small in an Unfamiliar Environment", Mimeo, University Of California at San Diego.
- [19] Shepard, A. (1993) "Contractual form, retail gasoline, and asset characteristic in gasoline retailing" *RAND Journal of Economics* 24-1:58-77.
- [20] STPI (1997) *Software Technology Parks of India*, Mimeo, Bangalore.
- [21] Tirole, Jean (1996) "A Theory of Collective Reputations (with Applications to the Persistence of Corruption and to Firm Quality)" *Review of Economic Studies* 63.1:1-22.

Figure 1
Proportion of fixed cost contracts

Figure 2
Share of overrun paid for by the firm

Figure 3:
Mean of project overrun
(percentage of initial evaluation)

Figure 4
Average Firm Turnover in 1997/98 (Millions \$US)

Figure 5:
Subjective complexity measure

Figure 6:
Size of the project (in man-months)

Figure 7:
Proportion of "simple" project
(cad, y2k, web pages, data manipulation)

Figure 8: Cumulative distribution of overrun

A: Young firms

B: Old firms

	Complete Sample (N=236)					External Projects (N=167)				
	Mean	Median	Standard deviation	Minimum	Maximum	Mean	Median	Standard deviation	Minimum	Maximum
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PANEL A: PROJECT CHARACTERISTICS										
Project size (man month)	113	26	403	0.38	5400	74.7	27	141	0.38	960
Proposal effort (% of project effort)	2.11	0.63	4.5	0	50	2.55	1.25	4.96	0	50
Specification effort (% of project effort)	13.8	10.0	13.0	0	100	13.5	10.0	14.0	0	100
Project cost >estimate (overrun)	0.74	1	0.44	0	1	0.75	1	0.43	0	1
Project cost =estimated cost	0.22	0	0.41	0	1	0.22	0	0.42	0	1
Project cost <estimate (underrun)	0.046	0	0.21	0	1	0.023	0	0.15	0	1
Total overrun (% of project cost)	24	15	34.4	-25	250	22.7	15	30	0	200
Causes of overrun:										
% due to ambiguity	20.4	0	33.5	0	100	19.5	0	33.6	0	100
% due to changes	48.1	50	41.9	0	100	45.4	50	42.7	0	100
% due to internal difficulties	7.8	0	22.4	0	100	9.06	0	25	0	100
% due to delay by the client	12.7	0	25.8	0	100	12.8	0	26.2	0	100
% due to other reasons	9.92	0	26.3	0	100	11.9	0	29.1	0	100
Project was delivered late	0.19	0	0.4	0	1	0.2	0	0.4	0	1
PANEL B: CLIENT										
Project is for the mother company	0.23	0		0	1	0				
OSDC project	0.063	0				0				
External project	0.71	1		0	1	1				
PANEL C: CONTRACT										
Time and material contract	0.3	0	0.46	0	1	0.15	0	0.36	0	1
Mixed contract	0.21	0	0.41	0	1	0.26	0	0.44	0	1
Fixed cost contract	0.48	0	0.5	0	1	0.58	1	0.49	0	1
Share of overrun paid for by the firm	47.4	38.3	46.3	0	1	57.1	76.5	45.1	0	1

Table 2
Share of overrun for paid by the firm as a function of initial contract

	Proportion paying 100%	Proportion paying between 0 and 100 %	Proportion paying 0%	Average share of the overrun paid for by the firm
	(1)	(2)	(3)	(4)
PANEL A: ALL CONTRACTS				
All contracts	39.29	17.85	42.86	47.4 (3.58)
Time and material contracts	11.1	11.12	77.78	15.6 (4.92)
Mixed contracts	34.29	25.71	40	51.6 (7.69)
Fixed cost contracts	54.12	18.82	27.06	63.1 (4.83)
PANEL B: EXTERNAL CONTRACTS				
All contracts	47.58	20.97	31.45	57.1 (4.06)
Time and material contracts	17.65	23.53	58.82	28.2 (9.56)
Mixed contracts	40.62	25	34.38	50.9 (8.08)
Fixed cost contracts	56.76	18.92	24.32	65.8 (5.07)

Table 3

Share of overrun paid by the firm and source of the overrun

	Share of the overrun paid for by the firm		OLS coefficient (share paid by the firm on share due to the firm)
	Client fully responsible (1)	Client and firm partly responsible (2)	Firm fully responsible (3)
PANEL A: ALL CONTRACTS			
All contracts	41.1 (5.41)	49.4 (6.47)	52.6 (5.24)
Fixed cost contracts	52.2 (7.56)	64.5 (9.15)	70 (7.19)
T&M and mixed contracts	27.4 (7.60)	36 (8.40)	39.8 (6.81)
PANEL B: EXTERNAL CONTRACTS			
All contracts	50.9 (6.63)	58.4 (7.42)	62.5 (5.75)
Fixed cost contracts	53.2 (8.14)	69.1 (9.67)	73.8 (7.30)
Other contracts	46.5 (11.7)	44.6 (10.8)	50.3 (8.50)
			0.17 (0.095)
			0.21 (0.13)
			0.21 (0.12)
			0.18 (0.10)
			0.28 (0.14)
			0.19 (0.15)

Table 4

Firms' and projects' characteristics

	External projects (for all firms)										Firms which have internal projects			
	Sample Mean (1)	Firm foundation date		ISO 9001 certification			Relationship with the client			Type of project				
		> 1993 (2)	1993 <=1993 (3)	Difference (4)	No (5)	Yes (6)	Difference (7)	New client (8)	Repeated (9)	Difference (10)	External (11)	Internal (12)	Difference (13)	
Yearly turnover 97/98 (million \$US)	4.71 (0.96)	2.56 (0.87)	6.24 (1.89)	-3.66 (2.35)	2.71 (0.81)	13.9 (4.65)	-11.2* (2.75)	5.21 (1.56)	3.82 (1.72)	1.39 (2.46)	8.11 (2.5)	2.2 (0.87)	5.92* (2.87)	
Number of employees	137 (27.2)	84 (17.8)	188 (50.12)	-104* (52.9)	72 (8.73)	453 (137)	-391* (63.8)	160 (46.6)	113 (7.4)	-46.4 (54.6)	273 (92)	73 (12)	200 (86)	
Project size (in man-months)	74.7 (10.9)	53.9 (10.8)	90.1 (17.1)	-36.8 (21.9)	48.9 (6.54)	183 (45.5)	-134.8* (25.7)	85.67 (16.2)	58.7 (12.59)	26.9 (22.2)	88.5 (22.5)	206.7 (85.1)	-118.2 (89.1)	
Share of yearly turnover coming from this project	18.5 (1.92)	16.2 (2.53)	20.2 (2.77)	-4.0 (3.88)	20.4 (2.32)	10.6 (1.85)	9.81* (4.81)	16.5 (1.84)	21.33 (3.91)	-4.78 (3.91)	19.3 (3.56)	28.6 (3.84)	-9.26 (5.25)	
Client is "big"	0.55 (0.039)	0.55 (0.054)	0.55 (0.059)	-0.051 (0.11)	0.54 (0.043)	0.59 (0.088)	-0.05 (0.14)	0.44 (0.050)	0.71 (0.056)	-0.22* (0.11)	0.61 (0.059)	0.28 (0.054)	0.31* (0.11)	
Proportion of "simple" projects (y2k, cad, data)	0.14 (0.027)	0.20 (0.048)	0.094 (0.030)	0.10* (0.051)	0.13 (0.029)	0.16 (0.065)	0.023 (0.068)	0.10 (0.030)	0.19 (0.048)	-0.09 (0.054)	0.1 (0.037)	0.072 (0.031)	0.032 (0.049)	
Subjective complexity (graded 1 to 5)	3.6 (0.07)	3.3 (0.14)	3.8 (0.10)	-0.47 (0.17)	3.53 (0.096)	3.95 (0.18)	0.42 (1.96)	3.62 (0.11)	3.62 (0.14)	-0.0059 (0.17)	3.71 (0.11)	3.82 (0.13)	-0.11 (0.17)	
Project return (size*markup)	92.6 (14.8)	59.8 (11.7)	120 (24.8)	-59.8* (29.42)	58.2 (8.11)	235.4 (62.3)	-177.2* (34.5)	101.7 (21.0)	78 (18.6)	23.7 (30.5)	123.4 (33.0)	297.1 (139.4)	-173.7 (134.0)	
Firm created before 1993	0.57 (0.038)	0	1	-1	0.47 (0.043)	0.22 (0.074)	0.25* (0.096)	0.44 (0.050)	0.4 (0.060)	0.047 (0.078)				
Firm is ISO certified	0.19 (0.43)	0.098 (0.036)	0.26 (0.045)	-0.16* (0.061)	0	1	-1	0.18 (0.038)	0.21 (0.050)	-0.024 (0.062)				
Contract is with a repeated client	0.41 (0.038)	0.38 (0.051)	0.43 (0.051)	-0.047 (0.077)	0.4 (0.042)	0.44 (0.089)	-0.038 (0.097)	0	1	-1				

Table 5
Contracts

External projects (for all firms)													Firms which have internal projects		
Sample Mean	Firm foundation date			ISO 9001 certification			Relationship with the client			Type of project					
	> 1993	<=1993	Difference	No	Yes	Difference	New client	Repeated	Difference	External	Internal	Difference			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)		
Proportion of fixed cost contracts	0.58 (0.038)	0.73 (0.053)	0.47 (0.052)	0.26* (0.075)	0.59 (0.042)	0.53 (0.090)	0.061 (0.097)	0.62 (0.049)	0.53 (0.061)	0.087 (0.078)	0.45 (0.061)	0.23 (0.051)	0.22* (0.080)		
Share of overrun paid by the firm	57.1 (4.06)	68.6 (5.16)	49.3 (6.25)	19.4* (8.12)	56.9 (4.59)	57.8 (8.84)	-0.98 (10.01)	64.2 (4.94)	44.2 (6.73)	20* (8.32)	46.7 (6.36)	20.2 (5.82)	26.5* (8.67)		
Share of overrun paid by the firm (fixed cost contracts)	62.1 (5.34)	71.8 (6.83)	59 (7.48)	12.8 (10.1)	69.9 (5.55)	49.5 (11.63)	20.4 (12.46)	73.4 (5.86)	49.9 (9.09)	23.57* (10.54)	58.7 (9.67)	44.8 (14.7)	13.9 (17.2)		

Table 6
Share of overrun paid for by the firm, by project size

External projects (for all firms)										Firms which have internal projects			
Firm foundation date		ISO 9001 certification				Relationship with the client				Type of project			
> 1993	<=1993	Difference	No	Yes	Difference	New client	Repeated	Difference		External	Internal	Difference	
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)		(10)	(11)	(12)	
PANEL A: Unconditional													
68.6	49.3	19.4*	56.9	57.8	-0.98	64.2	44.2	20*		46.7	20.2	26.5*	
(5.16)	(6.25)	(8.12)	(4.59)	(8.84)	(10.01)	(4.94)	(6.73)	(8.32)		(6.36)	(5.82)	(8.67)	
PANEL B: By project size													
<16 man months	72.1	48.6	23.4	60.4	0.0	69.8	46.1	23.7		43.5	8.3	35.1	
	(10.9)	(9.8)	(14.7)	(0.00)	(46.6)	(9.64)	(11.07)	(14.6)		(13.1)	(8.33)	(15.5)	
16-49 man months	45.2	50.2	-5.0	66.7	-22.5	62.7	27.8	34.9		46.4	27.5	18.9	
	(16.0)	(9.69)	(18.1)	(8.76)	(21.1)	(10.3)	(11.3)	(15.6)		(10.6)	(15.9)	(19.5)	
>40 man months	70.6	48.5	22.1	55.1	2.1	58.4	51.2	7.01		47.9	22.5	25.4	
	(10.3)	(8.31)	(13.5)	(8.5)	(13.9)	(7.79)	(13.4)	(15.3)		(11.6)	(8.69)	(14.20)	
PANEL C: Controlled contrast													
		15.6			15.3			22.1*				26.3*	
		(9.3)			(17.4)			(8.84)				(13.2)	
PANEL D: By project complexity													
"simple" (subjective complexity<=3)	76.2	56.6	19.6	64.1	77.8	71.6	56	15.6		56.7	47.04	9.26	
	(9.52)	(8.9)	(13.0)	(7.45)	(10.23)	(8.11)	(11.2)	(13.6)		(12.6)	(15.4)	(19.9)	
"complex" (subjective complexity>3)	63.17	45.9	17.23	52.3	51.9	60.13	37.4	22.7		43.8	11.2	32.6	
	(8.27)	(6.34)	(10.5)	(5.8)	(10.8)	(6.20)	(8.30)	(10.4)		(7.37)	(5.10)	(9.18)	

Table 7

Interaction of different kind of reputation

Foundation date		External projects (for all firms)				Firms which have internal projects	
> 1993	<=1993	ISO 9001 certification		Relationship with the client		Type of project	
		No	Yes	New client	Repeated	External	internal
		(1)	(2)	(3)	(4)	(5)	(6)
PANEL A: DIFFERENCE BETWEEN YOUNG AND OLD FIRMS							
Proportion of fixed cost contracts							
		0.27*	0.23	0.32*	0.17	0.31*	0.12
		(0.082)	(0.22)	(0.094)	(0.12)	(0.12)	(0.10)
Share of overrun paid for by the firm							
		25.6*	-9.71	17.1*	18.9	7.9	-1.52
		(8.85)	(23.95)	(9.89)	(14.1)	(13.6)	(11.8)
PANEL B: DIFFERENCE BETWEEN CONTRACTS WITH NEW AND REPEATED CLIENTS							
Share of overrun paid for by the firm							
	17.1	18.9	26.1			15.2	NA
	(13.4)	(10.4)	(18.2)			(13.0)	

Table 8
Overruns and delays

	External projects (for all firms)										Firms which have internal projects			
	Sample Mean (1)	Firm foundation date			ISO 9001 certification			Relationship with the client			Type of project			
		> 1993 (2)	<=1993 (3)	Difference (4)	No (5)	Yes (6)	Difference (7)	New client (8)	Repeated (9)	Difference (10)	External (11)	Internal (12)	Difference (13)	
Mean of overrun (% of initial estimate)	22.7 (2.33)	19.9 (2.84)	21.6 (2.65)	-1.77 (3.93)	18.7 (1.89)	30 (6.10)	-11.3 (4.88)	23.3 (2.59)	17.3 (2.86)	6 (3.94)	15.9 (2.55)	23.9 (-4.21)	-8.02 (4.87)	
Mean of overrun (controlling for size)				-1.83 (4.03)			-5.86 (6.71)			7.1 (4.18)			-9.48 (5.18)	
Std. deviation of overrun (%of initial estimate)	30.0	23.7	25.6	F=1.16 p=0.50	21.7	33.9	F=2.45 p=0.00	25.6	23.1	F=1.23 p=0.38	20.8	33.7	F=2.6 p=0.00	
Overrun caused by the firm	7.67 (1.58)	8.00 (2.34)	5.69 (1.28)	2.32 (2.51)	5.74 (1.32)	10.6 (3.24)	-4.82 (3.11)	8.09 (1.81)	4.58 (1.49)	3.51 (2.52)	4.61 (1.64)	7.46 (2.86)	-2.85 (3.28)	
Overrun caused by the firm (controlling for size)				2.63 (2.6)			0.23 (4.84)			3.9 (2.2)			-1.64 (3.51)	
Overrun caused by the client	12.5 (1.47)	9.44 (1.58)	14.4 (2.26)	-4.41 (2.96)	10.7 (1.33)	19.8 (5.03)	-9.01* (3.66)	12 (1.75)	13.2 (2.56)	-1.28 (3.00)	8.80 (1.73)	19 (3.54)	-10.2* (3.91)	
Project was delivered late	0.20 (0.031)	0.15 (0.043)	0.23 (0.043)	-0.074 (0.062)	0.18 (0.03)	0.28 (0.081)	0.10 (0.078)	0.22 (0.042)	0.17 (0.045)	0.06 (0.063)	0.18 (0.047)	0.20 (0.049)	-0.02 (0.068)	

Table 9
Share of overrun paid
by the firm, by project and
client size

	Young firms			Old firms		
	Size of project			Size of project		
	All	<median	>median	All	<median	>median
	(1)	(2)	(3)	(4)	(5)	(6)
All clients	68.7 (5.15)	72.5 (8.17)	63.3 (9.82)	46.6 (6.25)	54.7 (8.34)	45.7 (6.60)
Small or medium clients	77.5 (7.93)	79.9 (10.0)	73.2 (13.7)	65.4 (7.5)	61.1 (12.7)	68.2 (9.5)
Big clients	59.8 (9.49)	63.5 (13.5)	55.8 (13.9)	37.6 (6.56)	50.2 (11.2)	29.3 (7.72)

DEC 2000 Date Due

Lib-26-67

MIT LIBRARIES

3 9080 01917 5865