IT Outsourcing, Incomplete Contracts And Ethical Free Agency

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Abstract

We construct a dynamic, finite-horizon model of IT outsourcing that integrates incomplete contracts, bounded rationality, moral hazard and adverse selection. We prove that an *honest* firm – one which honors its contractual obligation even in the absence of legal restraints – can obtain strictly greater profits than an unconstrained profit-maximizer, even though the latter has access to a superset of strategies, including the option of mimicking the honest firm. Hence, honesty, which emerges endogenously as the optimal policy, can mitigate inefficiencies stemming from incomplete IT outsourcing contracts. On a broader note, our research provides a bridge between normative rationales for honesty – the province of ethics – and profit-maximization, which is axiomatic in economics, by providing a compelling economic rationale for honesty.

1 Introduction

It is well acknowledged that IT outsourcing projects are plagued by contractual incompleteness and asset-specificity, *cf.* Banerjee and Duflo (2000) , Bapna *et al.* (2010) . Extant literature suggests several remedies to mitigate the resulting inefficiencies, including contract redesign (*cf.* Chen and Bharadwaj 2009, Susarla *et al.* 2010, Susarla 2012), longer contract duration (*cf.* Ravindran *et al* 2015), vertical integration (see Klein *et al* 1978) and reputation effects, *cf.* Banerjee and Duflo (2000) , Ravindran *et al.* (2015) . Somewhat contrary to the remedies suggested, evidence suggests that vertical *disintegration* (in the form of increased outsourcing) with shorter contract duration and multiple contractual partners is the norm in several industries, Ravindran *et al.* (2015). We proffer a simple alternate explanation to account for the widespread prevalence of outsourcing contracts despite the problems posed by contractual incompleteness.

We develop a dynamic (multi-stage, multiperiod), analytical model of incomplete contracts between a principal and an agent in a repeated relationship, incorporating both moral hazard and adverse selection. The principal, who outsources IT services to the agent, is either an *unconstrained* or an *honest* profit-maximizer. The unconstrained principal, aptly characterized as 'opportunistic' or 'self-interested with guile' by Williamson (1985), maximizes his own payoff subject only to legal restraints. The honest principal ('self-interested without guile', Williamson 1985) honors his contractual obligations even in the absence of legal restraints. This distinction between unconstrained and honest profit-maximizers particularly matters under incomplete contracts of IT outsourcing where, due to inadequate legal recourse under unforeseen contingencies, there can be a divergence between the letter and the spirit of the contract. (See Banerjee and Duflo (2000) for interesting examples of such divergence in Indian software contracting.) Although our modeling choices– a finite horizon, different 'types' of the principal, incomplete and asymmetric information, and Bayesian players– are loosely similar to those of a 'reputations' model (Kreps *et al* 1992), our model incorporates several additional, demonstrably critical features such as honesty and bounded rationality[1]. Our research has several implications, which we summarize below.

- The 'irrational' (honest) type of principal can strictly outperform the unconstrained type, even though the unconstrained principal can selectively mimic the honest principal's strategies. Thus, a commitment to honesty emerges *endogenously* as optimal. Such an optimal commitment to honesty directly mitigates the effects of opportunism and the resulting inefficiencies arising out of incompleteness of most IT outsourcing contracts. In fact, the principal can induce the agent

[1] Bounded rationality manifests in our model as a proclivity to "trembles", which are "small departures from rationality" (Aumann 1997).

to make optimal relationship-specific investments using simple, finite-horizon contracts. Hence, we diverge from all previous explanations offered in the academic literature (including relational contracts and reputation effects) for the widespread use of outsourcing contracts.

The result that the 'irrational' (honest) type of principal can strictly outperform the unconstrained type has broader implications for both economics and *ethics* beyond the specific implications for IT outsourcing.

- *Implications for economics.* The result suggests a way to address two major critiques of economic models of bounded rationality:

  - The first critique is in the spirit of Rubinstein (1998), who argues that "...substantive rationality is actually a constraint on the *modeler* rather than an assumption about the real world... there are an infinite number of "plausible" models [incorporating irrationality] that can explain social phenomenon; without [rationality], we are left with a strong sense of arbitrariness." Our model demonstrates a plausible criterion to remedy the "sense of arbitrariness" in modeling irrationality and ease the constraint of "substantive rationality" on the modeler – that the irrational (commitment) type outperform the unconstrained type at least under some conditions.
  - A second critique pertains specifically to classical finite-horizon reputation models. Without adequate contextual justification, the presumption of commitment types who are not profit-maximizers, and whose payoffs are strictly dominated, appears arbitrary and contradicts economic Darwinism. Reputation models work around this concern by showing that the equilibrium properties, with the unconstrained type faking commitment, are preserved even when the probability of the commitment type's existence goes arbitrarily close to zero. Nevertheless, in these models, the *possibility* of the specific irrational type interferes with players' common knowledge of rationality (see Aumann 1992) and is a critical driver of equilibrium outcomes. Our research suggests an alternative metric, consistent with economic Darwinism, to address this criticism– that the commitment type in the model outperform the unconstrained type under plausible conditions.

- *Implications for Ethics*

  - Given that some irrational traits (including ethical values such as honesty) are commonly observed, our model postulates a set of primitives (such as bounded rationality and incomplete contracts) within the paradigm of economic modeling that explains the survival of these traits. Hence, our research provides a bridge between normative rationales for honesty– the province of ethics – and profit-maximization, which is axiomatic in economics, by providing a compelling *economic* rationale for honesty.

– By focusing on outcomes, traditional reputation models blur the distinction between an *intrinsic* commitment (to honesty, as an example) and a reputation acquired *instrumentally* to maximize profits. However, our model spotlights the distinction between intrinsic and instrumental ethicism, which is crucial for any meaningful study of ethics (see also the discussion around *ethical free agency* in Section 4).

2 Model

We develop an integrated moral hazard-adverse selection model, with the agency relationship extending over a finite horizon. A principal and an agent, both risk-neutral, expected-profit maximizers, engage in a contractual relationship spanning $N \geq 2$ periods. In any period $i \in \{1, ..., N\}$, events evolve in four stages; see Figure 1. In stage 1, the principal offers a contract. If the agent accepts the contract, she invests e_i in stage 2 that generates a value $\tilde{V}_i(e_i)$ for the principal in stage 3. Finally, the agent is paid in stage 4, possibly after *renegotiation*. Risk neutrality and the timeline of Figure 1 are fairly standard assumptions in the literature on incomplete contracts, *cf* Hart and Moore (1988, 1999) , Tirole (1999).

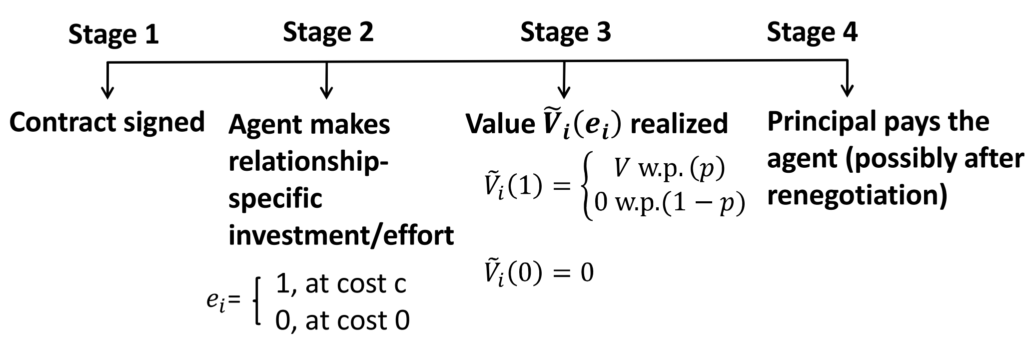


Figure 1: Sequence of events in period $i \in \{1, 2...N\}$.

The agent's investment (equivalently, effort), e_i, is unobservable and *relationship-specific*. The investment/effort can be either 'high' ($e_i = 1$) or 'low' ($e_i = 0$). The cost of investment is $C(e_i)$,where $C(1) = c > 0$ and $C(0) = 0$. The value $\tilde{V}_i(e_i)$ is jointly determined by e_i and nature. Specifically, $\tilde{V}_i(e_i) = e_i V$ with probability p, and 0 otherwise, where $pV > c$. Thus, $\tilde{V}_i(1) = V$ with probability p and 0 with probability $(1 - p)$, and $\tilde{V}_i(0) = 0$ identically. The value $\tilde{V}_i(e_i)$ is observable to both parties but non-contractible, i.e., it cannot be verified and arbitrated by a court of law, *cf* Hart and Moore (1988, 1999) , Banerjee and Duflo (2000), Bapna *et al* (2010). Further, the principal has residual property rights over $\tilde{V}_i(e_i)$.

The principal's *type*, which is *u*nconstrained or *h*onest, and indexed by u and h respectively, drives outcomes in stage 4. The unconstrained principal may renegotiate his contractual payment to the supplier (down to zero), whereas the honest principal never renegotiates. The honest and unconstrained types represent opposite, polar cases– the honest principal, with a lexicographic preference of ethics (honesty) over profit-maximization, epitomizes *ethical free agency*, whereas the unconstrained principal, with the reverse lexicographic preference, represents the pinnacle of *economic free agency* (See Section 4.1). Both the unconstrained and honest types of principal are susceptible to trembles– mistakes made in executing strategies– due to bounded rationality (*cf* Aumann, 1997). With a small probability m, the principal (of either type) trembles into *myopia* in stage 4 of each period; i.e., he inadvertently plays his optimal myopic (single-period) strategy instead of his optimal dynamic strategy[2]. This specific form of trembles is by no means critical to the model, but is appealing in dynamic contexts, where a combinatorial explosion of feasible actions– the *curse of dimensionality* (Bellman, 1957) – amplifies the effects of bounded rationality and leads to myopia. Thus, trembles *into myopia* provide a much-needed "technology of errors" (Kreps, 1990). It is readily seen that the two types of principal diverge in their optimal myopic strategies– the unconstrained principal always renegotiates the agent's payment down to zero, whereas the honest principal never does.

We let q_i and $(1 - q_i)$ denote the probabilities that the agent assigns at the beginning of period i to the principal being honest and unconstrained respectively. As the relationship proceeds, the agent updates his beliefs q_i in Bayesian fashion. All parameters c, V, p, N, m and q_1 are common knowledge. To avoid trivial cases, we assume that $p, m, q_1 \in (0, 1)$, and $N \geq 2$. For simplicity, no time discounting is considered. We denote the expected payoffs over N periods for the agent, the unconstrained principal and the honest principal by $\Pi^A(N), \Pi^u(N)$ and $\Pi^h(N)$ respectively.

3 Analysis

Observe that the unconstrained principal has access to two alternative strategies in stage 4 of any period: He can either renegotiate (thus revealing his type and ending the relationship) or mimic the

[2] Myopic policies ignore the effects of current actions on future periods, and hence, are rarely optimal in dynamic contexts (see Anand (2014) for an interesting exception). Yet, managers choose myopic policies for several reasons, including: an inability to navigate complex and multiple objectives (Conlisk 1996, Ethiraj and Levinthal 2009), incentive conflicts (Stein 1989, Noe et al 2012, Thanassoulis 2013), takeover threats (Stein, 1988), a looming equity offering (Mizik and Jacobson 2007) and a desire to signal their competence in the labor market (Laverty, 1996).

honest type and not renegotiate. Renegotiation in the first period itself would cut short the dynamic aspect of the relationship, collapsing the game into a trivial, single-period interaction. Hence, we focus on the more interesting case wherein the unconstrained Principal wants the relationship to continue for at least two periods, and hence mimics the honest type in stage 4 of the first period. Factors that favor the Principal's continuing the relationship beyond the first period are high values of: *(a)* the probability of success p in the next period, *(b)* prior probability q_1 of the principal being honest, and *(c)* the potential payoff V/c from future iterations of the relationship. A sufficient technical condition that we will assume for the rest of this paper is that $\frac{pV}{c} > \frac{2-p(1-q_1)}{pq_1}$.

We now derive the Perfect Bayesian Nash Equilibrium (PBNE) in pure strategies. Sufficient conditions for any contract to maximize the principal's payoffs are: *(i)* The agent exerts the first-best level of effort; and *(ii)* The agent's individual rationality constraint binds, i.e., she is indifferent between accepting and rejecting the offered contract. In our model, these translate to $e_i = 1$, $\forall i$ and $\Pi^A(N) = 0$. Theorem 1 proves that these conditions are met by a sequence of period-length, revenue-sharing contracts wherein the payment offered to the agent is $\alpha_i^x \tilde{V}_i$, where $0 \leq \alpha_i \leq 1$ and x, the principal's type $\in \{u, h\}$. All proofs are provided in the Technical Appendix (Section 5).

Theorem 1 *A pure-strategy PBNE for the dynamic (N-period) game, for* $N \geq 2$, *is as follows:*

Period j $(< N)$*: In stage 1, both types of the principal offer the revenue-sharing contract* $\alpha_j^* \tilde{V}_j$*, where* $\alpha_j^* = \frac{c}{(1-m(1-q_j))pV}$*. In stage 2, the agent sets* $e_j^* = 1$, if and only if *there was no renegotiation in periods* 1 *through* $(j-1)$*, after which the project value is realized in stage 3. In stage 4, the optimal dynamic strategy for both types of the principal is to not renegotiate, i.e., to pay* $\alpha_j^* \tilde{V}_j$ *to the agent. (However, renegotiation occurs when the principal is unconstrained and trembles into myopia with probability* m*.)*

Updated Beliefs: At the beginning of period $(j+1)$*, the agent's belief that the principal is honest is:*

$$q_{j+1} = \begin{cases} q_j, \ \text{if } \tilde{V}_j = 0 \ \text{(There is no room for the principal to renegotiate when } \tilde{V}_j = 0\text{)} \\ \frac{q_j}{q_j + (1-q_j)(1-m)}, \ \text{if } \tilde{V}_j = V \ \text{and the principal did not renegotiate in period } j \\ 0, \ \text{if } \tilde{V}_j = V \ \text{and the principal renegotiated in period } j \end{cases} \quad (1)$$

Period N*: In stage 1, both types of the principal offer the revenue-sharing contract* $\alpha_N^* \tilde{V}_N$*, where* $\alpha_N^* = \frac{c}{q_N pV}$*. In stage 2, the agent sets* $e_N^* = 1$, if and only if *there was no renegotiation in periods* 1 *through* $(N-1)$*, after which the project value is realized in stage 3. In stage 4, the unconstrained principal renegotiates (and pays* 0 *to the agent), whereas the honest principal pays* $\alpha_N^* \tilde{V}_N$ *to the agent.*

Theorem 1 reflects the differences in principals' strategies across the terminal and non-terminal periods. In the terminal period N, the unconstrained principal always renegotiates in equilibrium. In the non-terminal periods 1 through $(N-1)$, the strategies of both types of the principal are to not renegotiate; yet, the risk of renegotiation is not entirely eliminated because of the possibility of trembles into myopia. The offers of $\alpha_j^* = \frac{c}{(1-m(1-q_j))pV}$ for $j = 1, ..., N-1$ and $\alpha_N^* = \frac{c}{q_N pV}$ reflect the respective probabilities $(1-m(1-q_j))$ and q_N of no renegotiation, keeping the agent just indifferent between accepting and rejecting the contract.

The next Theorem proves that for a repetitive relationship of *any* length $(N \geq 2)$, the honest principal's payoffs are *strictly* greater than those of the unconstrained principal under plausible conditions.

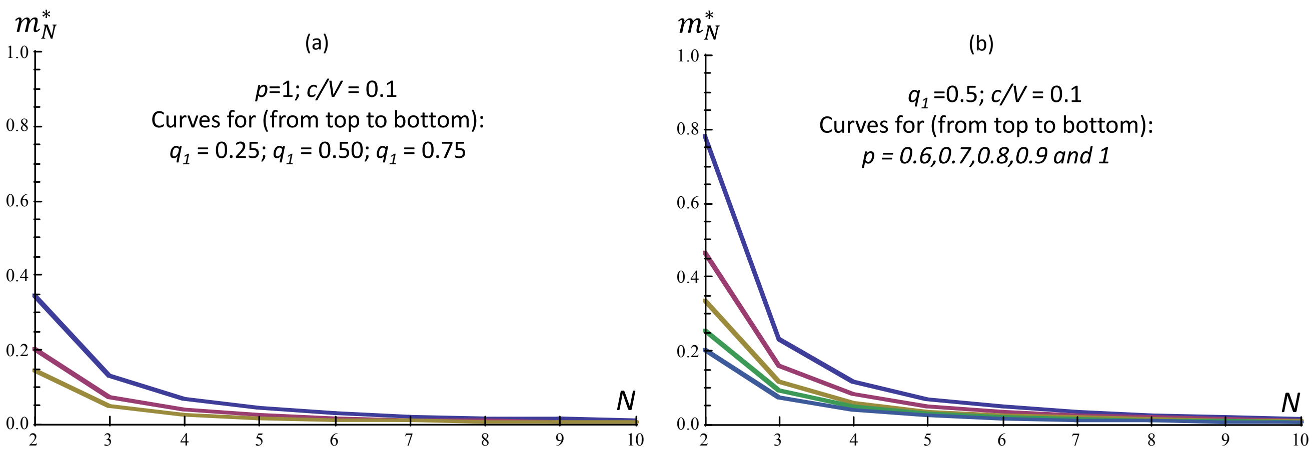
Theorem 2 *(i)* $\forall N \geq 2$, $\exists m_N^* \in (0,1)$ *such that* $\Pi^h(N) > \Pi^u(N)$ if $m > m_N^*$.

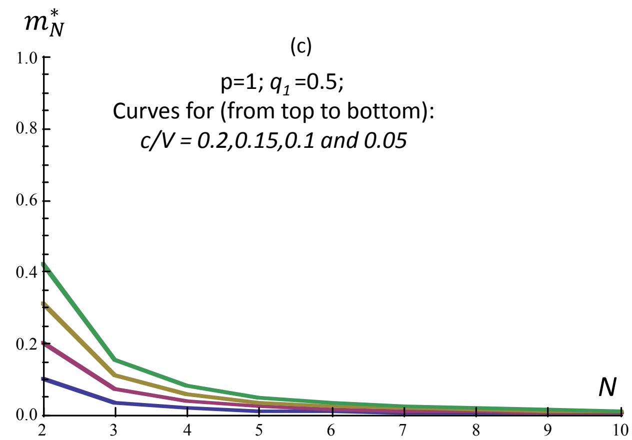
(ii) m_N^* *is strictly decreasing in* N.

(iii) $\lim_{N\to\infty} m_N^* = 0$.

(iv) $\forall N$, m_N^* *is strictly decreasing in* q_1, p *and* $\frac{V}{c}$.

Part *(i)* of Theorem 2 shows that for any N, including even for just one repetition of the relationship $(N = 2)$, the honest type's payoffs can be strictly greater than the unconstrained type's. Part *(ii)* of the Theorem proves that m_N^* is strictly decreasing in N. Thus, as N increases, the honest type's payoffs are greater than the unconstrained type's for progressively smaller trembling probabilities that asymptotically converge to 0 by part *(iii)* of the Theorem. Part *(iv)* formalizes the intuition that since trembles by the unconstrained type abruptly terminate the game, parameter values that increase future expected payoffs– high p, q_1 and V/c– favor the honest type.





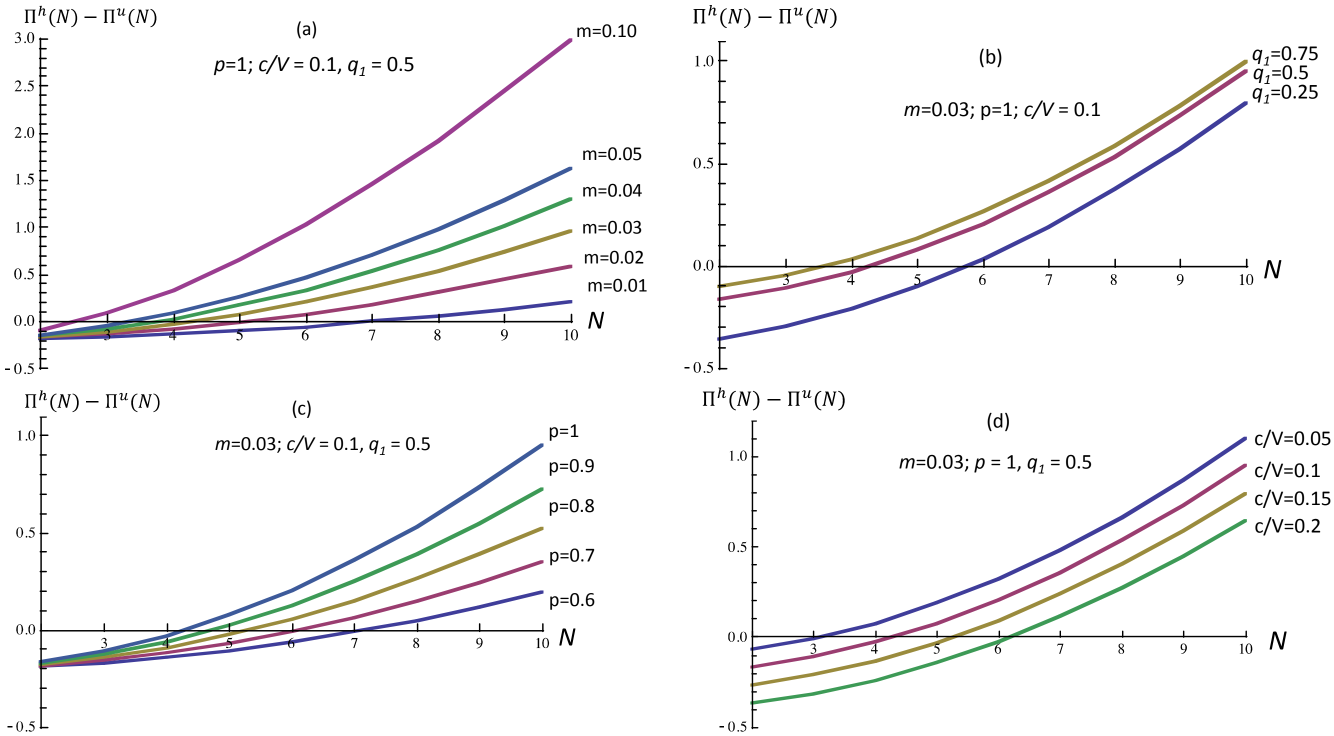
Figures 2 (a)-(c): m_N^* plotted against N for different parameter values

Figures 2(a)-(c) illustrate Theorem 2 for varying values of N, p, q_1 and V/c. As N, p, q_1 or V/c increase, m_N^* falls; hence, the honest type outperforms the unconstrained type at ever smaller m. The effect of N is particularly dominant: As N grows, m_N^* falls rapidly for any combination of p, q_1 and V/c, and becomes very small beyond $N \approx 6$.

The next Theorem fixes the trembling probability m and analyzes the effect of varying the number of interactions N.

Theorem 3 *(i)* $\forall m \in (0,1)$, $\exists N_m^*$ *such that* $\Pi^h(N) > \Pi^u(N)$ *if* $N > N_m^*$.
(ii) N_m^* *is decreasing in* m, q_1, p *and* $\frac{V}{c}$.

Theorem 3 proves that for any arbitrary trembling probability m, howsoever small, the honest type will outperform the unconstrained type provided the relationship is repeated long enough (for more than N_m^* periods). Figures 3(a)-(d) show that $\Pi^h(N) - \Pi^u(N)$ increases with N and intersects the x-axis at or just to the right of N_m^*. Consistent with part *(ii)* of Theorem 3, N_m^* is decreasing in m, q_1, p and $\frac{V}{c}$ in the figures. In all cases, N_m^* is quite modest– ranging from 2 to 7 periods. In practice, a period itself could consist of many potentially type-revealing interactions, whereas our model allows at most one tremble per period. To summarize, honesty is a robust strategy under bounded rationality, and can outperform unconstrained profit-maximization even in relationships spanning a limited number of interactions.



Figures 3(a)-(d): Profit difference between honest and unconstrained types of Principal for different parameter values.

3.1 Implications for IT Outsourcing

Incomplete contracts are ubiquitous in IT outsourcing, *cf.* Susarla (2012) – by depriving firms on either side of the contract of adequate legal recourse, unanticipated outcomes can lead to a whole host of problems for firms including: breach of the 'spirit' of the contract / opportunistic or 'bad-faith' behavior (or the perception of such), financial losses, disputes, dissatisfaction, legal liabilities and the souring of relationships. The remedies proposed by extant IT outsourcing literature, largely based on an empirical analysis of outsourcing contracts, include non-price contractual provisions such as extendability terms (Susarla *et al* 2010), decision-rights and flexibility provisions in contracts (Susarla 2012), reputations (Banerjee and Duflo 2000), the salutary effects of networks (Ravindran *et al* 2015), etc.

Our model of incomplete outsourcing contracts with adverse selection and moral hazard complements the growing empirical literature on IT outsourcing. We extend the current framework of IT outsourcing to include features that are demonstrably important in any real-world contracting model: ethics (modeled through 'honesty') and bounded rationality (modeled through 'trembles into myopia'). We show that both these, when interwoven appropriately with classical models of incomplete contracts, provide a simple yet robust explanation for why so many outsourcing contracts thrive without complex contractual remedies or extreme measures such as vertical integration. Our model and analysis subsume traditional reputation effects – as noted in the introduction, commitment types of reputation models (such as firms committed to honesty) fail to meet the bar of Economic Darwinism. One needs to show, as we do, why indeed would honesty survive in the first place. An appeal to relational contracts also becomes less alluring in light of the somewhat puzzling phenomenon raised by Ravindaran *et al* (2015) , in that "...IT outsourcers frequently cultivate a portfolio of multiple vendors...when theory of relational contracts would predict that firms ought to contract repeatedly with a few trusted partners." Our model provides a possible resolution: if honest firms are numerous enough, then contracting with multiple firms for different projects is less hazardous even when institutional governance (such as courts of law) are minimally available.

3.2 Extensions

We discuss some possibilities for both thematic and technical extensions of our model.

Thematic Extensions:

Stage-gate projects: Our multiperiod model can be adapted to study *stage-gate* projects (Cooper, 2001) where a project is divided into several, discrete milestones (or stages), with each period in our model corresponding to a stage. The stage-gate contract specifies a payment to the agent conditional on each milestone achieved. Such contracts are widely used in large IT outsourcing projects, as well as in construction and pharmaceutical industries, where moral hazard and opportunistic renegotiation are endemic.

Other ethical contexts: Our model narrowly equated ethical behavior to eschewing opportunistic renegotiation, for several reasons: *(i)* First, there is ample extant research on opportunism going back to Williamson (1975) and Klein *et al* (1978), and so the context is well understood. *(ii)* Unwillingness to renegotiate opportunistically is a conservative and non-controversial ethical construct. *(iii)* Our setting is a natural extension of the classical literature on reputations and incomplete contracts. Future research could adapt our model to other kinds of ethics and ethical contexts.

Ethics in Societies: Our model suggests two factors that could drive ethical choices and outcomes in societies: *(i) Regulatory complexity*, which blurs the distinction between complete and incomplete contracts, and exacerbates the effects of bounded rationality, whose degree is measured by m in our model; and *(ii) Societal inter-dependence* (or, how "close-knit" the society is, similar to *Relational embeddedness* of Ravindran *et al* 2015), for which a proxy measurement is provided by N, the extent of repetition in interactions. The two variables m and N together determine a tipping point for the self-enforcement of honesty: if $m > m_N^*$, the result $\Pi^h(N) > \Pi^u(N)$ should nudge the fraction of honest players in the population to 1. Conversely, if $m < m_N^*$, the fraction of honest players would converge to 0. This raises interesting questions for future research about optimal regulatory structures and the evolution of ethical norms.

Technical Extensions:

The assumptions of binary support for effort and realized project values (e_i and $\tilde{V}_i(e_i)$ respectively, for $i \in \{1, ...N\}$) facilitated the derivation of closed-form equilibria. We expect our key insights to hold under continuous support for effort and project values. As discussed, trembles into myopia provide an appealing "technology of errors" (Kreps, 1990) in dynamic contexts through the "curse of dimensionality" (Bellman, 1957). Future research could extend our model to continuous support for e_i or $\tilde{V}_i(e_i)$ and different kinds of trembles.

4 Postscript: Ethics and Neoclassical Economics

It seems to us that two elements are indispensable for any meaningful modeling of ethics within the traditions of neoclassical economics. The first element is a platform or context in which ethical (and unethical) decisions are meaningful choices. *Complete* contracts leave no wiggle room for actions guided by ethical concerns: Contractual/legal terms supplant ethical considerations by accounting for all contingencies. Viewed in this light, our context of incomplete contracts, far from being restrictive, is in fact a *necessary* condition for studying ethical behavior in contractual relationships. A second necessary element is one or more actors with *ethical free agency*, which we define and explain next.

4.1 Ethical Free Agency

The *homo economicus / rational* agent of neoclassical economics is an unconstrained (and unabashed) profit (or utility) maximizer, thus representing the pinnacle of *economic* free agency (or, 'free will'). Analogous to economic free agency, we define *ethical* free agency as the freedom to *choose* either to act ethically or to deviate from ethical norms, even when ethical considerations are not aligned with profit maximization. Ethical free agency is predicated on a *deliberate* choice, and excludes involuntary ethical behavior under legal or contractual constraints. Similarly, the *instrumental* ethicism of the rational agent in reputation models, in the service of profit-maximization, does not constitute ethical free agency. As noted earlier, the rational agent's instrumental ethicism facilitates garbling the distinction between honesty, rooted in ethical free agency, and a reputation for honesty which serves economic free agency.

We argue that any meaningful model of ethics must incorporate at least one player who can exercise ethical free agency, whereas, precisely because of his relentless commitment to profit maximization, the *homo economicus* of traditional economic models has *zero* ethical free agency. In the spirit of minimalism, our model incorporates a principal who is one of two types– unconstrained or honest profit-maximizer, possessing the maximum possible economic and ethical free agency respectively. The honest principal has a lexicographic preference for ethics (honesty) over profit-maximization, while the unconstrained principal has the reverse lexicographic preference.

4.2 Ethics and Economic Darwinism

A further difficulty arises: Rational agents, by convention, can reason and calculate to infinite depth instantly, costlessly and effortlessly. Thus, the perfectly rational player will always outperform any commitment type, including one committed to ethics, by selectively imitating the latter's strategy, as in reputation models. One troubling implication, based on economic Darwinism, is that ethical agents would be gradually weeded out of the population by rational agents.

One approach taken to address this concern is the use of utility functions augmented to reward specific behavioral traits, *cf* Rabin (1993, 1998), Fehr and Schmidt (1999), Bolton and Ockenfels (2000). In our view, actors with such enhanced utility functions have no more ethical free agency than the perfectly rational profit maximizer since the alignment of their utility-maximization with ethical behavior, from the actors' perspective, is involuntary and accidental. Frank (1987) takes a different approach: An agent is rewarded exogenously, not for his own honest behavior, but for transacting with an honest partner. Moreover, honesty can be signalled, even if imperfectly, before interactions occur. To his credit, Frank (1987)'s honest agent exercises ethical free agency, as does ours.

However, in our model, honesty is not exogenously rewarded with higher utilities or payoffs, nor can it be signaled *ex ante* as in much of the extant literature; see Sethi and Somanathan (2003) for an excellent review. Our research program addresses a foundational question at the heart of any unified theory of ethics and economics: *Does a commitment to ethics sabotage profits?* In other words, without special, exogenous utilities or payoffs, is ethical free agency fundamentally irreconcilable with economic free agency, whose goal is profit / utility maximization? Our research shows that the answer is no, and suggests that bounded rationality is a *sine qua non* for such an outcome. To enable reasonable profit-comparisons, both the unconstrained and honest types must be equally vulnerable to bounded rationality, as in our model. Williamson (1989) wrote presciently: "Those forms of organization that serve to *economize on bounded rationality* and *safeguard transactions against the hazards of opportunism* will be favored... [Emphasis ours]." We can extend Williamson (1989)'s twin criteria to evaluate which "types" of players will be favored. Honesty delivers on both of Williamson (1989)'s criteria– by trimming his set of feasible strategies, the honest type protects himself against trembles and thus "economizes on bounded rationality". In addition, honesty intrinsically "safeguards transactions against the hazards of opportunism". In contrast, the complex "selective imitation" strategy of the unconstrained (opportunistic) type is vulnerable to trembles and performs poorly under Williamson (1989)'s first criterion, of "economizing on bounded rationality".

It should be self-evident that not all kinds of commitments lead to superior performance. We can prove that a *myopic* type– one who renegotiates at every opportunity for immediate gains– is always outperformed by the unconstrained type in our model. Certain commitments, such as honesty, are superior to others. Identifying ethical commitments that can survive economic Darwinism seems to be a worthwhile research program for extending the reach of positive economics into ethics.

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5 Technical Appendix

5.1 Proof of Theorem 1.

Lemma 1 (i) *The dominant strategy for the unconstrained type of principal is to renegotiate in stage 4 of the terminal period N.*

(ii) *If* $q_i = 0$, *then* $e_j = 0 \; \forall j \in \{i, i+1, ..., N\}$.

Proof. (i) Profit by renegotiating in the terminal period $N = \tilde{V}_N(e_N) \geq (1 - \alpha_N^u)\tilde{V}_N(e_N)$, the profit without renegotiating, since $\alpha_N^u \geq 0$.

(ii) If $q_i = 0$, then $q_j = 0 \; \forall j \in \{i, i+1, ..., N\}$. By part (i), the unconstrained type of principal renegotiates in stage 4 of the terminal period N; and since $q_N = 0$, the agent's best-response is $e_N^* = 0$ in stage 2. Hence, the unconstrained principal renegotiates in stage 4 of period $N-1$, the agent responds with $e_{N-1}^* = 0$ since $q_{N-1} = 0$, and the result unravels by backward induction.

■

To prove Theorem 1, we proceed for now with the assumption that the equilibrium strategy of the unconstrained type of principal is to not renegotiate in stage 4 of the non-terminal periods. We will prove that the assumption holds under our proposed equilibrium. The honest principal never renegotiates and Lemma 1 has established the unconstrained principal's strategy in the terminal period. With the principal's equilibrium strategy in stage 4 thus settled, we derive a Perfect Bayesian Nash equilibrium in terms of (i) the contract offered by the principal in stage 1; (ii) the agent's beliefs after stage 1; and (iii) the agent's investment strategy in stage 2.

Consider stage 1 of any period $i \in \{1, ..., N\}$: A pure strategy (separating) equilibrium where $\alpha_i^u \neq \alpha_i^h$ is easily ruled out since the agent *must* assign a belief $\hat{q}_i = 0$ after stage 1 upon observing $\alpha_i^u \left(\neq \alpha_i^h\right)$, resulting in 0 continuation payoff for the unconstrained principal in periods $j \in \{i, i+1, ..., N\}$ per Lemma 1. Consider, therefore, a pooling equilibrium in stage 1 where $\alpha_i^u = \alpha_i^h = \alpha_i^* \; \forall i \in \{1, ..., N\}$ and the agent's belief after stage 1 of period $i \in \{1, ..., N\}$ is:

$$\hat{q}_i = \begin{cases} q_i \text{ if } \alpha_i^x = \alpha_i^* \text{ where } x \in \{u, h\} \\ 0 \text{ otherwise} \end{cases} \tag{2}$$

The agent's belief of equation (2) satisfies the Intuitive Criterion of Cho and Kreps (1987). Moreover, $q_i > 0$ for any $i \in \{1, ..., N\}$ or the game never proceeds to period i.

Define $I_{\{e_i=1\}} = 1$ if $e_i = 1$ and 0 otherwise. Also, $\Pi^x(K, \cdot)$ is the expected continuation payoff of the Principal of type x where $x \in \{h, u\}$ with $K \leq N$ periods to go, and π_i^A is the agent's expected payoff in period $i \in \{1, ..., N\}$. In stage 1 of period $i \in \{1, ..., N-1\}$, i.e., with $N-i+1$ periods to go including the i^{th} period, the honest type of principal solves the following program which maximizes his expected continuation payoff subject to the individual rationality constraint (IRC) of the agent (the unconstrained type of principal mimics and solves an identical program in the pooling equilibrium):

$$\begin{aligned}
&\Pi^h (N-i+1, q_i) = \max_{0 \leq \alpha_i \leq 1} \left((1-\alpha_i) \tilde{V}_i (e_i) + \Pi^h (N-i, q_{i+1}) \right) \\
&s.t. \\
&0 \leq \pi_i^A = \max_{e_i \in \{0,1\}} \left((1 - m(1-q_i)) \alpha_i pV - c \right) I_{\{e_i=1\}}, \\
&\text{where } q_{i+1} = \frac{q_i}{q_i + (1-m)(1-q_i)}, \text{ and} \\
&\Pi^h (1) = \max_{0 \leq \alpha_N \leq 1} (1-\alpha_N) \tilde{V}_N (e_N) \\
&s.t. \\
&0 \leq \pi_N^A = \max_{e_N \in \{0,1\}} (q_N \alpha_N pV - c) I_{\{e_i=1\}}
\end{aligned}$$

$\Pi^h (1)$ is the honest principal's expected payoff in the terminal period. By Lemma 1, the agent is paid in the terminal period only when $\tilde{V}_N (1) = V$ and the principal is of the honest type (the probabilities of which are p and q_N respectively). The agent invests, i.e., $e_N = 1$, whenever $\alpha_N \geq \frac{c}{q_N pV} = \alpha_N^*$. Hence, in equilibrium, the principal optimally offers $\alpha_N = \alpha_N^*$ (< 1 under our technical condition) so that $e_N^* = 1$ and the IRC binds for the agent. In the non-terminal period i, $m(1-q_i)$ is the probability of renegotiation through trembles by the unconstrained principal, and hence, $(1 - m(1-q_i))$ is the probability that the agent is paid his contractual share in the event $\tilde{V}_i (1) = V$. The agent invests, i.e., $e_i = 1 \; \forall i \in \{1, ..., N-1\}$ whenever $\alpha_i \geq \frac{c}{(1-m(1-q_i))pV} = \alpha_i^* (< 1)$. In equilibrium, both types of principal optimally offer $\alpha_i = \alpha_i^* \; \forall i \in \{1, ..., N-1\}$ so that $e_i^* = 1$ and IRC binds for the agent.

Finally, we prove that the unconstrained type of principal has no profitable deviation under the proposed equilibrium from his (assumed) strategy of not renegotiating in the non-terminal periods. Consider $N = 2$ first. On the equilibrium path, it is optimal for the unconstrained principal to not renegotiate in stage 4 of period 1 because the incremental gain from renegotiation $(\alpha_1^* V)$ is less than the expected future payoff (pV) under our technical condition, i.e., $\alpha_1^* < p$ whenever $\frac{pV}{c} > \frac{2-p(1-q_1)}{pq_1}$. Observe that q_i is non-decreasing in i, hence $\alpha_i^* \leq \alpha_1^* < p \; \forall i \in \{2, ..., N-1\}$, which completes the proof of Theorem 1 for all $N \geq 2$.

5.2 Intermediate results (used in proofs of Theorems 2 and 3)

We establish expressions for $\Pi^h(N)$ and $\Delta\Pi(N) \equiv \Pi^h(N) - \Pi^u(N)$. Observe from equation 1 that the agent updates his belief only when $\tilde{V}_i(1) = V$**.** Hence, consider only the 'successful' periods (where $\tilde{V}_i(1) = V$). Denote by $q_{(k)}$ the agent's belief in a period when there have been $k \geq 0$ successful investments in prior periods. Denote by $\alpha^*_{(k),T}$ and $\alpha^*_{(k),NT}$ the equilibrium contractual shares in the terminal (T) and non-terminal (NT) periods respectively when there have been $k \geq 0$ successful investments in prior periods. Then,

$$q_{(k)} = \begin{cases} q_1 \text{ for } k = 0, \text{ and} \\ \frac{q_{(k-1)}}{q_{(k-1)}+\left(1-q_{(k-1)}\right)(1-m)} = \frac{q_{(0)}}{q_{(0)}+\left(1-q_{(0)}\right)(1-m)^k} \text{for } 1 \leq k \leq N. \end{cases} \tag{3}$$

(Note that $q_{(0)} \equiv q_{1.}$) From Theorem 1 and equation (3), the equilibrium contractual payoffs in the non-terminal and terminal periods respectively are:

$$\alpha^*_{(k),NT} = \frac{c}{(1-m(1-q_{(k)}))pV} = \frac{c}{pV}\left(\frac{q_{(0)} + (1-q_{(0)})(1-m)^k}{q_{(0)} + (1-q_{(0)})(1-m)^{k+1}}\right), \text{ and} \tag{4}$$

$$\alpha^*_{(k),T} = \frac{c}{q_{(k)}pV} = \frac{c}{pV}\left(\frac{q_{(0)} + \left(1-q_{(0)}\right)(1-m)^k}{q_{(0)}}\right). \tag{5}$$

Since $\alpha^*_{(k),NT}$ and $\alpha^*_{(k),T}$ are decreasing in k, and since $\alpha^*_{(k),T} > \alpha^*_{(k),NT}$ from equations (4) and (5), it follows that

$$\alpha^*_{(0),T} \geq \max\left(\alpha^*_{(k),NT}, \alpha^*_{(k),T}\right) \ \forall k \geq 0. \tag{6}$$

Let s_N be the number of successful investments prior to period N. The honest principal's total expected payoff over N periods is:

$$\Pi^h(N) = \Pi^h(N\,|s_N = 0)\Pr(s_N = 0) + \sum_{j=1}^{N-1} \Pi^h(N\,|s_N = j)\Pr(s_N = j)$$

$$\begin{aligned} \Rightarrow \Pi^h(N) = \quad & (1-p)^{N-1}p\left(1-\alpha^*_{(0),T}\right)V \\ & + \sum_{s_N=1}^{N-1}\left[\binom{N-1}{s_N}p^{s_N}(1-p)^{N-1-s_N}\left(\sum_{k=0}^{s_N-1}\left(1-\alpha^*_{(k),NT}\right)V + p\left(1-\alpha^*_{(s_N),T}\right)V\right)\right] \end{aligned} \tag{7}$$

From equation (7) and inequality (6):

$$\Pi^h(N) > Np\left(1 - \alpha^*_{(0),T}\right)V \tag{8}$$

Finally, note that:

$$\begin{aligned}\Delta\Pi(N) &= \sum_{T=1}^{N-1}\sum_{s_T=0}^{T-1}\left[\binom{T-1}{s_T}p^{s_T+1}(1-p)^{T-1-s_T}(1-m)^{s_T}\, m\left(-\alpha^*_{(s_T),NT}V + \Pi^h(N-T, q_{(s_T+1)})\right)\right] \\ &+ \sum_{s_N=0}^{N-1}\left[\binom{N-1}{s_N}p^{s_N+1}(1-p)^{N-1-s_N}(1-m)^{s_N}\left(-\alpha^*_{(s_N),T}V\right)\right] \end{aligned} \tag{9}$$

where s_T are the number of successful investments prior to period T. The first term is the expected difference in payoffs between the two types when the unconstrained type trembles in a period $T \leq N-1$, and the second term is the expected difference in payoffs when the unconstrained type does not tremble.

5.3 Proof of Theorem 2

We first prove that $\Delta\Pi(N, q_1)$ is strictly increasing in N.

Proof that $\Pi(N)$ strictly increases in N. Note that:

$$\Delta\Pi(N+1, q_1) \equiv \Delta\Pi(N+1, q_{(0)}) = (1-p)\Delta\Pi(N, q_{(0)}) + p\left(m\left(-\alpha^*_{(0),NT}V + \Pi^h(N, q_{(1)})\right) + (1-m)\,\Delta\Pi(N, q_{(1)})\right),$$

where $q_{(k)}$ is given by equation (3). Rearranging terms and noting that $\Delta\Pi(N, q_{(0)}) = \Pi^h(N, q_{(0)}) - \Pi^u(N, q_{(0)})$, we get:

$$\Delta\Pi(N+1, q_{(0)}) = (1-p)\Delta\Pi(N, q_{(0)}) + p\left(\Pi^h(N, q_{(1)}) - m\alpha^*_{(0),NT}V - (1-m)\Pi^u(N, q_{(1)})\right). \tag{10}$$

Since it is suboptimal for the unconstrained type to renegotiate in the first period (from Theorem 1), $\alpha^*_{(0),NT}V < \Pi^u(N, q_{(1)})$. Thus,

$$\Delta\Pi(N+1, q_{(0)}) > (1-p)\Delta\Pi(N, q_{(0)}) + p\Delta\Pi(N, q_{(1)}) > \Delta\Pi(N, q_{(0)})$$

The last inequality follows from: (i) $q_{(1)} > q_{(0)}$ from equation (3), and (ii) $\Delta\Pi(N, q_{(0)})$ is increasing in $q_{(0)}$, straightforward to prove from equations (4), (5), (7) and (9).

■

We now formally prove Theorem 2.

Proof of parts (i) **and** (ii)**.** Consider $N = 2$ first. From equation (9), $\Delta\Pi(2) = mp^2V - \frac{m}{1-m(1-q_1)} - \frac{(1-pm(1-q_1))c}{q_1}$. Hence, $\Delta\Pi(2) > 0 \iff \frac{p^2V}{c} > \frac{1}{1-m(1-q_1)} + \frac{1-pm(1-q_1)}{mq_1}$. Define $f(m) = \frac{1}{1-m(1-q_1)} + \frac{1-pm(1-q_1)}{mq_1}$, which is a convex function of m because $\frac{\partial f^2(m)}{\partial m^2} = \frac{2}{m^3 q_1} + \frac{2(1-q_1)^2}{(1-m(1-q_1))^3} > 0$ for $q_1, m \in (0,1)$. Since $\lim_{m\to 0^+} f(m) = +\infty > \frac{p^2V}{c} > \frac{2-p(1-q_1)}{q_1}$ (by assumption) $= f(1)$, and $f(m)$ is convex and continuous, there exists $m_2^* \in (0,1)$ that is the smaller root of the quadratic equation $\frac{p^2V}{c} = f(m)$, such that $\frac{p^2V}{c} < f(m)$ for $m \in (0, m_2^*)$ and $\frac{p^2V}{c} > f(m)$ for $m \in (m_2^*, 1)$. It follows that $\Delta\Pi(2) > 0$ or $\Pi^h(2) > \Pi^u(2)$ iff $m \in (m_2^*, 1)$.

Now consider $N = 3$. Because $\Delta\Pi(N)$ is strictly increasing in N, $\Delta\Pi(3) > \Delta\Pi(2) > 0$ for $m \in (m_2^*, 1)$. Moreover, it can easily be shown $\forall N \geq 2$ that: (i) $\Delta\Pi(N)$ is continuous in m and (ii) $\Delta\Pi(N) < 0$ for $m = 0$. Hence, there must exist $0 < m_3^* < m_2^*$, such that $\Delta\Pi(3) > 0$ for all $m \in (m_3^*, 1)$. By extension, there exists a strictly decreasing sequence $m_2^* > m_3^* > ... > m_{(N-1)}^* > m_N^* > 0$ for all $N \geq 2$, such that $\Delta\Pi(N) > 0$ or $\Pi^h(N) > \Pi^u(N)$ for $m > m_N^*$. ■

Proof of part (iii)**.** We prove part (iii) by contradiction. Suppose $\lim_{N\longrightarrow\infty} m_N^* = \epsilon > 0$. (The limit exists from the Monotone Convergence Theorem, *cf* Abbott 2001[3].) Then, $\exists m \in (0, \epsilon)$ which contradicts part (i) of Theorem 3. Hence, $\epsilon = 0$, i.e., $\lim_{N\longrightarrow\infty} m_N^* = 0$. ■

Proof of part (iv)**.** We prove part (iv) only for q_1. (Proof for other parameters is analogous and available from the authors.) It is straightforward to show, from equations (4), (5), (7) and (9), that $\Delta\Pi(N)$ is strictly increasing in q_1 $\forall m \in (0,1)$. Hence, for any $q_1' > q_1$, $\Delta\Pi(N, q_1') > \Delta\Pi(N, q_1) > 0$ $\forall m \in (m_N^*, 1)$. Moreover, since $\forall N \geq 2$, $\Delta\Pi(N, q_1)$ is continuous and $\Delta\Pi(N, q_1)|_{m=0} < 0$ $\forall q_1 \in (0,1)$, there must exist $0 < m_N'^* < m_N^*$ such that $\Delta\Pi(N, q_1') > 0$ for all $m \in (m_N'^*, 1)$. ■

5.4 Proof of Theorem 3

Proof of part (i)**.** We construct a lower bound $G(N)$ for $\Delta\Pi(N) = \Pi^h(N) - \Pi^u(N)$ so that $\Delta\Pi(N) > 0$ whenever $G(N) > 0$. Bounding $\Delta\Pi(N)$ of equation (9) by using inequalities (6) and (8),

[3] Abbott, Stephen. 2001. Understanding Analysis. Springer.

we get:

$$\begin{aligned}
\Delta\Pi(N) &> \sum_{T=1}^{N-1}\sum_{s_T=0}^{T-1}\left\{\binom{T-1}{s_T}p^{s_T+1}(1-p)^{T-1-s_T}(1-m)^{s_T}\,m\left(-\alpha^*_{(0),T}V+(N-T)p\left(1-\alpha^*_{(0),T}\right)V\right)\right\} \\
&\quad +\sum_{s_N=0}^{N-1}\left\{\binom{N-1}{s_N}p^{s_N+1}(1-p)^{N-1-s_N}(1-m)^{s_N}\left(-\alpha^*_{(0),T}V\right)\right\} \\
&> \left(1-(1-mp)^{N-1}\right)\left(-\alpha^*_{(0),T}\right)V+\left(\frac{Nmp-1+(1-mp)^N}{m}\right)\left(1-\alpha^*_{(0),T}\right)V \\
&\quad +p(1-mp)^{N-1}\left(-\alpha^*_{(0),T}V\right) \\
&> -\alpha^*_{(0),T}V+\left(\frac{Nmp-1}{m}\right)\left(1-\alpha^*_{(0),T}\right)V-\alpha^*_{(0),T}V=G(N)
\end{aligned}$$

Thus, $G(N)>0\Rightarrow\Delta\Pi(N)>0$. And $G(N)>0$ iff $N>\frac{2\alpha^*_{(0),T}}{p\left(1-\alpha^*_{(0),T}\right)}+\frac{1}{mp}=\frac{2c}{p(pq_1V-c)}+\frac{1}{mp}$ (since $\alpha^*_{(0),T}=\frac{c}{pq_1V}$ from Theorem 1). It therefore follows that $\Delta\Pi(N)>0$ for all $N>\lceil\frac{2c}{p(pq_1V-c)}+\frac{1}{mp}\rceil$.
■

Proof of part (ii)**.** It can be shown that $\Delta\Pi(N)$ of equation (9) is strictly increasing in p, V, q_1, and decreasing in c. (The proofs are technical in nature and are omitted.) Hence, the threshold value of N above which $\Delta\Pi(N)>0$ must be decreasing in p, V, q_1, and increasing in c. (That such a threshold exists is proved in part (i).) Finally, that this threshold value of N decreases in m follows from parts (i), (ii) and (iii) of Theorem 2 (details available from the authors). ■