Crafting the Enterprise:
An Analysis of the Implementation and Evolution of an Extended Enterprise
for New Product Development, from the Perspectives of
Organizational Economics and Architectural Partitioning

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Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Engineering and Management

at the
Massachusetts Institute of Technology
June, 2001

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Abstract
The Extended Enterprise approach to product development holds the promise of delivering best in class products to the market in benchmark time, by leveraging leading suppliers, both internal and external to the larger firm, as technology development and module design and manufacturing partners. Recent work in organizational economics, by R. Gibbons, co-workers, and others, dealing with relational contracts within and between firms provides an initial formal theory of the structuring of cross-boundary relationships. Firms are also gaining experience implementing effective Extended Enterprise product development programs.

This thesis seeks to bring together the formal theory of organizational economics and the practice of Extended Enterprise product development to understand the fundamental causals and underlying rationality of the observed outcomes, in the particular engineering context of complex, architected products and the organizational context of large corporations. The thesis consists of four sections: (1) exposition of the basic theory of organizational economics judged applicable to Extended Enterprise product development; (2) extension of the theory to reflect product architectural partitioning decisions, and development of the resultant implications for the Extended Enterprise; (3) synthesis of the salient features of two extensive case studies of the decision sequences in an Extended Enterprise product development program, including analysis of the associated formal contracts; and (4) development of an expanded framework for placing the observed practice of Extended Enterprise within the analytical and structural constructs previously presented, leading to greater clarity of understanding of the fundamentals driving the observed outcomes, insights on effective structuring of the Extended Enterprise, and areas for useful model extension. The thesis concludes with a discussion of internal and external suppliers in the Extended Enterprise, and the critical role of company governance in crafting and sustaining the required relationships.

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Acknowledgements

I would like to express my sincere thanks to Professor Robert Gibbons for his guidance and expertise, shared insights, beneficial comments, willing accommodation, and good humor in the process leading to creation of this thesis. I also wish to thank the staff of the MIT System Design and Management Program, my SDM colleagues, and my company management for supporting me in this endeavor. A particularly strong acknowledgement and heartfelt thank-you go to the managers and staff who provided access to the materials and gave generously of their time to construct the industrial case studies abstracted in this thesis. Unfortunately, the agreed conditions for reporting the studies preclude me from identifying them here. And finally, a special thanks to my wife Jan and to my family, for seeing me through the two years of the SDM Program.
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Introductory Summary and Thesis Conclusions

The Extended Enterprise approach to product development holds the promise of delivering best in class products to the market in benchmark time, by leveraging leading suppliers, both internal and external to the larger firm, as technology development and module design and manufacturing partners. Given the risks and uncertainties of product development with significant new technology and design content, these partnerships are intended to reflect strategic relationships rather than commodity outsourcing.

Recent work in organizational economics, by R. Gibbons, co-workers, and others dealing with relational contracts within and between firms within the dynamic repeated game context of sequences of projects, provides an initial formal theory of the structuring of cross-boundary relationships. The focus is on incentives and relational versus formal contracts, from the viewpoint of the decision of whether to integrate and the different relational contracts facilitated by asset ownership.

Firms are also gaining experience implementing effective Extended Enterprise product development programs. For the current work, a case rich in implications for the structure and decision making processes for Extended Enterprise product delivery was identified. The program made a decision to bring in an outside supplier in what is generally considered a core internal technology competence. In another area, the program shut off a previous external partner for a module and switched to an internal supplier.

This thesis seeks to bring together the formal theory of organizational economics and the practice of Extended Enterprise product development to understand the fundamental causals and underlying rationality of the observed outcomes, in the particular engineering context of complex, architected products and the organizational context of large corporations. On the organizational side, this requires that consideration be given to the more complex relationships that exist in a large corporation, with corporate as well as multiple, individual product program interests all potentially interacting with suppliers. On the engineering side, system architecture and partitioning choices and engineering and technology decisions determine the “portability” of
the work product and the value associated with unique, custom enhancements and adaptations. Thus system design considerations interact with the organizational economics in ways that need to be understood to clarify how the Extended Enterprise functions in this product development environment.

The thesis consists of four sections: (1) exposition of the basic theory of organizational economics judged applicable to Extended Enterprise product development; (2) extension of the theory to reflect product architectural partitioning decisions, and development of the resultant implications for the Extended Enterprise; (3) synthesis of the salient features of two extensive case studies of the decision sequences in an Extended Enterprise product development program, including analysis of the associated formal contracts; and (4) development of an expanded framework for placing the observed practice of Extended Enterprise within the analytical and structural constructs previously presented, leading to greater clarity of understanding of the fundamentals driving the observed outcomes, insights on effective structuring of the Extended Enterprise, and areas for useful model extension. Sections 2, 3, and 4 constitute original work.

The first section develops the basic model constructs that provide the foundation for the subsequent model and structural extensions, and the vocabulary for the analysis of observed practice. The basic principal-agent model, the structure of a supply transaction, incomplete formal contracts, relational contracts and repeated games, organizational forms parsed by governance environment and asset ownership, and the Baker-Gibbons-Murphy organizational economics model of self-enforcing relational contracts and efficient organizational forms are covered.

In Section 2, the Baker-Gibbons-Murphy model is extended to encompass product architecture and partitioning decisions, with terms reflecting “modularization” and “customization.” A modularity metric is defined in this context. The mathematics of the model are developed to quantify the functional dependencies and parameter values leading to first-best and second-best economic outcomes, and the path along the effective discount rate axis is mapped, tying together the efficient organizational forms and boundaries, the optimal bonus levels, the action magnitudes and their relationships to first-best, and the total social surplus created.
Four important implications are established and quantified for the interplay of product architecture decisions and the efficient organizational forms supporting the Extended Enterprise in a world of incomplete contracts:

1. The Extended Enterprise can achieve first-best economic outcomes when the future of the relationship matters sufficiently, while spot outsourcing cannot; herein lies the essential theoretical advantage of the Extended Enterprise. For intermediate discount rates, relational outsourcing provides a regime of second-best results superior to those obtained under spot outsourcing.

2. The value of the Extended Enterprise grows as the potential for customization increases, creating the potential for value unique to the relationship; customization therefore suffers under spot outsourcing.

3. The greater the potential for customization value, the more robust is the Extended Enterprise relationship over fluctuations in the parties’ views of the future.

4. The Extended Enterprise survives only as long as the future is valued sufficiently; relational contracts cannot be made self-enforcing if the future becomes too heavily discounted.

Section 3 presents two case studies on the implementation and evolution of Extended Enterprise product development within one product program, selected on the basis of the rich sequence of decisions made. We examine the actual practice of Extended Enterprise in complex environments – complex products developed in large corporations. For Case A, an external module supplier was initially selected, over the competing internal supplier unit. Eventually, the external supplier was dropped for this module and the internal unit substituted, while retaining the external organization for a different product module. For Case B, dealing with a consumable material for the product, development was begun with another internal supplier but later switched to an external company. The goal for the case studies is to present the structural aspects of the decisions made, their context and assumptions, and their evolution, rather than the specific technical and managerial details.

Development of the case studies proceeded from examination of more than 250 program documents and substantive interviews with nine individuals involved in various roles both inside
and outside the product development program. A list of salient features for each case study is extracted to provide the key observables to be examined within the extended framework of Section 4. These include observations on:

- Two tiers of program decision authority: program management and company oversight
- Program management incentives based on meeting cost, schedule, and performance targets.
- Multiple alternative internal customers for internal suppliers.
- Multiple (Case A) and single (Case B) external supplier-to-Company relationships.
- Separate and sequential design and development and production contracts.
- Design and development contracts proposed but not signed for extended periods.
- Company policies on non-recurring expenses (NRE) and external partner decisions on NRE charges.
- Specific decision sequences.

The structure and specifics of the associated formal contracts are also analyzed, with the conclusion that the draft design and development agreements, which remained unsigned for much of the period covered, served instead primarily as guides to the expected relationship, in terms of key elements to be contracted, adjustment procedures, intentions and norms, constraints on future behavior, and bounds on parameters of the relationship.

Section 4 brings together theory and practice, in the context of an expanded framework that includes:

- an extended relationship topology appropriate to large corporations
- multi-tier decision structures
- asymmetries in participants’ views of the relationships and in their parameter estimates
- influence actions targeting other’s parameter estimates
- parameter manipulation and evolution, purposefully bounded by formal contracts and policies

The specifics of extended enterprise product development are mapped onto the formal model structures. Starting from the extended topology, the view of the relationship seen by each party is examined, and the interactions and asymmetries of these views and how they are constrained and manipulated by actions and by formal contracts and policies are explored.
The aim is to utilize the conceptual constructs and the analytic structures to gain insight into the fundamentals driving outcomes in practice, while also identifying where the structures and models need to be extended to provide richer explanatory power. It is our belief that the exposition repeatedly shows the interpretive power of the concepts underlying the theory as developed and extended, through the applications to specific aspects of the case studies.

The primary insights developed in this section include the assertion that internal suppliers differ in a fundamental manner in large corporations, where multiple product programs are supported and can distract. Also argued is the proposition that there is a crucial difference between company and program governance – in the extreme, the program is expected to behave tactically, while the company deals strategically, responsible for nurturing the relationship sought by the outside supplier, to support on-going transaction and repeated first-best outcomes through self-enforcing relational contracts. It is only through the company relationship that the program achieves first-best performance from its suppliers. And product architecture choices modulate the potential value of Extended Enterprise relationships, serving to distribute that value across the system in ways that affect relationship parameters and thus relationship viability.

The thesis concludes with a discussion of internal and external suppliers in the Extended Enterprise, and the critical role of company governance in crafting and sustaining the required relationships.

Overall, our conclusions may be summarized as:

- The heuristics of Extended Enterprise models and the specifics of Extended Enterprise practice can be mapped to formal organizational economic theory.
- Product architecture interacts with the organizational economics decision parameters.
- Formal contracts serve to frame the expectations of the relationship and manipulate and bound decision parameters.
- Decisions made in complex environments – complex products developed in large corporations – can be understood at varying levels of specificity when formal theory is augmented by an extended relationship topology appropriate to large corporations; multi-tier
decision structures; asymmetries in views of the relationships and in governing parameter estimates; parameter manipulation, evolution, and influencing; and parameter bounding by formal contracts and policies.
Section 1

Organizational Economics: Basic Theory

Introduction: Getting Started
We begin with an exposition of the basic theory of organizational economics, selecting topics and depth on the basis of their utilization in succeeding sections, in pursuit of our examination of the theory and practice of Extended Enterprise. The first section develops the basic model constructs that provide the foundation for the subsequent model and structural extensions, and the vocabulary for the analysis of observed practice. The basic principal – agent model, the structure of a supply transaction, incomplete formal contracts, relational contracts and repeated games, organizational forms parsed by governance environment and asset ownership, and the Baker-Gibbons-Murphy organizational economics model of self-enforcing relational contracts and efficient organizational forms are covered. Relational governance structures are identified with Extended Enterprise relationships. This foundation allows us develop original work in Section 2, where the Modularity Model is introduced as an extension of the Baker-Gibbons-Murphy model.

Basic Principal – Agent Model (Gibbons, 1998b and 1999a Lecture Note 1)
In order to make some of the material that follows more accessible to a general audience, we begin with a brief summary of some aspects of classic agency theory. A Principal contracts, formally or informally, with an Agent to produce an output. The agent chooses a set of actions $a$ that influences the value achieved for the output, $Q(a)$. The agent’s choice of actions is based on the incentives provided by the agreement with the principal, balanced by the personal costs $c(a)$ associated with alternative actions. These actions cannot be observed by the principal, so it is not possible for the principal to simply contract for a specific set of actions that maximize the output value. Other factors, not under the agent’s control, also impact the value obtained; these we capture in a noise term $\varepsilon$. The principal and the agent subsequently observe the output $Q(a, \varepsilon)$, and the agent receives the compensation specified by the agreement, assuming that the agreement is honored.
Generally speaking, the compensation contract contains both output-independent (salary) and output-dependent (bonus) terms. The principal retains the output value achieved less the compensation expense, while the agent gains the compensation received less the personal costs of the actions taken. Because of the stochastic component of the transformation from agent action to output value, the action actually selected by the agent will depend on the agent’s risk aversion and the magnitude of the uncertainties in the production process (variance of \( \varepsilon \)), in addition to the compensation formula. A high bonus coupled to a low salary is not very effective when the agent is very risk-averse or when the outcome is largely out of the agent’s control. On the other hand, a truly risk-neutral agent will ignore the output variance in choosing actions (assuming that the variance interacts additively with the agent’s chosen action, rather than as a multiplier, randomly amplifying or throttling the efficacy of the action selected; in the latter case, life gets more complicated).

The agent will select low cost actions first to increase the output value, and will turn to more personally costly actions only if the incentives provided make these “worthwhile,” in an expected value sense. When the marginal cost of increasing the magnitude of the actions vector reaches the marginal benefit to the agent of increased output value, under the compensation agreement, the agent will cease providing additional effort. The cost function \( c(a) \) is monotonically increasing – more actions are more personally costly – and concave upward – higher cost per payoff actions are deferred to later, after the lower cost actions are exhausted.

The total social surplus \( S(a, \varepsilon) \) created by the agent’s actions \( a \) in a particular realization is the output value achieved \( Q(a, \varepsilon) \), less the cost of the actions \( c(a) \), if we assume for simplicity that both the principal and the agent are risk-neutral. This social surplus represents the created economic value that is subsequently partitioned between the agent and the principal. The first-best action, \( a_{FB} \), is defined as the action which maximizes the expected value of the total social surplus, given the structures of \( Q(a, \varepsilon) \) and \( c(a) \). Whether the agent will select the first-best action is a separate issue, which depends on the compensation agreement design and other aspects of the problem, and will not be further pursued here. Denoting the expected value of \( Q(a, \varepsilon) \) by \( <Q(a)> \), we have:
\[ S(a_{FB}) = \max \{ <Q(a)> - c(a) \} \]

This calculation is schematically illustrated in Figure 1, where we have assumed for simplicity that \(<Q(a)>\) is linear in \(a\). \(S(a_{FB})\) occurs when the slope (marginal cost) of \(c(a)\) equals the (here constant) slope (marginal benefit) of \(<Q(a)>\), as discussed above.

![Schematic Illustration](image)

**Figure 1.** First-best action \(a_{FB}\) and total social surplus \(S(a)\) dependence on the expected value of the production function \(<Q(a)>\) and the cost function \(c(a)\).

In general, first-best outcomes will often not be achieved (Gibbons, 1998a). The structure of the relationships, constraints, and alternative opportunities can make it privately optimal for the agent to take actions which accrue to the agent a larger share of a smaller total surplus (Gibbons, 2000a). Proper choice of the relationship parameters may give the second-best outcome – the largest total social surplus that is possible with each party acting in rational self-interest within the system, but less than the first-best outcome – the best that can be imagined (Gibbons, 1999b). And poor choice of parameters can lead to highly inefficient outcomes. “Business history is littered with firms that got what they paid for” (Baker, Gibbons, and Murphy, 1994).

**Structure of a Supply Transaction** (Gibbons, 2000a and 2000b)

Following Gibbons, we will model a generalized supply transaction as involving an Upstream Party (supplier), an Asset (production equipment), and a Downstream Party (user). The upstream party supplies effort and uses the asset to produce an intermediate good that is of utility...
to the downstream party. In this application, the value of the intermediate good to the downstream party is $Q$. The intermediate good may also be consigned to an Alternative Use, where its value is $P$, with $P < Q$ – the good has been tailored to the needs of the downstream party, and has less value in other uses. The actions $a$ taken by the upstream party, at a cost $c(a)$, – the effort supplied – determine the efficiency and specialization of the asset in producing the intermediate good, and thus impact both the absolute and relative values of $Q$ and $P$. We will assume that $P$ is always strictly less than $Q; the location, specialization, or whatever of the asset always make the intermediate good more valuable to the downstream party than to the alternative use.

![Diagram](image)

**Figure 2.** Structure of a generalized supply transaction. (After Gibbons, 2000a and 2000b).

The ownership of the asset matters, because ownership of the asset is construed to impart decision rights about the disposition of the good produced using the asset. If the upstream party owns the asset, the ownership is labeled Non-Integrated, and the upstream party, whether an individual or a firm, is viewed as an Independent Contractor or Supplier, working with personally owned tools. Under non-integration, the decision rights retained upstream make assignment of the good to the alternative use an option.
Under Integrated Asset Ownership, the asset is held by the downstream party, guaranteeing delivery of the intermediate good to that user only. The upstream party becomes an Employee or a Division of the downstream firm, working with the employer’s tools.

![Diagram of Integrated and Non-Integrated Asset Ownership](image)

**Figure 3.** Integrated and Non-Integrated asset ownership within the structure of the generalized supply transaction.

We have assumed that specialization of the asset makes the intermediate good always of highest value to the downstream party – \( Q \) is always greater than \( P \), the alternative use value. But under non-integration, the supplier gets to say where the good is sold, and thus bargaining will occur over the price to be paid by the downstream party. By directing the good to the downstream party, an additional economic surplus of \( (Q - P) \) is created, which will be split between the supplier and the user if the transaction occurs. The supplier wants to get \( Q \) for the good, and the user wants to pay \( P \), the next best option for the supplier (Gibbons, 2000a). For simplicity, we will assume that the two parties have equal bargaining power. Then the transaction price agreed to will be \( (P+Q)/2 \) – the parties will evenly split the added surplus obtained by transacting with each other. Formally, this is the Nash bargaining solution with equal bargaining powers (Baker, Gibbons, and Murphy, 2001b; Gibbons, 1997).
We now have the circumstances leading to second best outcomes. The supplier, to increase the price obtained for the good, will take actions to increase $P$ as well as $Q$—either is equally worthwhile from the supplier’s self-interest. But the actions increasing $P$ may well have no effect on $Q$ (unproductive multitasking), or may actually be detrimental to $Q$. Such actions are inefficient, in that they are costly but do nothing, at best, to increase the value of the good in its most efficient use, and thus strictly reduce the total social surplus achieved. Nevertheless, they are privately optimal for the supplier.

More generally, non-integration creates the opportunity for holdup: “demanding renegotiation after investments have been made or new considerations have arisen” (Gibbons, 1999a Lecture Note 5; Milgrom and Roberts, 1992 p. 136). The downstream party wants the supplier to take only actions that increase $Q$, making the asset highly specialized or specific to the relationship with the user, with $Q >> P$. But the supplier has equal incentives to raise the value of $P$ and renegotiate the agreed price. High values of $P$ create upstream advantage and low values of $P$ move power to the downstream party. It is the combination of specific investments (which make $Q > P$) and the necessary incompleteness of most contracts (due to issues of bounded rationality, observability, and transaction costs, among others) that give rise to holdup; opportunistic behavior becomes both possible and personally beneficial (Milgrom and Roberts, 1992 p. 137; Klein, 1996).

Integration solves the holdup problem for the downstream party: the user owns the asset and redirection of the intermediate good to the alternative use is no longer possible. Asset ownership stops one class of inefficient actions. But a reverse holdup problem is created. The downstream user can renege on the promised compensation to the upstream party, now an employee or company division, simply taking the good. Solving one holdup problem often creates another (Gibbons, 2000b; Klein, 1991).

“We therefore have a situation dear to an economist’s heart: a tradeoff. Upstream ownership offers the upstream party some recourse should the downstream party renege, and hence decreases the downstream party’s temptation to renege, but upstream ownership also encourages the upstream party to consider
the interests of other parties, and hence may cause a temptation for the upstream party to renege.” (Gibbons, 2000a)

**Relational Contracts** (Gibbons, 1997 and 2000b)

Our discussion to this point has focused on “one-shot” transactions: agreements are made, actions are selected, outcomes are observed, compensation is paid or reneged, and the parties go their separate ways, with all choices having been made within the context of a singular encounter. These are “spot” relationships, occurring through isolated interactions either external (Spot Outsourcing) or internal (Spot Employment) to the firm.

But many and perhaps most transactions in the world take place in the context of relationships, where the parties will likely interact repeatedly over time. Past experiences and future expectations influence choices made in today’s encounter. The social structure is “relational” and the economic behavior to be expected may be analyzed using the theory of repeated games (Gibbons, 1997). The on-going relationships are governed by *relational contracts*, “informal agreements and unwritten codes of conduct that powerfully affect behavior” (Gibbons, 1999a Lecture Note 3). Relational contracts are pervasive, occurring between firms in all sorts of interactions that go beyond the spot market, as well as within firms, between workers and management, within employee peer groups, and between organizations, permeating the political and cultural dimensions of the company.

Formal contracts must specify *ex ante* in terms that can be verified by a third party *ex post*. But the power of a relational contract comes from its flexibility; “a relational contract can be based on outcomes that are observed by only the contracting parties *ex post*, and also on outcomes that are prohibitively costly to specify *ex ante*. A relational contract thus allows the parties to utilize their detailed knowledge of their specific situation and to adapt to new information as it becomes available” (Gibbons, 1999a Lecture Note 3). Such relationships are the paradigm for the Extended Enterprise.

Following Gibbons (1997), consider a stationary repeated game, with the choice in each period to cooperate, with payoff $C$, or to defect, with payoff $D$ in this period, with $D > C$. Assume both
parties adopt trigger strategies: if the other party defects, cooperation ceases forever and the defecting party receives instead the punishment payoff $P$ in all future periods, with $P < C$. Defection ruins the relationship in perpetuity. If cooperation is sustained, the payoff continues at $C$ in each period. The choice between cooperation and defection is repeated each period for each party, and all previous outcomes are known before the next play.

Thus the choice to be made is between maintaining the relationship and receiving the stream of payments $(C, C, C, C, \ldots)$, and precipitating termination of the relationship and receiving payments $(D, P, P, P, \ldots)$, with $D > C > P$. Clearly, cooperation will be selected only if the present value of the $(C, C, C, C, \ldots)$ payment stream is greater than that of the $(D, P, P, P, \ldots)$ stream, for each of the participants. Assigning a discount rate $r$ to the future payments, this condition becomes (ref C)

\[
2 \quad C + \frac{1}{r} C > D + \frac{1}{r} P \quad \text{or} \quad r < \frac{(C - P)}{(D - C)}
\]

If the future matters sufficiently for both parties (ie, if the discount rate $r$ for each is sufficiently low), long term self interest ($(C - P)$ forever) overcomes short term temptation ($(D - C)$ now) (Gibbons, 2000b). The “relational contract must be designed to be self-enforcing: each party’s reputation must be sufficiently valuable [$C$], relative to that party’s payoff from reneging on the relational contract [$D$], so that neither party wishes to lose his reputation by reneging [$P$]” (Gibbons, 2000b).
This structure has been derived assuming an infinitely repeated set of transactions. More realistically, one need only assume that the game concludes at an uncertain future date, with a probability of unplanned termination \( q \) after each period has been played. If the actual financial discount rate is \( s \), the effective discount rate \( r \) combines the discount for each successive future period and the diminishing probability of receiving each of those payments. This modified \( r_{eff} \) is still appropriate for the above discussion and is given by (Baker, Gibbons, and Murphy, 1994)

\[
(3) \quad r_{eff} = \frac{(s + q)}{(1 - q)}
\]

If future interactions are highly uncertain, \( q \) is high, leading to a large \( r_{eff} \), an inability to sustain the relationship (assuming the constraint on \( r \) is now violated), and a reversion to endgame behavior and short term self-interest.

The breakdown of a relational contract typically returns the parties to spot governance and pure short run self-interest, as assumed in the above trigger strategy. Thus, for example, in the case of non-integration a floor is placed on \( P \) for the upstream party by the best alternative use. The alternative use value of Figure 2 becomes a minimum on the punishment payoff of Figure 4, assuming the spot market transaction will be repeated each period and the reputational effects of reneging do not otherwise impact the alternative use value. (This value is a minimum, since the efficient outcome upon reversion to spot outsourcing will be to sell to the original user at the negotiated price of \((P+Q)/2\), given equal bargaining power). Similarly, the downstream party looks to alternative suppliers for his or her floor value of \( P \). Clearly, the reneging temptation in future periods will be reduced if the parties work to grow the payoffs from cooperation – to increase \( C \) – as well as striving to lower \( P \), for example through increasing switching costs as the relationship evolves. Conversely, change must be managed – fluctuations or systematic changes in the parameters of the relational contract may take the relationship out of the self-enforcing range, leading to reneging and breakdown. The no-layoffs policy of today may be abandoned tomorrow when the external environment permanently changes (Gibbons, 2000a).

More generally, because asset ownership changes the alternatives available to each of the parties, “the economic incentive to renege on a given relational contract depends on whether the parties
are integrated or not.” The decision to vertically integrate then becomes “an instrument in the
service of the parties’ relationship” (Gibbons, 2000b). Thus asset ownership becomes secondary
to the relational contracts that can then be supported – different relationships become possible
inside and outside the firm. “The guiding principle is to induce efficient actions (and discourage
inefficient actions) by implementing the best possible relational contract. The integration
decision is merely an instrument in this quest” (Gibbons, 2000a).

Organizational Forms and Organizational Economics (Baker, Gibbons, and Murphy, 2001b;
Gibbons, 2000b)
We now bring together the ownership environment (integrated versus non-integrated asset
ownership) and the governance environment (spot versus relational) to provide the segmentation
for the Baker, Gibbons, Murphy analysis of “Relational Contracts and the Theory of the Firm”
(2001b). Gibbons has utilized this partitioning to describe many of the classic contributions to
organizational economics (2000b).
Figure 5. Four organizational forms following from alternative governance and ownership environments. (After Gibbons, 2000b).

The Baker-Gibbons-Murphy model (2001b) analyzes the efficiency of the four organizational forms to illuminate how and why relational contracts differ when executed within and between firms, and under what circumstances one outperforms the others. The formal (asset ownership) and informal (relational) aspects of organizational structure do more than simply co-exist – they actively interact. Thus one should choose formal structure to facilitate informal structure (Gibbons 2000b).

Within this construct, Relational Outsourcing provides the paradigm for the Extended Enterprise. But the relational contract governing the relationship can be sustained only over certain ranges of the parameter values, those over which the relational contract is self-enforcing, with both parties
finding it in their economically defined self-interest to receive the continuing payoffs from sustained cooperation, rather than choosing to renege to capture the current windfall from defection. Breakdown of the relational contract reverts the potential interactions to spot governance. Or the downstream party may find it necessary to purchase the supplier (integrate the asset ownership) to stop inefficient actions. “In this model, the parties’ relationship takes center stage; the integration decision is merely an instrument in the service of that relationship. . . Simply put, the old ‘make or buy’ decision should instead be viewed as ‘make or cooperate’” (Gibbons, 2000a).

The next sections contain a summary of selected aspects of the Baker-Gibbons-Murphy model development (2001b), focusing on items deemed germane to our analysis of considerations in implementation of the Extended Enterprise. The intent is to be expository and to develop insight through simplified specific instances.

**Baker-Gibbons-Murphy Model** (Baker, Gibbons, and Murphy, 2001b)

The structure of the generalized supply transaction of Figure 2 and the alternative governance and asset ownership environments of Figure 5 provide the cases to be analyzed. Actions taken by the upstream party affect the value of the intermediate good to the downstream parties, both the primary and alternative users. The focus is on those actions and outcomes which cannot be fully specified in complete contracts – actions that are unobservable (subject to moral hazard) and outcomes that are observable by the parties involved but not verifiable, and thus non-contractible. As before, ownership of the asset imparts decision rights for the intermediate good produced with the asset.

For simplicity, the parties are assumed to be risk-neutral, to share the discount rate \( r \) that captures both the actual financial discount rate and the probability of unplanned termination of the relationship, and to possess equal bargaining power when negotiating under spot outsourcing. The intermediate good has no independent value after the period in which it was produced ends; it must be consigned to one or another use in each period. Importantly, the good’s value to the downstream party *always* exceeds its value in the alternative use. Given this assumption, if
reneging occurs under non-integration, the efficient outcome is for the downstream party to purchase the good at the negotiated spot price.

Each period, the upstream party chooses a vector of actions \( a \), at cost \( c(a) \), that affect both the value \( Q(a) \) of the intermediate good to the downstream party and its value \( P(a) \) in alternative use. More specifically, the value achieved for \( Q(a) \) is either high \((Q_H)\) or low \((Q_L)\), with the actions entering through the probability \( q(a) \) of obtaining \( Q_H \). Similar relationships hold for the alternative use value \( P(a) \). Zero actions give zero costs but guarantee that \( Q_L \) and \( P_L \) occur. Our assumption of downstream user value always exceeding alternative user value requires \( Q_H > Q_L \) and \( P_H > P_L \), independent of the actions taken. For reference, we have

\[
\begin{align*}
Q(a) &= Q_H \text{ with probability } q(a) = Q_L \text{ otherwise } \\
\Delta Q &= Q_H - Q_L \\
P(a) &= P_H \text{ with probability } p(a) = P_L \text{ otherwise } \\
\Delta P &= P_H - P_L
\end{align*}
\]

This construction separates the issue of asset specificity at the beginning of play (eg, \( Q_L >> P_L \) indicates high specificity) from the incentives for actions, which are shown in the Baker-Gibbons-Murphy model to be driven by the potential marginal returns for effort, \( \Delta Q \) and \( \Delta P \).

We have assumed that the actions \( a \) are unobservable (by anyone beyond the upstream party) and that the outcomes are not verifiable by a third party, so a contract based on the realized values of \( Q \) or \( P \) cannot be directly enforced (such as through a court). But \( Q \) and \( P \) are observable by the parties involved, so both the upstream and downstream parties can plan future actions based on known past outcomes – there exists the potential for relational contracts.

The total social surplus \( S(a) \) expected to be created by the upstream party’s actions \( a \) is the expected value of the economic worth of the intermediate good in its efficient use, \( \langle Q(a) \rangle \), less the cost of the actions taken, \( c(a) \):

\[
S(a) = \langle Q(a) \rangle - c(a)
\]

\[
S(a) = Q_L + q(a)\Delta Q - c(a)
\]

The choice of actions \( a \) thus modulates the surplus expected to be achieved for each of the cases.

For the relational governance cases, we define the relational compensation contract as \( (s, b_i) \), with \( s \) the salary paid by the downstream party to the upstream each period, and \( b_i \) the bonus
formula promised, specifying the bonus to be paid for each of the four possible combinations of realizations of $Q$ and $P$. The total social surplus is the created economic value available to be partitioned between the upstream and downstream parties. The salary provides a mechanism for distributing payoffs outside the bonus structure, allowing the bonus structure to be designed to maximize the total payoff available for partitioning. The salary, as simply a wealth transfer, has no effect on incentives and therefore actions.

Baker-Gibbons-Murphy proceed to calculate the total social surplus $S(a)$, the action vector $a$ that maximizes the upstream party’s expected utility (the upstream party’s share of the total surplus), and the payoff to each party after reneging for the two relational cases, for each of the four organizational forms. These are then combined as payment streams for each party and compared to obtain the conditions under which the relational contracts will be self-enforcing, for all possible realizations of $Q$ and $P$ (since the reneging decision is made after the outcomes are observed in each period).

The necessary and sufficient conditions for the relational contracts to be self-enforcing turn out to consist of the requirement that the sum of the upstream and downstream parties’ temptations to renege, plus the present value of the best fallback social surplus if either party reneges, must be less than the present value of the total surplus from continuing the relationship. Thus the governing inequalities take the form of our earlier equation (2). The efficient organizational form maximizes the total social surplus achievable for a given environment. And the existence of a surplus is necessary but not sufficient for the feasibility of a relational contract. Put more colloquially, “partnerships work only when both parties try to expand the pie” (Dyer, 1996).

**Baker-Gibbons-Murphy Model for Unproductive Multitasking**

We now turn to a specific case presented by Baker-Gibbons-Murphy in their Figure II. They assume that the actions vector $a$ has two components $a_1$ and $a_2$, that the probabilities $q(a)$ and $p(a)$ of achieving high valuations of $Q$ and $P$ respectively (that is, the production functions) are linear in the two action components, and that the cost function $c(a)$ is quadratic in the two components. Their Figure II plots the special case of unproductive multitasking, where action 1
affects only $q(a)$ and action 2 only $p(a)$. The bonus structure assumes a base bonus of $(b_L, \beta_L)$ for achieving $Q_L$ and $P_L$ respectively, plus an incentive bonus of $\Delta b$ for $Q_H$ and $\Delta \beta$ for $P_H$.

\begin{equation}
\begin{align*}
q(a) &= q_i a_i \\
p(a) &= p_2 a_2 \\
c(a) &= \frac{1}{2}a_1^2 + \frac{1}{2}a_2^2
\end{align*}
\end{equation}

Our Figure 6 is a reduced (and approximate) version of the Baker-Gibbons-Murphy Figure II, with some of the specifics removed and the region boundaries approximated. The spread in spot market values $\Delta P = P_H - P_L$ for the alternative use provides the horizontal axis, and the effective discount rate $r$ the vertical. The parameter regions where each organizational form is efficient, in the sense of maximizing the total social surplus achievable, are mapped for the unproductive multitasking special case cited.

![Diagram](image)

Figure 6. Reduced and approximate version of Baker-Gibbons-Murphy Figure II (2001b), showing dependence of efficient organizational form providing maximum total social surplus, on effective discount rate $r$ and spread in spot market values $\Delta P = P_H - P_L$ for alternative use, for unproductive multitasking.
To provide a reference for our discussion of these parameter regions, it is useful to point out that equations (1), (5), and (6) can be used to easily show that the first-best actions $a_{FB}$ and the corresponding maximum expected value of the total social surplus $S(a_{FB})$ are given by:

$$
\begin{align*}
  a_{1FB} &= q_1 \Delta Q \\
  a_{2FB} &= 0 \\
  S(a_{FB}) &= S^F_B = Q_L + \frac{1}{2} q_1^2 \Delta Q^2
\end{align*}
$$

As would be expected, spot governance dominates at high discount rates that steeply devalue the future, while relational governance becomes feasible at low values of $r$, where the future matters. Non-integrated asset ownership is preferred at low values of $\Delta P$, where the upstream party's payoff potential for unproductive investment in the alternative use is small. Under spot outsourcing, the bargained price for the good is the realized value of $(P+Q)/2$, and the actions taken and the expected total surplus will be (Baker, Gibbons, and Murphy, 2001b)

$$
\begin{align*}
  a_{1SO} &= \frac{1}{2} q_1 \Delta Q = \frac{1}{2} a_{1FB} \\
  a_{2SO} &= \frac{1}{2} p_2 \Delta P > a_{2FB} \\
  S^{SO} &= Q_L + \frac{3}{8} q_1^2 \Delta Q^2 - \frac{1}{8} p_2^2 \Delta P^2 < S^F_B
\end{align*}
$$

Thus because of the distraction of the alternative use value, with spot outsourcing action 1 is half of the first-best magnitude and the total surplus is strictly less than first-best. These inefficiencies are aggravated as the potential return on unproductive effort $\Delta P$ increases, until the $\Delta P$ term exceeds the $\Delta Q$ term in $S^{SO}$, and the effort expended by the upstream party reduces total surplus below that obtained by doing nothing, that is, choosing $a_1 = a_2 = 0$.

This marks the transition to spot employment, at high values of $r$. Under spot employment, the absence of future considerations means the downstream employer will renege on any promised compensation that cannot be specified by a formal contract; knowing this, the employee will not take any personally costly actions, and thus $S^{SE} = Q_L$. But this is better than spot outsourcing with massively unproductive $a_2$ actions driving $S^{SO}$ below $Q_L$, and the downstream party will purchase the asset to stop the inefficient actions. This is an illustration of one of the general results obtained by Baker-Gibbons-Murphy, that vertical integration is an efficient response to widely varying supply prices (here large values of $\Delta P$).
Relational Contracts in the Baker-Gibbons-Murphy Model (2001b)

Given the previously described bonus structure with incentive bonuses of $\Delta b$ for achieving $Q_H$ and $\Delta \beta$ for obtaining $P_H$, under relational governance the upstream party chooses actions to maximize the expected net payoff – that is to maximize the sum of each bonus multiplied by the probability of obtaining it, less the cost of actions taken.

$$
\text{(9)} \quad \max \{q_1 a_1 \Delta b + p_2 a_2 \Delta \beta - \frac{1}{2} a_1^2 - \frac{1}{2} a_2^2 \}
$$

\[
\begin{align*}
a_1^{RO} &= a_1^{RE} = q_1 \Delta b \\
a_2^{RO} &= a_2^{RE} = p_2 \Delta \beta \\
S^{RO} &= S^{RE} = Q_L + q_1^2 \Delta b(\Delta Q - \frac{1}{2} \Delta b) - \frac{1}{2} p_2^2 \Delta \beta^2
\end{align*}
\]

Note that the bonus structure fully determines the actions and thus the total social surplus; a given relational contract $(s, b_i)$ produces the same actions and the same surplus under both relational outsourcing and relational employment, assuming the reneging constraints are satisfied for both. The optimal relational contract will however generally be different for the two (Baker, Gibbons, and Murphy, 2001b).

Spot outsourcing produces half magnitude productive action $a_1$ relative to first-best, and unproductive action $a_2$. Spot employment forbids unproductive action $a_2$, at the expense of also providing no incentive at all for productive action $a_1$. Neither can achieve first-best outcomes. But at sufficiently low discount rates $r$, both relational outsourcing and relational employment can produce first-best actions and first-best total social surplus. Specifically, choosing the bonus structure $\Delta b = \Delta Q$ and $\Delta \beta = 0$ induces the upstream party to select first-best efforts, assuming the relational contract is feasible:

$$
\text{(10)} \quad \Delta b = \Delta Q \Rightarrow a_1^{RO} = a_1^{RE} = q_1 \Delta Q = a_1^{FB} \\
\Delta \beta = 0 \Rightarrow a_2^{RO} = a_2^{RE} = 0 = a_2^{FB} \\
\Rightarrow S^{RO} = S^{RE} = S^{FB}
$$

This is the power of relational governance: relational structures can achieve first-best actions, while spot governance cannot, within the confines of this model’s environment.

Given that relational outsourcing and relational employment are capable of producing first-best outcomes, when will they – under what circumstances will relational governance be self-
enforcing and thus feasible? That depends on the temptations to renege. Generally speaking, one party or the other will have a temptation to renege if the current period is considered in isolation. Under non-integration, the promised bonus payment \( b_i \) will be either less than or greater than the price \((P+Q)/2\) (realized) that would be negotiated under spot outsourcing, so one party or the other would be better off this period by reneging. Under integrated asset ownership, the downstream party would always be better off to withhold the bonus (assumed positive) this period. This temptation is overcome by the present value of the total surplus from continuing the relationship less the best fallback social surplus, through inequalities similar to equation (2).

More specifically, Baker-Gibbons-Murphy show that for the special case under discussion, the necessary and sufficient conditions for the relational contracts to be self-enforcing are (equations (8') and (12') in Baker, Gibbons, and Murphy, 2001b):

(11) relational employment:

\[
|\Delta b| + |\Delta \beta| \leq \frac{1}{r} (S^{RE} - \max[S^{SO}, S^{SE}])
\]

(12) relational outsourcing:

\[
|\Delta b - \frac{1}{2} \Delta \beta| + \frac{1}{2} \Delta P \leq \frac{1}{r} (S^{RO} - \max[S^{SO}, S^{SE}])
\]

As previously mentioned, the left hand sides capture the sum of the upstream and downstream temptations to renege, while the right hand sides give the present value of the total surplus from relational governance less the best fallback, either spot outsourcing or spot employment.

Note that a given bonus structure makes \( S^{RE} \) and \( S^{RO} \) the same, so higher incentives can be sustained under relational outsourcing than under relational employment: equation (12) can be satisfied under conditions where equation (11) is not, because the availability of the negotiated price to the upstream party under non-integration lowers the downstream payoff for reneging.

This result illustrates the main proposition established by Baker-Gibbons-Murphy: asset ownership affects the parties' temptations to renege on a relational contract. Thus relational contracts which are feasible inside a firm (e.g., between company divisions) may not be feasible outside the firm, and vice versa. Asset ownership matters.
The example also demonstrates another of the additional results derived by Baker-Gibbons-Murphy: higher powered incentives are feasible outside the firm under relational outsourcing than inside under relational employment. "Performance payments in relational incentive contracts will be smaller in firms than in (otherwise equivalent) markets" (Result 2, 2001b).

Baker-Gibbons-Murphy point out that along the boundary between relational outsourcing and relational employment in our Figure 6, the total surplus generated under the two types of relational contract will be the same, but the optimal relational employment contract will have $\Delta b^{RE} > 0$ and $\Delta \beta^{RE} = 0$, while the relational outsourcing contract giving the same surplus consists of $\Delta b^{RO} > \Delta b^{RE}$ and $\Delta \beta^{RO} > 0$; "the upstream party will work harder on both tasks under relational outsourcing than relational employment" (Baker, Gibbons, and Murphy, 2001b).

Higher powered incentives give higher actions, both productive and unproductive. In essence, under relational outsourcing the downstream party chooses to compensate the upstream for the unproductive actions which the upstream party will choose anyway (for reasons of bargaining position through increased realizations of $P$), in order to sustain the relationship. This attenuation of the second term on the left hand side of equation (12) and the offset within the first term by $-\frac{1}{2}A\Delta Q$ allow the incentive for productive actions $\Delta b$ to be increased above the levels sustainable under relational employment.

Baker-Gibbons-Murphy also establish several other results and corollaries which have not been discussed here. They conclude with an overview of the role of the manager within the economic theory of the firm.

"By emphasizing the importance of relational contracts, our model highlights a role for managers: the development and maintenance of relational contracts, both in the firm and in supplier relationships. . . . this role involves designing the relational contract . . . communicating this to employees, assessing outcomes . . . and deciding whether to honor the relational contract . . . We conclude that understanding the role of managers, who design and implement the relational contracts that underpin informal organizational processes, is essential to understanding firms" (Baker, Gibbons, and Murphy, 2001b).
Section 2

System Architecture, Modularity, and Efficient Organizational Forms: the Modularity Model and the Extended Enterprise

Introduction: System Architecture Meets Organizational Economics
Up to this point, we have recapitulated the established literature judged most germane to our intended analysis of the implementation and evolution of the Extended Enterprise. We now add engineering considerations particular to product development, specifically decisions about how the system is architected—partitioned into modules and interfaced to various material and information flows through the system.

We begin by extending the Baker-Gibbons-Murphy model of Section 1 to incorporate actions taken by the upstream party that are intended to capture the concepts of “modularization” and “customization.” A modularity metric is defined in this context. The mathematics of the model are developed to quantify the functional dependencies and parameter values leading to first-best and second-best economic outcomes, and the path along the effective discount rate $r$ axis is mapped, tying together the efficient organizational forms and boundaries, the optimal bonus levels, the action magnitudes and their relationship to first-best, and the total social surplus created.

Four important implications are established and quantified for the interplay of product architecture decisions and the efficient organizational forms supporting the Extended Enterprise in the world of incomplete contracts: (1) The Extended Enterprise can achieve first-best economic outcomes when the future of the relationship matters sufficiently, while spot outsourcing cannot; herein lies the essential theoretical advantage of the Extended Enterprise. For intermediate discount rates, relational outsourcing provides a regime of second-best results superior to those obtained under spot outsourcing. (2) The value of the Extended Enterprise grows as the potential for customization increases, creating the potential for value unique to the relationship; customization therefore suffers under spot outsourcing. (3) The greater the
potential for customization value, the more robust is the Extended Enterprise relationship over fluctuations in the parties’ views of the future. (4) The Extended Enterprise survives only as long as the future is valued sufficiently; relational contracts cannot be made self-enforcing if the future becomes too heavily discounted.

The Modularity Model

The Baker-Gibbons-Murphy model of Section 1 may be used to also analyze the efficient organizational forms for a different set of assumptions about the nature of the intermediate good and its production process. We address here the interplay between systems design choices and the governance and ownership environments leading to efficient outcomes. System architecture and partitioning selections and engineering and technology decisions modulate the “portability” of the work product, the value achieved in its efficient use by the downstream party, the switching costs of seeking alternative sources of supply, and other parameters of the organizational economics analysis.

The intermediate good will be the module, or more specifically in our later applications of the model analysis, the module design. It is to be utilized in systems produced for sale by the downstream party, as well as potentially by alternative system producers. The module design centerline is assumed to focus on the needs of the downstream party, implying that the module design is always more valuable to the downstream party than to alternative users and thus that the model assumption $Q_H > Q_L > P_H > P_L$ is satisfied.

We also retain the other assumptions of the previously discussed analysis, with the exception of the illustrative example of unproductive multitasking (equation (6), where action 1 affects only $q(a)$ and action 2 only $p(a)$). Instead, we will postulate two types of actions by the upstream party. Actions of type 1 affect modularity, performance, costs, etc. equally for all potential users of the module – such actions improve the “good things” that are common across potential applications and impact all downstream parties alike. Actions of type 2 affect the module design value for the downstream party only, through customization of attributes, specificity of form and fit, enablement of features proprietary to the downstream party, etc. – the “good things” that are
specific to the targeted application only. From the general linear production functions, we therefore take as our modularity model

\[ q(a) = q_1a_1 + q_2a_2 \]
\[ p(a) = p_1a_1 + p_2a_2 \]

(13) \[ p_1 = q_1; \quad p_2 = 0 \Rightarrow \]
\[ q(a) = q_1a_1 + q_2a_2 \]
\[ p(a) = q_1a_1 \]

Thus \( a_1 \) actions stochastically increment value equally for the mainline downstream party and alternative users, while \( a_2 \) actions add value only for the mainline user. With a potential \( p_3 \) term chosen equal to zero, there is no provision for adding value solely to the alternative users. This is of course an approximation to any reality, but plausibly reflects placing the mainline user at the centerline of the design process.

On the costs side, we retain the quadratic cost function of equation (6), where the amount of action 1 being supplied does not impact the cost of action 2 – doing more of one type does not make the other type more costly. This suggests that there is limited competition for resources in performing actions of type 1 versus type 2: to a first approximation, different skills and resources are used for modularization and customization, or the shared resource pool is sufficiently large that putting resource on one does not raise costs for the other. An alternative cost function would be quadratic in the sum of the two types of actions – the two actions are directly traded off one against the other in impacting the cost incurred. Exactly the same resource is directed against both modularization and customization, and an increment to one requires an equal decrement to the other, to maintain constant total cost. For the types of complex products and large organizations which are our focus in the implementations of the Extended Enterprise examined in this thesis, reality may be somewhat biased towards the former assumption captured in its extreme in equation (6) – cost as the sum of quadratics, rather than the latter quadratic of a sum. But reality certainly lies somewhere in between, and interpretation of results derived from the assumption of the cost function of equation (6) should consider the applicability of the approximation.
For simplicity, we will also assume that the potential increase in module design value for the mainline and alternative users is comparable – that is, that \( \Delta P = \Delta Q \). Efforts by the upstream party have similar payoffs for incrementing the value realized for both the targeted and the alternative users. More generally, one could analyze the case where \( \Delta P \) is some fixed fraction, less than one, of \( \Delta Q \), reflecting the added customization value achievable for the mainline downstream party but not the alternative user. Instead, we have chosen to set \( \Delta P \) equal to \( \Delta Q \) and capture the added customization value through the relationship of the production functions: \( q(a) \) is always greater than \( p(a) \) if any customization is done \((a_2 > 0)\).

Within this model, one may define a modularity metric, in terms of the relative effort required to improve performance in a modular context, versus a custom context. A highly modular component is highly substitutable, with minimal customization, while a highly custom component has low modularity. Thus \( q_1 a_1 \) measures value generation in the modular domain, while \( q_2 a_2 \) measures value created through customization, and the ratio \( q_1/q_2 \) captures the relative modularization potential, in terms of relative return on effort applied. We thus take:

\[
\frac{q_1}{q_2} \gg 1 \Rightarrow \text{high modularization potential}
\]

\[
\frac{q_1}{q_2} \ll 1 \Rightarrow \text{low modularization potential; high customization potential}
\]

In summary, our modularity model assumes

(14) \[ q(a) = q_1 a_1 + q_2 a_2 \]

\[ p(a) = q_1 a_1 \]

\[ c(a) = \frac{1}{2} a_1^2 + \frac{1}{2} a_2^2 \]

\[ \Delta Q = \Delta P \]

We now utilize the Baker-Gibbons-Murphy model to pursue an analysis of the efficient organizational forms along a slice through the parameter space covered by Baker-Gibbons-Murphy, due to the \( \Delta Q = \Delta P \) assumption, as shown in Figure 7.
Figure 7. Parameter domain of the modularity model, relative to the Baker-Gibbons-Murphy analysis of Figure 6. Dependence of efficient organizational form providing maximum total social surplus, on effective discount rate $r$ shown, together with associated bonus structure and optimal actions relative to first-best (FB).
We first calculate the first-best actions $a_{FB}$ and the associated maximum expected value of the total surplus $S_{FB}$, using equations (1), (5), and (14):

\begin{align}
& a_{1FB} = q_1 \Delta Q \\
& a_{2FB} = q_2 \Delta Q \\
& S_{FB} = Q_L + \frac{1}{2} \Delta Q^2 (q_1^2 + q_2^2)
\end{align}

Effort should be applied to support both modularization ($q_1$) and customization ($q_2$), scaling relative to the modularization potential $q_1/q_2$.

Under spot outsourcing, again assuming that the bargained price for the module will be the realized value of $P+Q/2$, the optimal actions and the expected total surplus can be shown to be, for the modularity model assumptions (ref 3 and equation (5))

\begin{align}
& a_{1SO} = q_1 \Delta Q = a_{1FB} \\
& a_{2SO} = \frac{1}{2} q_2 \Delta Q = \frac{1}{2} a_{2FB} \\
& S_{SO} = Q_L + \frac{1}{2} \Delta Q^2 (q_1^2 + \frac{3}{4} q_2^2) < S_{FB} \\
& S_{FB} - S_{SO} = \frac{\Delta Q^2 q_2^2}{8}
\end{align}

First-best is achieved for action 1 but not action 2, and as a consequence the total surplus under spot outsourcing is strictly less than first-best. Action 1 impacts the realized value of $P$ and $Q$ equally and thus fully supports maximizing the negotiated price $(P+Q)/2$, while action 2 affects only $Q$ and therefore pays off for the upstream party at only half strength. Too little customization is achieved, relative to first-best outcomes.

Spot employment is not a viable organizational form under the model assumptions. By the same argument as previously (page 28), in the absence of future considerations the employee will not take any personally costly actions, and thus again $S_{SE} = Q_L$. But equation (16) contains no negative terms, making $S_{SO}$ always greater than $Q_L$ and thus $S_{SE}$.

\begin{align}
& a_{1SE} = 0 \\
& a_{2SE} = 0 \\
& S_{SE} = Q_L < S_{SO}
\end{align}

Spot employment is never optimal, because there are no unproductive actions available to the upstream party (benefiting only alternative users) within the model, and therefore no benefit to the downstream party from killing productive efforts ($Q$ enhancing) in order to stop unproductive but costly activities (solely $P$ enhancing). A more complete treatment, incorporating contractible elements of performance, is given by Baker, Gibbons, and Murphy (2001a); the employee will then take costly actions, but only against the contracted components. However, the absence of
solely $P$ enhancing activities in our formulation makes clear that spot employment will remain unpreferred even in an enhanced construction along those lines.

**Relational Contracts and the Modularity Model**

We again assume incentive bonuses of $\Delta b$ for achieving $Q_H$ and $\Delta \beta$ for obtaining $P_H$. The upstream party chooses actions based on maximizing the sum of each bonus multiplied by the probability of obtaining it, less the costs of actions taken.

\[
\max \{ q_i a_i \Delta b + q_2 a_2 \Delta b + q_i a_i \Delta \beta - \frac{1}{2} a_1^2 - \frac{1}{2} a_2^2 \}
\]

\[
a_{i \text{RO}} = a_{i \text{RE}} = q_i (\Delta b + \Delta \beta)
\]

\[
a_{2 \text{RO}} = a_{2 \text{RE}} = q_2 \Delta b
\]

Both bonuses drive action 1 (modularization), while only the mainline bonus incents action 2 (customization).

For ease of notation, we scale the bonuses by $\Delta Q$, defining the bonus fractions $f_b$ and $f_\beta$.

\[
f_b \equiv \frac{\Delta b}{\Delta Q} \\

f_\beta \equiv \frac{\Delta \beta}{\Delta Q}
\]

After some arithmetic, it can be shown from equations (5), (14), (18), (19), and (16) that

\[
S^\text{RO} = S^\text{RE} = Q_L + \Delta Q^2 q_i^2 (f_b + f_\beta) - \frac{\Delta Q^2 q_i^2}{2} (f_b + f_\beta)^2 + \Delta Q^2 q^2 f_b - \frac{\Delta Q^2 q_i^2}{2} f^2
\]

\[
S^\text{RO} - S^\text{SO} = \frac{\Delta Q^2 q_i^2}{8} - \frac{\Delta Q^2 q_i^2}{2} [f_b - 1]^2 - \frac{\Delta Q^2 q_i^2}{2} [(f_b + f_\beta) - 1]^2
\]

Spot outsourcing cannot give first-best outcomes, as shown by equation (16), but relational governance can. Specifically, choosing the bonus structure $\Delta b = \Delta Q$ and $\Delta \beta = 0$ induces the upstream party to select first-best efforts:

\[
\Delta b = \Delta Q \Rightarrow f_b = 1
\]

\[
\Delta \beta = 0 \Rightarrow f_\beta = 0
\]

\[
\Rightarrow a_{i \text{RO}} = a_{i \text{RE}} = q_i \Delta Q = a_{i \text{FH}}
\]

\[
\Rightarrow a_{2 \text{RO}} = a_{2 \text{RE}} = q_2 \Delta Q = a_{2 \text{FB}}
\]
\[ S^{RO} = S^{RE} = Q_L + \frac{1}{2} \Delta Q^2 (q_1^2 + q_2^2) = S^{FB} \]

Equations (11) and (12) provide the necessary and sufficient conditions for relational contracts to be self-enforcing. A given bonus structure makes \( S^{RE} \) and \( S^{RO} \) equal (equations (18) and (20)), since the same actions are induced. Relational employment and relational outsourcing differ in the incentive structures which can be sustained without reneging. And the total surplus generated under spot employment is strictly less than that of spot outsourcing (equation (17)).

Thus the right hand sides of equations (11) and (12) become:

\[
\frac{1}{r} (S^{RE} - \max[S^{SO}, S^{SE}]) = \frac{1}{r} (S^{RE} - S^{SO}) = \frac{1}{r} (S^{RO} - S^{SO})
\]

Equations (11) and (12) may thus be rewritten as

(22) relational employment:
\[
\frac{r}{\Delta Q} \left( |f_b| + |f_\beta| \right) \leq \frac{q_2^2}{8} - \frac{q_2^2}{2} [f_b - 1]^2 - \frac{q_2^2}{2} [(f_b + f_\beta) - 1]^2
\]

(23) relational outsourcing:
\[
\frac{r}{\Delta Q} \left( |f_b - \frac{1}{2}| + |f_\beta - \frac{1}{2}| \right) \leq \frac{q_2^2}{8} - \frac{q_2^2}{2} [f_b - 1]^2 - \frac{q_2^2}{2} [(f_b + f_\beta) - 1]^2
\]

First-best efforts can be sustained as long as \( f_b = 1 \) and \( f_\beta = 0 \) (from equation (21)) result in self-enforcing relational contracts – as long as equations (22) or (23) can be satisfied. This gives, for both relational employment and relational outsourcing,

(24) \[
\frac{r}{\Delta Q} \leq \frac{q_2^2}{8} \Rightarrow r_{FB}^{RE} = r_{FB}^{RO} \leq \frac{\Delta Q q_2^2}{8} \equiv r_{FB}
\]

Both relational outsourcing and relational employment are feasible for low enough effective discount rates \( r \) (\( r \leq r_{FB} \)), and provide first-best outcomes. This is the power available through relational structures when the future of the relationship has been made important enough, and the key potential advantage of the Extended Enterprise over spot outsourcing. For effective discount rates less than or equal to \( r_{FB} \), relational outsourcing or relational employment give first-best outcomes, by maintaining the feasibility of bonuses at the \( f_b = 1 \) and \( f_\beta = 0 \) levels and thereby
inducing first-best actions for both \(a_1\) and \(a_2\). These conclusions are captured in the bottom band of the upper part of Figure 7.

As we increase the effective discount rate \(r\) above \(r_{FB}\), the preferred organizational form by definition is the one that provides the maximum feasible total social surplus. Note that in the efficient organizational form, action 1 is first-best for spot outsourcing at high values of \(r\), above the middle range of \(r\) values we are now analyzing, and also first-best for relational outsourcing / relational employment for \(r\) less than \(r_{FB}\), below the middle range of \(r\) values. We will therefore postulate (but have by no means shown) that action 1 also remains first-best at the intermediate discount rates bridging the two bands. This assumption then implies that the self-enforcing relational contract spanning the middle band of Figure 7, which is postulated to provide for first-best actions of type 1 throughout the band, will satisfy the condition \((f_b + f_{\beta}) = 1\), since

\[
\begin{align*}
(25) \quad a_1^{RO} &= a_1^{RE} = q_1(\Delta b + \Delta \beta) = q_1 \Delta Q (f_b + f_{\beta}) = a_1^{FB} = q_1 \Delta Q \Rightarrow (f_b + f_{\beta}) = 1
\end{align*}
\]

Under this condition, by equation (22) relational employment cannot be sustained for discount rates above \(r_{FB}\). But relational outsourcing can be. Equations (23) and (20) become

\[
\begin{align*}
2r & \leq q_2^2 - q_2^2 [f_b - 1]^2 \\
S^{RO} &= Q_L + \frac{1}{2} \Delta Q^2 q_1^2 + \frac{1}{2} \Delta Q^2 q_2^2 (2f_b - f_b^2) \\
&\Rightarrow \text{ for } f_b \geq \frac{1}{2}, r \leq r_{FB} (3 - 2f_b)
\end{align*}
\]

\[
\begin{align*}
(26) & \quad r_{FB} \leq r_{FB}^{RO} \leq 2r_{FB} \\
(27) & \quad \text{ at } r_{FB}^{RO} = r_{FB}, \quad f_b = 1, \quad f_{\beta} = 0 \quad a_1^{RO} = a_1^{FB}, \quad a_2^{RO} = a_2^{FB} \\
& \quad S^{RO} = Q_L + \frac{1}{2} \Delta Q^2 (q_1^2 + q_2^2) = S^{FB} \\
(28) & \quad \text{ at } r_{FB}^{RO} = 2r_{FB}, \quad f_b = \frac{1}{2}, \quad f_{\beta} = \frac{1}{2} \quad a_1^{RO} = a_1^{FB} \quad a_2^{RO} = \frac{1}{2} a_2^{FB} \\
& \quad S^{RO} = Q_L + \frac{1}{2} \Delta Q^2 (q_1^2 + \frac{3}{4} q_2^2) = S^{RO} < S^{FB}
\end{align*}
\]
Thus for the intermediate effective discount rates, between $r_{FB}$ and $2r_{FB}$, relational outsourcing is the optimal organizational form but achieves second-best outcomes. Action 1 (modularization) remains first-best, while action 2 (customization) deteriorates from first-best at the lower boundary to half of first-best at the spot outsourcing transition line. The optimal bonus that still stabilizes the relationship goes from full focus on the mainline user ($Q$), with $f_b = 1$ and $f_\beta = 0$, to half strength incentives directed to the targeted ($Q$) and alternative ($P$) users, with $f_b = \frac{1}{2}$ and $f_\beta = \frac{1}{2}$, simply matching the expected negotiated price at the spot outsourcing boundary. To sustain the relationship, the downstream party becomes increasingly willing to compensate the upstream supplier for the investment which the upstream party will make anyway in the alternative use value, as the present value attributed to future relationship declines and the effective discount rate $r$ increases. Modularization value is sustained (because it pays off equally for the intended and alternative users), while customization value suffers. These outcomes are illustrated in the middle band of the upper part of Figure 7.

As previously discussed, $q_1a_1$ gives the value generation in the modularization domain, while $q_2a_2$ measures value achieved through customization. The relative potential customization – modularization return on effort is captured by the ratio $q_2/q_1$. In each optimal organizational form domain, we have shown that the total expected value generated, net of costs incurred, is

$$\text{Expected net value generated} = (S - Q_L) = \frac{1}{2} Q^2 q_1^2 (1 + f q_2^2/q_1^2)$$

where $\frac{1}{2} \leq f \leq 1$, depending on the efficient organizational form domain.

The relative modularization potential modulates the expected net value generated by the upstream party’s efforts; modularization potential ($q_1$) gives a baseline value creation, which is augmented by customization efforts ($q_2$) in proportion to the square of what might be termed the relative customization potential $q_2/q_1$. Additionally, we note that

$$S^{FB} - S^{SO} = \frac{\Delta Q^2 q_2^2}{8} \propto q_2^2$$

$$r_{FB} = \frac{\Delta Q q_2^2}{8} \propto q_2^2$$

The availability of the potential for customization ($q_2$) drives the divergence between first-best and spot outsourcing outcomes in total social surplus. And the existence of this potential for
adding more value through relationship makes the relational contract more robust – the relational contract remains self-enforcing at higher effective discount rates $r$, because there is more relative value uniquely available for division between the upstream and mainline downstream parties. Customization suffers under spot outsourcing; the greater the potential for customization value, the greater the loss. And thus relational governance becomes most valuable when the customization potential is high.

**Implications for the Extended Enterprise**

The Extended Enterprise constitutes a network of transaction relationships, based on relational contracts between firms that foster utilization of the parties’ detailed knowledge of the specifics of their situation to adapt to new circumstances and new information as they unfold. This exercise of the Baker-Gibbons-Murphy model has established four important implications for the interplay of product architecture decisions and the efficient organizational forms supporting the Extended Enterprise:

- The Extended Enterprise can achieve first-best economic outcomes when the future of the relationship has been made important enough. And spot outsourcing cannot. Even when first-best outcomes cannot be sustained, relational outsourcing provides a regime of second-best results superior to those obtained under spot outsourcing.

- The value of the Extended Enterprise grows as the potential for customization increases. The potential for customization creates the potential for value unique to the relationship. Customization therefore suffers under spot outsourcing.

- The greater the potential for customization value, the more robust is the Extended Enterprise relationship over fluctuations in the parties’ views of the future, because the potential for the creation of unique value to be divided between the parties is greater.

- The Extended Enterprise survives only as long as the future is valued sufficiently. Relational contracts cannot be made self-enforcing if the future becomes too heavily discounted.
Section 3

Case Studies in Extended Enterprise Product Development in a Large Corporation: Decisions Made and Decisions Reconsidered

Introduction: Case Studies

We now turn from the formal models of organizational economics and our extensions reflecting product architectural partitioning decisions to the actual practice of Extended Enterprise in complex environments – complex products developed in large corporations.

Two case studies within one product program are presented. These were chosen on the basis of the rich sequence of decisions made. For Case A, an external module supplier was initially selected, over the competing internal supplier unit. Eventually, the external supplier was dropped for this module and the internal unit substituted, while retaining the external organization for a different product module. For Case B, dealing with a consumable material for the product, development was begun with another internal supplier but later switched to an external company.

Our goal for these case studies is to present the structural aspects of the decisions made, their context and assumptions, and their evolution, rather than the specific technical and managerial details. The product program context is first described, followed by a narrative of the decision history and environment. Nine salient features of the case study are abstracted and summarized; these will provide the key observables for the analysis of Section 4. The formal contracts associated with both case studies are examined and particular features extracted and generalized; an example of one version of a generic contract template utilized in similar circumstances is also included as Appendix A. The narrative exposition and extraction of salient features are then repeated for the second case study.

Development of the case studies proceeded from examination of more than 250 program documents and substantive interviews with nine individuals involved in various roles both inside
and outside the product development program. In particular, contemporaneous reporting, technical, and contractual documents were sought, to place recollections and viewpoints from the interviews in context. Personal engineering knowledge of both the technologies and the product development processes assisted interpretation of the information obtained. Frank and full information was provided, with the stipulations that neither the individuals nor the particular program and internal and external suppliers involved would be identified, and that the case study documentation would center on the structural aspects of the decisions made.

Product Program
The program has developed the base platform for a series of electromechanical products, priced in the thousands of dollars and sold worldwide over a number of years. The products are partitioned into a series of electromechanical, electronic, and software modules, and also utilize several proprietary consumable materials which are sold to the end customer over the life of the product. These modules and materials provide the architectural basis for extended enterprise relationships with internal and external suppliers. Successful integration of the modules and of the materials to deliver benchmark product performance is a primary challenge in the development of the platform.

The highly competitive market in which these products participate drives a focus on delivering fully competitive baseline performance with value-added features and functionality, at benchmark purchase and operating costs, timed to meet the market window opportunities for each product in the series. Thus program schedule (time to market) and module and material costs (unit manufacturing costs and total cost of ownership), at required performance, become the management metrics against which decisions are evaluated. Program development budgets are allocated at the corporate level each year and constitute boundary conditions for decision processes.

To attain time to market and benchmark costs in a new platform, the Program adopted an engineering strategy of extensive competitive benchmarking and identification of best of breed approaches and implementations for each individual module, to derive very tough cost targets achievable by best in class suppliers, without the injection of new technology specific to the
product. These cost targets, properly extrapolated to the planned first product launch date, provided the basis, together with a baseline architecture, performance specifications, and general technology approach, for solicitation of bids for module design and development from a short list of potential extended enterprise partners.

The general structure of the partner relationship is configured around two sequential contracts: the first for module design and development, and the second for module production. The design and development agreement imposes limitations on the production agreement, particularly in the area of the unit price to be charged for each module manufactured, and also contains provisions for payment by the Program to the supplier of negotiated development costs labeled as Non-Recurring Expenses or NRE. Abbreviated versions of these formal contracts are also established with internal suppliers. The contracts start from a generic template for extended enterprise relationships but are each negotiated separately and differ in specifics, additions, and omissions when signed. A discussion of these contract terms in the generic extended enterprise template, for both external and internal suppliers, is provided in a subsequent section.

Product development takes place within a formal product development process, paced by phase gate reviews involving an extensive internal self-assessment and external assessors expert in each major architectural, technical, and process area for the product. Proceeding to the next major program phase requires decision by the senior vice president of the parent organization, and delay in phase gate exit, especially in the early phases, is not uncommon. These delays are usually processed through Exception Reviews covering only the issues that prevented phase exit, by the same senior management after another external expert assessment. Major program directional decisions, including the selection of extended enterprise partners, are also reviewed and approved by senior management. Thus senior management oversight is exercised overall through these classes of review and decision meetings and through the annual budget allocation process. External developments, shortfalls against program targets, and internal affordability can all lead to the cancellation of a development program, as the program competes for funding within the portfolio of products at various stages of development within the parent company.
Case Study A

Case Study A involves the product Program; the parent Company in which the Program resides together with other product development programs; two major electromechanical modules developed by extended enterprise partners (referred to here as Modules 1 and 2); a specific external vendor working in the technology areas of both modules (the External Module Supplier or EMS); and an organization internal to the company which produces modules of type 1 for some other company products (the Internal Module Supplier or IMS).

Both the EMS and the IMS organization carried history into the decision process for initial partner selection by the Program. EMS was at that time engaged in supplying modules of both type 1 and type 2, packaged as a single combined unit, for another program within the company, and had developed a positive reputation for competence and responsiveness in that interaction. From its side, EMS also had the experience of already working with the Company as an extended enterprise partner, and understood something of the company practices and pitfalls in this arena. IMS had provided type 1 modules to a previous program carried out at the same location some time before, involving some of the same individuals now staffing up the new Program. The perception of IMS was one of excess cost and uncertain quality in the class of products developed at this site. As perceptions drive decisions, our focus will be on the facts of their existence and nature, rather than on any assessment of their validity.

The program goals made clear that rigorous target costing for each module was required if best in class pricing for product purchase and product operation were to be achieved. A target costing process was developed, involving best of breed benchmarking, adjustment for specification differences, assumption of lowest cost worldwide component sourcing and assembly, and industry year over year productivity improvements. Defensible and transparent targets for partner bids were generated through this procedure, and served to move cost negotiations from the target cost number to discussion of more accurate input data for the target costing process. Partner principles were also developed, including strategic relationship, world class capability, compatible development directions and company ideals, benchmark prices, complementing for partner weaknesses when necessary, partner co-location, and open procedures for target setting.
EMS’s response to the initial bid solicitation was viewed as positive and responsive. EMS was visited by Program staff members, at which time EMS presented a proposal and stated that they expected to meet the target cost. IMS’s initial response was above the target; later IMS submitted a revised bid that too precisely matched the target and therefore was not viewed as credible. Given these responses and EMS’s existing extended enterprise relationship with another Company program, EMS was selected as the partner for both Module 1 and Module 2. The partner selections were subsequently approved by a senior management governing board. A phase exit review was also held and passed within a couple of weeks of this date.

Treatment of development costs (NRE or non-recurring expenses) varied from partner to partner. The Company intent is that generally NRE should be fully bid and charged to the Company, so that the lowest possible production cost is achieved, unburdened by the partner’s need to recover development costs. But NRE is a major component of the partner’s bid (together with target cost response and maximum unique tooling charges to be paid by the Company), so the partner considers the impact of the NRE asked against the probability of award of the development contract, in the context of the overall development budget allocated by the Company to the Program, from which the NRE must be paid. IMS has stated that the NRE contained in the bid and charged to the Company represents 50% of their total development costs for each of the periods. While the accuracy of this representation cannot be easily verified, at least some members of the Program staff find this estimate plausible, based on their observations of IMS’s activities in developing Modules 1 and 2.

Draft design and development contracts were provided to the module partners a few weeks after the selections were approved. At that time, the Program intention was that the contracts would be closed and signed one month later. This failed to happen until much later in the program, primarily because, according to one of the interviews, quality and cost targets were tightly specified in the design and development contract, so the partner had to sign up for meeting the target cost to close the negotiation. Instead, it appears that the unsigned contract acted as an (unenforceable) statement of the framework for the relationship, over an extended period of time. NRE was paid as incurred and prototype modules were provided, using Purchase Orders as the contractual mechanism enabling payments to be made.
The module specifications derived from the initial functional requirements and baseline architecture, used as the basis for partner design and development contract bids, were necessarily incomplete. These evolved as the module and system designs developed and testing revealed interactions and shortfalls. Nevertheless, EMS maintained the originally bid NRE payment schedule, aside from Program requests for life testing and more extensive on-site residency, which were added and paid separately by the Program. Words such as “outstanding” and “commitment” were used by the Program at the time to describe the early relationship with EMS.

For Module 1 in particular, some of the specifications tightened considerably as system testing proceeded. In addition, a major change in the design approach to the module was required because of constraints imposed by design choices made for other modules, and this took EMS into configurations outside their previous experience. Cost outlooks started to diverge farther from target. EMS could not commit to meeting the revised specification in one significant area with the existing design approach, and alternative approaches were expected to produce still more cost impacts.

At about this time, initially informal contact was reestablished with IMS, the internal organization producing type 1 modules for some other Company products. IMS had access to specialized technology that solved the problems created by the EMS design approach change, at some increased cost. The Program considered proposing transfer of the technology to EMS, following up on the partner principle of complementing for partner weaknesses when necessary, but rejected this option as placing too much of the design responsibility inside the Company while still maintaining the external partnership. The diversion and at a minimum time delay of seeking Company approval for such a transfer was also an issue, and it was not at all certain that the proposal would ultimately be accepted.

On the other hand, the practical reality of providing assistance to partners is well established – several of the initial partners “have ended up needing significant program help.” Earlier, expertise residing elsewhere in the Company was tapped by the Program to assist EMS in problem solving for both Module 1 and Module 2. Knowledge transfer was generally viewed as
bi-directional by those interviewed, with the relative balance varying among the module partners but overall probably biased towards knowledge outflow from the Company.

After assessing the available options, the Program made a decision to transfer development responsibility of Module 1 from EMS to IMS. EMS would retain the design and development responsibility for Module 2, where the problems encountered by this point were viewed as more tractable. The challenge was how to break the news without breaking the relationship. The communication of the termination decision for Module 1 was handled personally, at the highest levels of the organizations, sensitively and discreetly. The senior Program manager personally traveled to the EMS home office to discuss the situation. From all reports, the relationship with EMS was preserved, without apparent repercussions. Prototype Module 1 parts continued to be supplied until IMS could initiate shipments. Relations with the resident, who represented both Modules 1 and 2, remained positive, and no adverse impact on Module 2 development was seen. One participant offered the opinion that the EMS engineers, given the unresolved technical challenges at that point, seemed "relieved" rather than offended by the decision. EMS received no additional NRE payments for Module 1 because of the termination, although at Program request the support of Module 2 was increased, so the total NRE payments to EMS did not decline significantly. To the degree that EMS was in fact charging out only half of its actual NRE for Module 1, EMS absorbed its share of the sunk costs. EMS benefited from the R&D knowledge it generated during the development process, as well as from the information that inevitably flows in both directions between the Program and the partner. And EMS maintained its positive relationship and reputation with both the Program and the wider Company.

From this point, development of Module 2 by EMS and of Module 1 by IMS moved forward. Good relationships were continued and established respectively. IMS was viewed as adequately responsive and more focussed on meeting cost targets. IMS structured its development of Module 1 as part of a matrix organization, with the same engineers servicing multiple product programs within the Company. EMS had previously acted similarly, with one set of engineers covering Modules 1 and 2 for both this Program and their earlier program engagement with the Company.
The formal design and development contract for Module 2 was signed by EMS when closure on the target cost was achieved, and some time later the same was accomplished for an abbreviated internal contract with IMS for Module 1, at a new target cost reflecting the evolved module requirements. During this period the Program also passed the second major phase gate review. A contract for Module 1 was never signed during EMS’s tenure as Module 1 development partner.

Our examination of Case A ends at this point in the product development history.

**Salient Features of Case Study A**

One may extract a number of salient features of Case Study A, which will be further pursued in the subsequent discussions.

1. Two tiers of product development program decision making, through Program management and Company oversight.
2. Program management incentives based on meeting Program product manufacturing and ownership cost targets and time to market schedule, at required performance.
3. Multiple alternative internal customers for the IMS organization. Historical perception by some Program staff of IMS as high cost supplier for this product class.
4. Multiple EMS – Company relationships: Modules 1 and 2 for previous program, Module 1 for Program (later terminated), Module 2 for Program (ongoing), bi-directional knowledge flow through existing programs, future possibilities.
5. Separate and sequential module design and development and module production contracts.
6. Design and development contract proposed but not signed for much of design and development period.
7. Company baseline policy to fully pay partner non-recurring expenses (NRE).
8. EMS decision to bid only half of NRE incurred (per EMS statements).
9. Decision to terminate EMS development of Module 1. Decision to not transfer proprietary technology to EMS to support continued development of Module 1. Maintenance of EMS – Program relationship following termination decision. EMS choice to willingly absorb uncompensated sunk NRE costs for Module 1.
**Formal Contracts**

The two separate and sequential forms of formal contracts utilized are the Design and Development Agreement and the Production Agreement. We will focus on the former as it is the governing agreement (once negotiated and signed) for the product development phases covered by the case studies. The production agreement becomes important because (1) it will be negotiated at a later date and thus influences current decisions and actions; (2) it will provide the bulk of the revenues and in principle all of the profits achieved by the module supplier through the partnership; and (3) its terms are constrained by the design and development agreement. Full contracts are signed with external partners (such as EMS), while abbreviated forms are used with internal supplier organizations (such as IMS).

As previously noted, a more or less generic template for extended enterprise relationships is used as the basis for the initial contract proposal, but each contract negotiated in the end differs in particular terms, additions, and omissions relative to the body of the template, as well as, of course, in the specific costs and targets carried in the attachments. An example of one version of the generic extended enterprise module design and development agreement template is shown in Appendix A. It should be reemphasized that some of the key clauses will differ significantly in the contract as signed, reflecting the particulars of the relationship between the company and the specific partner. Aspects of the structure and positions taken in this generic contract will be discussed shortly.

An important context setting instrument for the formal contract and more generally for the relationship between the Company and the partner is a roles and responsibilities chart constructed for each module. It lists about fifty topical areas required to design and deliver a module that fully meets requirements, and assigns which organization (Company, partner, or both) is respectively responsible, accountable, consulted, and informed for that area. Generally speaking, the partner has primary responsibility for module design, manufacturing quality, cost, conformance to specifications, reliability, maintainability, and inventory, among others. The company carries similar responsibilities at the system level, again along with other areas.
The formal module design and development contract consists of nine sections of general applicability (but subject to individual negotiation with each partner, or in the language of the contract, each Developer) and a set of attachments that contain the specific module specifications, schedule, and costs for this particular Developer. These specify the currently agreed target cost to be charged by the supplier for the module in production, the maximum charge for tooling unique to the module as designed for the Company and the minimum production life for the tools, and the NRE payment amounts and schedule. An important addition to the generic contract template utilized by the Program studied here is specification of the formal Change Request review process, requiring Change Control Board approval for changes to the agreed target cost, among other parameters important to the design and development agreement.

The key areas covered in the contract template include design responsibility; design conformance to module specifications; target costs; manufacturing quality; separated production agreement to be negotiated in the future; unique tooling and NRE payments; dispute resolution procedures; termination conditions; intellectual property rights; and the various proprietary, confidentiality, warrantee, liability, etc. clauses required for the conduct of business between corporate entities. The Company explicitly owns the unique tooling (clause II.8.c) which may be used to fill Company orders only, and the design is to be used to manufacture modules exclusively for the Company (IV.2.b). Inability to meet the target cost can lead to termination of the agreement (II.6), and in the event of termination for cause, the Company owns the right to manufacture the design elsewhere (VIII.2.a). Each party agrees not to advertise using the other’s brand, without permission (IX.2). The target cost carries over to the Production Agreement, with provision for sharing between the Company and the Developer any loss or gain from target cost changes, in this version of the contract template (II.12). Services are to be provided to the Company at the most favorable rates offered by the Developer to any other customer (II.9). This most favored partner clause is more broadly constructed in other versions of the contract, which also include statements of intent to purchase all modules required worldwide from the Developer, through the to-be-negotiated production agreement.
A subset of this contract template, labeled Heads of Agreement, is utilized with internal supplier organizations, with the contract running only a quarter of the length of the full external document outlined above. Coverage does include the key areas of design responsibility; design conformance to module specifications; target costs; manufacturing quality; production procurement; and NRE. As might be expected for an agreement within the company, items dealing with dispute resolution, termination, intellectual property, and proprietary, confidentiality, warrantee, liability, and other general terms are largely absent. NRE and tooling are to be handled within the standing procedures of the internal supplier’s parent division and are thus not included in the attachments, which are limited to Module Specifications, Time Schedule / Milestones, and Target Cost.

The internal agreement is presumably enforceable by the company senior management, which can order the contracting organization to deliver what was agreed, absorbing internally any added costs incurred. The external Design and Development Agreement template has a richer character. The primary purpose of the document appears to be to provide a charter for the relationship between the company and the extended enterprise partner, much of which, at the level of outcomes, is insufficiently specified to be enforceable by a third party.

Recall that in Case Study A the Design and Development Agreement was proposed at the beginning of the engagement but not closed for much of the period intended to be covered by the contract. This outcome was typical for the Program’s relationships with the other module partners as well. Instead, the draft agreement serves as a guide to the expected relationship, in terms of:

- **Key contracted elements.** Key elements to be contracted, such as target cost, module specifications, manufacturing quality, development schedule, tooling costs and life, and NRE, and the division of responsibilities and required behaviors in achieving the contracted elements, are listed.

- **Adjustment procedures.** It is recognized that these contracted elements must of necessity evolve as the system is developed, and that in addition many of them are highly interdependent. Thus processes to evolve the contracted values are described, such as the Change Control Board decision authority on target cost adjustments in Case Study A.
• ** Intentions and norms.** These procedures are also generally not fully contractible and so are expressed as intentions and norms, framing expected behavior within the relationship. Phrases such as “mutual intent,” “quickly as possible,” “use best efforts,” “negotiate in good faith,” “mutually agreed upon,” “all reasonable manners,” “good faith modification,” etc. permeate the document.

• **Constraints on future behavior.** Contractible constraints are placed on future behavior, either directly or in terms of consequences. Unique tooling and the design may be used only to manufacture modules for the Company. The target cost is the price to be charged in the Production Agreement. Services provided must be priced on a “most favored partner” basis. Etc.

• **Bounds on parameters of the relationship.** In addition to direct limitations on future behavior, the agreement bounds parameter values that drive the magnitudes of payoffs and consequences of alternative actions. For example, in the general model NRE is fully paid by the Company and paid as incurred, lowering reneging incentives. The Company can terminate the relationship for specific causes but then may take the design elsewhere, limiting holdup. And so on.

**Case Study B**

The second case study within the same product program, Case Study B, involves the product Program; the parent Company; a Consumable material which is sold to the end customer over the life of the product; a packaging and dispensing module used to provide the Consumable to the customer, referred to here as Module C; an organization internal to the company which develops and manufactures similar consumable materials for some other company products (the Internal Consumable Supplier or ICS); and a specific external vendor working in the general area of this class of consumable materials (the External Consumable Supplier or ECS).

As previously mentioned, the Program engineering strategy sought to minimize adoption of new technology, in order to focus on time to market and best in class costs. Because the Consumable plays a major role within the overall performance of the product, the Program view was that early design stability for the Consumable was highly desired, to enable integration of the product modules and the overall system to proceed smoothly. The intention was to utilize a surrogate
test vehicle to establish proper functionality of the Consumable design, and to then adjust module interface parameters to conform the modules to the Consumable to achieve system performance for the product.

As with the Module 1 IMS organization, the ICS organization was also perceived by some members of the Program staff to be slow, insufficiently responsive, and possibly not the lowest cost developer of Consumable materials for the class of products produced on this site, based on interactions on some prior programs. As before, we focus on the perceptions as they existed at the time, rather than on any judgments of their validity. The ECS had no significant prior relationships or history with either the Program or the Company.

Program development was initiated with ICS, as the in-house experts, requested to support development of the Consumable. Obligations to other Company programs, timing relative to the annual budget process, and internal organizational issues slowed the ICS response and limited initial resource commitments by ICS to the task. Subsequently, based on schedule and program cost impacts, a decision was reached by the Program to utilize a Consumable material from another part of the Company. Shortly thereafter, this decision was modified to require development of one new component for the existing Consumable, by the ICS organization, to unambiguously meet a future worldwide acceptability criterion.

This modification proved more difficult than anticipated, and the assumption of full compatibility between the Consumable design choice and the hardware embodied in the surrogate test vehicle was called into question. The outlook for the Consumable cost was somewhat above target, no technical resident from ICS was posted to the Program site, and, overall, the Program perception was that of a lack of what they considered adequate commitment and ownership from the ICS group. During this period, the Program utilized a chance individual relationship to contact ECS, based on a belief that ECS might have or be developing a similar Consumable for use in equipment related to the surrogate test vehicle. Some possibility of ECS developing a compatible Consumable for the Program was confirmed.
The Consumable design approach, based on component modification of the Consumable material from the other company program, had to be abandoned after a fundamental incompatibility was clearly established. The Program responded, after some promising initial testing, by officially bringing in ECS as the Consumable developer, and quickly converted Program hardware to the ECS Consumable. ICS was to pursue another design combination in parallel as the backup, using the surrogate test vehicle. Maintaining Program schedule and accessing lower costs were given as the basis for the Program decision.

From the beginning, ECS was viewed by the Program as highly responsive, maintaining a rotating residency at the site, and quickly delivering on each request. Contracts covering confidentiality and nonanalysis were promptly signed, followed soon after by intellectual property indemnification. But as with EMS and Module 1 in Case A, while a baseline design and development agreement was presented, none was signed at this time.

Significantly, throughout the ECS involvement with the Program, no NRE payments to ECS were requested or made, beyond some later assistance with resident expenses. Consumable materials for testing were provided at near per unit production cost pricing throughout the product development process, rather than at significantly higher prototype prices approaching likely actual costs to ECS, using purchase orders as the contractual mechanism. Thus ECS absorbed essentially all of their internal development costs for the Consumable, treating them as business development expenses. Only successful completion of the Program product development and conclusion of the Production Agreement would provide significant revenue and any profit to ECS. The interviews made clear that the prestige of supplying Consumable material to the Company was viewed by ECS as a strategic payoff for this endeavor.

Development of the Consumable candidates continued in parallel, with the ECS effort labeled and treated as mainline by the Program, and ICS operating on the surrogate test vehicle as the Program backup. ICS believed that it was being held to higher standards than those required of ECS during this period. Concerns by senior Company management for the role of ownership of the Consumable in the product family business case forced the Program to make the ICS candidate mainline for a time. But schedule impact arguments and some performance shortfalls
soon returned the ECS Consumable to the Program test hardware. While ICS continued the parallel development work, official discussions between ECS and ICS were also initiated.

To address business case concerns while taking advantage of ECS capabilities in supporting the Program schedule, agreement was reached at a senior management review to retain ECS as the Consumable material developer, but to manage the relationship through the ICS organization. Company control of the flow of the proprietary Consumable material to the market was facilitated through ICS responsibility for the packaging and dispensing module used to provide the Consumable to the customer, Module C.

By all reports, this three way arrangement among the Program, ECS, and ICS proceeded well. ICS brought significant expertise and supporting infrastructure to the challenges of the Consumable delivery and integration. It is only at this point that a Design and Development Agreement was signed between ECS and the Company. As in Case A, closure on the target cost was a primary reason for the delay in achieving a signed contract. No payments for NRE from the Company to ECS were provided. In part because of the carryover of modifications of earlier confidentiality, intellectual property, and other agreements, this contract for consumable materials is significantly shorter than the module design and development agreement template shown in Appendix A and discussed above. With ICS responsible for the Module C that delivers the Consumable, the focus of the ECS contract is more on meeting specifications, furnishing information, and performing services.

The Program agreement is with the ICS organization, for delivery of Module C packaged with the ECS Consumable. Heads of Agreement, as previously described, are utilized for the formal internal contract. The roles and responsibilities chart also follows the previously described form.

Our description of Case B, as previously with Case A, ends at this point in the product development history.
Salient Features of Case Study B

Case Study B shares a number of salient features with Case Study A. Retaining the numbering scheme of the Case Study A section, these include the following.

1. Two tiers of product development program decision making, through Program management and Company oversight.

2. Program management incentives based on meeting Program product manufacturing and ownership cost targets and time to market schedule, at required performance.

3. Multiple internal customers for the ICS organization. Historical perception by some Program staff of ICS as slow, insufficiently responsive, and possibly not the lowest cost supplier of Consumable for this product class.

4. Separate and sequential module design and development and module production contracts.

5. Design and development contract proposed but not signed for much of design and development period. Confidentiality, nonanalysis, and intellectual property indemnification covered in separate, early contracts.

6. Company baseline policy to fully pay partner non-recurring expenses (NRE).

Case Study B also differs from Case Study A in a number of areas.

4. Single ECS – Company relationship, without prior history, represented by this engagement. Point of entry for future opportunities.

8. ECS decision to charge essentially no NRE to Company.

9. Decision to engage ECS for development of Consumable. Subsequent reinstatement of ECS as Consumable supplier, persuading senior management to rescind directive.

Section 4

Organizational Economics, Product Architecture, and Participant Decision Parameters: Towards Understanding of the Extended Enterprise

Introduction: Modeling Meets Practice
In this section, we bring together the analytic constructs of the formal theory of organizational economics, from Section 1, the conclusions on the interactions of product architectural choices with efficient organizational forms for the Extended Enterprise, from Section 2, and the observed practice of Extended Enterprise, as captured in the two case studies and their associated formal contracts, from Section 3. Our aim is to utilize the conceptual constructs and the analytic structures to gain insight into the fundamentals driving outcomes in practice, while also identifying where the structures and models need to be extended to provide richer explanatory power.

We will nest many of the issues within an expanded framework that accommodates an extended relationship topology appropriate to large corporations; multi-tier decision structures; asymmetries in views of the relationships and in governing parameter estimates; parameter manipulation, evolution, and influencing; and parameter bounding by formal contracts and policies. Starting from the extended topology, we will examine the view of the relationship seen by each party, and explore the interactions and asymmetries of these views and how they are constrained and manipulated by actions and by formal contracts and policies.

Our primary insights include assertions that internal suppliers differ in a fundamental manner in large corporations; that it is only through the company that the program achieves first-best outcomes, because the relational contract resides at the company level; and that product architecture choices distribute the Extended Enterprise value across the system in ways that affect relationship parameters. We conclude with a discussion of internal and external suppliers in the Extended Enterprise, and the critical role of company governance in crafting and sustaining the required relationships.
We are operating in the area of informal modeling, and will phrase explanations in the terminology of the previous sections, even where extensions of the models presented are clearly needed. We will be evocative and approximate in attempting to identify the broad conceptual underpinnings of particular outcomes. Hopefully time will show our arguments to be at least directionally correct and thus useful.

**Case Studies Analysis Structure**

To frame our analysis of some of the salient features of the two case studies, we employ the structures of our earlier exposition of aspects of the formal theory of organizational economics, in the form shown in Figure 8. We start with the generalized supply transaction of Figure 2, and identify the intermediate good as the Module Design and Consumable Design, for case studies A and B respectively. The asset or production equipment utilized to create these intermediate goods is the Design and Development Resources – the physical and intellectual resources available to those taking actions, through which the supplied efforts will produce designs of greater or lesser value to the downstream parties, the targeted and alternative product development programs or users. The internal supplier, the IMS of case study A and ICS of case study B, is here labeled the Division, and the external supplier, EMS and ECS respectively in the case studies, is identified as the Outside Supplier.

Our focus is on the implementation of the Extended Enterprise in large corporations, and we have added in Figure 8 an important feature to the structure of the relationships – the existence of multiple internal programs serviced by the one Division and potentially in competition for the resources and attention of the Division. The topology shown allows us to consider the views of the relationships seen respectively by the Division, the Outside Supplier, the Program, and the Company. It is our belief that important asymmetries and temporal dependencies of these views drive many of the empirically observed outcomes captured in the salient features summaries of the case studies.
The significance of the soft (dotted line) boundary drawn within the Company will be discussed shortly.

**Internal Supplier View**

During the early engagements with nascent programs, the internal supplier or Division must choose where and in what proportions to apply limited design and development resources, among the alternative programs. It is unclear which programs will ultimately provide the large payoffs to the company, and which will not – the Division does not know if a given program corresponds to $Q$ or to $P$, that is, to the most efficient or an inferior utilization of its Design and Development Resources asset. During this period, the Division retains a level of decision rights about the disposition of the intermediate good (the Design) produced with this asset, and thus takes on, within limits, the character of an Outsourcing asset ownership environment, in spite of its location within the firm.

This limited upstream decision right authority is indicated by the dotted line boundary in Figure 8. To the degree that the Company does not assert its decision rights as employer of the division (because of a similar lack of knowledge on where the most efficient asset utilization resides, for example), integrated asset ownership is not exercised even though it is in fact in place. Related
issues are explored through formal models by Aghion and Tirole (1997) and Baker, Gibbons, and Murphy (1999), in the context of transfers of decision authority within organizations. Such limited transfers in our situation correspond to the aforementioned dotted line boundary of Figure 8. Aghion and Tirole see the delegation as following from information asymmetries and catalog a number of factors tending to increase delegation, but treat all delegation as formal. Baker, Gibbons, and Murphy’s analysis, based on what may be paraphrased in part as spot versus relational outsourcing or retention of formal / informal authority, applies more directly to the present situation. In particular, their model of the “uninformed boss” (the Company) informally delegating decision authority to the subordinate (the Division), in a relational setting based on subsequent inspections by the boss of the realized payoffs of the subordinate’s decisions, appears to map to our description.

Our modularity model helps us understand how the Division will behave during this period of ambiguity. The Division views any given incipient downstream program as possessing an uncertain future and poorly estimated potential value, and thus ascribes a high value of the effective discount rate $r$ (equation (3) with a significant $q$ term) to the relationship – the program may well not survive to the next stage production agreement. The Division therefore takes Spot Outsourcing actions initially, emphasizing modularity that benefits all similar alternative programs, and, from the viewpoint of a particular program, shortchanging customization: $a_1$ actions are taken and $a_2$ actions are downplayed, in the terminology of equation (14). Common elements are given attention, consistent with the early ICS activities in Case Study B.

The internal supplier understands that program success will ultimately require a level of customization, but waits to make the $a_2$ investments until the program is identified as a $Q$ rather than a $P$. This identification, when it occurs, also drastically lowers the probability of program termination, reducing $r$ significantly and making relational governance feasible. The firm, for similar reasons, reinstates the assertion of its decision rights under integrated asset ownership. We thus move to the domain of Relational Employment. Early on, the firm abrogated its responsibility under integrated asset ownership to stop ultimately unproductive actions (customization directed towards “losing” programs), because it couldn’t tell where they were. Now that it can, it does.
We thus have a movement from spot outsourcing behavior by the internal Division early-on in the product development process to the expected relational employment. At low enough values of \( r \), relational employment can achieve the same first-best outcomes as relational outsourcing in both customization and modularization, as we have illustrated with our modularity model. At this level of abstraction, neither the external supplier nor the internal division is intrinsically advantaged, as long as the future matters sufficiently, once the identity of the efficient (winning) program is established.

But this discussion also motivates the assertion that internal suppliers differ in a fundamental manner in large corporations, where multiple product programs are supported, from those in small companies focused on a single product. In the latter case, relational employment prevails from the beginning – there are no competing internal programs, and \( Q \) can lie in only one place. Life is different in interesting ways inside the large firm. Multiple start-up programs compete for the upstream Division’s attention, and efficient asset utilization is unclear, until where both longevity (low \( r \)) and highest value (\( Q \)) are located is discovered, enabling value creation from customization actions and making first-best actions feasible through relational governance.

**Outside Supplier View**

The Outside Supplier tends to view its engagement with one or more of the Company programs as the venue for its relationship with the Company as a whole. These transactions may remain in the spot market commodity domain, if the supplier sees no particular value in dealing with this firm many times versus once, or with this company versus another. However, the Outside Supplier (EMS and ECS respectively in the two case studies) can also make the decision to seek a long term relationship with the firm, because its reputation from its dealings with the current company Program will provide the access for future transactions with other programs, and because it judges that this totality of transactions constitute the efficient utilization of its Design and Development Resources asset. The Outside Supplier assesses the value of Design creation for the Program in question not in isolation, but within the sum of access potentially gained to a series of Company programs whose integrated value is estimated to correspond to \( Q \), not \( P \).
We thus have an important distinction in the assessment of Design value to the Program between the internal Division and the external Outside Supplier. The internal Division is "guaranteed" access to each program, by policy (generally "right of first refusal" on company programs), and consequently initially evaluates its actions relative to the particular Program in isolation, as we have argued above. The Outside Supplier gains access to other Company programs only through its performance with the Program in question, and thus evaluates strategically, estimating its probability of acceptable performance success on the Program (adequate value created to sustain the relationship) together with the financially and probabilistically discounted value of future program engagements. The Division has the security to engage the Program tactically, within limits, while the Outside Supplier must make its choices at a strategic level. The Outside Supplier wants the Company relationship, but has initial access only to the Program.

Clearly, several model extensions are suggested by these arguments. The asymmetry of potential relationships between the internal and external suppliers could be captured by analyzing the topology of Figure 8 for the internal supplier, with the possibility of relational employment with an Alternative User (alternative program) of value $R$, as well as the efficient asset utilization with the Downstream Party (targeted program) of value $Q$, in the terminology of Figure 2 (this formal extension was suggested by R. Gibbons). The time evolution of the internal supplier's estimates of $R$ and $Q$ could also be usefully modeled as a two stage game superimposed on the above structure, with the uncertainty resolved between stages.

In terms of our modularity model as it stands, the Outside Supplier may conduct an assessment of the strategic potential of transaction with the Company and immediately assign a low effective discount rate $r$ to the relationship, placing major value on expectations for the future. Thus the Outside Supplier engages at the Relational Outsourcing level from the beginning. First-best actions become possible, and the Outside Supplier will fully pursue both modularization ($a_1$) and customization ($a_2$) actions, in contrast to the expected early conduct of the internal Division.

Such behavior is apparent in the case studies. Both EMS and ECS assigned strategic value and a low effective $r$ to the relationship, for different reasons – EMS because this was a successive program engagement within the Company and because two modules (1 and 2) were involved,
ECS because the Program provided entrée to the Company with success paying off strategically in prestige and reputation. For ECS, achieving $Q_H$ in the current game would raise both $Q$ and $P$ for future games, through a form of enhanced “brand equity.” Again, a model extension is suggested, coupling the current and future period parameters. The Program viewed both EMS and ECS as highly responsive partners – the “customization” $a_2$ actions were taken, in contrast to early behavior by both IMS and ICS, which favored “modularization” $a_I$ actions only, in agreement with the modularity model.

**Program View**

Program management incentives in the case studies focussed on meeting Program quality, cost, and delivery targets. The local management relational horizon was thus only through execution of the second contract, for module production, and achieving schedule and cost targets was paramount. If one supplier, internal or external, was faltering, another supplier who offered higher confidence of meeting the targets was to be preferred. The Program operated at high relative $r$, with the here-and-now driving choices. Relationship beyond the second game was not a prominent local consideration. Clearly, our use of high values of $r$ to deduce behaviors and outcomes is awkward for this case of a program acting tactically and actually playing a two stage game (design and development, and production) in the extreme. More explicit modeling of the situation as described would be beneficial.

The challenge for the Program was to achieve the high levels of both the customization ($a_2$) and modularization ($a_I$) actions required for benchmark costs and performance, while operating locally in a spot governance domain. Run of the mill cost and performance will not do in a highly competitive market; largely first-best outcomes are needed.

Part of the Program response was to attempt to create a “hard” system interface with respect to the Consumable, utilizing a surrogate test vehicle to establish functionality of the Consumable design, and then adjusting module interface parameters to conform the modules to the Consumable, rather than vice versa. The Program sought to push the customization away from the Consumable design, and onto the modules with which the Design interfaced. By emphasizing modularization of the Design, the Program lowered its dependence on first-best $a_2$
actions in support of customization; decreasing the value of \( q_2 \) in equations (14), (30), and (31) was pursued. Such a strategy intended to reduce the penalty for operating in the spot governance domain, assuming other suppliers with similar modularization value outcomes were available in the spot market.

A more complete proposal for the resolution of this seeming contradiction within the Program between a heavily discounted view of the future and a strong need for first-best outcomes will be given below.

**Company View**

The Company by definition owns the assets utilized by its units, specifically by the various Programs and the internal supplier Division. The Program, if successful, acts as the internal supplier to marketing and sales. Since effective delivery of a product in terms of cost, performance, and schedule tends to rewarded with advancement and assignment to new product development programs, the Company seeks to operate in the relational domain with the Program management, seeking first-best outcomes. The high level success criteria are very explicit for the Program, driving the relentless Program management focus on current outcomes in its transactions with its suppliers, as discussed above. Relational Employment is crucial to Company market success.

In contrast, we have argued above that the control of the Division exercised by the Company evolves as programs progress from initiation to mainline, and that the Division exercises limited upstream decision authority in spite of its location inside the firm. This leads to actions approaching Spot Outsourcing early-on, in the Division’s initial responses to new-start Program needs. The Division directs its first-best efforts to established programs, and husbands resources applied to the newcomers, until better estimates of longevity and value are available. One may speculate that the Division is also attempting to influence how the Program partitions the product, manipulating where in the system the customization \( q_2 \) value is placed by the Program, by initially offering the Program the modular design where Division actions against \( q_1 \) modularization benefit all potential users. If you have multiple customers that you cannot sort by
relative value, pursuing strictly universally beneficial \( a_t \) actions may maximize your expected payoff.

The Company requires the success of not one program one time, but of a succession of programs delivered over a period extending indefinitely into the future, each at or at least very near benchmark in cost and performance at the time of introduction. To support this need for repeated transaction and predominantly first-best outcomes, the Company seeks to behave relationally in many cases – those beyond the commodity markets (where the absence of customization can give spot governance first-best results). Relationships with best-in-class suppliers, internal and external, are required – suppliers whose \( Q_H \) exceeds those of others in the field. The process for selecting partners with whom to transact – deciding who has the highest \( Q_H \) – is outside the current model. To repeatedly achieve first-best results, the Company fosters Relational Employment internally and Relational Outsourcing externally, operating at a low effective discount rate \( r \) in the terms of the model as presented here.

Herein lies the crucial difference between Company and Program governance. In the extreme, the Program is expected to make the outcome of the current game paramount – to behave tactically, while the Company husbands the relationships which insure that repeated games result in first-best outcomes – the Company deals strategically. Success of program management in the current game, against quite aggressive goals, is highly deterministic in the decision of whether the management ever gets to play another significant game in the form of a future program, be it product extensions or a new product platform. In such an environment, the future is highly discounted in any program decision affecting current achievement of product targets.

**Interactions and Asymmetries of Participants’ Views**

We are now able to resolve the Program need for first-best outcomes while operating locally with a heavily discounted approach to supplier relationships. The mutual needs of the Outside Supplier, the internal Division, and the Company for repeated interaction, value creation through customization, and first-best outcomes are reciprocally serviced through relational governance and low individual values of the effective discount rate \( r \). The strategic relationships bypass the Program, which obtains the benefits of relational governance from its location within the
Company, while often behaving locally in a spot governance mode with a high personal value of \( r \) when dealing with upstream parties. First-best outcomes are still achievable, because the dominant relationships of the upstream parties are with the Company, not the Program in isolation.

We are also now in a position to plausibly motivate many of the outcomes observed in the case studies. As discussed above, the Program sought to minimize the customization required for the Consumable by creating a “hard” system interface and moving the customization onto interacting modules. This strategy led to a Program view that the Consumable supplier could be changed with less impact to the program schedule, since the customization value (\( q_2 \) in equations (14), (30), and (31)) was being attenuated and first-best \( a_2 \) customization actions were consequently of less import.

In contrast, the internal Division (ICS) view, based on its historical experience, was that customization was critical to successful product integration – \( q_2 \) was necessarily large, the difference between first-best and spot outsourcing outcomes was quite significant, and a relational contract could thus be self-enforcing at relatively high values of the effective discount rate (equation (31)). ICS imputed significantly more value to their relationship with the Program than the Program ascribed. The two parties saw the nature of the design and development task differently.

The relational contract was in the self-enforcing range for ICS but not for the Program, because of the asymmetry in the estimates of the two parties of the relationship parameters. Similar asymmetries in relationship parameters that result in taking the relationship outside the self-enforcing range, following from a different cause – shocks to the external environment, are discussed by Klein (1991, 1996). ICS felt its distraction by other pressing obligations early in the engagement with the Program could be survived because of the customization value it brought, while the Program viewed the lack of perceived responsiveness as raising the discount rate on its future with ICS beyond that sustainable by the lower customization value it believed it required. In terms of equations (27)–(29), \( r_{FB} \) and \( r_{FB}^{RO} \) were estimated differently by the two
parties. It is interesting to note that the internal ICS organization served to provide much of this customization value in its final role of managing the external ECS supplier.

**Influencing and Time Evolution of Parameter Estimates**

This last observation raises the more general issue of the importance of current estimates of relationship parameters as the context for decisions. Beyond the asymmetry in estimates made by pairs of transacting parties, already illustrated above, parties act to actively influence the estimates held by their counterparts. Such signaling behaviors are readily apparent in the case studies. For example, from the beginning both EMS and ECS responsiveness signaled their views of the Program relationship as a (potentially, in the case of ECS) strategic relationship with the Company; they made clear at the start that they were operating at a low effective discount rate $r$. The Design and Development contracts remained unsigned, but the transactions continued unimpeded – EMS and ECS had signaled their view that the governance was relational. And so on.

EMS and ECS also sought to influence how the Program estimated its parameters for the two stage game being played at the Program level (design and development phase, and production phase). In terms of the constructs of Figure 4, the Program decision to continue its relationship with a particular supplier was based on its estimates of the relative payoffs from Cooperation $C$, versus Defection $D$ followed by Punishment $P$. We noted earlier that the Program sought to raise its $P$ by reducing customization value for the Consumable, lowering the penalty for switching to the best alternative supplier. This system partition decision also had the outcome of seeking reduction in the benefits of cooperation with a given supplier, by redistributing $C$ across the system. The Program’s protection of its ability to switch suppliers eroded the probability of achieving a self-enforcing relational contract, as reflected in equation (2).

But the outside suppliers also acted to manage the perception of the parameters of the relationship. The early responsiveness shown by both EMS and ECS served to increase Program confidence that the payoff from cooperation would be achieved, lowering the uncertainty component of the effective discount rate applied to $C$, and to indicate that EMS and ECS would apply significant effort, raising the expected value of $C$ for the Program.
EMS charged the Program only half of the NRE (non-recurring expenses) it reported incurring; ECS charged essentially none at all. Both EMS and ECS were lowering the Program’s value of \( D \), the temptation to renege, in order to sustain the relationship with the Company, especially before the creation of customization value grew \( C \) relative to \( P \). These NRE choices by the external upstream parties also raised \( C \) for the Company, to the degree one assumed that this NRE policy would continue into future games. Conversely, the same assumption raises the upstream parties’ \( D \) – the expectation that NRE will be absorbed means that the suppliers’ money could be saved by reneging.

More generally, transfers of responsibilities, acceptance of constraints, etc. between the two parties to a relationship usually alter both parties’ sets of \((D, C, P, r)\) parameters. Pledging to accept a current cost raises my \( D \) (since I could choose to not pay) and your \( C \) (if the cost otherwise would be carried by you). But our views of the value of our relationship depend not on our individual \( D, C, \) or \( P \) in isolation, but on the relative payoffs of alternative courses of action – on \((C - P)\) relative to \((D - C)\), as captured in equation (4). Raising my \( D \) in order to increase your \( C \) may help both of us by moving these difference terms in the right directions. Such exchanges of \( D, C, P, \) and \( r \) can thus be mutually beneficial, if they serve to make relational governance and first-best outcomes feasible, by moving the relational contract into the self-enforcing range for both parties.

**Impacts of Contracts and Policies**

The formal contracts and the policies adopted by the parties act in a similar manner to manipulate the parameters of the relationship. More precisely, they constrain the ranges over which the parameter values are likely or allowed to evolve, and limit parameter excursions and fluctuations, with the intended outcome that a self-enforcing relational contract between the Company and the Outside Supplier is both more likely to be established and to survive. For example, the stated company NRE policy of expecting NRE to be fully bid and to then reimburse the NRE as incurred decreases the Program’s future value of \( D \) (since the payments have already been made) and correspondingly raises the Outside Supplier’s current value of \( C \) (since the payments are being received), as well as lowering the supplier’s sensitivity to the actual value of
\( r \), since the payment stream has been moved forward. Program promises are turned into Program sunk costs. These actions allow the supplier’s expectation of future payoff \( C \) to be lower, or in the terminology of the case studies, the Outside Supplier can offer the lowest possible production cost to the Program, unburdened by the need to recover the development costs incurred.

The formal contract also directly affects the relational. The agreement on target pricing and on the mechanisms for pricing changes in the design and development contract serves to limit the potential for hold-up by the upstream party, lowering the value of \( D \) for the outside supplier and raising \( C \) for the Program. The design and development contract provision for company (Program) ownership of unique production tooling similarly acts to limit holdup by the upstream party, since the Program can terminate the relationship for specific causes and take the design elsewhere. Again, \( D \) for the supplier is reduced, and \( C \) for the Program increased.

The existence of two sequential contract stages, separating the production agreement from the design and development contract, raises the potential for end-game behavior, by the Program and potentially by the Outside Supplier, if the perceived value of future relationship with the Company has degenerated sufficiently. The Program seeks to dampen \( D \) for the supplier through the pricing provisions and tool ownership already discussed, thus raising its \( C \). The downstream tool ownership also constrains the ability of the Outside Supplier to take unproductive actions investing in alternative use value during the production phase. The potential for diverting the production asset to \( P \) rather than \( Q \), in terms of Figure 2, is largely prevented by moving the Company – Outside Supplier relationship from Relational Outsourcing during the design and development phase to one approaching Relational Employment during the production agreement, where end-game behavior (high \( r \)) would otherwise take the transaction to Spot Outsourcing.

One suspects that these choices illustrate the insight from the Baker-Gibbons- Murphy analysis of unproductive multitasking shown in Figure 6 (Baker, Gibbons, and Murphy, 2001b), where the potential for high return on investments in alternative use value (large \( \Delta P \)) make Relational Employment the efficient organizational form at intermediate effective discount rates \( r \). Relational Employment remains self-enforcing where Relational Outsourcing is not, if discount rates rise when alternative use investments also become tempting.
The Interplay of Organizational Economics, Product Architecture, and Participant Decision Parameters in the Extended Enterprise

In this section, we have brought a level of economic theory and Extended Enterprise implementation together, seeking insights to the fundamentals driving outcomes, on the practice side, and starting points for useful extensions to the formal structures and theory, on the modeling side. We have utilized selected constructs from the formal theory of organizational economics, as summarized in Section 1, and our development of the interactions of product architectural choices with efficient organizational forms for the Extended Enterprise, from Section 2, to examine aspects of the product development environment and rich decision history captured in the two case studies and their associated formal contracts, abstracted in Section 3.

These theoretical considerations have generally provided conceptual but not fully detailed explanations for much that was observed in the case studies, identifying hypotheses on fundamental drivers of behavior and simultaneously pointing to areas for useful model extensions. We believe that this exposition has repeatedly, through a range of specific examples, shown the interpretive power of the concepts underlying the theory developed, when augmented by an expanded context that includes:

- an extended relationship topology appropriate to large corporations
- multi-tier decision structures
- asymmetries in participants’ views of the relationships and in their parameter estimates
- influence actions targeting other’s parameter estimates
- parameter manipulation and evolution, purposefully bounded by formal contracts and policies

This analysis has motivated the assertion that internal suppliers differ in a fundamental manner in large corporations, where multiple product programs are supported and can distract. We have also argued that there is a crucial difference between Company and Program governance – in the extreme, the Program is expected to behave tactically, while the Company deals strategically, responsible for nurturing the relationship sought by the Outside Supplier, to support on-going transaction and repeated first-best outcomes. It is only through the Company relationship that the Program achieves first-best performance from its suppliers. And product architecture choices
modulate the potential value of Extended Enterprise relationships, serving to distribute that value across the system in ways that interact with relationship parameters and thus affect relationship viability.

**Whither Now? Internal and External Suppliers and the Extended Enterprise**

We have modeled the Extended Enterprise as rooted in relational governance. Our analysis of the Modularity Model has posited the fundamental source of incremental value in the Extended Enterprise in the accessibility of first-best outcomes when the future is sufficiently important, under conditions of incomplete contracting where spot outsourcing cannot achieve first-best. But such advantage is available under both relational outsourcing and relational employment at low enough values of the effective discount rate $r$. What then of the choice between internal and external suppliers within the Extended Enterprise?

Our modularity model appears to favor the outside supplier, in that relational outsourcing provides the most efficient organizational form for a range of intermediate discount rates, and relational employment does not. In this range, incentive systems that can be maintained under relational outsourcing are defeated by reneging temptations under relational employment, within the model structure. And our extensions of the relationship topology suggest that the internal division will fail to take first-best actions early-on, while the external supplier will behave relationally from the beginning, motivated to use the program activities as the basis for a relational contract with the firm as a whole.

Nevertheless, the internal supplier may offer proprietary technology or other competitive advantage to the program above that available externally – the $Q_H$ offered internally can be larger than the external $Q_H$, and the company may choose to keep the advantage inside the firm, rather than selling externally or upgrading the potential external partner. Yet in other supplier performance dimensions, such as costs and schedule, the internal supplier may be disadvantaged, lacking access to the open market and the associated economies of scale and cumulative experience advantages, and the disciplining influences of market competition.
Another consideration also arises when product innovation requires coordination among multiple, complementary elements to achieve the system benefits — when the innovation is systemic, not autonomous. Chesbrough and Teece (1996) argue that

“when innovation is systemic – independent companies will not usually be able to coordinate themselves to knit those innovations together. . . . Key development activities that depend on one another must be conducted in-house . . . Without directed coordination, the necessary complementary innovations required to leverage a new technology may not be forthcoming.”

In our terms, the risks associated with systemic innovations may simply be too great to enable relational governance to coordinate the activities externally — the discount rate is simply too high.

For all these reasons and many more, internal supply to company programs may be preferred in a particular case. The basic dilemma is that the external supplier lives in the spot as well as relational outsourcing world, with the feasibility of high powered incentives, the advantage of market scale, and the discipline of market accountability, while the captive internal supplier does not, but offers proprietary innovations, systemic coordination, and efficient and more robust relational employment when alternative use investment temptations rise.

Clearly this is an area rich in promise for insight from further model development. In the meantime, we speculate that structured partnerships between internal and external suppliers, jointly servicing multiple company programs, may provide superior outcomes under a range of circumstances. In such a construct, service to programs is partitioned by the match of the specific program needs to the somewhat complementary capabilities of properly selected internal and external supplier partners. The relational status of the external supplier is strongly reinforced. For the internal division, the external partner serves as a controlled intrusion of the supplier market into the company, providing a window on the strong incentive world and a reference point for best-in-class performance in the open market, while retaining internal proprietary advantages and coordination in multiple dimensions. At the same time, maintaining a level of overlapping internal and external capabilities lessens the potential for holdup, helps
provide supply assurance, and enables other benefits flowing from alternatives and limited redundancy.

**Role of the Company**

We close by reemphasizing the critical role of the company in crafting and sustaining the Extended Enterprise. The company, as distinct from the programs, acts strategically to enable a succession of near first-best program outcomes, over a period extending indefinitely into the future. It does so by fostering relational employment internally and relational outsourcing externally, accessing best-in-class suppliers. The company’s reputation determines the available games to be played, and the company’s relationships enable the repeated games that deliver the first-best (or nearly so) on-going value stream to the company.

Company oversight is crucial. The company, not the program, ultimately owns the quality of the external and internal relationships, and holds the responsibility of crafting and sustaining the self-enforcing relational contracts that characterize the Extended Enterprise and enable it to produce first-best outcomes. It executes this responsibility through formal and informal manipulation of the parameters of the relationships: through formal contracts and policies bounding parameters, through actions, directed if necessary, to adjust both parties’ parameter estimates into the self-enforcing range, and through constraints on allowable actions by the programs.

The health of the company’s relational contracts is central. Baker-Gibbons-Murphy’s articulation of the role of the manager within the firm bears repeating:

> “By emphasizing the importance of relational contracts, our model highlights a role for managers: the development and maintenance of relational contracts, both in the firm and in supplier relationships. . . . this role involves designing the relational contract . . . communicating this to employees, assessing outcomes . . . and deciding whether to honor the relational contract . . . We conclude that understanding the role of managers, who design and implement the relational contracts that underpin informal organizational processes, is essential to understanding firms” (Baker, Gibbons, and Murphy, 2001b).
References


EXTENDED ENTERPRISE MODULE DESIGN AND DEVELOPMENT AGREEMENT

THIS EXTENDED ENTERPRISE MODULE DESIGN AND DEVELOPMENT AGREEMENT ("Agreement") is entered into by Company with offices at ________________ ("Company") and ________________ with offices at ________________ ("Developer"), effective ________________ ("Commencement Date").

The parties agree as follows:

I. DEFINITIONS

1. Module Specifications. "Module Specifications" shall mean the specifications and critical parameters for the Module provided by Company to Developer, including without limitation IOC, interface requirements and Target Cost, as further set forth in Attachment A and as modified, enhanced and/or supplemented as provided in this Agreement.

2. Module. "Module" shall mean the subject of the design provided for herein and an integral part of the System, which will be made by Developer according to the Module Specifications.

3. NRE. "NRE" shall mean nonrecurring expenses incurred by Developer in performance of its obligations hereunder.

4. System. "System" shall mean the Company-specified device of which the Module is an integral part.

5. Target Cost. "Target Cost" shall mean the unit production price for the Module.

6. Company Unique Tooling. "Company Unique Tooling" shall mean all items of tooling which Developer must produce or procure in order to develop unique feature or appearance aspects of the Module, as identified in Attachment B and amended from time to time by mutual agreement. Developer shall use Company Unique Tooling solely for the purpose of manufacturing prototypes and Modules for Company, and for no other use or purpose without the express written permission of Company.

II. MODULE DEVELOPMENT AND DESIGN


(a) The parties shall work in concert on the design of the Module. Developer shall have primary design and developmental responsibility for the Module by selecting and building into it original and improvement items and aspects thereof, but Company shall be actively engaged in the design and developmental process, proposing in its discretion some original and improvement items and aspects thereof and assisting Developer in all reasonable manners.

(b) Company shall have overall responsibility for the design of the System.
2. Conformance with Module Specifications.

(a) Company shall provide to Developer such specifications for the System as Company deems necessary for Developer’s purposes together with the Module Specifications, which cumulative specifications shall be mandatory and binding on Developer. The parties acknowledge that due to the developmental nature of the work under this Agreement, the Module Specifications and/or System specifications may evolve as the design and developmental work is completed, and that the parties shall modify and/or enhance Attachment A from time to time to reflect agreed-upon modifications and/or enhancements.

(b) Developer shall be responsible for total conformance by the Module with the Module Specifications. Company reserves the right to reject the Module without incurring further liability in the event that the Module does not conform totally to the Module Specifications. During the initial design and development phase, Company shall specify and inform Developer of the specific defective parts per million levels for the Module for both startup and line balance, such levels to apply during the production phase.

3. Regulatory Compliance. The parties agree that the Module design will comply with regulatory and government agency requirements for countries in which the System will be marketed. Company will communicate those requirements to Developer as soon as possible, and upon such communication, such requirements will be deemed part of the Module Specifications.


(a) Developer acknowledges and agrees that the design and development work to be performed under this Agreement will require the Module to interface with other modules of the System which are being designed by Company and/or third parties. In order to ensure that the Module design enables the incorporation of the Module into the System such that it performs its intended function and meets overall System specifications, Developer agrees, at the request of Company, to meet with co-designers of other System modules from time to time and share such information as Company shall request, subject to Section IV.4 below. Any changes in System specifications or Module Specifications will be communicated promptly to all affected parties.

(b) The parties also acknowledge that in order to perform their obligations in a timely manner, it may be necessary for employees of one party to co-locate within facilities of the other party from time to time, for such periods as the parties agree are required under the circumstances then pertaining.

5. Time Schedule. The preliminary development time schedule and associated milestones for the Module are contained in Attachment C. Developer agrees to use best efforts to meet or exceed this schedule. While it is understood that communications between the parties will be frequent and ongoing, the parties agree to meet not less than monthly to review the design and current schedule. In addition, the parties agree to meet promptly upon the request of either party if problems in the work of either party are discovered or events give rise to the inability of either party to meet its scheduled benchmarks. Such meetings shall be attended by senior managers of each party with the authority to commit such resources as are necessary to insure that negative impact on the schedule is prevented or minimized to the extent possible.
6. **Target Costs.** The parties agree that it is their mutual intent to design the Module so that it meets all System and Module Specifications at the worldwide benchmark cost. The parties agree to establish a target cost for the Module, which target cost will be identified in Attachment D and used as a guideline during the design and developmental process. The parties agree that inability to meet the target cost shall be a reason for the termination of this Agreement by Company upon notice and without further liability at any time, provided that in the event such inability is caused by changes made by Company to the Module Specifications, the parties shall negotiate in good faith a change to target cost commensurate with such Base Specification change(s). The parties further agree that certain issues beyond the direct control of the parties, such as worldwide commodity costs, may require the good faith modification of the target cost during the term of this Agreement, in which case the parties agree to negotiate in good faith a commensurate increase or decrease to the target cost, supported by sufficient documentation to justify the change.

7. **Prototypes.** Developer agrees to provide Company with such prototypes of the Module as Company shall require. Company shall notify Developer of its requirements for prototypes as quickly as possible. Such prototypes shall comply with the agreed specifications for the same, which may be different from the Module Specifications, and shall be manufactured using such tooling as the parties shall agree from time to time. Company shall pay the agreed-upon cost of any delivered prototype which conforms to the specifications, within forty five (45) days of receipt of Developer’s correct invoice therefor.

8. **Company Unique Tooling.**

   (a) The total cost for Company Unique Tooling shall not exceed the sum of \[\text{COST}\]. Company shall pay Developer the actual costs of the production of Company Unique Tooling in 1/3 (one third) increments upon (a) placement of the Tool purchase order by Company with Developer, which shall occur at such point as the design of the part or component requiring Company Unique Tooling is fixed; (b) acceptance by Company of the first product of Company Unique Tooling for every part that comprises the Module; and (c) acceptance by Company in writing of all of the first production parts or components which comprise the Module, provided further that the Module has satisfied the Field Readiness Demonstration Test.

   (b) Company Unique Tooling shall be capable of producing not less than the number of parts (or sets of parts) as set forth on Attachment B. Developer shall care for and perform necessary maintenance on Company Unique Tooling to ensure that it meets its agreed upon production life.

   (c) All right, title and interest in and to Company Unique Tooling shall be vested in Company from the commencement of the fabrication of same. Developer holds Company Unique Tooling as bailee and shall not substitute any property for Company Unique Tooling, use such Tooling except for filling Company orders, or reproduce Company Unique Tooling. Developer shall make entries in its books showing that Company Unique Tooling is held for the account of Company and shall furnish Company on demand a true and complete inventory of Company Unique Tooling held by Developer for any period of time requested by Company. While in Developer’s custody or control Company Unique Tooling shall (a) be plainly marked or otherwise identified as “Property of Company” and stored in a separate area in Developer’s place of business, (b) be held at Developer’s sole risk, (c) be kept insured by Developer at its own expense in an amount equal to the then current replacement cost with loss payable to Company. Developer shall return Company Unique Tooling to Company immediately upon demand.
9. **Continuing Development and Engineering Support.** During the term of this Agreement, Developer agrees to provide Company with such ongoing development and engineering support, including without limitation remanufacturing support, as Company shall require at both Company’s facility (as designated in the first paragraph of this Agreement) and the build site(s) identified by Company from time to time. Such support shall be provided at Developer’s most favorable rates and charges as offered by Developer to any other of its customers for such services and support. (Charges for support shall be included within any agreed NRE as itemized in Attachment E.)

10. **Choice of Materials.** Developer shall use best efforts to ensure that the Module and its packaging comprise materials which can be remanufactured and/or recycled to the maximum extent possible within the target cost.

11. **Business Continuity.** During the term of this Agreement, Developer shall operate a mutually agreed upon business continuity program including off-site recovery capability and the ability to resume its obligations under this Agreement after a disaster or major disruption.

12. **Production Agreement.** If the development of the Module is successfully completed as set forth herein, Developer agrees to negotiate in good faith with Company terms and conditions of manufacture and sale of Modules to Company or Company customers worldwide, directly or through third parties, such terms and conditions to be in the form of an amendment to the parties' then current Multinational Purchase Agreement or other production agreement as applicable. Such terms and conditions shall include without limitation (a) the Target Cost (as set forth in Attachment D), subject to modification solely in a writing duly signed by both parties in accordance with the terms and conditions of this Agreement or the applicable production agreement, provided that in the event of any modification of the Target Cost, each party shall bear responsibility for fifty percent (50%) of any increase and shall be credited with fifty percent (50%) of any decrease respectively, and further provided that the parties shall use best efforts to ensure that the Target Cost corresponds to worldwide benchmark cost; (b) in the event a Module component part and/or raw material becomes obsolete, Developer’s obligation to identify a suitable alternative thereto, redesign (to the extent necessary) the Module to accommodate such alternative, and demonstrate continued compliance of such redesign with the Module Specifications; and (c) the express incorporation of Sections VIII.2(a) and VIII.2(b) of this Agreement.

### III. NONRECURRING EXPENSES

1. Developer will be fully responsible, and Company shall have no liability whatsoever, for NRE unless the parties have executed an Addendum to this Agreement to the contrary which identifies the specific items, maximum dollar value, and payment schedule of NRE to be reimbursed to Developer by Company (Attachment E).

2. In the event the parties have executed the foregoing Addendum, Developer shall provide to Company such evidence of the reimbursable NRE as Company shall require, and Company’s obligation to reimburse Developer shall be contingent upon the receipt of such evidence. All payments of NRE shall be made within forty five (45) days of Company’s receipt of Developer’s correct invoice. Upon termination of this Agreement by either party for any reason (other than Company’s breach) following the payment of any NRE and provided that Developer has not performed all of its obligations under this Agreement as of the effective date of such termination, then in addition to any other remedy set forth in this Agreement, Developer shall refund to Company all NRE payments made by Company prior to the date of termination.
IV. PROPRIETARY RIGHTS

1. **Developer Proprietary Rights.** Company agrees that all patents (to the extent that any such patents are valid), copyrights, and proprietary know-how possessed by Developer prior to the Commencement Date of this Agreement, and relating to the design and development of the Module, shall remain the sole property of Developer.

2. **Company Proprietary Rights.**

   (a) Developer agrees that any invention, innovation, discovery, writing, or other work product of Developer, its employees, agents, and/or subcontractors relative to or resulting from the design and development of the Module, which is made during or after the design and development of the Module, and/or which is made based upon confidential information supplied from Company to Developer shall become the property of Company. In addition, all patent applications resulting from the design and development of the Module, regardless of the employment of any of the inventors thereof, shall be assigned by Developer to Company. Developer agrees promptly to disclose any such inventions, innovations, discoveries, writings, patent applications or other work products of Developer, its employees, agents, and/or subcontractors to Company, and Developer further agrees to promptly obtain or to cooperate with Company to obtain patent, copyright, or other appropriate intellectual property protection on each such invention, innovation, discovery, writing, or other work product in the United States and in other countries. In addition, Developer shall use its best efforts to perform all lawful acts requested by Company (a) to perfect Company’s title as to each of those items for which title shall pass to Company as set forth herein, and (b) where applicable, to enable Company or its nominee to obtain and maintain copyright, patent or other legal protection therefor anywhere in the world. Company will pay the actual costs incurred by Developer in rendering such assistance.

   (b) Developer agrees that the design of the Module shall be used exclusively for the manufacture of Modules for Company and third parties designated by Company and no other purpose without the prior written consent of Company, which consent may be withheld for any reason. For the purposes of this sub-clause “design” shall be taken to mean all aspects of the physical configuration of the Module, including (without limitation) its outward appearance, which permit the Module to interact in a successful, effective and as-intended manner with the System.

3. **Documentation.** Developer shall provide Company, at Company’s request, with such full and complete copies of all mechanical, process, electrical/electronic and other designs and supporting documentation (including all CAD files and any documentation related to software or firmware) of aspects of the Module as Company shall specify from time to time, and all rights, title and interests in and to such designs shall be as set forth in Section IV.2 above.

4. **No License.** Nothing in this Agreement shall be construed as a license of any patent, copyright, design, software, technology, know-how, or any other intellectual property from Company to Developer. Notwithstanding the foregoing, Company agrees to negotiate, in good faith, license terms respecting patents resulting from patent applications related to development performed under this Agreement for uses not competitive with Company.
V. WARRANTIES

1. Developer warrants and represents:
   
   (a) That it shall provide sufficient qualified personnel to perform Developer's obligations hereunder and shall perform all development in a competent and professional manner, in accordance with industry practices and standards generally applicable; and
   
   (b) That (a) Developer's internal computer-based communications and business systems infrastructure and (b) the Module including any prototypes and/or production units, individually and in combination with the System, will accurately process date and date related data including, but not limited to calculating, comparing, and sequencing into, within and between the twentieth and twenty first centuries; and
   
   (c) That no original or improvement item or aspect of the Module proposed and used by Developer in the design and development of the Module infringes the intellectual property right (including without limitation any right based on patents, copyrights and/or trade secrets) of a third party or entity; and
   
   (d) That Developer shall not in the design and development of the Module infringe the intellectual property rights (including without limitation rights based on patents, copyrights and/or trade secrets) of any third party or entity; and
   
   (e) That Developer has the right and authority to grant the rights and licenses set forth in this Agreement.

2. Developer agrees promptly to notify Company of any third party intellectual property rights of which Developer becomes aware which may be infringed by any original or improvement item or aspect proposed by either party and used by Developer in the design and development of the Module. Except as otherwise agreed by the parties, the warranty set forth herein is not applicable to design work performed by Company or third parties at the express request of Company.

3. THE EXPRESS WARRANTIES SET FORTH IN THIS ARTICLE, AND THE OBLIGATIONS AND LIABILITIES OF DEVELOPER HEREUNDER, ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

VI. CONFIDENTIALITY

1. Developer shall treat as confidential, whether or not so identified, all information heretofore or hereafter provided to Developer by Company pursuant to or related to this Agreement, including, but not limited to, System specifications, Module Specifications, drawings, blueprints, technical documentation, mechanical designs, electrical wiring diagrams, schematics, printed circuit board schematics, Module hardware or software architecture and source code, manufacturing processes, equipment testing procedures, quality inspection procedures, and vendor lists, whether in written or oral form "(Confidential Information") , and shall not disclose any of said Confidential Information to any third party without the prior written consent of Company.

2. Developer shall neither use Confidential Information nor circulate it within its own organization except to the extent necessary for:
(a) negotiations, discussions and consultations with the authorized representatives of Company regarding the Module;

(b) designing, developing and providing the Module for Company;

(c) preparing documentation, reports, estimates or other documentation required under this Agreement; and

(d) any purpose Company may hereafter authorize in writing.

3. The obligations set forth above in Sections IV.1 and IV.2 shall terminate with respect to any particular portion of the Confidential Information when (a) Developer can conclusively document that:

   (i) It was in the public domain at the time of Company’s communication thereof to Developer;

   (ii) It entered the public domain through no fault of Developer subsequent to the time of Company’s communication thereof to Developer,

   (iii) It was in Developer’s possession free of any obligation of confidence at the time of Company’s communication thereof to Developer,

   (iv) It was rightfully communicated to Developer free of any obligation of confidence subsequent to the time of Company’s communication thereof to Developer,

   (v) It was developed by employees or agents of Developer independently of and without reference to any of the Confidential Information of Company any other information that Company has disclosed in confidence to any third party,

   (vi) It was communicated by Company to a third party free of any obligation of confidence,

(b) The Confidential Information is subject to a subpoena or other legal process issued by a court or administrative agency of competent jurisdiction. In such event, and unless prohibited by such court or agency, Developer shall notify Company of such demand at least ten (10) days prior to the due date for such disclosure (unless Developer receives services less than 10 days before such due date, in which case Developer shall notify Company as quickly as possible), cooperate with Company’s efforts to participate in the disclosure or seek protective relief to eliminate or limit such disclosure, and comply with the requirements of Section VI.6.

4. Developer acknowledges and agrees that the performance of the design work of the Module may require the sharing of information, some of which may be confidential, with certain third parties performing design work for the Module and/or System as designated by Company. Developer agrees to enter into a nondisclosure agreement with such third parties in the event either Developer or such third parties deem information required to be shared to be subject to obligations of confidentiality owed to Company, and such nondisclosure agreement shall contain all of the material provisions of this Article VI.

5. Developer’s communications to Company shall not be in violation of any third party rights and shall be made without any obligations of confidence.

6. Developer agrees not to disclose the existence, subject matter or any of the terms and conditions of this Agreement, including, but not limited to the Attachments hereto, to any third party without the prior written consent of Company, except in order to obtain required agency approvals. When
disclosure is required by a government agency or department, Developer shall mark all information disclosed as confidential and request that the information be kept confidential.

VII. INDEMNIFICATION AND LIMITATION OF LIABILITY

1. Indemnification.

(a) Developer shall indemnify, defend and save Company and its direct and indirect customers and end users harmless from any and all losses, expenses, damages or other liability, including attorneys’ fees, resulting from any suit, claim or proceeding brought against Developer, Company or Company customer acquiring the System containing the Module by or through Company alleging that the Module infringes any intellectual property right, including without limitation patent, copyright, trade mark, trade secret, of a third party.

(b) Company shall promptly notify Developer in writing of any action or claim, allow Developer, at Developer's expense, to direct the defense, give Developer full information and reasonable assistance required to defend such suit, claim or proceeding at no out-of-pocket expense to Company, and allow Developer to pay any judgment. Developer shall have no liability for settlement costs incurred without its consent.

(c) Should Company’s or any Company customer’s use of any such Module, spare part or consumable, be enjoined, or in the event that Developer desires to minimize its liability hereunder, Developer will, at its option and expense, either (a) enable Company without cost to Company, to substitute a fully equivalent noninfringing Module for the infringing Module, (b) enable Company to modify the infringing Module so that it no longer infringes but remains fully equivalent in function and performance and meets all required specifications, or (c) obtain for Company and each end-user customer of Company the rights to continue use of the Module.

(d) The above indemnity shall not apply to the extent that (i) an alleged infringement arises from the System without regard to the Module; or (ii) the Module is altered or modified by someone other than Developer, unless such modification is made by Company pursuant to agreement with Developer; or (iii) the alleged infringement results solely from a design or specification required and specifically directed by Company or provided to Developer by Company.

2. Limitation of Liability. IN NO EVENT SHALL EITHER PARTY BE LIABLE TO THE OTHER FOR LOST CONTRACTS, LOST PROFITS OR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES IN ANY WAY ARISING OUT OF OR RELATING TO THIS AGREEMENT, HOWEVER CAUSED, UNDER A CLAIM OF ANY TYPE OR NATURE BASED ON ANY THEORY OF LIABILITY, INCLUDING CONTRACT, TORT (INCLUDING WITHOUT LIMITATION NEGLIGENCE) OR WARRANTY, EVEN IF THE POSSIBILITY OF SUCH DAMAGES HAS BEEN COMMUNICATED. THIS DISCLAIMER DOES NOT APPLY TO (A) THE AFORESAID INDEMNIFICATION OR (B) DAMAGES ARISING OUT OF OR RELATING TO DEVELOPER’S FAILURE TO COMPLY WITH ITS CONFIDENTIALITY OBLIGATIONS UNDER ARTICLE VI.

VIII. TERM AND TERMINATION

1. Term. Unless sooner terminated pursuant to any applicable provision of this Agreement, this Agreement shall commence on the Commencement Date and continue in full force and effect until such time as the parties enter into a production agreement pursuant to Section II.12 of this Agreement.
2. **Termination.**

(a) Either party may terminate this Agreement by written notice of termination to the other party upon:

(i) A material breach by the other party which has not been cured within thirty (30) days of written notice of such breach, if said breach has not been cured, or in the case of a breach which cannot with due diligence be cured within a period of thirty (30) days, if the defaulting party has not instituted within the thirty (30) days steps necessary to remedy the default or prevent it from re-occurring and thereafter diligently followed such steps. However, prior to termination, the parties will make all reasonable efforts to resolve the dispute;

(ii) A material breach which cannot be cured;

(iii) The sale or transfer of substantially all of Developer’s business or of a material change in the ownership of the business;

(iv) The filing of a petition for reorganization, bankruptcy, assignment for the benefit of creditors or receivership by the other party.

Developer agrees that in the event of Company’s termination pursuant to this Section VIII.2, Company’s remedies shall include, but not be limited to, a grant to Company of a non-exclusive, irrevocable, royalty-free and fully paid up, perpetual, worldwide right and license to all patent, trade-mark, trade-name, copyright, trade secret and registered design rights relating to the design and development of the Module that are possessed by Developer prior to the Commencement Date, together with Company’s right to sublicense the foregoing to subsidiaries, affiliates and/or third parties designated by Company for the purpose of manufacture (or having manufactured), assembly, use, import, sale or offer for sale, lease, or disposal of any products incorporating such technology (including intellectual property embodied therein), to the extent that the same is used in the Module. Developer shall also provide, at the request of Company, engineering assistance and documentation sufficient to enable Company and/or Company’s designee to manufacture or have manufactured the Modules. In addition, Developer hereby grants to Company the right to contract with Seller’s vendors for such purpose. Should such license grant be implemented, both parties agree to meet in a timely manner to negotiate in good faith the process of such implementation.

(b) In addition, Company may terminate this Agreement at any time in its complete discretion upon not less than thirty (30) days’ prior written notice, in which case Developer agrees to negotiate in good faith with Company terms and conditions of a non-exclusive, irrevocable, perpetual, worldwide right and license to all patent, trade-mark, trade-name, copyright, trade secret and registered design rights relating to the design and development of the Module and possessed by Developer prior to the Commencement Date, together with Company’s right to sublicense the foregoing to subsidiaries, affiliates and/or third parties designated by Company for the purpose of manufacture (or having manufactured), assembly, use, import, sale or offer for sale, lease, or disposal of any products incorporating such technology (including intellectual property embodied therein), to the extent that the same is used in the Module. Such right and license shall include, at the request of Company, engineering assistance and documentation sufficient to enable Company and/or Company’s designee to manufacture or have manufactured the Modules, together with the right to contract with Developer’s vendors for such purpose. The license fee payable by Company on account of this manufacturing license shall be payable by the
end of each calendar quarter during which Modules are made under the foregoing license and shall for each such unit be a sum equal to the price which Company would have paid Developer for manufacture and sale of the Module less Company's cost of making or having the Module made (including all reasonable overhead allocations).

3. **Effect of Termination.**

   (a) The parties agree to continue to perform in compliance with the terms of this Agreement until the effective date of termination except as otherwise agreed in writing.

   (b) As soon as possible after termination of this Agreement (howsoever caused) and at Company's direction, Developer will deliver to Company or a third party designated by Company any and all Company Unique Tooling, files, computer or other equipment or materials owned by Company and held by Developer, or grant to Company full access to its premises to enable Company to repossess the same.

   (c) Except as expressly set forth herein, Company's sole obligation shall be to pay Developer for the work completed as of the date of termination, and Company shall have no other or further obligation or liability to Developer of any sort or nature.

   (d) The provisions of this Agreement which by their nature would survive the termination of this Agreement (including, without limitation, any terms pertaining to Developer's grant to Company of any perpetual licenses hereunder) shall so survive.

**IX. GENERAL PROVISIONS**

1. **Records Review.** Developer shall make its premises available to Company upon reasonable notice during regular business hours for the purpose of inspection by Company of Developer's inventory, work in progress, and those books, records and documents relevant to verifying compliance with the terms and conditions hereof.

2. **Advertising.** Developer shall not use any Company brand, trade mark, service mark, service or proprietary name, or logo on any advertisement or for promotional purposes without Company's prior written approval. Company shall not use any Developer trademark, service mark, brand, service or proprietary name, mark the logo on any advertisement or for promotional purposes without Developer's prior written approval.

3. **Insurance.** Developer agrees to procure and maintain insurance of a kind and amount which will effectively guarantee that Developer can defend and indemnify Company against any protectable intellectual property right against which Developer has agreed to indemnify Company under this Agreement. The amount of insurance deemed necessary for Developer to indemnify Company will be negotiated in good faith by Company and Developer, depending on the anticipated development and production of the Module, and may be renegotiated from time to time. A certificate of insurance evidencing such coverage must be provided to Company upon Company's request. Developer shall provide Company with 30 days prior written notice of cancellation, non-renewal, or material change in Developer's coverage. The amount of insurance purchased by Developer will not limit the liability of Developer to Company.

4. **Remedies Cumulative.** Any and all remedies provided in this Agreement or available at law and in equity shall be available to the Parties on a cumulative basis and not in the alternative.
5. **Waiver.** The failure of either party hereto at any time to exercise any of its rights under this Agreement, shall not be deemed a waiver thereof, nor shall such failure in any way prevent said party from subsequently asserting or exercising such rights.

6. **Force Majeure.** Neither party shall have any liability or be deemed to be in breach of this Agreement for any delays or failures in performance of this Agreement which result from circumstances beyond the reasonable control of that party, including without limitation labor disputes involving that party. The party affected by such circumstances shall promptly notify the other party in writing when such circumstances cause a delay or failure in performance and its anticipated duration; provided, however, that should such event continue for more than sixty (60) days or should any series of such events continue for an aggregate period of more than sixty (60) days, Company shall have the right to terminate this Agreement without further liability to Developer.

7. **Assignment.** Neither this Agreement, nor any part of the rights granted herein, shall be transferred, assigned, sublicensed, or conveyed by either party, in whole or in part, nor shall this Agreement inure to the benefit of any successor, assignee, sublicensee, trustee, or any representative of either party without the prior written consent of the other party. Notwithstanding the foregoing, Company may, upon written notification to Developer, assign its rights and obligations hereunder, or any portion thereof, to one or more of Company’s subsidiaries and/or affiliates.

8. **Subcontracting.** Developer may sub-contract the performance of its obligations under this Agreement or any part thereof to a third party subject to Company’s prior written consent and provided that Developer shall remain primarily responsible for the performance of such obligations and shall guarantee the performance of such third party in accordance with the terms of this Agreement.

9. **Severability.** If any provisions of this Agreement shall be held invalid or unenforceable by any court of competent jurisdiction, the remaining provisions of this Agreement shall remain in full force and effect.

10. **Headings.** Headings contained herein are for convenience and reference only and in no way should be construed to modify, amplify, or otherwise affect the construction or interpretation of this Agreement.

11. **Notices.** All notices hereunder shall be sufficiently given if sent by one party to the other by prepaid, certified, or registered mail or by express mail addressed to its office as herein below set forth or to such new address as such party may have specified to the other party by notice hereunder. Notices as provided herein shall be deemed given when received.

12. **Independent Contractors.** The parties agree that during the term of this Agreement Developer shall be an independent contractor, and nothing set forth herein shall be deemed or construed to render the parties as joint ventures, partners or employer/employee. Under no circumstances shall Company be considered the employer of any Developer employee nor shall Company have any right or obligation with respect to any employee of Developer. Unless otherwise agreed in writing, (a) neither party shall hold itself out or purport to act or act on behalf of the other party, (b) neither party shall represent itself as the agent or representative of the other party without the express written approval of that other party, and (c) neither party shall enter into any agreements or contracts on behalf of the other party.
13. **Ethical Standards.** Both Company and Developer agree to comply with the Company and Developer ethics policies in effect during the Agreement term.

14. **Dispute Resolution Procedure.**

(a) The parties voluntarily agree to resolve disputes as set forth in this Section IX.14. All negotiations pursuant to this Section are confidential and shall be treated as compromise and settlement negotiations for all purposes, including the United States Federal Rules of Evidence and state rules of evidence.

(b) The parties shall initially attempt to resolve disputes at the operating manager level by those directly involved. Should the operating managers be unable to agree on a resolution of the dispute within a reasonable time, either party may notify the other in writing of the dispute and its election to submit the dispute to a hearing of senior executives. Within ten (10) business days of delivery of such a notice, each party shall appoint a senior executive (the “Senior Executive”) to carry out the provisions of this Section and advise the other party in writing of the name, position, address and telephone of the senior executive. Such Senior Executive shall be empowered by his or her respective employer with full authority to resolve the dispute.

(c) The Senior Executives of the parties shall together, within thirty (30) days after notice is delivered, listen to presentations of no longer than one hour each made by representatives of each party. The Senior Executives shall then attempt, in good faith, to resolve the dispute or claim. In the event they agree upon a resolution of the dispute or claim, they shall set forth that resolution in writing and each party shall be bound by that resolution.

(d) In the event Senior Executives are unable to resolve a dispute involving matters arising under this Agreement, the dispute shall be submitted by the claiming party to arbitration in accordance with the then current Center for Public Resources Rules for Non-Administered Arbitration of Business Disputes by a sole arbitrator mutually acceptable to the parties. The arbitration shall be governed by the United States Arbitration Act, and judgment upon the award rendered by the arbitrator shall be binding on the parties and may be entered by any court having jurisdiction thereof. The arbitration shall take place in [ ] or such other location agreed upon by the parties. The costs of arbitration shall be shared equally by the parties to the dispute. Any monetary awards shall be limited in accordance with the provisions of this Agreement and, accordingly, (a) the arbitrator is specifically prohibited from awarding any punitive damages or other damages excluded by this Agreement and (b) each party irrevocably waives any right to recover damages outside the scope of these limitations.

(e) The dispute resolution procedure set forth in this Section IX.14 shall not apply to indemnified matters.

15. **Binding Effect.** This Agreement shall be binding upon, and inure to the benefit of, the representatives, successors, and permitted assigns of the parties hereto.

16. **Counterparts.** This Agreement may be executed simultaneously in counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument. It shall not be necessary that any single counterpart be executed by both parties hereto provided that each party shall have executed at least one counterpart.
17. **Governing Law.** This Agreement shall be governed by, and for all purposes be construed and deemed to be a contract made under and pursuant to, the substantive laws of the State of __________ without regard to its conflict of laws principles. The parties specifically agree that the 1980 United Nations Convention on Contracts for the International Sale of Goods, as such may be amended from time to time, shall not apply to this Agreement.

18. **Entire Agreement.** This Agreement, including all Attachments, constitutes the entire Agreement between the parties with reference to the Module and supersedes and cancels any previous agreement, negotiations, commitments and understandings, either oral or written, and may not be changed or modified in any manner except as expressly provided herein or by an instrument in writing signed by duly authorized officers or representatives of the parties.

**DEVELOPER**

Signed:

By:

Title:

Date:

**COMPANY**

Signed:

By:

Title:

Date:

Attachment A:  Module Specifications
Attachment B:  Company Unique Tooling
Attachment C:  Time Schedule / Milestones
Attachment D:  Target Cost
Attachment E:  NRE