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Organizational form, incentives and the management of information technology: Opening the black box of outsourcing

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Abstract

In this work, we attempt to show how operations researchers can effectively manage the production costs of computing services. The thesis of this paper is that an outsourcing firm, by virtue of the fact that it manages the IT function for multiple firms, is privileged to information not available to the focal firm. We derive the conditions under which this privileged information allows the partner firm to construct superior incentives for its employees, resulting in superior IT management. Further, we detail the circumstances under which outsourcing will not provide additional benefit, and what sorts of partners are likely to provide the greatest benefit. The two main findings are that for low levels of uncertainty, both in-house and relational management are equally acceptable. However, as uncertainty increases, the value of relational management increases. Conclusions are drawn and extensions are proposed, related to economies of scale and transactions costs.

Keywords: Governance; Outsourcing

1. Introduction

The study of IT is important since accepted thought has moved beyond the *productivity paradox* and it is now firmly believed that IT does generate value [1]. Because of this, researchers need to recognize that the organization of IT work has important economic impacts on the ability of IT units to provide service [2]. Additionally, it is important for researchers to recognize that the ability to manage interorganizational relationships is one of the most valuable capabilities of a firm [3–5]. This is supported by a 1999 study by Michael F. Corbett and Associates which indicates that executives spend fully one-third of their budgets on the management of external relationships [6]. This tremendous need to coordinate with outside entities prompted Frank Casale, CEO of the Outsourcing Institute, to propose a new executive officer—the Chief Relationship Officer—whose sole job is to manage relationships with these outside entities [7].

There are a multitude of research-worthy questions addressing the impacts of economic organization on IT productivity. For example, should IT be centrally managed or dispersed throughout the firm? How would the federal form of organization impact the IT unit's productivity? To whom should the chief information officer (CIO) report? Is it necessary, efficient or detrimental to have both a CIO and a chief technology officer (CTO) in the same firm? How many authority layers should be included in the IT unit? These questions and many others arise naturally as

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questions about how to manage the IT unit. In this paper, we seek to add to the understanding of IT management by addressing a simpler question—*should an IT unit be managed in-house or through a relationship with another firm*?

Specifically as introductory work, this paper focuses on the specific domain of archetypical outsourcing, as exemplified by the IBM-Kodak announcement of 1989 [8]. This idealized situation is a relationship between two large firms, where the partner firm assumes management responsibilities for a mature IT function, previously managed by the focal firm. In this type of relationship, the partner hires the staff of the focal firm, whom was already charged with providing the service. Further, the partner firm, as a normal course of action, purchases all of the IT equipment already dedicated to the task and uses this same equipment operated by the same people to provide the service.

Though this work focuses on the provision of existing services, by a transfer of assets from focal firm to partner, the logic contained herein extends to the provision of new services. Even in cases where the focal firm uses a relationship to manage a new task, both the human and IT capital are market commodities, which are equally accessible to the focal firm as to the partner firm. This, combined with the fact that there are hundreds of potential IT partners, suggests that the resource advantage is not a unique human resource (such as Bill Gates, Jack Welsh, or Warren Buffet), but some sort of firm level resource embedded in the processes and information used by the partner.

We propose that the resource advantage of a partner over a focal firm lies in the information available to each. Because the partner has more detailed information about the performance of the IT function, it is better able to reward IT personnel. This corresponds with the idea that the only long-term source of IT advantage is the ability to manage IT [9]. The superior information available to partners as a result of their organizational form provides this ability. To address the question of whether an IT unit should be managed in-house or through a relationship, the decision maker must seek an explanation of what superior organizational attributes the partner firm possesses. These attributes must not only allow it to manage the IT unit more efficiently, but to manage it so much more efficiently that the perspective value added more than compensates for the additional costs intrinsic to relational management.

The remainder of this paper is organized as follows. Section 2 provides a literature review of the aspects of outsourcing specific to this paper. Section 3 develops a general model of outsourcing based on information. Section 4 offers a specific example of the general model to further illustrate several important factors. Section 5 examines several extensions of this work and suggests directions for future research. Finally, Section 6 concludes by summarizing the contributions and findings of the paper.

2. Literature review

Even though popular opinion holds that outsourcing is an advantageous way to manage IT functions, the evidence on the value of outsourcing is far from equivocal [10–12]. While the outsourcing question has been addressed in the past, its continued growth has merited a new interest by researchers. For example, Snir and Hitt [13] suggest that outsourcing contracts suffer failure because the outcomes are not verifiable to a court. They propose, by establishing a pilot project with a very small payoff and a full project with a very large payoff, that only the vendors of high quality will be willing to perform the pilot project due to the fact that only they can recoup their losses in the full project. Low-quality vendors, on the other hand, will not perform the pilot project because their poor quality will be evident, preventing them from being awarded the large project. This research has been extended to examine how internet technologies allow firms to build spot markets for IT outsourcing services [14]. Clemons and Hitt [15] observe another problem specific to information intensive relationships—poaching. Poaching is the misappropriation of information by a partner firm. Poaching occurs because, unlike a physical asset, an information asset is not consumed in use and it cannot be returned upon conclusion of the contractual relationship. This enables partner firms to appropriate the information assets, without obvious indications of the appropriation.

Additional literature salient to specific aspects of IT outsourcing is provided in the following sub-sections. Specifically, the review covers production costs in the outsourcing context. It then discusses the importance of the organization of firms in the understanding of cost advantages. Next, it discusses the nature of archetypical IT outsourcing work in order to illuminate the important factors to be modeled. A brief overview of literature in the area of incentives follows and the review concludes with an overview of the importance of the research perspective.

2.1. Production costs

By far, the most common way of understanding the decision between in-house and relational management for IT functions has been transaction cost economics (TCE). TCE seeks to explain the locust of transactions as an attempt to economize on costs [16–18]. The seminal paper in IS proposes the *electronic markets hypothesis*, which suggests that IT will reduce transaction costs, and thereby increase the use of market, rather than hierarchical organization [19]. TCE has been used extensively by Clemons and colleges [15,20–22]. The most widely known application is the *move to the middle hypothesis*, which posits that IT not only reduces market transaction costs, but also reduces the transaction costs of hierarchical organization. Thus, TCE considerations may make firms move to markets in some cases, and move to hierarchies in other cases [11]. While this TCE-based research has been carried forward by a variety of authors [23–27] and has yielded considerable insight, it is incomplete.

As Williamson notes "...economizing takes place with reference to the sum of production costs and transaction costs, whence tradeoffs in this respect must be recognized." [18, p. 22]. Thus far, there is a significant gap in the IS literature in trying to explain both the transaction and production costs (an important exception is [28]). It should not be surprising that such a gap exists, as it is mirrored in the economics literature. Rather than integrate classical production cost economics with TCE, research has tended to apply one or the other of the approaches [29]. Lyons observes, "A trade-off between asset specificity and economies of scale or scope is central to the transaction cost theory of vertical integration as developed by Oliver Williamson. Until now, however, there appears to be no systematic empirical work that examines its implications." [30, p. 432]. Thus, a need to account for the impacts of production costs exists not only in the IS literature, but in the TCE literature in general.

2.2. Organization of firms is important

I seek to fill the production cost gap by developing a formal model to explain the production cost advantages of partners. However, rather than use the classical economics' concept of a firm as a black box, we use TCE's concept that the organization of the firm is important [18,31]. Thus, we propose a model of production cost advantage based on the internal organization of partners. In this sense, our work is an extension of [28]. While they develop a description of the interactions between TCE and production costs, we concentrate on the development of a formal, rigorous model of the production costs. Our formal model could then be compared to TCE in the same way as Gurbuxani and Whang compared agency predictions to TCE. Separately, our model could be combined with a formal model of transaction costs to develop a more thorough understanding of the interactions.

The idea that organizational form creates resources is not new. Coase [16] suggested that there was some resource generated simply by organizing as a firm, which provided advantage over a market. Similarly, Williamson [17] expanded on this idea and showed how M-form organizations might have resource advantages over U-form organizations, simply by virtue of the form. Maskin, et al. propose that the distribution of shocks can be mitigated by a choice of the appropriate organizational form [32]. Bárcena-Ruiz and Espinosa [33] show that the incentive scheme of a firm depends on whether the goods it produces are complements or substitutes. In this model, firms chose between U-form and M-forms of organization specifically to allow them to provide the proper incentives to managers.

To the best of our knowledge, this represents the first attempt to develop such a formal model of the production advantages of a provider firm. Previous literature has generally assumed a *black box*, with some sort of economies of scale advantage. However, such an assumption does not explain what the scale economies arise from, and such an assumption is often unwarranted as "... most large companies have the critical mass required to achieve economies of scale." [34, p. 169].

This focus on production cost aspects is particularly salient in the context of archetypical outsourcing. This is true because the relevant question is not whether to organize the IT department within a hierarchy or as an independent entity. Rather, the question is whether to organize the IT department within one hierarchy over another hierarchy. Thus, many of the TCE considerations relative to internal organization will remain constant. For example, of the three categories of transactions costs that limit firm size—bounded rationality, bureaucratic insularity, and atmospheric consequences [17]—only the atmospheric conditions are likely to be systematically different between partner firms and focal firms. At the same time, all of the TCE considerations based on non-integrated transactions are present. Thus it becomes especially important to explain some production-based advantage of providers.

2.3. Knowledge work

One important characteristic of the management of IT is the predominant use of knowledge workers. IT professionals are knowledge workers and as such, much of the work they do is unobservable [35]. Knowledge workers are very different than traditional production workers because their main task is carried out in the mind, rather than in the physical world. This makes it very difficult to monitor their effort. For example, a knowledge worker who is laying face down on her desk in an unlighted room may be working very hard, or may be sleeping. A production worker, charged with a physical task, does not exhibit this same characteristic. Furthermore, knowledge workers are often more competent in the domain of expertise than the managers in charge of them. Thus, even if the manager could observe the workings of the mind, he would be unsure of how well the developer was working. Though, much of the developer's effort involves intangibles that are invisible to the end user, but that certainly effect usability. Consequently, in developing a theory of IT management, it is essential to account for the knowledge work aspect of IT.

A question that naturally arises in the context of knowledge work is how to monitor the knowledge workers. One of the obvious resources that a firm has is knowledge about itself. A firm knows its processes, how these processes are performed, and the outputs of those processes. This means that senior management knows what the different units do (or at least that senior management knows better than anyone else does). By comparing across units, senior management can know how well each of them perform, and reward them appropriately. As units are more similar, management can more accurately compare performance in order to calibrate the rewards to align the incentives of the division with the goals of the firm.

The difference between a focal firm and a partner is organization of these divisions. In a focal firm the divisions are arranged by business function, with at least two different business functions, one of which is IT. In a partner, these divisions are arranged by firms, with at least two different firms, but the same IT function. Taking this organizational form as given allows for the construction of a model of firm performance where the resource advantage is endogenous. The differential organization of partners and focal firms gives rise to different, productive, inimitable, resources that can provide the partner sustained competitive advantage in the delivery of IT services.

We also note that the information available to senior managers might be very tacit, so that it cannot be simply sold to another firm. Stein [36] examines the situation in which information may be *soft*. Soft information is tacit, and difficult to transmit. Stein shows that in the presence of soft information a more decentralized organizational structure performs better, with decision makers spread about the information space. On the other hand, if information is easy to transfer, a hierarchical organizational form results in enhanced performance, where decision makers are grouped at the top of the hierarchy. While the model is framed in the reverse of the model of this paper, Stein goes on to provide an empirical example from the banking industry, which corresponds to the idea of this paper. The empirical model shows that community banks reduce lending to small business after being acquired by a larger bank. Stein posits that this occurs because small business lending is dominated by soft information, which cannot be transmitted up the hierarchy. Thus, even within the same bank, with the same employees, a change in organizational form leads to a change in the firm's ability to use information. This is precisely the idea that we propose here.

2.4. The ability to structure incentives as a valuable resource

A variety of evidence suggests that incentives motivate managers even for particularly complex incentive schemes. For example, because stock options have limited downside risk, they become more valuable as firms pursue riskier courses of action, thereby motivating managers to pursue riskier courses of action [37]. Empirical evidence supports the idea that linear compensation results in less risky behavior than options-based compensation [38]. Clemons calls this the *law of the wallet*, which is the idea that "you get what you pay for: If you pay for code, for example, you will get many lines of code . . ." [39, p. 84]. Clemons goes on to note, "incentives can bring vendor behavior in line with a focal firm's expectations thereby improving performance." (p. 84).

In the domain of knowledge worker, the employees know how to do the work. The firm's problem is structuring a set of incentives to induce them to exert the proper level of effort. Thus, one of the primary functions of senior management is to construct incentive schemes to motive employees. Recognition and promotion provide incentives for agents to exert effort as surely as monetary incentives [40,41]. Gibbs observes that, ". . .managers generally work in hierarchies in which advancement appears to be an important part of the incentive system" [41, p. 249]. Of course, managers also receive salaries, plus bonuses, and may receive raises to each as additional incentives. Further, managers may be

compensated by having an increased budget, increased discretionary power, perks, recognition, and personal power. It is the job of senior managers to develop these incentives to elicit an optimal level of performance from the employees. The ability of senior managers to construct such schemes depends upon two factors. The first arises from individual talent and finesse making it largely intangible. The other, which we explore here, is the information about performance available to the senior manager.

The effectiveness of incentives depends on how accurately senior management can measure performance. Senior management would like to pay an employee for his effort, but the effort of a knowledge worker is not directly observable. However, by virtue of organization, senior management does have information about the output of a number of employees performing specific tasks. For example, one popular incentive scheme is stock options. The idea behind this scheme is to use aggregate firm performance as a measure of individual effort. However, firm performance is influenced by a number of factors other than any individual's effort, such as overall market movements, and thus does not accurately reward agents for their individual effort. In an effort to more closely link the effort to the reward firms, like *Level* 3, offer stock options with a strike price indexed relative to a market index, so that the options have no value unless the firm performs better than the average market performance [42]. This corrects for overall market movements and motivates management to put forth more effort than a straight options grant.[1]

The lesson is that conditioning incentives on additional information can allow senior management to provide superior motivation. Further, the more the conditioning information reveals the actual effort of the agent, the better the incentives will be. The thesis of this paper is that an IT partner, by virtue of the fact that it manages the IT function for multiple firms, possesses privileged information not available to the focal firm. We derive the conditions under which this privileged information allows the partner firm to construct superior incentives for its employees, resulting in superior IT management. Further, we detail the circumstances under which partnering with a provider will not provide additional benefit, and what sorts of partners provide the greatest benefit.

2.5. Focus on implications for IT managers

Our work is different than prior IS work in an other important way. Prior work seeks to explain the impacts of IT on firm organization [11,19,28,43], while our work explains the impacts of firm organization on IT. Thus, our work is much more aimed at telling CIOs what to do than at telling CEOs what to expect. For example, Venkatraman and Zaheer [44] examine the effects of IOSs on the performance of independent insurance agents. The authors find that the introduction of an integrated IOS facilitates the generation of additional policies, but find no effect on business performance. Zaheer and Venkatraman [45] expand on this finding by modeling the process of electronic integration. They find that, properly administrated, an IOS can bring about the benefits of a hierarchical organization while still retaining high-powered market incentives. Lee et al. [46] study electronic data interchange (EDI) benefits from the point of view of the partner firms, rather than the champion firm of an EDI solution. They show that EDI used for continuous replenishment processes increases inventory turnover and reduces stockout, even after controlling for exogenous variables. Adopters, such as grocery warehousers in this case, achieved increased operational efficiency as a result of EDI. Bakos [47] also contributes to this perspective in a strategic examination of IOSs. He finds that such systems can decrease response time, thereby improving interorganizational communication.

Prior literature has focused on justifying the value of IT, but very little research has focused on how to best manage IT for the benefit of IT. One notable exception is the work of Lacity and others. The most prevalent theme in the outsourcing literature is an attempt to identify best practices. Lacity and Willcocks [48] look at data from 61 outsourcing agreements between 1991 and 1995, to identify five best practices. The find that selective outsourcing more frequently resulted in cost savings than total outsourcing, presumably because few partner firms have talents in all areas of outsourcing. Similarly, [34,49] examine a number of outsourcing arrangements and discuss the outcomes. They provide great insight into the nature of firm outsourcing decisions and how those decisions are effected by the organization of the firm. While their focus is on explaining how to manage the IT function, the explanation is done trough case study, using examples, rather than constructing a formal model. We hope to add to the IS literature by proposing a formal model that focuses on how the firm structure impacts IT.

[1] Incidentally, Level 3 performed 70 points better than the market index, in 1999, giving the CEO $121 million in options.

As the theoretical and industry discussion illustrates, not only is there a gap in theoretical knowledge, but also there is an important practitioner question that this knowledge could address. We hope to address this deficiency, contributing both to the theoretical understanding, and the practitioner decision making process.

3. The model

A firm is a group of interdependent units. These *units* are broken up along *functional* areas and *objectives*. An objective is a goal of a firm, such as *produce an automobile* or *sell real estate*. Organizing along objective lines results in a form of vertical integration, although units are not necessarily linked in a linear way. The functional areas are specific tasks common to multiple objectives, such as website hosting, application support, and data center management. Organizing along functional lines results in a specialist firm, like an ASP or software design firm. A unit then is a specific function for a specific objective. For example, *website hosting* in order to *sell real estate* would be a unit, as illustrated in Fig. 1.

A firm is a collection of different units, usually arranged either by objective or by function. We can think of an automotive firm as being arranged by objective, while an ASP firm is arranged by function. This choice of organizational form yields benefits (and imposes costs) upon the firm. Specifically, communication is more efficient within a firm than across firm boundaries. We normalize the ability to communicate externally to zero, so that the only information available to the firm is information about its internal units. In the sense of the model presented here, a firm is an imaginary envelope that traps information. In IT related tasks this is reasonable assumption. A firewall, for example, is specifically a device for trapping information at a firm border. The physical walls of a building trap information with the building. Firm email, intranets, and phone facilities function so that it is often easier to transmit information internally than externally. We do not suggest that firms do not communicate with other firms. We simply suggest that internal communication is far greater than external communication.

Each unit has one employee, who produces the output of the unit. In the case of the IT department the employee is the *developer*. The goal of the firm is to properly incent this employee to put forth some level of effort, e, that generates output, y. These incentives are not necessarily monetary, but also occur in the form of promotions, awards, or a *good word*. For the purposes of this paper, motivating the employee is the same as motivating the unit. The problem is that the output of the functional area is only imperfectly correlated with the manager's effort. Thus, the observed output of functional area j in firm k is

$$y_{jk} = e_{jk} + \varepsilon_{jk}, \tag{1}$$

where ε_{jk} is assumed to be normally distributed with a mean of zero and a variance of σ^2_{jk}.

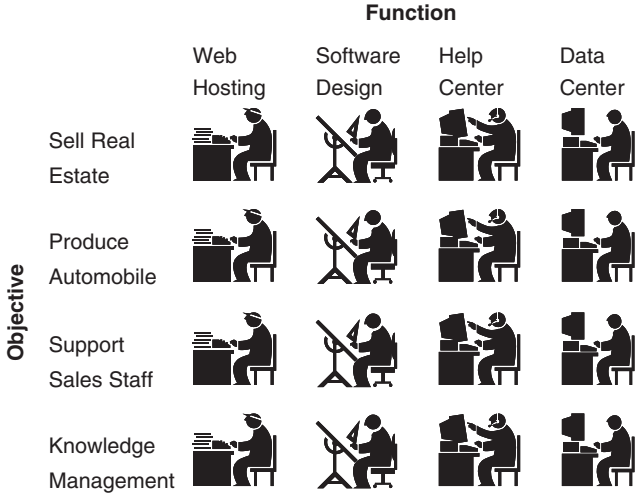

Fig. 1. Firm-function organization.

Eq. (1) suggests that not all of the output of a given unit is directly under the control of the unit employee. Software may be buggy, systems machinery can fail, or users can fail to adopt. Further, IT professionals are knowledge workers and as such, much of the work they do is unobservable [35]. Thus, the effort level cannot be directly observed and the incentive can depend only on the observed output, y. This makes sense for IT because much of the manager's effort involves intangibles that are invisible to the end user, but that certainly effect usability. Thus, we present a standard agency problem in which the principle cannot observe the agent's effort. To this, we add the additional innovation that output is not a perfect indicator of effort. The problem of the firm is to choose an incentive scheme, $i(y_{jk,}y_{lm})$, to best motivate the risk adverse manager to perform. The only difference between a focal firm and its partners is the information available to them in the form of output data. A firm can be considered as a set $F = \{y \in y_{jk}\}$, so that a firm is a set of outputs, and the firm can use those outputs to structure incentive schemes.

The employee must choose the level of effort to maximize his utility subject to the incentive offered by the firm and some disutility of effort. This choice can be represented as

$$\max_{e_{jk}} U(i_{jk}(y_{jk}, y_{lm})) - D(e_{jk}). \tag{2}$$

Thus, the employee's utility is based on his output relative to another employee and the cost is based on actual effort. Cost of effort is assumed to be increasing. The firm problem is to choose a set of incentives to motivate employees to undertake the profit maximizing level of effort. This can be represented, in the two employee case, as

$$\max_{i_{jk}, i_{lm}} ([y_{jk} - C(i_{jk}(y_{jk}, y_{lm}))] + [y_{lm} - C(i_{lm}(y_{jk}, y_{lm}))]). \tag{3}$$

Thus, the firm chooses the incentive schemes that induce the employees to produce outputs, which are firm revenues. However, the firm must pay the cost of these incentives.

3.1. Analytical model

The focus of this work is on explaining the impacts of differing levels of information availability. To this end, economies of scale and managerial talent are held constant. The size of each firm, given that the IT function is contained within it, is identical. Specifically, the IT function will be in a firm with exactly two employees under either outsourcing or in-house management. Furthermore, the ability of each firm to manage the IT function is held constant. In reality, firms are of different size, and economies of scale may exist that depend upon this size. Likewise, firms, as unique entities, are likely to have different talents, which may allow some to better manage IT functions. A full model of outsourcing would have to account for both of these factors. However, the spirit and goal of this model is to offer a detailed examination of a single, organizational characteristic.

For parsimony and generalizability assume two functions (IT and other) and two firms (1 and 2) yielding four outputs (y_{IT1}, y_{IT2}, y_{o1}, y_{o2}). Assume that each unit receives its own shock denoted by $\varepsilon_{\text{ObjectiveFunction}}$. We define a *focal firm* as a firm that manages multiple *different* functional areas with the same objective. We define the *partner* as a firm that manages multiple *identical* functional areas with different objectives. In this case, firm 1 is the focal firm. The question then is which organization can structure a better incentive for the IT manager in firm 1. If IT is insourced then the incentive for the IT manager is based on the output of the IT manager of firm 1 (y_{IT1}) and the output of the other manager in firm 1 (y_{o1}). If IT is outsourced, the incentive is based on the output of the IT manager of firm 1 (y_{IT1}) and the output of the IT manager of firm 2 (y_{IT2}). Thus, the incentive offered by the focal firm to the IT manager is

$$i_1(y_{IT1}, y_{o1}), \tag{4}$$

and, the incentive offered to IT manager by the partner firm is

$$i_{IT}(y_{IT1}, y_{IT2}). \tag{5}$$

It can be shown that if employee o1 of the focal firm exerts a level of effort e^*, then an incentive scheme can be designed by the partner firm such that if employee IT2 of the partner firm exerts a level of effort e^*, then $i_{IT}(y_{IT1},y_{IT2})$ is equivalent to $i_1(y_{IT1},y_{o1})$, in that $i_{IT}(y_{IT1},y_{IT2})$ motivates the developer to exert at least as much effort as $i_1(y_{IT1},y_{o1})$. However, this result rest on the assumption that

$$\text{Var}(\varepsilon_{IT1}|\varepsilon_{IT2}) < \text{Var}(\varepsilon_{IT1}|\varepsilon_{o1}). \tag{6}$$

The assumption in (4) implies that if the measurement error of an IT manager's effort is less given the measurement error of other IT managers in different firm, than given the measurement errors of other functional areas in the same firm, then the partner can provide incentives at least as good as the focal firm, and thus operate the IT department at least as efficiently.

Outsourcing will be a good solution when the variance among firms is less than the variance among functional areas. This means that the IT function in a firm is more similar to the IT function in other firms than it is to non-IT functions within the same firm. If variance among functional units is taken as fixed this leads to the following proposition.

Proposition 1. *If* $\mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{IT2}}) < \mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{o1}})$ *then for any incentive scheme* $i_1(y_{\mathrm{IT1}}, y_{\mathrm{o1}})$, *based on the output of the focal firm's IT unit and the other unit of the focal firm, resulting in effort level* e_{IT} *on behalf of the developer*; *the partner firm can find an equivalent scheme* $i_{\mathrm{IT}}(y_{\mathrm{IT1}}, y_{\mathrm{IT2}})$ *based on the output of the focal firm's IT unit and the output of the partner's other IT unit, that would result in the same effort level* e_{IT} *on behalf of the developer.*

What the proposition indicates is that the partner firm can encourage at least the same level of effort in its employees as the focal firm. This is the case, no matter how complex the focal firm's incentive schemes may be. This powerful result hinges on the conditional variances, so the reverse case (that the focal firm can duplicate the partner firm's incentives) does not hold. Furthermore, as Eq. (14) in the Appendix includes a z term, which introduces additional variability into the measurement of output, it is immediately obvious that the duplicated incentive is more costly for a risk adverse IT manager. As variance increases, the focal firm must offer higher expected value of compensation to encourage the same level of effort. At the same time, the partner firm would have to actually increase the variability (risk to the manager) to offer an equivalent scheme. It seems intuitive, and we will show in a specific example below, that the partner firm should be able to offer a lower cost incentive that inspires the same level of effort on behalf of the IT manager.

The idea that partner firms focusing on specific functions rather than overall objectives can offer better incentives to employees is supported in the literature. For example, Kathy Hudson, the Kodak CIO responsible for the momentous outsourcing deal says, "If you are a really good technical person—an expert in applications development, for instance, do you think you'll have a better career at a photography company or a computer company?" [50, p. 78]. Further, Lacity and Hirshheim [49] provide a number of case studies in which managers indicate that they expect IT personnel to have better opportunities when transferred to a partner firm. The actions of the employees seem to support this, because they typically transfer to the infrastructure partner rather than seek employment in another manufacturing type firm.

Proposition A. *If* $\mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{IT2}}) < \mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{o1}})$ *then it is not necessarily true that the partner can find an equivalent scheme based on the output of the same function in other objectives that results in the same effort level* e_{IT} *on behalf of the IT manager.*

Proposition 1A is a restatement of Theorem 1 that provides important insight into the understanding of interorganizational partnerships. Proposition 1A states the boundary conditions under which the focal firm may not expect a relationship to be advantageous. If a partner firm cannot bring additional information with which to gage the productivity of functional employees then it is not able to provide superior incentives to those employees.

It is important to consider the conditions that would cause $\mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{IT2}}) < \mathrm{Var}(\varepsilon_{\mathrm{IT1}}|\varepsilon_{\mathrm{o1}})$ so that the partner firm would have superior evaluative information than the focal firm. An obvious candidate condition is that the partner firm performs substantially similar activities across a number of similar objectives. This is the typical concept of firm specialization. The innovation offered in this case is simply to explain the source of the value of specialization. Rather than appealing to the idea that some firms are simply better than others, we propose that it is because of the information inherent in the firms' organizational structure.

Another possibility is that there are functional and objective shocks. Functional shocks would be those shocks that occur to all units in a specific function, while objective shocks would occur to all units with a similar objective. A perfect example of a functional shock would be a change in legal reporting requirements that required rework of financial software. Thus, the financial reporting function would be impacted across multiple objectives. An example of an objective shock, would be cyclical variation in the objective area, like Christmas. Given these types of shocks, the observed output of a manager would be

$$y_{j,k} = e_{j,k} + o_k + f_j. \tag{7}$$

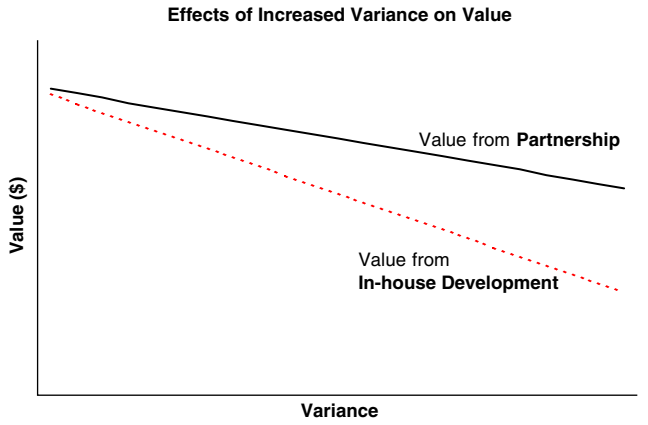

Fig. 2. Effects of variance on value of relational management.

This characterization shows that the observable output of a unit manager is a function of his effort plus the shock to the objective plus the shock to the function. The focal firm would know the o_k while the partner firm would know the f_j. The conditional variance of the unit manager from the focal firm's point of view would be the variance of the f_i's and the conditional variance from the point of view of the partner firm would be the variance of the o_k's. Thus, the variance condition for Proposition 1 becomes $\mathrm{Var}(o) < \mathrm{Var}(f)$. Thus, when shocks to IT infrastructure are larger than shocks to business objectives, it makes more sense to form partnerships with the partners in order to control the variance.

Another useful case to look at is the limiting case where output is observable without error. It is obvious that

Proposition 2. $\lim_{\mathrm{Var}(\varepsilon_{\mathrm{IT},1})\to 0}\mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{IT},2}) = \lim_{\mathrm{Var}(\varepsilon_{\mathrm{IT},1})\to 0}\mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{o},1}) = 0.$

Simply stated as the output of a certain unit becomes more accurately observable, the value of using relationships over internal management decreases to zero. This implies that partnerships provide no special value for highly standardized, easily observable tasks. This seems a contradiction to the standard wisdom, which suggests that firms should outsource the mundane, commodity like tasks and keep in-house the unique tasks. However, the result above is symmetrical in the sense that it suggests that keeping tasks in-house also provides no special advantage. Thus, other considerations must be used to make the decision (Fig. 2).

If there are significant economies of scale, for example, firms may very well want to offload a mundane task to a partner. On the other hand, if there are significant transactions costs, a firm may choose to keep such a task in-house. The point is that if two firms are otherwise equal, then it does not really matter where a mundane task is handled. This intuition makes more sense than the typical prescription that firms should always outsource these types of tasks.

3.2. Why is relational business becoming more prevalent

Taken together, the idea that firms should use relational business management for IT infrastructure when the infrastructure shocks are greater than the objective shocks and the idea that as a unit's output becomes less variable both in-house and relational management are equally acceptable provide a basis for understanding the rise of the relational mode for the management of IT units. To see this we first note that Proposition 2 implies the smaller the variance of a business unit's output, the lower the relative advantage of one form over the other. This implies that, for well-behaved functional forms, the larger the variance in a unit, the more benefit will accrue to the superior management form. In recent years, the shocks to IT infrastructure have been incredible as firms move from mainframe, to client server, to network systems architectures. So incredible, in fact, that many academics and practitioners alike refer to IT infrastructure and its attendant business environment as the *New Economy*. This new economy is fundamentally shaped by the leveraging of advantages derived from developments in hardware, software, and networking technologies and therefore inextricably linked to the rapid cycles of change in these enabling technologies. Thus, the magnitude of the shocks in

IT infrastructure functions are likely to be much greater than the magnitude of the shocks within business objectives, resulting in greater value in delegating management of those units to firms that can better measure the functional shocks.

However, increased turbulence is not unique to IT intensive business units. One key difference between business in the past and business now is the pacing of action, colloquially termed the *clockspeed*. The speeding up of the pace of firm activities to exploit extremely short windows of opportunity [51] to gain competitive advantages has led to the coining of the phrase Internet Time to describe the heightened pace of operations [52]. This increased pacing of action suggests that even holding the size of shocks constant, firms have more frequent shocks. Thus, over any time period, the variance of observed output for all units would tend to be higher. If, as we have claimed above, increasing variance increases the benefit of choosing the superior management form, then increased business clockspeed should make it more imperative than ever to choose correctly.

The trends in business in the last several decades provide two implications in our model. First, increased IT shocks relative to manufacturing shocks tend to make relational management the preferred mode for managing IT business units. Second, the increase speed of business tends to intensify the relative advantage of relational management over in-house management of IT infrastructure-based units.

4. Specific example

Basing an employee's compensation on the output of another employee boils down to a situation wherein, whoever works the hardest gets a reward. There can be variation in the actual mechanism. For example, handicapping might be used, so that one employee would have to work some amount harder than the other. However, the basic premise is well represented by a model in which whoever works harder gets the bonus. Thus, we illustrate the model with that example.

Assume that the only incentive scheme available to each firm is offering a lump sum reward with a value of one, and that reward is offered to the employee with the greatest output. This could represent a promotion, a bonus, a corner office, or any other reward. Mathematically this is expressed as

$$i_{jk}(y_{jk}, y_{lm}) = \begin{cases} 1 & \text{if } y_{jk} > y_{lm}, \\ 0 & \text{if } y_{jk} \leqslant y_{lm}. \end{cases} \tag{8}$$

Further, assume that the utility of this reward is also one, and the utility of no reward is zero. The developer takes the other employee's effort as given, so he sees the expected utility of a given level of effort as the normal cumulative distribution function (CDF).[2] The employee's decision then reduces to choosing the level of effort where the marginal increase in expected utility as a result of effort is equal to the marginal cost of effort.

When the developer works for the focal firm the CDF from which he derives his benefit has a greater variance than the CDF from which he would draw his value if he worked in the provider firm. This is illustrated in Fig. 3.

As Fig. 3 illustrates, the provider firm is able to offer better incentives to the developer, so that the developer exerts more effort. Incentive costs and benefits are held constant, and yet the developer working for the provider firm put for effort equal to P, while the same developer, if working for the focal firm, would put forth effort level F, which is less than P. There are two things to note about this result. First, the marginal cost curve is assumed not to cross the marginal benefit curve in the increasing portion of the marginal benefit curve. This is a simplifying assumption that is added to insure only one equilibria. If the marginal cost curve is allowed to cross the marginal benefit curve in the increase portion, there could conceivably be three equilibriums, two of which are stable. This corresponds to the idea that the developer might be equally happy working very hard for a large chance of being awarded the reward, or of putting forth a minimal effort and having a small chance of winning the reward. There is no reason to believe that this is untrue, but including it in the model does not add anything, and omitting it does not detract from the main point. Thus, for parsimony, we assume that there is only one equilibria, and that it is located in the decreasing portion of the marginal benefit curve.

The more interesting insight offered by Fig. 3, is that beyond effort level S the effort level induced by the focal firm's higher variance incentive actually induces greater effort. The intuition here is that as effort becomes more observable,

[2] The expected value is the probability of each state times the value of that state integrated over the possible range of states. In this case, because the value is 1, this amounts to the normal probability distribution integrated over the relevant range, which is the normal CDF.

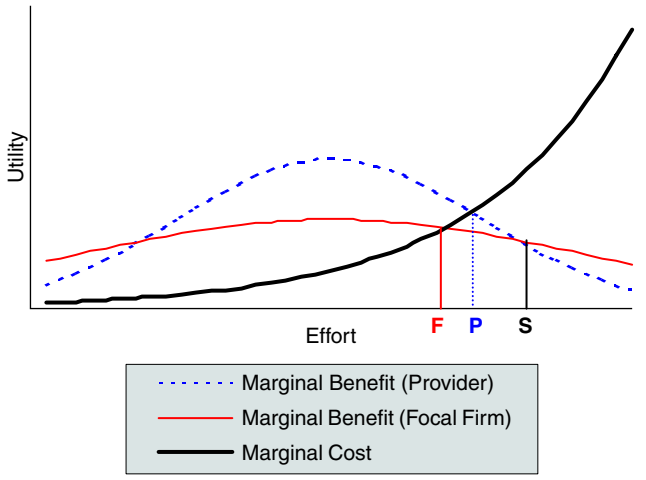

Fig. 3. Employee's effort choice.

the harder worker is more certain of winning the reward. Thus, engaging in extra effort to insure winning becomes less valuable. At the limit, with complete observability of effort, the developer would only work until he had surpassed the other employee. We observe this in sporting events, where at the end of the game the team with a commanding lead will send in the second string. However, the same lead would not warrant such behavior early in the game where outcomes where more uncertain.

This seems like a contradiction to the propositions developed earlier, but it is not. The important factor to understand is that the provider firm can introduce variance into its observations, so that beyond point S it mimics the CDF of the focal firm. This means that the provider firm purposefully chooses to ignore some of the output information, and by doing so actually encourages greater effort. Think about how different the last few minutes of a sporting event would be if each team got to roll a die and add that number to their score. This is a very interesting area for further investigation, perhaps worthy of its own paper, but that is a task for another time. The important, and pleasing, take-away is that *more information is not necessarily better*. This is a well-known view in the IS literature [53], but goes against the grain of many economic models.

Fig. 3 can also be used to illustrate the value of the risk aversion assumption. Clearly, there is risk aversion in the decreasing portion of the marginal benefit curve. However, it is not strictly necessary. Risk neutrality would be indicated by a flat marginal benefit curve, arising from an upwardly sloping linear CDF. Higher observability would cause the linear CDF to be steeper, which would result in a higher marginal benefit curve. Given the shape of the marginal cost curve, this would cause the developer to exert greater effort. The developer could even be risk seeking, given particular assumptions on the shape of the marginal cost curve, and the model would still be viable. Thus, in this example, if the developer was risk neutral, but capital constrained the model still makes sense.

5. Extensions

5.1. Economies of scale

It is important to note what is excluded from this model. One of the often-cited reasons for using relational management is to take advantage of economies of scale [34]. The model does not explicitly address the economies of scale issue, which is desirable in three ways. First, it allows for economies of scale to be added as another factor in the relational decision. If significant economies of scale do exist, they would tend to shift the partner curve in Fig. 3 upward, making the case stronger for the relational model. In addition, this would allow for an unambiguous answer to the question of whether a firm should use a relation to manage a variance free function. Second, the removal of economies of scale allows us to focus on one specific effect that occurs regardless of the underlying cost structure. While economies of scale considerations may outweigh incentive factors in some cases, the incentive effects will still

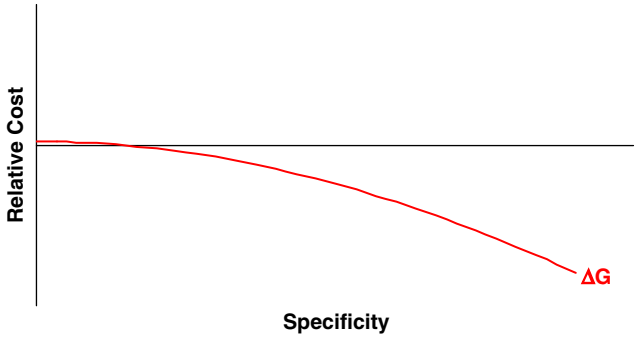

Fig. 4. TCE considerations for comparative governance costs.

be present. Third, the economies of scale arguments lack strength in many circumstances [34]. The costs of software licenses do not change, equipment costs are similar, and the staff is often the same. The bottom line is that "...the economies of scale stated by vendors were largely overstated." [34, p. xii].

5.2. Transaction cost economics

Williamson offers a model for integrating production and transaction costs, it has *heuristic model* [18, pp. 90–95]. Williamson proposes that bureaucratic inefficiencies manifest in internal organization, so that market transactions are preferred at low levels of asset specificity. Define ΔG as the cost difference between internal and external control, so that positive ΔG indicates that the cost internal organization is greater than the cost of market organization. As asset specificity increases, so does the threat of opportunism adding significant costs to the market transaction, thus making ΔG negative. However, as was pointed out earlier, bureaucratic inefficiencies are likely to exist regardless of which hierarchy produces the IT services. There will be reporting layers, resulting in bureaucratic insularity in both firms. There will be bounded rationality in both firms, and though the atmospheric conditions will be different, they will not be systematically better or worse in one firm. Consider for a moment the famous IBM, Businessland, Kodak announcement. IBM is a larger firm than Kodak, so it is likely that they would suffer more from problems of bounded rationality and bureaucratic layers. On the other hand, Businessland is smaller than Kodak, and would probably suffer less from such problems. However, in either case, there will be significant transaction costs associated with internal organization, that are a problem regardless of which firm internalizes the IT department. Thus, the comparative governance costs based on TCE considerations can be represented as in Fig. 4.

The important point to note in Fig. 4 is that the TCE considerations indicate that a relationship is only sensible at low levels of specificity. However, relational management of IT is a high time specificity proposition. Thus, one could expect most IT management to be handled in-house rather than through a relationship based on TCE considerations. Yet, many IT relationships are observed in practice. This leads us to add in consideration of production costs.

Production cost advantage can be seen as arising from the difference between $\mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{IT2})$ and $\mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{o1})$. As we have asserted throughout $\mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{IT2}) < \mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{o1})$. However, specificity as embodied in idiosyncratic processes and procedures would tend to reduce the difference between the two. That is to say, as the IT process of a firm became more unusual relative to the IT process in other firms $\mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{IT2})$ would tend to get larger. Further, to the extent that those differences arise due to the idiosyncratic nature of a particular focal firm $\mathrm{Var}(\varepsilon_{IT1}|\varepsilon_{o1})$ may become smaller. Thus, as specificity of the IT function to a focal firm increases we would expect the comparative production cost advantage (ΔP) to decrease and even become negative. However, the variance to the partner firm is never greater than the unconditioned variance, and the information gains to the focal firm can never reduce variance below zero, so the potential advantage is bounded.[3] Combining the production costs with the TCE considerations is shown in Fig. 5.

[3] Reversing the argument shows that the advantage is bounded both above and below. In other words, the partner firm's production costs can only be so much lower than the focal firm's based on information superiority.

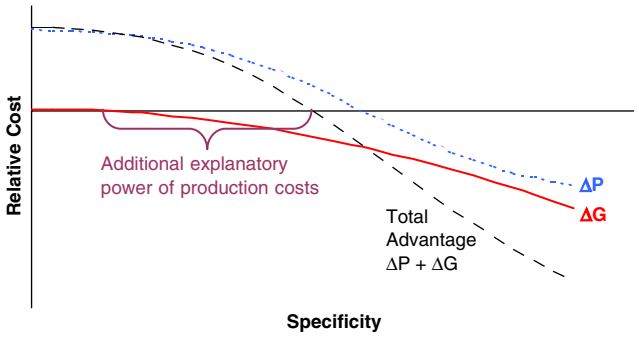

Fig. 5. Production cost and TCE considerations for comparative governance costs.

As the figure illustrates adding production cost considerations adds explanatory power to the basic TCE model. While the predictions are the same on the effects of specificity, the range over which relational management generates greater benefit than in-house management of the IT function is increased. Further, the total benefit of the relation is increased. At the same time, the costs of choosing the wrong governance structure are increased. This may help to explain why tests of asset specificity have proved to be overwhelmingly supportive of TCE [54]. The double impact of specificity on transaction and production costs, increases the chance of measuring its effects.

5.3. The rise of IT outsourcing

Our model of incentives provides some explanation about the recent rise in prominence of the relational method of managing IT units. In recent years, both the speed and the complexity of the business environment have increased. This occurs due to many factors including globalization, the development of a rich study of management, and the tide of innovations impacted upon businesses. This tends to result in a more uncertain and variable environment. Our results suggest that in such an environment, it becomes more important to select the appropriate management form. Thus, while it may be the case that managing through relationships was always the ideal way to organize units, the incremental value was not great enough to justify the cost. Now, however, the chaotic business environment increases the relative advantage to the relational form.

In addition to the changes in speed and variance in the environment, recent years have seen a rise in knowledge work [35]. The effort involved in knowledge work is intangible, and unobservable. It is very possible that the employee laughing next to the water cooler is exerting more value creating effort than the employee sitting at his desk typing in code. This move to knowledge work has two important implications for firm's ability to develop incentives. First, both the effort and the output of agents become more difficult to observe. Second, the knowledge of managers does not always overlap the knowledge of employees, so that the generalist manager might very well know less about the process than the employee. This introduces another source of error into the measurement of output. Both of these effects increase the variance of the measurement of output, and hence increase the relative advantage of choosing the better management method. Note that this is different than the increases in the actual variance as described above. The move to knowledge work does not necessarily change the variance of output, it changes the variance of the measurement of output.

For these arguments to hold, it is necessary that while the variance of observed output increases, the relative change in the conditional variance not greater for in-house management. As noted in the Introduction, the IT environment is characterized by extremely fast change, and in fact, is one of the great drivers of the increased business variance. Thus, not only is there little reason to suspect that in-house management results in better relative performance, but there is good reason to believe the opposite—that the variance of IT infrastructure units has been increasing more rapidly than the variance of business units in general. Recall that the conditional variance of relational management is the component of variance attributable to in-house differences, while the conditional variance of in-house management is the component of variance due to variance in the IT functions. Moreover, IT is generally knowledge work. In fact, as more routine IT tasks are automated the mix of work done by humans becomes increasingly knowledge based.

These two facts indicate that even for a fixed level of overall environmental variance, the advantage arising from moving IT from in-house to relational management is increasing.

Thus, of late, the value of using the relational form to manage IT units has been increasing in two ways. It has been directly increasing as IT becomes more complex and more knowledge based, by increasing the difference between the conditional variance of in-house management and the conditional variance of relational management. The value of the relational form has also been increased by the overall increase in the variance of measurement of business unit output in the more chaotic environment of the new economy.

6. Conclusions

Interorganizational relationships focused on IT are an ongoing concern of most firms, and an important research question to academics. However, neither academics nor practitioners have satisfactorily explained the fundamental premise of outsourcing—that the partner is better than the focal firm at providing IT services. Not only must a partner be better, but also it must be superior enough to justify the very real expenses associated with IT outsourcing. Armed with a better understanding of the circumstances under which the partner is, in fact, superior, focal firms will be better able to make the initial step in deciding whether outsourcing is even a viable option.

I have presented a model that proposes why an outsourcing partner might perform better than a focal firm might. The model contains several innovations. First, the source of the advantage (the resource) was not exogenously assumed, but rather derived as a property of the organization structure of the partner. This allows for a richer description of the resource, including the boundary conditions where the resource might not be present.

The second innovation is in the richness of the analytical model. Whereas standard agency theory models focus on a very small range of incentives—usually commission versus salary—our model focuses on the ability to generate any incentive. This is certainly more realistic in the case of IT professionals who are frequently paid in stock options, which are computationally much more complex than a simple commission. Further, the general incentive form allows us to consider other, subtler, forms of compensation such as power, freedom, recognition, and good will. Once again, these forms of compensation are more important for management and for IT professionals, than for a typical employee.

A third advance of the model was to hold constant both economies of scale and IT managerial talent, and explain how a purely organizational explanation of outsourcing advantage could arise from differences in the type of information available to firms. Thus, this work provides an extension to the works of others that have suggested economies of scale and managerial talents as sources of IT advantage for outsourcing vendors. This work provides a new direction for researchers to investigate in building an understanding of the increasingly important domain of IT outsourcing.

A fourth contribution of this work is to offer an introductory attempt to join classical economics to TCE, recognizing not only the costs of transacting, but also the relative production cost advantages of different firms. To this end, a model is developed that uses the same level of analysis for production as TCE work traditionally uses. Specifically, the internal production costs of a firm are assumed to depend on characteristics of the firm, rather than to be the traditional *black box*. Only by formulating models of transaction costs and production costs at the same level of detail, can researchers hope to reconcile these two viewpoints. While, far from being the final word on the subject, this work does add to the literature aimed at a holistic understanding of all of the factors in outsourcing.

By focusing on the information/knowledge assets available to a partner we develop an analytical model that shows how information which reduces the variance of observed output allows a firm to structure better incentives. The basic intuition is that partners have access to the output of other functional areas, which are doing the same job. The ability to observe a matched sample gives the partner an edge in designing incentives. Further, because much of this information is tacit, the partner cannot simply sell the information to the focal firm.

The basic result then is that because the partner has access to information about similar departments, it can more accurately estimate the IT department's effort and reward accordingly. This result is tempered by the caution that if the other IT departments/projects are dissimilar to what the partner is able to observe, then that partner provides no additional benefit. Thus, if either the firm itself or the project is unusual there is no benefit to outsourcing. In addition, if the project is ordinary, but very different from what the partner usually does, then outsourcing provides no particular benefits.

Until now, the study of outsourcing has largely put the cart before the horse, going in to great detail about how to manage a focal firm–partner relationship, without ever asking when a relationship is even appropriate. By establishing

these boundary conditions, this paper makes way for a better understanding of outsourcing success, and failure. This will allow managers to decide which projects are the best candidates for outsourcing and which partners are the best candidates for a specific project, before they begin the difficult undertaking of constructing a contract to manage the outsourcing relation.

Appendix: Proofs

Proof of Proposition 1. Note that much of the proof of Proposition 1 comes from the work in [32]. We repeat this work here for the convenience of the reader, to illustrate the underlying workings of the model, and to correct a minor typographical error in the original.

I show that some functions f and g exist so that any incentive focal firm 1 can offer based on $y_{\mathrm{IT}1}$ and $y_{\mathrm{o}1}$ can be replicated by the IT partner based on $y_{\mathrm{IT}1}$ and $y_{\mathrm{IT}2}$. This can be expressed as

$$i_{\mathrm{IT}}(y_{\mathrm{IT}1}, y_{\mathrm{IT}2}) = i_1(f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2}), g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})). \tag{9}$$

If all of the error terms are normally distributed then is suffices to show that the mean of $y_{\mathrm{IT},1}$ equals the mean of $f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})$ and the variance of $y_{\mathrm{IT},1}$ equals the variance of $f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})$, and the mean of $y_{\mathrm{o},1}$ equals the mean of $g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})$ and the variance of $y_{\mathrm{o},1}$ equals the variance of $g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})$. As Maskin et al. [32] have shown, if one chooses

$$\alpha = \frac{\sigma_{(\mathrm{IT},1),(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)}} - \frac{\sigma_{(\mathrm{IT},1),(\mathrm{o},1)}}{\sqrt{\sigma^2_{(\mathrm{o},1)}\sigma^2_{(\mathrm{IT},2)}}}, \tag{10}$$

$$\beta = \sqrt{\frac{\sigma^2_{(\mathrm{o},1)}}{\sigma^2(\mathrm{IT},2)}}, \tag{11}$$

$$\gamma = \left(1 - \sqrt{\frac{\sigma^2_{(\mathrm{o},1)}}{\sigma^2_{(\mathrm{IT},2)}}}\right) e^*, \tag{12}$$

and

$$z \sim \mathit{NORMAL}(\alpha e^*, \mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{o},1}) - \mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{IT},2})), \tag{13}$$

where z is independent of the y's, the proper f and g functions exist. These functions are

$$f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2}) = y_{\mathrm{IT},1} - \alpha y_{\mathrm{IT},2} + z \tag{14}$$

and

$$g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2}) = \beta y_{\mathrm{IT},2} + \gamma. \tag{15}$$

To see this simply note that the expected value of $f(\bullet)$ equals the expected value of $y_{\mathrm{IT},1}$, the expected value of $g(\bullet)$ equals the expected value of $y_{\mathrm{o},1}$, the variance of $f(\bullet)$ equals the variance of $y_{\mathrm{IT},1}$, the variance of $g(\bullet)$ equals the variance of $y_{\mathrm{o},1}$, and the covariance of $f(\bullet)$ with $g(\bullet)$ equals the covariance of $y_{\mathrm{IT},1}$ with $y_{\mathrm{o},1}$. Because the variables are all normally distributed these are sufficient statistics, indicating that $f(\bullet)$ and $g(\bullet)$ are indistinguishable from $y_{\mathrm{IT},1}$ and $y_{\mathrm{o},1}$. We prove this below

$$E[f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})] = E[y_{\mathrm{IT},1} - \alpha y_{\mathrm{IT},2} + z] = e - \alpha e^* + \alpha e^* = e = E[y_{\mathrm{IT},1}], \tag{16}$$

$$\begin{aligned}
\mathrm{VAR}[f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})] &= \mathrm{VAR}[y_{\mathrm{IT},1} - \alpha y_{\mathrm{IT},2} + z] \\
&= \sigma^2_{(\mathrm{IT},1)} - 2\alpha\sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} + \alpha^2\sigma^2_{\mathrm{IT},2} + \mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{o},1}) - \mathrm{Var}(\varepsilon_{\mathrm{IT},1}|\varepsilon_{\mathrm{IT},2}) \\
&= \sigma^2_{(\mathrm{IT},1)} - \frac{\sigma^2_{(\mathrm{IT},1),(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)}} + \frac{\sigma^2_{(\mathrm{IT},1),(\mathrm{o},1)}}{\sigma^2_{(\mathrm{o},1)}} + \sigma^2_{(\mathrm{IT},1)} - \frac{\sigma^2_{(\mathrm{IT},1),(\mathrm{o},1)}}{\sigma^2_{(\mathrm{o},1)}} - \sigma^2_{(\mathrm{IT},1)} + \frac{\sigma^2_{(\mathrm{IT},1),(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)}} \\
&= \sigma^2_{(\mathrm{IT},1)} = \mathrm{VAR}[y_{\mathrm{IT},1}],
\end{aligned} \tag{17}$$

$$E[g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})] = E[\beta y_{\mathrm{IT},2} + \gamma] = \beta e^* + (1-\beta)e^* = e^* = E[y_{\mathrm{o},1}], \tag{18}$$

$$\begin{aligned}\mathrm{VAR}[g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})] &= \mathrm{VAR}[\beta y_{\mathrm{IT},2} + \gamma] = \beta^2 \sigma^2_{(\mathrm{IT},2)} = \frac{\sigma^2_{(\mathrm{o},1)}}{\sigma^2_{(\mathrm{IT},2)}} \sigma^2_{(\mathrm{IT},2)} \\ &= \sigma^2_{(\mathrm{o},1)} = \mathrm{VAR}[y_{\mathrm{o},1}],\end{aligned} \tag{19}$$

and

$$\begin{aligned}&\mathrm{COV}[f(y_{\mathrm{IT},1}, y_{\mathrm{IT},2}), g(y_{\mathrm{IT},1}, y_{\mathrm{IT},2})] \\ &\quad = \mathrm{COV}[y_{\mathrm{IT},1} - \alpha y_{\mathrm{IT},2} + z, \beta y_{\mathrm{IT},2} + \gamma] \\ &\quad = \beta \sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} - \alpha\beta \sigma^2_{(\mathrm{IT},2)} \\ &\quad = \sqrt{\frac{\sigma^2_{(\mathrm{o},1)}}{\sigma^2_{(\mathrm{IT},2)}}} \sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} - \left(\frac{\sigma_{(\mathrm{IT},1),(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)}} - \frac{\sigma_{(\mathrm{IT},1),(\mathrm{o},1)}}{\sqrt{\sigma^2_{(\mathrm{o},1)} \sigma^2_{(\mathrm{IT},2)}}} \right) \sqrt{\frac{\sigma^2_{(\mathrm{o},1)}}{\sigma^2_{(\mathrm{IT},2)}}} \sigma^2_{(\mathrm{IT},2)} \\ &\quad = \frac{\sigma^2_{(\mathrm{o},1)} \sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} \sigma_{(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)} \sigma_{(\mathrm{o},1)}} - \left(\frac{\sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} \sigma_{(\mathrm{o},1)} - \sigma_{(\mathrm{IT},1),(\mathrm{o},1)} \sigma_{(\mathrm{IT},2)}}{\sigma^2_{(\mathrm{IT},2)} \sigma_{(\mathrm{o},1)}} \right) \sigma_{(\mathrm{o},1)} \sigma_{(\mathrm{IT},2)} \\ &\quad = \frac{\sigma_{(\mathrm{o},1)} \sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} - \sigma_{(\mathrm{IT},1),(\mathrm{IT},2)} \sigma_{(\mathrm{o},1)} + \sigma_{(\mathrm{IT},1),(\mathrm{o},1)} \sigma_{(\mathrm{IT},2)}}{\sigma_{(\mathrm{IT},2)}} \\ &\quad = \sigma_{(\mathrm{IT},1),(\mathrm{o},1)} = \mathrm{COV}[y_{\mathrm{IT},1}, y_{\mathrm{o},1}].\end{aligned} \tag{20}$$

Thus, it follows that the partner can offer any incentive that the focal firm is able to offer. □

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