RESOURCE RELATEDNESS, ECONOMIES OF SCOPE, AND CORPORATE STRUCTURE

Arkadiy V. Sakhartov
The Wharton School
University of Pennsylvania
2017 Steinberg Hall–Dietrich Hall
3620 Locust Walk
Philadelphia, PA 19104–6370
Phone (215) 746 2047
Fax (215) 898 0401
arkadiys@wharton.upenn.edu

Draft 1.0
January 21, 2015

I appreciate comments provided by Exequiel Hernandez, Rahul Kapoor, Anoop Menon, Ethan Mollick, and Charlotte Ren. I am thankful to the Management Department at The Wharton School for funding my research and to Wharton Computing for supporting the computations.

RESOURCE RELATEDNESS, ECONOMIES OF SCOPE, AND CORPORATE STRUCTURE

ABSTRACT

The idea that corporate structure should be carefully selected to match corporate strategy has been acknowledged since Chandler (1962). Scholars highlighted the degree of centralization of resource allocation decisions and the type of incentives used to motivate business unit managers as two important features of corporate structure. The development of the theory about the effect those features have on value realized with corporate diversification has generated some critical controversies. In particular, whether firms should be structured as centralized or decentralized to realize greater economies of scope from resource redeployment remained unclear. Similarly, whether all diversified firms should use collaborative or parochial incentives was not resolved. Finally, how the incremental benefits of the highlighted features of corporate structure bear upon relatedness was speculated rather than rigorously derived. To overcome those limitations, the present study develops a simulation model explicating the interdependences of economies of scope and corporate structure. The study appears to be the first to rigorously derive these interdependences. The results of the present study offer several stimulating insights for corporate diversification research.

Keywords: corporate diversification; corporate structure; resource redeployment; relatedness; real options

RESOURCE RELATEDNESS, ECONOMIES OF SCOPE, AND CORPORATE STRUCTURE

INTRODUCTION

The challenge of designing firms for implementing value–creating strategies has long been at the focus of management research. Organizational theory (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967) highlighted that a firm's internal organization should fit its external environment. Strategy scholars (Chandler, 1962) elaborated that organizational design is critical for firms diversifying in multiple businesses because management of such firms is more complex than in focused firms. Diversified firms can realize corporate advantages only when their corporate structures involve certain design features enabling their diversification strategies (Collis and Montgomery, 1998). Two features of corporate structure are often noted in the literature: the degree of centralization corporate headquarters retains over resource allocation decisions (Eisenmann and Bower, 2000; Hill *et al*., 1992), and the base for incentives to reward unit managers (Gupta and Govindarajan, 1986; Hill *et al*., 1992; Kretschmer and Puranam, 2008).

Despite the general recognition of importance of organizational design for implementing firms' strategies, some controversy remains in the development of the ideas about how to optimally structure diversified firms (Table 1).

- Having analyzed the growing adoption of corporate diversification, Chandler (1962) proposed that the strategy is best implemented with a decentralized corporate structure. With that structure, headquarters relegates most of resource allocation discretion to managers of business units serving their respective product markets. Each unit's manager should be rewarded based on the individual performance of the unit in its product market.
- Based on the concept of economies of scope (Panzar and Willig, 1981), the proposition that decentralization and parochial incentives should uniformly benefit all diversified firms was modified. Economies of scope, representing cost savings from redeploying

resources across units, are greater between more–related businesses (Penrose, 1959) and make the performance of such businesses more–interdependent. The management of cross–unit interdependencies requires that the corporate center retain the power to resolve conflicts between units and coordinate their activities. Following that logic, Hill *et al.* (1992: 504) argued that the more–related the businesses combined by a diversified firm, the greater the benefits of centralization of resource allocation (Panel A of Figure 1). In addition, the use of incentives based on the firm–wide performance is more important for firms diversifying into more–related businesses because such incentives enhance the interdivisional cooperation to implement firm–wide economies (Hill *et al*., 1992: 505).

- A recent focus on designing firms for fast–paced environments revised the conception of the optimal corporate structure. In dynamic markets, effective collaborations within diversified firms are initiated by self–interested unit managers (Martin and Eisenhardt, 2010). Moreover, economies of scope from redeployment of resources between related units, are enabled by a decentralized modular structure and do not require incentives based on firm–wide performance (Helfat and Eisenhardt, 2004).

The juxtaposition of the above insights introduces several key ambiguities. First, should firms be structured as centralized or decentralized to achieve economies of scope from resource redeployment? Second, should such firms adopt parochial or collaborative incentives? Finally, how the incremental benefits of the features of corporate structure bear upon relatedness?

Insert Table 1 and Figure 1 here

To resolve the identified tensions in the conception of the optimal corporate structure, the present study uses the simulation method. The method is optimal for the setting where the *potential* economies of scope represent a complex real option to switch the firm's resources between its businesses. With this representation, relatedness reduces the exercise price for the option, the cost of redeploying resources between businesses. The simulation overcomes analytical intractability of the option value (Broadie and Detemple, 2004: 1163) present where resources can be switched at any time (making the option an American type option) and such switching is costly (making the option a path–dependent option). Moreover, the simulation enables the modeler to derive the *realized* economies of scope resulting from the game played between corporate headquarters and self–interested business unit managers. By varying the degree of relatedness and estimating the corporate value resulting from different corporate structures, the simulation explicates optimal corporate structures for different conditions of potential economies of scope.

The simulation reconfirms the importance of centralization and collaborative incentives for the realized economies of scope but alters some of the existing qualitative insights (Table 1). For example, in contrast to Hill *et al*. (1992), the centralized structure is shown to facilitate unrelated diversification and hamper related diversification. In contrast to Helfat and Eisenhardt (2004) and Hill *et al*. (1992), collaborative incentives are revealed to be needed for both related and unrelated diversification. The model's results also revise the moderation hypotheses of Hill *et al*. (1992) about how an advantage of a particular corporate structure bears upon relatedness (Figure 1). Notably, relatedness negatively (rather than positively) moderates the benefit of centralized over decentralized structure. In addition, while collaborative incentives enhance (as per Hill *et al*., 1992) the benefit of related diversification with decentralized structure; such incentives reduce (contrary to Hill *et al*., 1992) the benefit of related diversification with centralized structure. The derived results qualify the existing insights about optimal corporate structure, improving theoretical understanding of how to better design organizations. The insights developed with the simulation model also lay the groundwork for better empirical identification of the value realized in corporate diversification.

RESOURCE RELATEDNESS, ECONOMIES OF SCOPE, AND CORPORATE STRUCTURE

MODEL

The current section develops a simulation model with separately tunable resource relatedness (and some additional determinants of economies of scope described below) and features of corporate structure. The model allows the modeler to set different levels of resource relatedness faced by firms and the internal features of corporate structure; evaluate economies of scope realized with that combination of the parameters; and adjust to various levels of the parameters. By replicating computations with different sets of the parameters, the simulation isolates corporate structures optimal for different levels of resource relatedness and the interactions between relatedness and benefits of the features of corporate structure in the existing research.

The model considers a firm operating two businesses i and j.[1] The firm's value (V_0^R) includes economies of scope (*R*) from redeploying resources between i and j at any time from the present time ($t=0$) to the end of the resources' lifecycle $(t=T)$.[2] The resources are initially split equally between i and j. Each period, all or part of resources deployed in i (j) can be redeployed to j (i). Key elements of the model, the determinants of potential economies of scope, the determinants of realized economies, and the valuation technique are described below.

Determinants of potential economies of scope

The present model builds off the model in Sakhartov and Folta (2014) where economies of scope from resource redeployment are enhanced by inducements, return advantages in one business over another; economies of scope are reduced by redeployment costs. To specify inducements, the model casts returns in i and j as geometric Brownian motions (GBM's). Formally,

[1] While the model generalizes to more than two businesses, the present study follows the pragmatic approach in prior research (Triantis and Hodder, 1990; Kogut and Kulatilaka, 1994) and considers diversification in only two businesses.
[2] Like Kogut and Kulatilaka (1994) and Triantis and Hodder (1990), the present study evaluates economies of scope from redeployment for resources with a finite useful life. The assumption may be relaxed by enlarging *T*.

$$C_{it} = C_{i0} e^{\left[\left(\mu_i - \frac{\sigma_i^2}{2}\right)t + \sigma_i W_{it}\right]} \qquad (1)$$

$$C_{jt} = C_{j0} e^{\left[\left(\mu_j - \frac{\sigma_j^2}{2}\right)t + \sigma_j W_{jt}\right]} \qquad (2)$$

$$dW_{it} dW_{jt} = \rho dt, \qquad (3)$$

where C_{it} (C_{jt}) represents returns at time *t* when a unit of resources is deployed in i (j); W_{it} and W_{jt} are Brownian motions with the correlation coefficient, ρ; σ_i and σ_j are return volatilities; and μ_i and μ_j are return drifts. Modeling returns as GBM's highlights that returns are more uncertain the further one looks into the future. Continuous–time specifications have precedents in modeling corporate diversification (Kogut and Kulatilaka, 1994; Triantis and Hodder, 1990). Such a model captures features of 'fast–paced markets' (Helfat and Eisenhardt, 2004: 1218), where firms encounter frequent and sharp disturbances to returns which would be underplayed by a discrete–time characterization of returns. Another important benefit of the continuous–time model is that, beyond enabling flexibility to redeploy resources, the model highlights managerial discretion to select the optimal time for redeployment.[3] The parameters involved in the chosen specification capture inducements in the following ways. A difference between C_{j0} and C_{i0} represents the current advantage in returns in j over i. Volatilities σ_i and σ_j the magnitude of possible future differences in returns between i and j. Correlation ρ inversely represents the likelihood that returns between i and j will diverge in the future.[4]

The baseline redeployment cost is specified based on the insight that redeployment is an adjustment causing the loss in efficiency of deploying resources in the new business relative to

[3] There is also an essential technical advantage of the continuous–time model over a discrete–time model. With two or more discrete periods, step probabilities for states of returns between periods get negative for an extensive set of combinations of return volatilities and return correlation (Boyle, Evnine, and Gibbs, 1989). That situation makes the function of value of redeployability undefined over extensive domains, remarkably constraining the generalizability of results of a discrete–time model.
[4] A detailed description of the mentioned parameters represent inducements can be found in Sakhartov and Folta (2014).

their continuous deployment in that business; the loss is mitigated by relatedness (Montgomery and Wernerfelt, 1988).[5] Because the model captures efficiency with returns, the model specifies the baseline cost X_{it}^{b} (X_{jt}^{b}) of redeploying resources to i (j) as a product of such returns in the business to which resources are redeployed C_{it} (C_{jt}), the marginal redeployment cost S , and the amount of resources $m_{it}-m_{it-\partial t}$ ($m_{jt}-m_{jt-\partial t}$) redeployed since the last period $t-\partial t$. Formally,

$$X_{it}^{b}=C_{it}S(m_{it}-m_{it-\partial t}) \qquad (4)$$

$$X_{jt}^{b}=C_{jt}S(m_{jt}-m_{jt-\partial t}). \qquad (5)$$

The specification has precedents: Kogut and Kulatilaka (1994: 130) also model switching costs as a percentage of value outcomes, even though in their model such a measure of efficiency is production costs. There is also an important technical advantage of proportional redeployment costs. With fixed redeployment costs, possible future scenarios at any time point are compounded with past redeployments, blowing the dimensionality and making the problem numerically intractable. Finally, S is assumed not to depend on the direction of redeployment (from i to j *versus* from j to i) and is lower the more related i and j.[6]

Determinants of realized economies of scope

The realized economies of scope depend on two considerations: (1) how close the *actual* cost of redeploying resources between the business units is to the *baseline* redeployment cost; and (2) whether resource redeployments are implemented at optimal times and in optimal amounts. The implications of the two considerations for the model are described immediately below.

[5] Resource adjustment may be affected by considerations other than efficiency. There may be time lags in redeployment. Despite the apparent relevance of such features of strategic contexts, this study follows Kogut and Kulatilaka (1994) and keeps the model parsimonious, reducing all redeployment obstacles to direct monetary considerations. Introducing additional parameters capturing redeployment lags might compromise the ability to explicate the interaction between relatedness and corporate structure.

[6] The assumption of symmetric redeployment costs is common (*e.g.*, Kogut and Kulatilaka, 1994) and presents such costs as determined by relatedness of a pair of businesses.

RESOURCE RELATEDNESS, ECONOMIES OF SCOPE, AND CORPORATE STRUCTURE

While the baseline cost $X_{it}^{b}\ (X_{jt}^{b})$ of redeploying resources to i (j) is determined by relatedness between i and j, the actual ease of the withdrawal of resources from j (i) and their transfer to i (j) can depend on the effort committed by unit $j(i)$ giving the resources. The manager of unit $j(i)$ whose resources are redeployed may be reluctant to put the effort in releasing and retraining her unit's employees and dismantling her unit's equipment, even if the destination unit for redeploying those resources is related. The effort the manager of the giving unit actually puts into the resource withdrawal and transfer is difficult to verify. Those ideas are operationalized by specifying the dependence of the actual cost $X_{it}^{r}\ (X_{jt}^{r})$ of redeploying resources on the level of effort committed by the manager of the business giving the resources and the disutility Y_{jt} (Y_{it}) of that effort to the manager giving the resources:

$$X_{it}^{r} = X_{it}^{b}(1-e_{jt}) \qquad (6)$$

$$X_{jt}^{r} = X_{jt}^{b}(1-e_{it}) \qquad (7)$$

$$Y_{jt} = e_{jt}(m_{it} - m_{it-\partial t})/100 \qquad (8)$$

$$Y_{it} = e_{it}(m_{jt} - m_{jt-\partial t})/100. \qquad (9)$$

To capture consideration (2), the model involves the two features of corporate structure discussed in the introduction. The first feature, corporate structure, is modeled as centralized or decentralized. With centralized structure, the decision to redeploy all or part of resources from i to j or *vice versa* is at the full discretion of the corporate headquarters. The manager of the unit whose resources are redeployed obeys the order to immediately withdraw the requested amount of resources and transfer them to the recipient unit. The manager of the recipient unit obeys the order to immediately accept the transferred resources. With decentralized structure, each unit manager decides whether and when to give (accept) some resources to (from) another unit.

Incentives are the second feature modeled as either collaborative or parochial. With collaborative incentives, the manager of unit i (j) is rewarded based on the performance of both her unit i (j) and another unit j (i). With parochial incentives, the manager of unit i (j) is rewarded based only on the performance of her unit i (j) but not another unit j (i). That feature of corporate structure is operationalized based on Kretschmer and Puranam (2008) such that

$$U_{it} = (1-\beta)(m_{it}C_{it} - Z_{it}X_{it}^{r}) + \beta(m_{jt}C_{jt} - Z_{jt}X_{jt}^{r}) \quad (10)$$

$$U_{jt} = (1-\beta)(m_{jt}C_{jt} - Z_{jt}X_{jt}^{r}) + \beta(m_{it}C_{it} - Z_{it}X_{it}^{r}). \quad (11)$$

In that operationalization, U_{it} (U_{jt}) is the remuneration earned by the manager of business $i(j)$ at time t. Variable Z_{it} (Z_{jt}) is an indicator variable equal one when some resources are redeployed to $i(j)$ and zero otherwise. Parameter β, taking values between zero and $k/2$, determines the dependence of the remuneration of the manager of i (j) on the net return earned by another business $j(i)$ at time t. An ancillary parameter k takes values between zero and one and reveals the proportion of the firm's value paid to the unit managers. Parameter β is the main characteristic of whether incentives are collaborative or parochial. In particular, when $\beta \to k/2$, incentives are collaborative because each unit manager gets nearly half of the remuneration distributed in both her and another unit. Alternatively, when $\beta \to 0$, incentives are parochial because each unit manager gets nearly all the remuneration distributed in her unit and nearly no remuneration from another unit.

Valuation technique

Like any simulation, the valuation of economies of scope from resource redeployment is a logically consistent algorithm imposed on the modeled processes (Davis *et al.*, 2007: 491; Harrison *et al*., 2007: 1233). The logical consistency derives from the mathematical structure developed for the valuation of stock options in financial markets. Paralleling a stock option written on two stocks, economies of scope from resource redeployment represent a switching option based on returns C_{it} and C_{jt} in businesses i and j. The valuation must respect the premise that market players balance the expected value against the risk of investments in the market. Rather than impose restrictions on risk preferences other than non–satiation, an established valuation approach is to convert the distribution of returns C_{it} and C_{jt} to a new distribution including a risk premium in an equilibrium market. That new distribution is the equivalent martingale probability measure Q (Cox and Ross, 1976; Harrison and Kreps, 1979). The transition to Q (described in Appendix) involves the replacement of drifts μ_i and μ_j in Equations 1 and 2 with the risk–free interest rate r. Using Q does not imply that market players are risk–neutral. The logic behind Q is that the equilibrium between players, gaining and loosing on deals with the option, makes value *expected* net present value from such deals zero.[7]

To derive the impact of corporate structure on realized economies of scope, the model estimates the expected net present value accumulated over $t \in [0,T]$ with alternative corporate structures: (a) centralized structure and collaborative incentives $(E^Q[V_0^{H,B}])$; (b) centralized structure and parochial incentives $(E^Q[V_0^{H,P}])$; (c) decentralized structure and collaborative

[7] Triantis and Hodder (1990) also use Q to derive the value of the switching option.

incentives $(E^Q[V_0^{A,B}])$; and (d) decentralized structure and parochial incentives $(E^Q[V_0^{A,P}])$. These values are separately computed as the values expected under the probability measure, *Q*.

Values $E^Q[\cdot]$ are not tractable analytically because the real option to redeploy resources is an American type option complicated with redeployment costs (Broadie and Detemple, 2004). To derive $E^Q[\cdot]$, the model employs the binomial lattice method of Cox, Ross, and Rubinsten (1979).[8] With the method, GBM's are approximated by binomial processes, whereby returns ($C_{it+\partial t}$ and $C_{jt+\partial t}$) in the next period $(t+\partial t)$ take one of four states: (uu) $C^u_{it+\partial t}=u_iC_{it}, u_i>1$ and $C^u_{jt+\partial t}=u_jC_{jt}, u_j>1$ with probability q^{uu}; (ud) $C^u_{it+\partial t}=u_iC_{it}, u_i>1$ and $C^d_{jt+\partial t}=d_jC_{jt}, d_j<1$ with probability q^{ud}; (du) $C^d_{it+\partial t}=d_iC_{it}, d_i<1$ and $C^u_{jt+\partial t}=u_jC_{jt}, u_j>1$ with probability q^{du}; or (dd) $C^d_{it+\partial t}=d_iC_{it}, d_i<1$ and $C^d_{jt+\partial t}=d_jC_{jt}, d_j<1$ with probability q^{dd}. The calculation of q^{uu}, q^{ud}, q^{du}, q^{dd}, u_i, d_i, u_j, and d_j, is described in Appendix. The method also requires to discretize resource capacity, $D_t=\{m_{it}, m_{jt}\}$, allocated between i and j. Parameters m_{it} and m_{jt} are proportions of resources deployed at time *t* in i and j. Resource capacity D_t is discretized so that $m_{it}\in\left\{0,\frac{1}{L},\frac{2}{L},...,1\right\}$ and $m_{jt}\in\left\{0,\frac{1}{L},\frac{2}{L},...,1\right\}$, where *L* is a whole number.

After the discretization, the principle of dynamic optimality (Bellman, 1957) can be used to compute $E^Q[V_t^{H,B}]$, $E^Q[V_t^{H,P}]$, $E^Q[V_t^{A,B}]$, and $E^Q[V_0^{A,P}]$ at any time *t*. The estimation algorithm does not differ between $E^Q[V_t^{H,B}]$ and $E^Q[V_t^{H,P}]$ calculated for the same centralized structure. The estimation algorithm does not differ between $E^Q[V_t^{A,B}]$ and $E^Q[V_t^{A,P}]$ either, because the two values are calculated for the same decentralized structure. The difference in the

[8] The binomial lattice method was extended to multivariate options by Boyle *et al*. (1989).

estimated value in each of those two pairs derives only from the difference in the value of β used with different incentives. There is, however, a substantial difference in the algorithm for the estimation of the value between centralized and decentralized structures (*i.e.*, between $E^Q[V_t^{H,B}]$ and $E^Q[V_t^{A,B}]$ and between $E^Q[V_t^{H,P}]$ and $E^Q[V_0^{A,P}]$). The difference in the algorithm derives from the difference in the structure of the game between centralization and decentralization. Therefore the two algorithms are considered in turn.

Valuation with centralized structure

The game played between the corporate headquarters and the two unit managers has the following form. At any time t on any node of the lattice for C_{it} and C_{jt}, the headquarters can dictate one of three scenarios: (a) business i redeploys the proportion $m_{jt} - m_{jt-\partial t}$ of the firm's resources to business j, (b) j redeploys $m_{it} - m_{it-\partial t}$ of the firm's resources to i, or (c) both i and j keep the resource deployments as in the previous period $t - \partial t$.

If business i receives the order to redeploy some resources to another business, the manager of that business selects the level of effort e_{it}^* maximizing the expectation for the net present value $I_t^{H,B(P)}$ accumulated by that unit manager:

$$\begin{aligned} E^Q[I_t^{H,B(P)}] &= \max_{e_{it}}[(k-\beta)m_{it}C_{it} + \beta(m_{jt}C_{jt} - X_{jt}^r) - U_{it} + \\ &e^{-r\partial t}(q^{uu}I_{t+\partial t}^{H,B(P),uu}|m_{it} + q^{ud}I_{t+\partial t}^{H,B(P),ud}|m_{it} + q^{du}I_{t+\partial t}^{H,B(P),du}|m_{it} + q^{dd}I_{t+\partial t}^{H,B(P),dd}|m_{it})]. \end{aligned} \tag{12}$$

The manager of another business j will expect to attain the net present value $J_t^{H,B(P)}$:

$$\begin{aligned} E^Q[J_t^{H,B(P)}] &= \beta m_{it}C_{it} + (k-\beta)(m_{jt}C_{jt} - X_{jt}^r) + \\ &e^{-r\partial t}(q^{uu}J_{t+\partial t}^{H,B(P),uu}|m_{it} + q^{ud}J_{t+\partial t}^{H,B(P),ud}|m_{it} + q^{du}J_{t+\partial t}^{H,B(P),du}|m_{it} + q^{dd}J_{t+\partial t}^{H,B(P),dd}|m_{it}). \end{aligned} \tag{13}$$

In that case, the corporate headquarters will expect to attain the net present value $V_t^{H,B(P)}$:

$$E^{Q}[V_t^{H,B(P)}]=(1-k)(m_{it}C_{it}+m_{jt}C_{jt}-X_{jt}^{r})+\\ e^{-r\partial t}(q^{uu}V_{t+\partial t}^{H,B(P),uu}\big|m_{it}+q^{ud}V_{t+\partial t}^{H,B(P),ud}\big|m_{it}+q^{du}V_{t+\partial t}^{H,B(P),du}\big|m_{it}+q^{dd}V_{t+\partial t}^{H,B(P),dd}\big|m_{it}). \tag{14}$$

If business j receives the order to redeploy some resources to another business, the manager of that business selects the level of effort e_{jt}^{*} maximizing the expectation for the net present value $J_t^{H,B(P)}$ accumulated by that unit manager:

$$E^{Q}[J_t^{H,B(P)}]=\max_{e_{jt}}[(k-\beta)m_{jt}C_{jt}+\beta(m_{it}C_{jt}-X_{it}^{r})-U_{jt}+\\ e^{-r\partial t}(q^{uu}J_{t+\partial t}^{H,B(P),uu}\big|m_{jt}+q^{ud}J_{t+\partial t}^{H,B(P),ud}\big|m_{jt}+q^{du}J_{t+\partial t}^{H,B(P),du}\big|m_{jt}+q^{dd}J_{t+\partial t}^{H,B(P),dd}\big|m_{jt})]. \tag{15}$$

The manager of another business i will expect to attain the net present value $I_t^{H,B(P)}$:

$$E^{Q}[I_t^{H,B(P)}]=\beta m_{jt}C_{jt}+(k-\beta)(m_{it}C_{it}-X_{it}^{r})+\\ e^{-r\partial t}(q^{uu}I_{t+\partial t}^{H,B(P),uu}\big|m_{jt}+q^{ud}I_{t+\partial t}^{H,B(P),ud}\big|m_{jt}+q^{du}I_{t+\partial t}^{H,B(P),du}\big|m_{jt}+q^{dd}I_{t+\partial t}^{H,B(P),dd}\big|m_{jt}). \tag{16}$$

In that case, the corporate headquarters will expect to attain the net present value $V_t^{H,B(P)}$:

$$E^{Q}[V_t^{H,B(P)}]=(1-k)(m_{it}C_{it}+m_{jt}C_{jt}-X_{it}^{r})+\\ e^{-r\partial t}(q^{uu}V_{t+\partial t}^{H,B(P),uu}\big|m_{jt}+q^{ud}V_{t+\partial t}^{H,B(P),ud}\big|m_{jt}+q^{du}V_{t+\partial t}^{H,B(P),du}\big|m_{jt}+q^{dd}V_{t+\partial t}^{H,B(P),dd}\big|m_{jt}). \tag{17}$$

If businesses i and j receive the order to keep the resource deployments held in the previous period, the manager the businesses and the headquarters expect to attain the following net present values:

$$E^{Q}[I_t^{H,B(P)}]=(k-\beta)m_{it}C_{it}+\beta m_{jt}C_{jt}+\\ e^{-r\partial t}(q^{uu}I_{t+\partial t}^{H,B(P),uu}\big|m_{it}+q^{ud}I_{t+\partial t}^{H,B(P),ud}\big|m_{it}+q^{du}I_{t+\partial t}^{H,B(P),du}\big|m_{it}+q^{dd}I_{t+\partial t}^{H,B(P),dd}\big|m_{it}) \tag{18}$$

$$E^{Q}[J_t^{H,B(P)}]=\beta m_{it}C_{it}+(k-\beta)m_{jt}C_{jt}+\\ e^{-r\partial t}(q^{uu}J_{t+\partial t}^{H,B(P),uu}\big|m_{it}+q^{ud}J_{t+\partial t}^{H,B(P),ud}\big|m_{it}+q^{du}J_{t+\partial t}^{H,B(P),du}\big|m_{it}+q^{dd}J_{t+\partial t}^{H,B(P),dd}\big|m_{it}) \tag{19}$$

$$E^{Q}[V_t^{H,B(P)}]=(1-k)(m_{it}C_{it}+m_{jt}C_{jt})+\\ e^{-r\partial t}(q^{uu}V_{t+\partial t}^{H,B(P),uu}\big|m_{it}+q^{ud}V_{t+\partial t}^{H,B(P),ud}\big|m_{it}+q^{du}V_{t+\partial t}^{H,B(P),du}\big|m_{it}+q^{dd}V_{t+\partial t}^{H,B(P),dd}\big|m_{it}). \tag{20}$$

Based on the calculations in Equations 14, 17, and 20 accounting for the level of effort the unit giving the resources would commit, the corporate headquarters selects an optimal resource deployment decision (m_{it}^{*}, m_{jt}^{*}) such that:

$$E^{Q}[V_t^{H,B(P)}] = \max_{(m_{it}, m_{jt})} \{E^{Q}[V_t^{H,B(P)}(m_{it}, m_{jt})]\}. \tag{21}$$

Following the principle of dynamic optimality (Bellman, 1957), the calculations in Equations 12–21 start at the penultimate period $t = T - \partial t$ on the binomial lattice and proceed recursively backward to the present time $t = 0$, where the main results needed for analyses are $E^{Q}[V_0^{H,B(P)}]$. The calculation at the penultimate period is enabled by imposing the terminal conditions: $I_T^{H,B(P),uu} = 0$, $I_T^{H,B(P),ud} = 0$, $I_T^{H,B(P),du} = 0$, , $I_T^{H,B(P),dd} = 0$, $J_T^{H,B(P),uu} = 0$, $J_T^{H,B(P),ud} = 0$, $J_T^{H,B(P),du} = 0$, , $J_T^{H,B(P),dd} = 0$, $V_T^{H,B(P),uu} = 0$, $V_T^{H,B(P),ud} = 0$, $V_T^{H,B(P),du} = 0$, $V_T^{H,B(P),dd} = 0$. Those conditions imply that at time $t = T$, the firm's resources are fully amortized (*i.e.*, exhaust their value–generating potential in businesses i and j).

Valuation with decentralized structure

The game played between the two unit managers has the following form. At any time t on any node of the binomial lattice for returns C_{it} and C_{jt}, the manager of unit i (j) evaluates the following options: (a) i (j) keeps the resource deployment $m_{it-\partial t} = m_{it}$ ($m_{jt-\partial t} = m_{jt}$) held in the previous period $t - \partial t$, or (b) business i (j) redeploys the proportion $m_{it-\partial t} - m_{it} > 0$ ($m_{jt-\partial t} - m_{jt} > 0$) of the firm's resources to business j (i) and exerts effort e_{it}, (e_{jt}). Formally, the two business units solve the problems:

$$\begin{aligned} E^{Q}[I_t^{A,B(P)}] = \max_{m_{it} \le m_{it-\partial t}, e_{it}} [(k-\beta) m_{it} C_{it} + \beta (m_{jt} C_{jt} - X_{jt}^{r}) - U_{it} + \\ e^{-r\partial t} (q^{uu} I_{t+\partial t}^{A,B(P),uu} \big| m_{it} + q^{ud} I_{t+\partial t}^{A,B(P),ud} \big| m_{it} + q^{du} I_{t+\partial t}^{A,B(P),du} \big| m_{it} + q^{dd} I_{t+\partial t}^{A,B(P),dd} \big| m_{it})] \end{aligned} \tag{22}$$

$$E^Q[J_t^{A,B(P)}] = \max_{m_{jt} \le m_{jt-\partial t}, e_{jt}} [(k-\beta)m_{jt}C_{jt} + \beta(m_{it}C_{jt} - X_{it}^r) - U_{jt} + e^{-r\partial t}(q^{uu}J_{t+\partial t}^{A,B(P),uu}\big|m_{jt} + q^{ud}J_{t+\partial t}^{A,B(P),ud}\big|m_{jt} + q^{du}J_{t+\partial t}^{A,B(P),du}\big|m_{jt} + q^{dd}J_{t+\partial t}^{A,B(P),dd}\big|m_{jt})]. \tag{23}$$

If the manager of unit i (j) finds that $m_{it}^* < m_{it-\partial t}$ ($m_{jt}^* < m_{jt-\partial t}$)—redeployment of some resources $m_{it-\partial t} - m_{it}^*$ ($m_{jt-\partial t} - m_{jt}^*$) with effort e_{it}^* (e_{jt}^*) is optimal, she makes an offer to the manager of another unit $j(i)$ to accept redeployment of proportion $m_{it-\partial t} - m_{it}^*$ ($m_{jt-\partial t} - m_{jt}^*$) of the firm's resources. The manager of the unit $j(i)$ receiving the offer evaluates the problem:

$$E^Q[J_t^{A,B(P)}] = \max\{E^Q[J_t^{A,B(P)}(m_{jt} = m_{jt-\partial t})], E^Q[J_t^{A,B(P)}(m_{it}^* < m_{it-\partial t})]\} \tag{24}$$

$$E^Q[I_t^{A,B(P)}] = \max\{E^Q[I_t^{A,B(P)}(m_{it} = m_{it-\partial t})], E^Q[I_t^{A,B(P)}(m_{jt}^* < m_{jt-\partial t})]\}. \tag{25}$$

If the second term in the maximization in Equation 24 solves the problem, unit j accepts the redeployment. In that case, the corporate headquarters expects the net present value $V_t^{A,B(P)}$:

$$E^Q[V_t^{A,B(P)}] = (1-k)(m_{it}^*C_{it} + m_{jt}^*C_{jt} - X_{jt}^r) + e^{-r\partial t}[q^{uu}V_{t+\partial t}^{H,B(P),uu}\big|(m_{it}^*, m_{jt}^*) + q^{ud}V_{t+\partial t}^{H,B(P),ud}\big|(m_{it}^*, m_{jt}^*) + q^{du}V_{t+\partial t}^{H,B(P),du}\big|(m_{it}^*, m_{jt}^*) + q^{dd}V_{t+\partial t}^{H,B(P),dd}\big|(m_{it}^*, m_{jt}^*)]. \tag{26}$$

If the second term in the maximization in Equation 25 solves the problem, unit i accepts the redeployment. In that case, the corporate headquarters expects the net present value $V_t^{A,B(P)}$:

$$E^Q[V_t^{A,B(P)}] = (1-k)(m_{it}^*C_{it} + m_{jt}^*C_{jt} - X_{it}^r) + e^{-r\partial t}[q^{uu}V_{t+\partial t}^{H,B(P),uu}\big|(m_{it}^*, m_{jt}^*) + q^{ud}V_{t+\partial t}^{H,B(P),ud}\big|(m_{it}^*, m_{jt}^*) + q^{du}V_{t+\partial t}^{H,B(P),du}\big|(m_{it}^*, m_{jt}^*) + q^{dd}V_{t+\partial t}^{H,B(P),dd}\big|(m_{it}^*, m_{jt}^*)]. \tag{27}$$

To evaluate $E^Q[V_0^{A,B(P)}]$, the calculations in Equations 22–27 start at $t = T - \partial t$ and proceed recursively backward to $t = 0$. The calculation is initiated with the terminal conditions: $I_T^{A,B(P),uu} = 0$, $I_T^{A,B(P),ud} = 0$, $I_T^{A,B(P),du} = 0$, , $I_T^{A,B(P),dd} = 0$, $J_T^{A,B(P),uu} = 0$, $J_T^{A,B(P),ud} = 0$, $J_T^{A,B(P),du} = 0$, , $J_T^{A,B(P),dd} = 0$, $V_T^{A,B(P),uu} = 0$, $V_T^{A,B(P),ud} = 0$, $V_T^{A,B(P),du} = 0$, $V_T^{A,B(P),dd} = 0$.

RESULTS

The analysis of how corporate structure interacts with diversification strategy in determining realized economies of scope involves two parts. First, by varying the degree of relatedness and the type of incentives, the model derives optimal incentives and the interaction between incentives and relatedness. Second, by varying resource relatedness and the degree of centralization of resource allocation decisions, the model derives the optimal centralization of corporate structure and the interaction between centralization and relatedness.

Incentives, resource relatedness, and realized economies of scope

Figure 2 illustrates how the advantage of collaborative incentives for centralized $(E^Q[V_0^{H,B}]-E^Q[V_0^{H,P}])$ and decentralized $(E^Q[V_0^{A,B}]-E^Q[V_0^{A,P}])$ corporate structures bears upon relatedness. Two observations from Figure 2 are worth highlighting and explaining. First, as evident in the positions of the lines above zero, collaborative incentives are always advantageous. The advantage of collaborative incentives with the decentralized structure is intuitive. In decentralized structure, self–interested unit managers, while not stimulated with a portion of overall returns of the firm, avoid some beneficial resource redeployments separating the realized economies from the potential optimal value for such economies. The advantage of collaborative incentives with the centralized structure is less intuitive. The advantage occurs because, while unit managers cannot avoid valuable resource redeployments, the lack of firm–wide incentives makes mangers exert little effort to prepare resources for efficient redeployment. This result indicates that centralized structure cannot substitute for collaborative incentives, and both coordinating mechanisms are needed to enhance the realized economies of scope. That collaborative incentives may be advantageous when the firm diversifies into unrelated business is also counterintuitive and contradicts the existing arguments of Chandler (1963) and Hill *et al*.

(1992) about the optimal corporate structure. The advantage of collaborative incentives with unrelated diversification occurs because the lack of relatedness raises the baseline redeployment costs and broadens the room for the unit managers to make the realized redeployment cost lower. Obviously, that room is more likely to be efficiently exploited with collaborative incentives.

Insert Figure 2 here

Second, the interaction between relatedness and the advantage of collaborative incentives differs between centralized and decentralized corporate structures and, for centralized structure, runs counter to the existing qualitative prediction. While relatedness enhances the benefit of collaborative incentives (as per Hill *et al*., 1992) with decentralized structure, relatedness reduces the benefit of collaborative incentives (contrary to Hill *et al*., 1992) with centralized structure. The rejection of the existing prediction takes place because, with centralized structure, the headquarters forces the unit managers to commit redeployments based on the utility of such redeployments to the firm. In that situation, the lack of collaborative incentives would make the managers exert no or very little effort making the redeployment cost prohibitively expensive, *especially in the case of unrelated diversification*. This combination (decentralized structure and low relatedness) is the condition where the collaborative incentives make most difference in the realized economies of scope. In contrast, with high relatedness, the baseline redeployment cost is low anyway; and the lack of effort by the unit managers at reducing the redeployment costs does not discourage the headquarters from resource redeployment.

Centralization, resource relatedness, and realized economies of scope

Having diagnosed that collaborative incentives are always advantageous for realizing economies of scope from resource redeployment, the present section restricts its focus to collaborative incentives. Figure 3 reveals how the advantage of centralization $(E^Q[V_0^{H,B}]-E^Q[V_0^{A,B}])$ is moderated by relatedness. The dash–dot line in Figure 3 arbitrarily represents the moderation hypothesis of Hill *et al*. (1992). The line with circles corresponds to the calculations performed in full compliance with the developed simulation model. The main model does not consider an opportunity that centralized and decentralized corporate structures may systematically differ in the amount of bureaucracy costs. In particular, the centralized structure is likely to have additional costs (such as corporate overheads, large corporate staff, muted incentives, time lags in resource deployment decisions, *etc*.) avoided in the case of decentralization. That possibility is accounted for by introducing moderate (the broken line) and high bureaucracy costs (independent of relatedness). Several features of Figure 3 are important.

Insert Figure 3 here

First, regardless of the level of bureaucracy costs, relatedness reduces the advantages of centralization. That result directly contradicts the qualitative prediction of Hill *et al*. (1992) that the advantages of centralization are greater with related diversification. The pattern emerges because high relatedness makes the baseline redeployment cost low and suffices to motivate the unit managers to undertake resource redeployments without a centralized order (obviously, only when incentives are collaborative). Low relatedness, in contrast, requires much effort from the unit managers to make redeployments profitable. In that case, redeployments are unlikely to be voluntary committed by the unit managers and are forces by the headquarters.

Second, in the most plausible scenario of moderate bureaucracy costs, there is a threshold level of relatedness only below which centralization is advantageous. Above the threshold level of relatedness, the bureaucracy costs surpass the benefits of administering the use of economies of scope in centralized structure, making decentralization more economical.

DISCUSSION

The idea that corporate structure should be carefully selected to match corporate strategy has been acknowledged since Chandler (1962). Scholars highlighted the degree of centralization of resource allocation decisions and the type of incentives used to motivate business unit managers as two important features of corporate structure. The development of the theoretical insights about the effect those features have on economies of scope realized with corporate diversification strategies has generated some critical controversies. In particular, whether firms should be structured as centralized or decentralized to realize greater economies of scope from resource redeployment remained unclear. Similarly, whether all diversified should use collaborative or parochial incentives was not resolved. Finally, how the incremental benefits of the highlighted features of corporate structure bear upon relatedness was speculated rather than rigorously derived. To overcome those limitations, the present study develops a simulation model explicating the interdependences of economies of scope and corporate structure. The study appears to be the first to rigorously derive these interdependences. It turns out that the results of the present study offer several stimulating insights for corporate diversification research.

First, the paper elaborates that collaborative incentives are beneficial for both related and unrelated diversification. Although past research highlighted the importance of collaborative incentives, that importance was restricted to the contexts of high relatedness of the combined business. The undertaken formalization of economies of scope highlights that the lack of relatedness increases the demand to motivate unit managers with collaborative incentives so that resource redeployments are implemented more efficiently. In contrast high baseline efficiency of resource redeployment in the contexts of related diversification reduces the need to administer the additionally incentivize corporate diversification strategies. That finding revises the known qualitative insight that relatedness positively moderates the benefits of collaborative incentives.

Second, the study revises the key role played by centralization in realizing economies of scope from resource redeployment. The model demonstrates that the advantages of centralized resource allocation are stronger in unrelated than related corporate diversification. That result reverses the known theoretical prediction that relatedness should positively moderate the advantages of centralized structure. The unexpected prediction has an explanation similar to the explanation for collaborative incentives provided above. High relatedness makes the default efficiency of resource redeployment high and suffices to motivate unit managers to undertake profitable redeployments, even when corporate structure does not oblige managers to do so. Low relatedness, in contrast, makes redeployments less attractive to business unit managers, demanding the interference of the corporate headquarters.

APPENDIX: Application of martingale valuation

The market, specified by Equations 1,2 and 3, is free of arbitrage and complete, because the number of sources of randomness (W_{it}'s) is equal to the number of risky assets (C_{it}'s). By the First Fundamental Theorem of Finance (Björk, 2004: 137), because the market is free of arbitrage, there exists a martingale probability measure, Q. By the Second Fundamental Theorem of Finance (Björk, 2004: 146), because the market is complete, the martingale probability measure, Q, is unique and can be used for the risk–neutral valuation of an option. Under Q, the dynamics for C_{it} and C_{jt} are changed to reflect their martingale property: $E^Q[C_{it+\partial t}] = e^{r\partial t} C_{it}$ and $E^Q[C_{jt+\partial t}] = e^{r\partial t} C_{jt}$ (Björk, 2004: 183):

$$C_{it} = C_{i0} e^{\left[\left(r - \frac{\sigma_i^2}{2}\right)t + \sigma_i \overline{W_{it}}\right]}$$

$$C_{jt} = C_{j0} e^{\left[\left(r - \frac{\sigma_j^2}{2}\right)t + \sigma_j \overline{W_{jt}}\right]}$$

$$d\overline{W}_{it} \, d\overline{W}_{jt} = \rho \, dt$$

where $\overline{W_{it}}$ and $\overline{W_{jt}}$ are two new correlated Brownian motions with the same correlation coefficient ρ as in Equation 3; r is the risk–free interest rate; and all other parameters remain as specified in Equations 1,2 and 3. Note that drifts μ_i and μ_j do not feature in the martingale dynamics for returns and, accordingly, do not affect the estimated value.

Probabilities on the binomial lattice approximation are as follows (Boyle *et al*., 1989):

$$q^{uu} = \frac{1}{4}\left[1 + \sqrt{\partial t}\left(\frac{r - \frac{1}{2}\sigma_i^2}{\sigma_i} + \frac{r - \frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right]$$

$$q^{ud} = \frac{1}{4}\left[1+\sqrt{\partial t}\left(\frac{r-\frac{1}{2}\sigma_i^2}{\sigma_i}-\frac{r-\frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right]$$

$$q^{du} = \frac{1}{4}\left[1+\sqrt{\partial t}\left(-\frac{r-\frac{1}{2}\sigma_i^2}{\sigma_i}+\frac{r-\frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right]$$

$$q^{dd} = \frac{1}{4}\left[1+\sqrt{\partial t}\left(-\frac{r-\frac{1}{2}\sigma_i^2}{\sigma_i}-\frac{r-\frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right],$$

where q^{uu} is probability that $C_{it+\partial t} = u_i C_{it}$ and $C_{jt+\partial t} = u_j C_{jt}$; q^{ud} is probability that $C_{it+\partial t} = u_i C_{it}$ and $C_{jt+\partial t} = d_j C_{jt}$; q^{du} is probability that $C_{it+\partial t} = d_i C_{it}$ and $C_{jt+\partial t} = u_j C_{jt}$; q^{dd} is probability that $C_{it+\partial t} = d_i C_{it}$ and $C_{jt+\partial t} = d_j C_{jt}$; $\partial t = T / N$ is a time step equal to the ratio of the resources' lifecycle, *T*, and the number of steps, *N*. Multipliers, u_i and d_i (u_j and d_j), for the states of returns are found as $u_i = e^{\sigma_i \sqrt{\partial t}}$ ($u_j = e^{\sigma_j \sqrt{\partial t}}$) and $d_i = 1/u_i$ ($d_j = 1/u_j$).

REFERENCES

Bellman R. 1957. *Dynamic Programming*. Princeton University Press, Princeton, NJ.

Björk T. *Arbitrage Theory in Continuous Time*. Oxford University Press Inc.: New York.

Boyle PP, Evnine J, Gibbs S. 1989. Numerical evaluation of multivariate contingent claims. *Review of Financial Studies* **2**(2): 241–250.

Broadie M, Detemple J. 2004. Option pricing: Valuation models and applications. *Management Science* **50**(9): 1145–1177.

Burns T, Stalker GM. 1961. *The Management of Innovation*. Tavistock: London.

Chandler A. 1962. *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. MIT Press: Cambridge, MA.

Collis DJ, Montgomery CA. 1998. Creating corporate advantage. *Harvard Business Review* **May–June**: 70–83.

Cox JC, Ross SA. 1976. The valuation of options of alternative stochastic processes. *Journal of Financial Economics* **3**(1–2): 145–166.

Cox J, Ross S, Rubinstein M. 1979. Option pricing: A simplified approach. *Journal of Financial Economics* **7**(3): 229–263.

Davis JP, Eisenhardt KM, Bingham CB. 2007. Developing theory through simulation methods. *Academy of Management Review* **32**(2): 480–499.

Eisenmann TR, Bower JL. 2000. The entrepreneurial M–form: Strategic integration in global media firms. *Organization Science* **11**(3): 348–355.

Gupta AK, Govindarajan V. 1986. Resource sharing among SBUs: Strategic antecedents and administrative implications. *Academy of Management Journal* **29**(4): 695–714.

Harrison JM, Kreps DM. 1979. Martingales and arbitrage in multiperiod securities markets. . *Journal of Economic Theory* **20**(3): 381–408.

Helfat CE, Eisenhardt KM. 2004. Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management Journal* **25**(13): 1217–1232.

Hill CWL, Hitt MA, Hoskisson RE. 1992. Cooperative versus competitive structures in related and unrelated diversified firms. *Organization Science* **3**(4): 501–521.

Kretschmer T, Puranam P. 2008. Integration through incentives within differentiated organizations. *Organization Science* **19**(6): 860–875.

Kogut B, Kulatilaka N. 1994. Operating flexibility, global manufacturing, and the option value of a multinational network. *Management Science* **40**(1): 123–139.

Lawrence PR, Lorsch JW. 1967. *Organizations and Environment: Managing Differentiation and Integration*.Harvard University Press: Cambridge, MA.

Martin JA, Eisenhardt KM. 2010. Rewiring: Cross–business–unit collaborations in multibusiness organizations. *Academy of Management Journal* **53**(2):265–301.

Montgomery CA, Wernerfelt B. 1988. Diversification, Ricardian rents, and Tobin's q. *RAND Journal of Economics* **19**(4): 623–632.

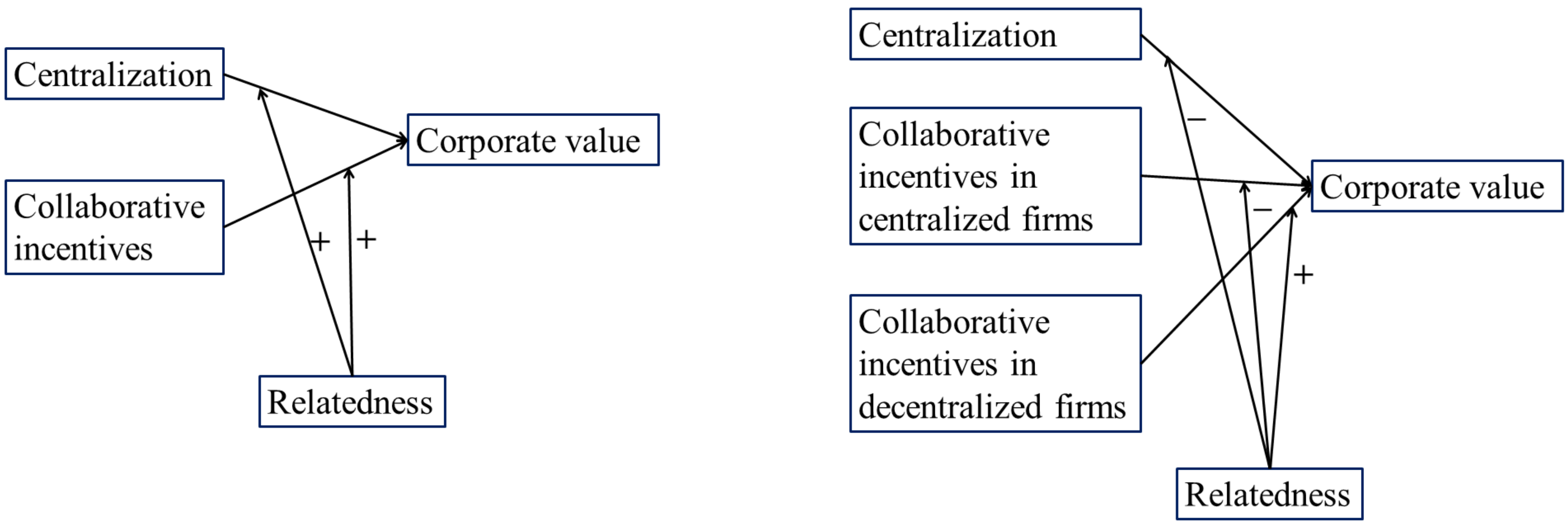
Penrose ET. 1959. *The Theory of the Growth in the Firm*. John Wiley: New York.

Sakhartov AV. Folta TB. 2014. Getting beyond relatedness as a driver of corporate value. *Strategic Management Journal* **forthcoming**.

Thompson JD. 1967. *Organizations in Action: Social Science Bases of Administrative Theory*. McGraw–Hill: New York.

		Phase 1: Management of corporate diversification (Chandler, 1962)	Phase 2: Management of related *versus* unrelated corporate diversification (Hill *et al.*, 1992)	Phase 3: Management of related corporate diversification in fast–paced markets (Helfat and Eisenhardt, 2004)	Present study
Type of corporate diversification	Related	Decentralization	Centralization	Decentralization	Decentralization
		Parochial incentives	Collaborative incentives	Parochial incentives	Collaborative incentives
	Unrelated	Decentralization	Decentralization	Not considered	Centralization
		Parochial incentives	Parochial incentives	Not considered	Collaborative incentives

Table 1. Development of the conception of optimal corporate structure



A. Existing theory (Hill *et al*., 1992) **B. Present study**

Figure 1. Implications of relatedness for advantages of alternative corporate structures

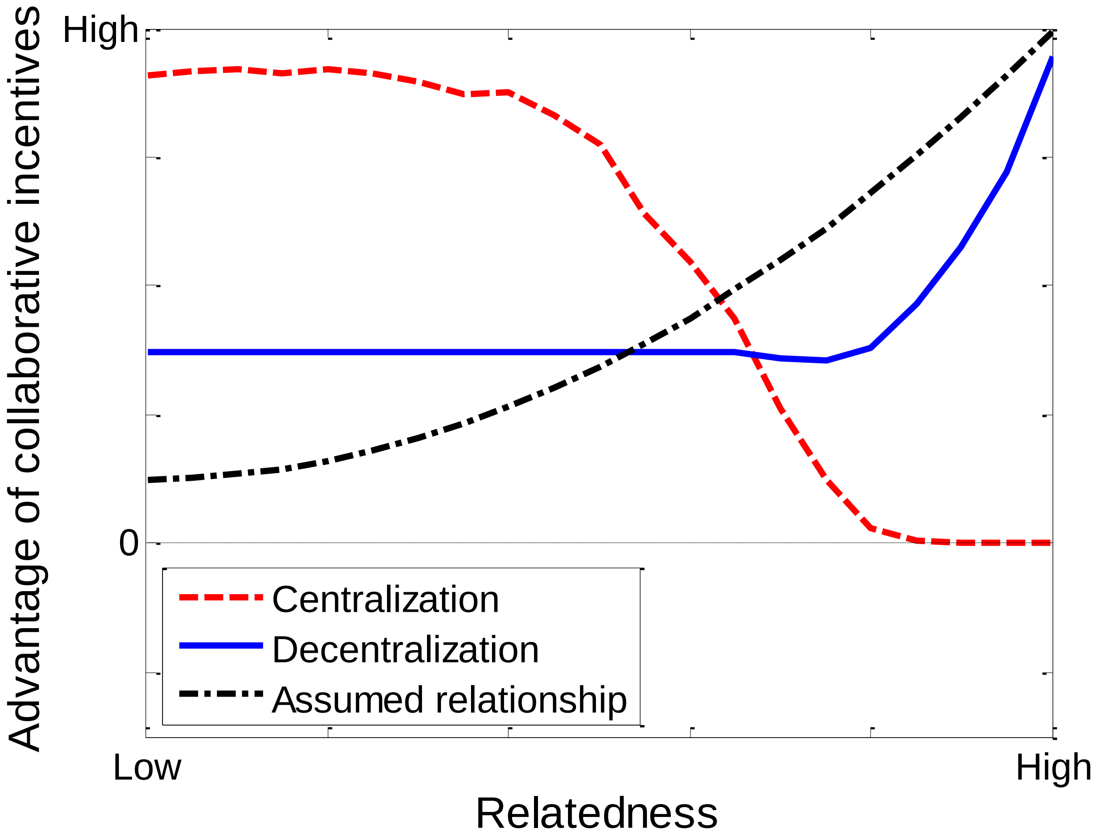


Figure 2. Joint impact of incentives and relatedness on realized economies of scope

Advantage of collaborative incentives is the difference in the expected net present value of the firm between the modes where incentives are collaborative ($\beta = k/2$) and parochial ($\beta = k/20$). With centralized structure, the resource redeployment decision is within the full discretion of the corporate headquarters and the advantage is estimated as $(E^Q[V_0^{H,B}] - E^Q[V_0^{H,P}])$. With decentralized structure, the resource redeployment decision is within the joint discretion of the business unit managers and the advantage is estimated as $(E^Q[V_0^{A,B}] - E^Q[V_0^{A,P}])$. Relatedness is represented inversely with the marginal redeployment cost $S \in [0,50]$. The assumed relationship arbitrarily represents Hypothesis 4 in Hill *et al*. (1992: 505). Other parameter values used to generate the figure are $C_{i0} = C_{j0} = 0.08$, $\sigma_i = \sigma_j = 0.9$, $\rho = 0$, $T = 1, r = 0.08, N = 50, L = 2, k = 0.7$.

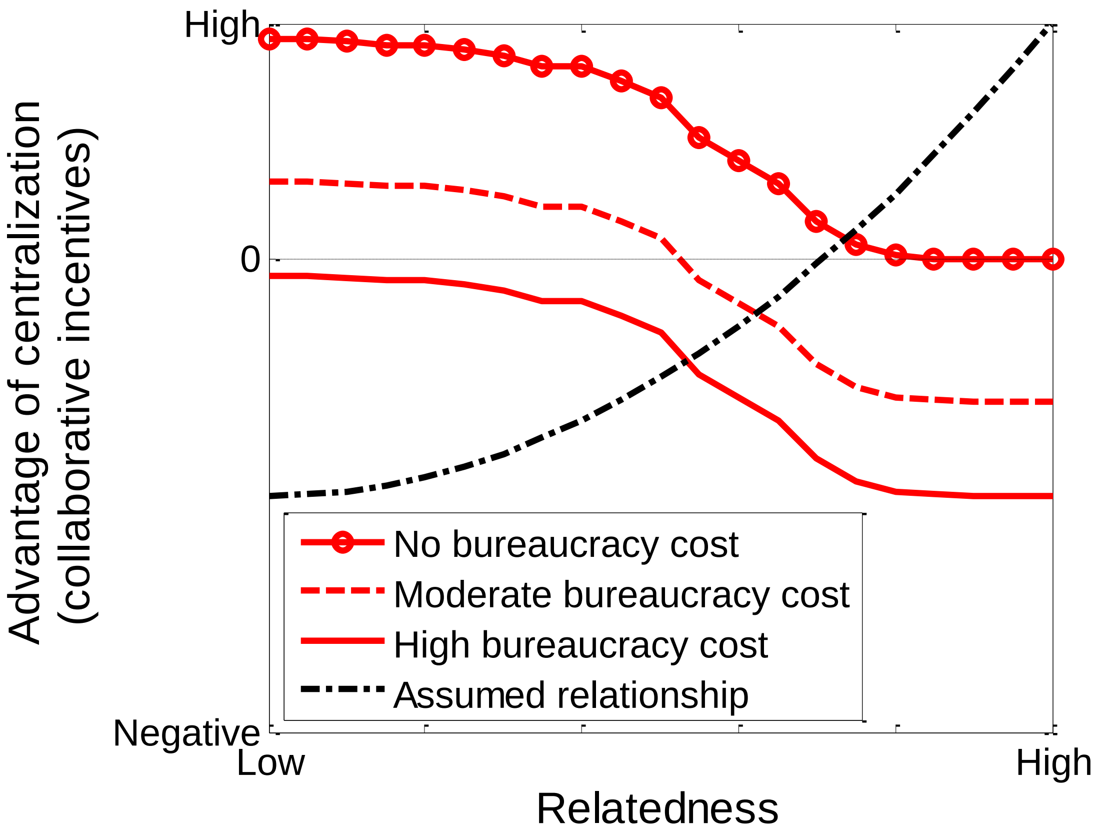


Figure 3. Joint impact of centralization and relatedness on realized economies of scope

Advantage of centralization is the difference $(E^{Q}[V_0^{H,B}]-E^{Q}[V_0^{A,B}])$ in the expected net present value between the centralized firm and the decentralized firm when incentives are collaborative ($\beta = k/2$). Relatedness is represented inversely with the marginal redeployment cost $S \in [0,50]$. The assumed relationship arbitrarily represents Hypothesis 1 in Hill *et al*. (1992: 504). Other parameter values used to generate the figure are $C_{i0} = C_{j0} = 0.08$, $\sigma_i = \sigma_j = 0.9$, $\rho = 0$, $T = 1, r = 0.08, N = 50, L = 2, k = 0.7$. The used values of bureaucracy costs are 0.003 for moderate costs and 0.005 for high costs.