RESOURCE REDEPLOYMENT IN MULTI-BUSINESS FIRMS: CENTRALIZED OR DECENTRALIZED?

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Abstract

Although multi-business firms can profit from resource redeployment, we know little about the organizational arrangements that firms use when they make redeployment decisions. This study examines a critical organizational choice, namely the centralization or decentralization of decision making. Using a formal model, the study demonstrates that in the presence of agency costs of decentralization and communication and monitoring costs of centralization, centralization may lead to higher profits than decentralization even when relatedness is at a low to moderate level. Decentralization can also be more profitable than centralization when relatedness is high. These conclusions contrast with prior research on contemporaneous resource sharing in which centralization (relative to decentralization) was thought to improve performance in more but not less related diversified firms.

Keywords: resource redeployment, resource allocation, economies of scope, centralization, related diversification

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INTRODUCTION

Multi-business firms can increase their profits by redeploying resources from less profitable to more profitable businesses. Through resource redeployment, a firm can earn "inter-temporal" economies of scope (Helfat and Eisenhardt, 2004), in contrast to "intra-temporal" economies of scope that derive from the contemporaneous sharing of resources among businesses (Panzar and Willig, 1981; Teece, 1980). When the returns to different businesses within a firm diverge, the firm has an "inducement" to redeploy resources to businesses where the resources produce higher profits (Penrose, 1959; Sakhartov and Folta, 2014 and 2015; see also Helfat and Eisenhardt, 2004). Inter-temporal economies often accrue from the redeployment of "non-scale free" resources that are fungible across businesses yet have capacity constraints, which limits contemporaneous sharing among businesses (Anand, Kim, and Lu, 2016; Levinthal and Wu, 2010). Many empirical studies have shown that diversified firms use resource redeployment in an effort to improve performance (Anand and Singh, 1997; Anand, 2004; O'Brien and Folta, 2009; Berry, 2010; Kaul, 2012; Miller and Yang, 2016; Lieberman, Lee, and Folta, 2017; Garg and Zhao, 2018; Dickler and Folta, 2020; Giarratana and Santaló, 2020; Sohl and Folta, 2021; Chauvin and Poliquin, 2023). Evidence also suggests that the redeployment of non-scale free resources is positively associated with stock market returns (Wu, 2013) and firm growth (Giarratana, Pasquini, and Santaló, 2021).

Although resource redeployment has the potential to increase profits, whether a diversification strategy improves performance depends on its implementation (Chandler, 1962; Collis and Montgomery, 2004). A substantial amount of research has examined the organizational arrangements that enable diversified firms to profit from contemporaneous resource sharing (see *e.g.*, Hill, Hitt, and Hoskisson, 1992; Goold, Campbell, and Alexander, 1994). Other research has analyzed how the organizational structure of R&D affects knowledge sharing and innovation (*e.g.*, Argyres and Silverman, 2004; Argyres, Rios, and Silverman, 2020). However, prior research has paid relatively little attention to the organizational arrangements that firms use when redeploying resources (for an exception, see Helfat and Eisenhardt, 2004). Here we investigate how a critical organizational choice, namely the centralization or decentralization of decision making (Collis and Montgomery, 2004), affects the profitability of resource redeployment.

Although a small amount of research has provided examples of firms that have centralized decisions to redeploy resources, such as DuPont (Chandler, 1962) and Omni Corporation (a pseudonym for a diversified high-technology company) (Helfat and Eisenhardt, 2004), firms can also decentralize these decisions. That is, even if top management may often (but not necessarily always) be in a better position than the business units to identify a redeployment opportunity, due to the breadth of internal and external information that top management receives, the question still arises: is it more profitable for firms to centralize or decentralize the decision to undertake a resource redeployment opportunity that has been identified?

We use a formal model to investigate the conditions under which centralization or decentralization of the decision to redeploy resources leads to higher profits, in which neither centralization nor decentralization is universally superior. Instead, the superiority of a particular corporate structure is contingent on the balance between agency costs under decentralization and the cost of centralization, which in turn depends on the two key contextual determinants of the value from redeployment identified in prior research: return asymmetry and relatedness (e.g., Helfat and Eisenhardt, 2004; Sakhartov and Folta, 2014, 2015). The model incorporates adjustment costs of redeployment (Helfat and Eisenhardt, 2004; Sakhartov and Folta, 2014, 2015; Hashai, 2015), which are tied to the extent of relatedness, and financial incentives for the business units to undertake resource redeployment.

The model demonstrates that decentralization can be more profitable than centralization when relatedness is high. The model also shows that centralization can lead to greater profits than decentralization when relatedness is at a low to moderate level. These conclusions contrast with prior research on organizational arrangements in diversified firms in which centralization (relative to decentralization) was thought to improve performance in more related diversified firms, and decentralization was thought to improve performance in less related diversified firms (Hill *et al.*, 1992; Eisenmann and Bower, 2000). In this research, centralization enabled firms to profit from relatedness by facilitating the contemporaneous sharing of resources across businesses. In contrast, profits from resource redeployment depend not only on relatedness but also on return asymmetries between businesses (Helfat and Eisenhardt, 2004; Sakhartov and Folta, 2014, 2015). Without a difference in returns between businesses, firms have little reason to redeploy resources because firms also bear the costs of redeploying resources. Because a low return asymmetry can partially or fully offset the effect of high relatedness on the profitability of resource redeployment, and vice versa, the relationship between relatedness and centralization or decentralization is more complicated for resource redeployment than for contemporaneous resource sharing.

The paper proceeds as follows. We first discuss organizational arrangements in diversified firms, and then provide an overview of the formal model that we use to investigate the profitability of centralization versus decentralization in redeployment decisions. With this backdrop, we present the formal model and explain the intuition behind the results. Finally, we discuss implications for research on resource redeployment and organizational arrangements in diversified firms.

CENTRALIZATION VERSUS DECENTRALIZATION IN DIVERSIFIED FIRMS

The extent of resource similarity among businesses, often referred to as the extent of relatedness, is a fundamental concept in the study of diversification (Rumelt, 1974). The extent of relatedness plays a role in resource redeployment because greater relatedness leads to lower adjustment costs of repurposing any resources that are redeployed to another business (Helfat and Eisenhardt, 2004;

Sakhartov and Folta, 2014, 2015). However, most research on organizational arrangements in diversified firms that accounts for relatedness has considered only the extent of contemporaneous (intra-temporal) sharing of resources among businesses.

Prior research has argued that (more highly) related and unrelated (or less related) diversification call for different organizational arrangements, especially among M-form firms in which business units are organized by product category (Eisenmann and Bower, 2000; Hill *et al*., 1992).[1] Because unrelated diversified M-form firms require little ongoing communication and coordination across business units, top management can decentralize operating decisions and potentially some strategic decisions to the units, which reduces information processing requirements between headquarters and the units (Chandler, 1962; Eisenmann and Bower, 2000; Williamson, 1975). Due to low coordination needs, these firms are also less likely to use integrative mechanisms such as cross-unit teams. In addition, top management can put in place "high-powered" incentives that tie business managers' pay to the performance of their units, thereby reducing the need for oversight of the units by headquarters (Hill *et. al*., 1992; Williamson, 1985; Williamson, 1991).

In contrast, related diversified M-form firms may seek to generate intra-temporal economies of scope by sharing resources contemporaneously among business units, especially scale free resources that are not subject to capacity constraints (Levinthal and Wu, 2010).[2] However, decentralized decision making may fail to ensure cross-unit coordination to share resources if individual units and their managers are averse to the additional effort that would be required (Eisenmann and Bower, 2000).[3] This sort of agency cost may lead top management in related

[1] Centralization differs from decentralization by the level in a firm at which decisions are made: "an administrative organization is centralized to the extent that decisions are made at… high levels in the organization; decentralized to the extent that discretion and authority to make… decisions are delegated by top management to lower levels of… authority" Simon *et al.* (1954: 1).
[2] Firms may also generate intra-temporal economies of scope from non-scale free resources such as plants and distribution channels, although these intra-temporal economies are limited by capacity constraints of the resources.
[3] Unit managers may also misrepresent information to top management, although this is not the focus of our analysis. For example, agency costs can lead to inefficient capital allocation (*e.g.*, Scharfstein and Stein, 2000).

diversified firms to use centralized decision making (Eisenmann and Bower, 2000; Hill *et al.*, 1992). Top management may also tie business unit manager pay to the performance of the entire firm, so that managers have incentives to share resources with other units, and firms may use integrative mechanisms to promote cross-unit coordination (Gupta and Govindarajan, 2000; Hill *et al.*, 1992).

Whether these arguments apply when firms seek inter-temporal economies of scope through resource redeployment is an open question. In contrast to resource sharing, resource redeployment does not require ongoing cross-unit coordination. However, just as for contemporaneous resource sharing, the lack of effort by the business units may affect the profitability of resource redeployment.

For example, consider the redeployment of a plant from one business unit to another unit that could put the plant to a more profitable use. On the day of the plant's redeployment, suppose that all the old managers and workers are gone. The unit that receives the plant is likely to have a problem: a plant doesn't come with a user's manual. A significant amount of information about plant operations generally is not codified but could be helpful to the receiving unit when it shifts production to a new product—such as why the particular equipment and plant configuration were chosen, what things routinely go wrong and how to fix them, and the like. Therefore, the receiving unit would benefit from help from the current plant managers and engineers who possess tacit knowledge about plant operations. However, the unit in which the plant currently resides may be averse to devoting additional effort to this task. A lack of effort to make the plant usable to the receiving unit could lead to higher costs and lower productivity after the plant is redeployed than if the receiving unit had received help from the other unit, reducing the profits from redeployment.

This example illustrates the well-known principal-agent problem, in which the imperfect observability of the effort (and other actions) of the agent (*i.e.*, the unit manager) creates a "moral hazard" for the principal (*i.e.*, top management at headquarters), because the agent acts in his or her own best interest instead of acting in the principal's best interest (Hölmstrom, 1979). A common approach to mitigate the principal-agent problem is for the principal to provide economic incentives to the agent that are aligned with the interests of the principal (Jensen and Meckling, 1976). Thus, top management could offer a business unit that is giving up a resource a share of the profits of the unit to which the resource is redeployed, or tie business unit manager pay to the profits of the firm (which includes the profits of all business units to which resources may be redeployed). Because top management can provide incentives to the business units to help offset the agency costs of redeployment, firms may be able to decentralize redeployment decisions. As Goold et al. (1994: 142) argue more generally: "business unit managers are perfectly able to collaborate with other businesses without parental involvement, if they perceive that it is beneficial to do so."

If instead a firm centralizes the decision to redeploy resources, the firm incurs additional communication and monitoring costs even when top management has perfect information about the returns to redeployment.[4] Under centralization, when top management transmits a decision to the business units to redeploy resources, this entails communication between three parties – top management and the two units involved in the redeployment – instead of communication only between the units when the decision is decentralized. Thus, centralization entails the additional time of individuals who are involved in discussions between top management and each of the units to communicate the redeployment decision. If top management runs into resistance from the units, this may lead to more back and forth communication. In addition, centralization entails costs of monitoring because, unlike under decentralization, the business units do not redeploy their resources voluntarily. Top management cannot observe effort by the business units and must engage in monitoring to ensure that the unit that is charged with redeploying its resources does so. The additional communication and monitoring due to centralization has a direct cost, either an

[4] The model presented here abstracts from the cost of making the decision itself, such as the cost of evaluating information about the returns to redeployment. These costs apply under both centralization and decentralization, as top management (under centralization) and the business units (under decentralization) must evaluate relevant information.

opportunity cost of management time or a cost of employing more people to handle these tasks. Moreover, the additional communication lengthens the amount of time before the decision is implemented, delaying the flow of profits from redeployment, which is another cost of centralizing the redeployment decision.

We investigate the conditions under which a firm will make greater profits by decentralizing versus centralizing the decision to undertake a resource redeployment opportunity when the firm faces a tradeoff between the agency costs of effort under decentralization and the costs of centralization. Key factors that influence the profitability of redeployment in the absence of agency and centralization costs – namely the extent of relatedness and return asymmetry across business units – also strongly affect whether centralization or decentralization leads to greater firm profits.

OVERVIEW OF THE MODEL

Resource redeployment can take place in several ways. A firm may exit one business and redeploy all the resources to a new business, as Omni Corporation did when some of its markets matured (Helfat and Eisenhardt, 2004). Alternatively, a firm may redeploy resources among its existing businesses without completely exiting any business, as in the plant redeployment example given above. A firm may also exit a portion of an existing business and redeploy the resources to another existing business, as Procter & Gamble did when it discontinued a line of cosmetics in one beauty products business and redeployed the plant to an existing beauty products business (Lieberman *et al.*, 2017). The model presented below can accommodate all of these forms of redeployment.

In modeling centralization and decentralization, we examine only the redeployment decision and not the decision-making structure of the entire organization. Firms may centralize some decisions and decentralize others (Collis and Montgomery, 2004). In addition, we consider a firm with a simple M-form structure, in which there is a headquarters unit and separate business units that report to headquarters. This enables us to focus on the core question of centralization at headquarters versus delegation of redeployment decisions to the business units.

The model differs from prior research by modeling resource redeployment together with centralization/decentralization and agency costs on the part of business units, business unit incentives to mitigate agency costs, and costs of centralization in multi-business firms. Previous work has provided formal models of the returns to redeployment (*e.g.*, Sakhartov and Folta, 2014, 2015) and formal models of incentives for cross-unit collaboration in light of agency costs (*e.g.*, Kretschmer and Puranam, 2008; Oxley and Pandher, 2016), but these have yet to be modeled together. In addition, none of these models incorporated centralization and decentralization. Modeling all of these considerations together introduces substantial complexity. To make the model as transparent as possible, we use a single-period setting in which a firm has a set of resources at the start of the period and the returns to any redeployment accrue during the period.[5]

In the model, the firm has a potential redeployment opportunity and must decide what portion of its resources (if any) to redeploy from one unit to another and the resulting portion of the firm's resources that will be used in each business unit. Top management (at headquarters) can make the decision to redeploy resources or it can let the business units decide. To simplify the analysis, the model includes three actors: headquarters and two business units. The decision of whether to transfer resources from one business unit to the other (and if so, how much) involves the permanent redeployment of resources.

The model incorporates key determinants of firm profits when a firm redeploys resources, namely the asymmetry of returns between business units and the extent of relatedness. The greater is the asymmetry of returns between a business that gives up resources and a business that receives the resources, the greater are the profits from redeploying resources to a higher-valued use (Sakhartov

[5] The returns during this period can also be thought of as the present discounted value of the future use of resources.

and Folta, 2015). The return asymmetry reflects the opportunity cost of the continued use of resources in a lower-performing business (Levinthal and Wu, 2010). In addition, the extent of relatedness captures the ease with which resources in one business can be used in another business. The more similar the resource requirements are between businesses (Rumelt, 1974), the lower are the adjustment costs of repurposing resources because the resources can be more easily and quickly integrated into another business (Helfat and Eisenhardt, 2004; Sakhartov and Folta, 2014; Hashai, 2015). Therefore, greater relatedness increases the profits from redeployment.

In addition, the model specifies a cost of centralization due to additional communication and monitoring costs if the redeployment decision is centralized, as noted above. The model also incorporates effort that the business units expend to produce profits from resources, as well as the disutility of effort with respect to both productive activity in their own units and the preparation of resources for redeployment. Thus, an agency cost of redeployment arises because each business unit is averse to expending effort to prepare resources for use in another business unit, as in the earlier plant example, even though it may be profitable for the firm as a whole. Because top management cannot observe effort by the business units, top management provides incentives to the units to expend effort on preparing resources for redeployment (a form of cooperation) and on productive activity in their own units. In the model, all parties in the firm have full information about the returns to the use of resources in different business units, the adjustment costs of resource redeployment (which depend on the extent of relatedness), business unit incentives, and the cost of centralization. This assumption makes it possible to focus on key factors that determine the profitability of centralization versus decentralization – namely agency costs, centralization costs, relatedness, and return asymmetry – without adding further complexity to the model.

After setting up the model, we derive the effort provision functions of the business units – the amount of effort that each unit will choose to devote to resource redeployment and to productive activity in its own unit as a function of the incentives given to the units, the units' disutility of effort, the cost of centralization (if the decision is centralized), the extent of relatedness, and the asymmetry of returns. If the decision is centralized, top management sets the amount of resources to be redeployed (if any) and the corresponding amount of resources allocated to each unit after redeployment, as well as the incentives given to the units, so as to maximize the profits of the firm. In making these decisions, top management considers the effort provision functions of the business units. The units then decide how much effort to put into productive activity within their units and how much effort to put into preparing resources for redeployment (henceforth termed "redeployment activity"). If instead the decision is decentralized, top management again sets the incentives in light of the effort provision functions of the business units. However, the units decide not only how much effort to devote to redeployment and productive activity, but also the amount of resources to redeploy and the corresponding amount of resources allocated to each unit after redeployment. The output of the model shows the conditions under which centralization or decentralization of the redeployment decision is more profitable for the firm.

FORMAL MODEL

Figure 1 depicts the timeline for the model. At the start of the period (denoted with the subscript $t = 0$), the proportion of the firm's total resources in business i is m_{i0} and the proportion of the firm's resources in business j is $m_{j0} = (1 - m_{i0})$. These proportions are set exogenously. The rate of return to resources (profits per unit of resources) in each business unit during the time period of the model ($t = 1$) is also given exogenously. R_{i1} represents the rate of return to resources for business i, and R_{j1} represents the rate of return to resources for business j. Other exogenously determined initial conditions are the extent of relatedness between businesses i and j, γ, and the cost of centralization, δ. The latter equals zero if the decision is decentralized and has a positive value under centralization that reflects the additional costs that centralization entails. Two additional initial conditions are chosen by the firm: 1) incentives given to the business units, k and β, which are explained below, and 2) whether the redeployment decision is centralized or decentralized.

Insert Figure 1 here

Given these initial conditions, the firm must decide what proportion of its resources to use in each business i and j during the time period (t = 1), denoted m_{i1} and m_{j1} respectively. The firm can choose to redeploy a portion of its resources $(m_{i1} - m_{i0})$ from business j to business i. Alternatively, the firm can choose to redeploy a portion of its resources $(m_{j1} - m_{j0})$ from business i to business j, depending on which direction of redeployment produces higher profits (if any). If the redeployment decision is centralized, top management at headquarters (denoted HQ in Figure 1) mandates resource allocations m_{i1} and m_{j1}, and the units select the amount of effort that they will devote to productive activity within the unit (ε_{ip} for the unit in business i and ε_{jp} for the unit in business j) and to cooperative activity to prepare resources for redeployment (if any) (ε_{ic} for the unit in business i and ε_{jc} for the unit in business j). If the redeployment decision is decentralized, the lower-performing business unit (the unit with lower returns to its resources) may choose to offer resources to the higher-performing unit (the unit with higher returns to its resources) that could employ the resources more profitably. In the model, the lower-performing unit offers an allocation of resources m_{i1} and m_{j1}, and selects its productive and cooperative efforts (ε_{ip} and ε_{ic}, respectively). The higher-performing unit then accepts or rejects the proposed resource allocation and selects its productive and cooperative efforts (ε_{jp} and ε_{jc}, respectively).

The outcome of the model is firm profits and effort provision by the business units for redeployment and productive activity under centralization and decentralization. The profits under each organizational arrangement are then compared. Next we explain the model in more detail.

Profits

The profits of the firm if it redeploys resources depend on the returns to resources in each business and several other factors shown in the following equation, which are explained below:

$$\pi = (1-k)\begin{Bmatrix} m_{i0}R_{i1}\varepsilon_{ip} + \min[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip} + (1-\delta)\gamma\max[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip}\varepsilon_{jc} \\ + m_{j0}R_{j1}\varepsilon_{jp} + \min[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp} + (1-\delta)\gamma\max[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp}\varepsilon_{ic} \end{Bmatrix}. \quad (1)$$

In the model, the total amount of a firm's resources is normalized to 1 for ease of analysis. Therefore, the proportions m_{i1} and m_{j1} in businesses *i* and *j* respectively, when multiplied by the total quantity 1 of firm resources, also represent the amount of resources in businesses *i* and *j* respectively. When the firm puts the quantities m_{i1} and m_{j1} of its resources into businesses *i* and *j* respectively, $m_{i1}R_{i1}$ is the profit that the firm makes in business i and $m_{j1}R_{j1}$ is the profit that the firm makes in business j. To generate profits from a business, the business unit must devote effort to productive activity within the unit (ε_{ip} for the unit in business i and ε_{jp} for the unit in business *j*, both of which have a lower bound of zero and an upper bound of one). In this specification, the multiplicative effect of effort allows profits to vary directly with the amount of effort expended.

The first three terms inside the large parentheses in Equation 1 pertain to the profits earned by business *i*. The second three terms inside the large parentheses pertain to the profits earned by business *j*. Next we explain the three terms for the profits of business *i*; the logic for the three terms for the profits of business *j* is identical except that the statements below about business *i* instead apply to business *j* and vice versa.

The first term inside the large parentheses reflects the profits earned by business *i* during the time period ($t = 1$) on the resources that business i has at the start of the period ($t = 0$), m_{i0}, which is multiplied by the return to resources R_{i1} in business i and effort e_{ip} on productive activity needed to generate profits from the resources. The second term inside the large parentheses reflects the reduction in profits if resources are redeployed from business i to business j during the time period ($t = 1$); the term (m_{i1} - m_{i0}) is negative and the profits earned by business i decrease by the amount of the second term. Otherwise, if no resources are redeployed to business i during the time period ($t =$ 1) or if resources are redeployed to business i from business j (so (m_{i1} - m_{i0}) is positive), the value of the second term in the large parentheses in Equation 1 is zero.

The third term in the large parentheses captures the profits on any resources that are redeployed to business i from business j, reflecting the returns to these resources as well as adjustment and centralization costs of redeployment. If no resources are redeployed to business i or if business i redeploys resources to business j, the term has a value of zero because max[0, $m_{i1} - m_{i0}$)] equals zero. When a positive amount of resources ($m_{i1} - m_{i0}$) is redeployed to business i, these resources earn a return of R_{i1}. A larger asymmetry between the returns in each business, R_{i1} and R_{j1}, provides a stronger inducement to redeploy resources to the more profitable business.[6]

When resources are redeployed to business i from business j, business i also bears the adjustment costs of repurposing the redeployed resources for use in its unit. As noted earlier, higher relatedness of resources leads to lower adjustment costs, and *vice versa*. In the model, γ represents relatedness, the similarity of resource requirements between businesses i and j (Rumelt, 1974). The parameter γ is inversely related to adjustment costs, which are captured by the term $(1-\gamma)$, such that $0 \le \gamma \le 1$ (Sakhartov and Folta, 2015). If $\gamma = 0$, redeployment is prohibitively costly and

[6] Because the current model considers a single time period and abstracts from uncertainty, inducements are reflected in a single dimension that Sakhartov and Folta (2015) refer to as "the current return advantage." When there is uncertainty about future returns, inducements also reflect the magnitudes of uncertainty of each return and their correlation.

adjustment costs have a maximum value of 1, reflecting that resources in one business cannot be used in another business; if $\gamma = 1$, redeployment is costless and adjustment costs have a value of 0. An intermediate level of relatedness leads to intermediate adjustment costs and reduction in profits from redeployment. Thus, $\gamma \max[0, (m_{i1} - m_{i0})]R_{i1}$ represents the profits earned on resources that are redeployed net of adjustment costs, before accounting for the costs of centralization and effort.

If the firm centralizes the redeployment decision, the firm bears a cost of communication and monitoring, δ, such that $0 \le \delta \le 1$. Note that if no resources are redeployed, the cost of centralization is zero because there is no decision to communicate and no monitoring. When resources are redeployed, the cost of centralization eats into the profits from redeployed resources. The larger is the amount of resources to be redeployed, the larger is the amount of communication with the business units because the scale of the decision is greater, and the greater is the amount of monitoring needed to ensure redeployment of the larger amount of resources—both of which increase costs. Hence, the cost of centralization is multiplicative with respect to the amount of redeployed resources and the profits that they confer.

In addition, for business *i* to generate a profit from resources that it receives through redeployment, the business must devote effort e_{ip} to productive activity, reflected in a multiplicative effect on the redeployed resources. Cooperative effort by business *j* to prepare resources for redeployment to business *i*, e_{jc}, which has a lower bound of zero and an upper bound of one, also affects profits. In particular, business *j* must expend cooperative effort to prepare resources for redeployment in order for business *i* to achieve profits from these resources. This is reflected in the multiplicative effect of effort by the unit that is redeploying resources.[7] Thus, if business *j* expends

[7] Because the values of γ, ε_{ic}, and ε_{jc} each have a minimum value of zero and a maximum value of one, the terms $\left(1-\gamma\varepsilon_{ic}\right)$ and $\left(1-\gamma\varepsilon_{jc}\right)$ each have a minimum value of zero and a maximum value of one.

no cooperative effort, business i is unable to use the resources and there is no value to resource redeployment regardless of the extent of relatedness. In this formulation, greater relatedness can to some extent offset the effect of lower (but nonzero) effort by business j to redeploy resources to business i, and *vice versa*.

Finally, the firm provides incentives to the business units to expend effort. Headquarters must decide what incentives (if any) to give the business units to expend effort on productive activity within their units (Hill *et al.*, 1992) and on redeployment activity (if any). In the model, each business unit receives a proportion α of the profits of its own unit, which provides an incentive for productive activity, and a proportion β of the other unit's profits (similar to the set-up of multi-unit incentives in Kretschmer and Puranam, 2008), which provides an incentive to prepare resources for redeployment. The sum of α and β is denoted as k, which represents the proportion of the firm's total profit that headquarters gives to the business units as a reward (where $k \leq 1$).[8] For this reason, the terms inside the large parentheses in Equation 1 are multiplied by $(1 - k)$, which represents the proportion of the profits that the firm receives after paying a reward, k, to the business units.

In this incentive design, the reward that each unit receives is an increasing function of effort on both productive and redeployment activity. When $\beta = 0$, each unit is rewarded based only on the profits generated by its own unit. When $\beta = k/2$, then $\alpha = \beta$ and the reward that each unit receives depends on the performance of the firm as a whole (*i.e.*, the reward to each unit depends equally on the profits generated by its own unit and the profits generated by the other unit).

[8] The reward to business unit i equals $\alpha\pi_i + \beta\pi_j$ and the reward to business unit j equals $\alpha\pi_j + \beta\pi_i$. The sum equals the total reward to the business units, $(\pi_i + \pi_j)(\alpha + \beta)$, which equals total firm profits times k, $(\pi_i + \pi_j)(k)$, where $k = \alpha + \beta$. As Kretschmer and Puranam (2008) note, a linear incentive structure has the advantage that it can motivate effort regardless of the level of unit profits, can accommodate different weights on unit and firm-wide performance, can be transformed into rewards based on differences in unit profits, and is tractable to implement within organizations and mathematically.

Alternatively, headquarters may provide incentives in which a unit's reward depends less strongly on profits in the other unit, such that $0 < \beta < k/2$.

Business Unit Utility and Optimal Effort Provision

The model incorporates agency costs of effort aversion by the business units with respect to resource redeployment, as well as standard agency costs of effort aversion with respect to productive activity within the units. In setting incentives for productive and cooperative (redeployment) activity, top management at headquarters faces a common trade-off in principal-agent problems in which an increase in the compensation to an agent (*e.g.*, a business unit) for one type of activity leads the agent to reallocate effort toward that activity (*e.g.*, resource redeployment) and away from other activities (*e.g.*, productive activity) (Hölmstrom and Milgrom, 1991). In the model, each business unit must decide how much effort to devote to productive activity within the unit (ε_{ip} for the unit in business i and ε_{jp} for the unit in business j), and how much cooperative effort to devote to preparing resources for redeployment (if any) (ε_{ic} for the unit in business i and ε_{jc} for the unit in business j). As is typical of moral hazard problems (Hölmstrom, 1979), effort by one unit is not observed by headquarters or by the other business unit. The model specifies a standard convex cost of both productive and redeployment efforts ($(\varepsilon_{ip}^2 + \varepsilon_{ic}^2)$ for the unit that runs business i and $(\varepsilon_{jp}^2 + \varepsilon_{jc}^2)$ for the unit that runs business j), reflecting the marginal disutility of effort expended on each type of activity (Gibbons, 1998; Kretschmer and Puranam, 2008).

Although the business units receive incentives to expend effort on productive and redeployment activity, the units also bear the costs of effort. Therefore, the net reward to each business unit i or j, denoted as the utility U_i or U_j of each unit respectively, depends on the reward that each unit receives from headquarters and the unit's cost of effort on productive and redeployment activity. The utility of the unit that runs business *i* is modelled as follows:

$$\begin{aligned} U_i &= (k-\beta)\left\{m_{i0}R_{i1}\varepsilon_{ip} + \min[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip} + (1-\delta)\gamma \max[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip}\varepsilon_{jc}\right\} \\ &+\beta\left\{m_{j0}R_{j1}\varepsilon_{jp} + \min[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp} + (1-\delta)\gamma \max[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp}\varepsilon_{ic}\right\} \\ &-R_{i1}(\varepsilon_{ip}^2+\varepsilon_{ic}^2) \end{aligned} \quad . (2)$$

Symmetrically, the utility of the unit that runs business j is as follows:

$$\begin{aligned} U_j &= (k-\beta)\left\{m_{j0}R_{j1}\varepsilon_{jp} + \min[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp} + (1-\delta)\gamma \max[0,(m_{j1}-m_{j0})]R_{j1}\varepsilon_{jp}\varepsilon_{ic}\right\} \\ &+\beta\left\{m_{i0}R_{i1}\varepsilon_{ip} + \min[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip} + (1-\delta)\gamma \max[0,(m_{i1}-m_{i0})]R_{i1}\varepsilon_{ip}\varepsilon_{jc}\right\} \\ &-R_{j1}(\varepsilon_{jp}^2+\varepsilon_{jc}^2) \end{aligned} \quad . \quad (3)$$

In Equation 2, business unit *i* receives the proportion $k-\beta$ (equal to α) of the profits that the unit generates. The reward to business unit *i* also includes the proportion β of the profits that business unit *j* generates, which represents the incentive for redeployment. Equation 2 also includes the disutility of productive and cooperative (redeployment) effort by business unit *i* $(\varepsilon_{ip}^2+\varepsilon_{ic}^2)$ such that the disutilities of the two types of effort have symmetric effects on the business unit's utility. In addition, the model scales the disutility of effort by the returns to resources because the returns in each unit are key drivers of redeployment. For business *i*, the disutility of effort is scaled by the rate of return to resources in business *i*, R_{i1}, because the return to resources in the business *i* represents the opportunity cost of redeploying resources.[9] The logic for Equation 3 is similar to that for Equation 2, except that business *i* in Equation 2 is business *j* in Equation 3 and *vice versa*.

In the model, each business unit is interested in maximizing only its own utility. Given the utility function of business unit *i* in Equation 2, the unit selects the optimal productive (ε_{ip}^*) and

[9] Scaling the disutility of effort by the difference between the returns in the two units makes little difference to the substance of the results of the model.

cooperative (ε_{ip}^{*}) efforts that maximize its utility, formally denoted as the efforts that meet the condition $\left(\varepsilon_{ip}^{*}, \varepsilon_{ic}^{*}\right) = \arg\max_{\varepsilon_{ip}, \varepsilon_{ic}} \left(U_i\right)$. Likewise, given the utility function of business *j* in Equation 3, the unit selects the optimal productive (ε_{jp}^{*}) and cooperative (ε_{jp}^{*}) efforts that meet the condition $\left(\varepsilon_{jp}^{*}, \varepsilon_{jc}^{*}\right) = \arg\max_{\varepsilon_{jp}, \varepsilon_{jc}} \left(U_j\right)$. As shown in the utility functions, both productive and cooperative effort are costly and compete with one another in the choice made by each unit. A unit may choose to boost profits only from productive activity within its own unit by committing productive effort ε_{ip} (ε_{jp}), or a unit may choose to also enhance inter-temporal economies of scope by committing some amount of cooperative effort ε_{ic} (ε_{jc}).[10]

Formally, this can be modelled as a non-cooperative game in which each business unit chooses its optimal productive and cooperative efforts, which account for the other unit's best response to the effort levels that the unit chooses. Each business unit must consider the response of the other unit because the reward that the business unit receives depends on the productive and cooperative efforts of the other business unit. The Nash equilibrium in this game is defined by the joint solution to the following four equations: $\frac{\partial U_i}{\partial \varepsilon_{ip}} = 0$, $\frac{\partial U_i}{\partial \varepsilon_{ic}} = 0$, $\frac{\partial U_j}{\partial \varepsilon_{jp}} = 0$, and $\frac{\partial U_j}{\partial \varepsilon_{jc}} = 0$.

Since the model is symmetric for both directions of return asymmetry, without loss of generality we present results for one direction of return asymmetry, *i.e.*, $R_{j1} \geq R_{i1}$, $m_{j1} \geq m_{j0}$ and $m_{i1} \leq m_{i0}$. Accordingly, Equation 1 can be simplified as follows:

$$\pi = \left(1-k\right)\left[m_{i1}R_{i1}\varepsilon_{ip} + m_{j0}R_{j1}\varepsilon_{jp} + (1-\delta)\gamma(m_{j1} - m_{j0})R_{j1}\varepsilon_{jp}\varepsilon_{ic}\right]. \qquad (1.1)$$

[10] A unit could choose to devote effort only to resource redeployment. Although the unit would cease to exist, the firm can still reward the employees with a share of the profits of the other unit as additional compensation (e.g., a bonus).

In this case, Equations 2 and 3 are restated as follows:

$$U_i = (k-\beta)m_{i1}R_{i1}\varepsilon_{ip} + \beta\left[m_{j0}R_{j1}\varepsilon_{jp} + (1-\delta)\gamma(m_{j1}-m_{j0})R_{j1}\varepsilon_{jp}\varepsilon_{ic}\right] - (\varepsilon_{ip}^2 + \varepsilon_{ic}^2)R_{i1}, \quad (2.1)$$

$$U_j = (k-\beta)\left[m_{j0}R_{j1}\varepsilon_{jp} + (1-\delta)\gamma(m_{j1}-m_{j0})R_{j1}\varepsilon_{jp}\varepsilon_{ic}\right] + \beta m_{i1}R_{i1}\varepsilon_{ip} - (\varepsilon_{jp}^2 + \varepsilon_{jc}^2)R_{j1}. \quad (3.1)$$

When resources are redeployed from business *i* to business *j*, the optimal effort provision by each business unit to productive activity within the unit and to cooperative redeployment activity, as defined by the solution to the Nash equilibrium in the non-cooperative game, is as follows (see the Online Appendix for the formal derivation):

$$\begin{cases} \varepsilon_{ip}^* = \dfrac{(k-\beta)m_{i1}}{2} \\ \varepsilon_{ic}^* = \dfrac{\beta(k-\beta)(1-\delta)\gamma(m_{j1}-m_{j0})m_{j0}R_{j1}}{4R_{i1} - \beta(k-\beta)[(1-\delta)\gamma]^2(m_{j1}-m_{j0})^2R_{j1}} \\ \varepsilon_{jp}^* = \dfrac{2(k-\beta)m_{j0}R_{i1}}{4R_{i1} - \beta(k-\beta)[(1-\delta)\gamma]^2(m_{j1}-m_{j0})^2R_{j1}} \\ \varepsilon_{jc}^* = 0 \end{cases} . \quad (4)$$

Centralization *versus* Decentralization

To solve for optimal profits, π^*, using Equation 1.1 and the business units' effort provision functions (Equation 4), it is necessary to determine the portions of the firm's resources m_{i1} and m_{j1} that are used in businesses *i* and *j*, respectively, and the amount of resources that the firm redeploys from one business to another (if any). The final piece of the model concerns the locus of these resource allocation decisions, namely whether they are centralized or decentralized.

When resource redeployment is centralized, top management controls the resource allocation decisions m_{i1} and m_{j1}, including any redeployment of resources required to achieve these resource allocations. Given that m_{j1} equals 1 - m_{i1}, and therefore that any redeployment of resources can be formulated in terms of the difference between m_{i1} and m_{i0} (where m_{i0} is known), the resource allocation decision can be modelled simply as the choice of m_{i1}. In making this resource allocation decision, top management faces a complex situation because it cannot observe productive and cooperative efforts by the units. Formally, top management seeks a solution to the problem $(k^*, \beta^*, m_{i1}^*) = \arg\max_{k,\beta,m_{i1}}(\pi^c)$, in which top management chooses k, β, and m_{i1} to maximize profits under centralization, π^c, subject to the optimal business unit productive and cooperative redeployment efforts $\varepsilon_{ip}^*(k,\beta,m_{i1})$, $\varepsilon_{ic}^*(k,\beta,m_{i1})$, $\varepsilon_{jp}^*(k,\beta,m_{i1})$, and $\varepsilon_{jc}^*(k,\beta,m_{i1})$ that are characterized by Equation 4 (in which m_{j1} equals $1 - m_{i1}$). The choice of (k^*, β^*, m_{i1}^*) is made in a sequential game with the units where top management first considers the units' optimal effort provision $\varepsilon_{ip}^*(k,\beta,m_{i1})$, $\varepsilon_{ic}^*(k,\beta,m_{i1})$, $\varepsilon_{jp}^*(k,\beta,m_{i1})$, and $\varepsilon_{jc}^*(k,\beta,m_{i1})$, and then decides on (k^*, β^*, m_{i1}^*). After top management announces the incentives k^* and β^* and the resource allocation choice m_{i1}^*, the units commit their respective efforts, which maximizes profits under centralization.

In contrast, when resource redeployment is decentralized, although top management still sets the incentives k and β, the units make the resource allocation choice m_{i1}. Formally, headquarters seeks a solution to the problem $(k^*, \beta^*) = \arg\max_{k,\beta}(\pi^d)$, in which top management chooses k and β so as to maximize profits under decentralization, π^d, subject to the optimal efforts of the units $\varepsilon_{ip}^*(k\ ,\beta)$, $\varepsilon_{ic}^*(k\ ,\beta)$, $\varepsilon_{jp}^*(k\ ,\beta)$, and $\varepsilon_{jc}^*(k\ ,\beta)$ that are still characterized by Equation 4, and subject to the resource allocation choice m_{i1}^* made by the units.

In the model, as in most decentralized organizations, one business unit cannot compel another unit to redeploy resources. Instead, under decentralization a business unit may choose to offer resources to another unit that could employ the resources more profitably. In return, if the resources are redeployed, the business unit that offers the resources would receive a share β^* of the profits generated by the redeployed resources in the other unit. Formally, this can be modelled as an ultimatum game, in which one unit offers to redeploy some amount of resources to another unit, and that unit decides whether to accept or reject the offer depending on whether it is better than or equal to the unit's *status quo* utility.[11]

In the ultimatum game, business unit i considers portions of its resources that it might redeploy to business unit *j* such that $0 \le m_{i1} \le m_{i0}$, and business unit *i* assesses $\varepsilon_{ip}(m_{i1})$, $\varepsilon_{ic}(m_{i1})$, $\varepsilon_{jp}(m_{i1})$, and $\varepsilon_{jc}(m_{i1})$, as well as the resulting values of U_i and U_j. If some choices $m_{i1} < m_{i0}$ provide superior utility to retaining the *status quo* in which $m_{i1} = m_{i0}$, business unit i selects the choice of m_{i1} that maximizes its utility U_i, $m_{i1}^* = \arg\max_{m_{i1} < m_{i0}} (U_i)$, subject to the participation constraint that the utility U_j for business unit *j* is greater than or the same as that at the start of the period, $U_j(m_{i1}^*) \ge U_j(m_{i0})$ (because otherwise business unit *j* will not accept the offer). Business unit *i* then gives the amount of resources $(m_{i0} - m_{i1}^*)$ to the other unit. Alternatively, if all choices $m_{i1} < m_{i0}$ are inferior to the *status quo* $m_{i1} = m_{i0}$ for business unit *i*, and business unit i receives an offer (if it is made) from the other unit where $m_{i1} > m_{i0}$, business unit *i* accepts that offer if its utility is greater than or the same as that at the start of the period, $U_i(m_{i1}^*) \ge U_i(m_{i0})$. The same procedure applies to the behavior of business unit j. The business unit considers portions of its resources that it might redeploy to business unit *i* such that $m_{i0} \le m_{i1} \le 1$, and business unit *j* assesses $\varepsilon_{ip}(m_{i1})$, $\varepsilon_{ic}(m_{i1})$, $\varepsilon_{jp}(m_{i1})$, and $\varepsilon_{jc}(m_{i1})$, as well as the resulting values of U_i and U_j. If some choices $m_{i1} > m_{i0}$ are superior to the *status quo* $m_{i1} = m_{i0}$ for business unit *j*, the business unit selects the choice that solves

[11] This part of the model also avoids another simultaneous game between the units in addition to the game where efforts are chosen. Adding another simultaneous game would make it difficult to solve for the effort provision functions analytically due to the large number of equations and the large number of variables.

$m_{j1}^{*} = \arg\max_{m_{i1} > m_{i0}} (U_j)$ subject to the participation constraint for business unit *i*, $U_i(m_{i1}^{*}) \geq U_i(m_{i0})$, and gives the amount of resources $(m_{i1}^{*} - m_{i0})$ to the other unit. Alternatively, if all choices $m_{i1} > m_{i0}$ are inferior to the *status quo* $m_{i1} = m_{i0}$ for business unit *j*, the business unit considers an offer (if it is made) from the other unit where $m_{i1} < m_{i0}$ and accepts that offer if it meets the participation constraint $U_j(m_{i1}^{*}) \geq U_j(m_{i0})$.

The key output of the model is the advantage (or disadvantage) of the centralization of the redeployment decision relative to decentralization. This is expressed as the difference in firm profits between centralization and decentralization, scaled by profits under decentralization, $\left(\pi^c - \pi^d\right)/\pi^d$. Although it is possible to solve analytically for productive and cooperative efforts, ε_{ip}, ε_{ic}, ε_{jp}, and ε_{jc}, the function $\left(\pi^c - \pi^d\right)/\pi^d$ is intractable analytically. For this reason, the results presented below are solved for numerically in MATLAB using the optimal effort provision functions of the units and a fine grid for m_{i1} to maximize either firm profit under centralization or the utility of the unit providing resources for redeployment under decentralization.[12]

RESULTS

To solve the model numerically, it is necessary to specify ranges for the values of the key determinants of inter-temporal economies from resource redeployment – the return asymmetry and the extent of relatedness – which are given exogenously in the model. The values chosen here for these variables are for illustrative purposes and can be altered without changing the substance of the results. The return asymmetry $(R_{j1} - R_{i1})$ between business *i* (designated as the lower-performing

[12] To solve the maximization problem numerically, MATLAB searches for the solution on a grid of discrete values. A fine grid means that the distance between the discrete values is small enough that the optimal choice does not fall in between two discrete values and that reducing the distance between the discrete values does not change the solution.

business) and business j (the higher-performing business), which operationalizes inducements to redeploy resources from business i to j when $R_{j1} > R_{i1}$, can take on values between 0 and 0.30, $(R_{j1} - R_{i1}) \in [0, 0.30]$. The lower bound for this interval reflects no asymmetry of returns, and the upper bound is set high enough that going above that level does not change the results presented below. In the reported results, the rate of return in business i is set to be $R_{i1} = 0.01$, and 50 percent of the firm's resources are in each business at the start of the period, such that $m_{i0} = m_{j0} = 0.50$. In addition, as noted earlier, relatedness γ between businesses i and j, and the cost of centralization δ, are each within the interval 0 to 1.

To more clearly convey the intuition of the results, we present results for exogenously determined values of the incentives given to the business units, k and β. This enables us to focus on our key variables of interest, including effort by the business units on redeployment activity, the cost of centralization, and the relationship with relatedness and the return asymmetry. The results for the optimal k and β (given the range of values for the other variables noted above) are similar in substance to those presented below.

We begin with the case in which the business units receive strong incentives to expend effort on redeployment activity. As noted earlier, firms may not need to centralize redeployment decisions if they can use incentives to motivate business units to expend effort to prepare resources for redeployment. We therefore begin with a base case of $\beta = k/2$, such that the reward to each unit depends equally on the profits that it generates and the profits generated by the other unit. In addition, we set $k = 0.7$, and therefore $\beta = 0.35$, so the business units together receive a relatively high 70 percent of the firm's profit. We also begin with a base case in which the cost of centralization, δ, is zero. Then we present results for nonzero values of δ and for lower values of the incentive β to redeploy resources, holding $k = 0.7$.[13] The results for alternate values of k are similar in substance to those presented below.

In the model, given the values of k and β, top management (under centralization) or the business units (under decentralization) choose the optimal value of m_{i1} given the extent of relatedness, the return asymmetry, the cost of centralization, and the units' effort provision functions. We present results showing all possible combinations of relatedness and return asymmetry within the bounds specified above. As indicated below, if redeployment takes place, regardless of whether the redeployment decision is centralized or decentralized, it is always optimal to redeploy all of the resources in the lower-performing unit to the higher-performing unit.[14] This occurs because the disutilities of effort on productive and redeployment activity are symmetric (and thus equally costly) in their effects on each business unit's utility. Therefore, the lower-performing unit will choose to expend effort only on the most profitable use of its resources.[15]

Filled contour maps presented in the figures below depict four possible outcomes. First, in what is labelled Area I, no resource redeployment occurs regardless of whether the decision is centralized or decentralized. Second, in what is labelled Area II, resource redeployment occurs only if the decision is centralized. Third, in Area III, resource redeployment occurs under both centralization and decentralization. Finally, in Area IV, resource redeployment occurs only if the decision is decentralized.

[13] We exclude the values of $k = 0$, $k = 1$, $\beta = 0$, and $\beta = 1$ from the analysis. This ensures that headquarters retains a non-zero portion of firm profits, that each business unit receives a non-zero portion of the profits of the firm and of the other unit, and therefore each unit has a non-zero incentive to redeploy resources.

[14] In this situation, as noted earlier, although the business unit that redeploys resources ceases to exist at the end of the period, that business unit still receives the reward for redeployment during the time period of the model.

[15] It is possible to alter the model to accommodate the possibility that not all resources in the lower-performing unit will be redeployed. For example, top management may be unwilling to fully exit a lower-return business (e.g., because it is a legacy business) or only a portion of a business unit's resources may earn a higher return in another business unit. The results are qualitatively the same as those presented below.

The solution to the model for the base case with respect to the advantage of centralization relative to decentralization is shown in Figure 2. The corresponding amounts of effort on productive and redeployment activity for the lower- and higher-performing units under centralization and decentralization are shown in Figures 3 and 4 respectively. Panel A in Figure 2 shows the advantage of centralization relative to decentralization, $\left(\pi^c - \pi^d\right)/\pi^d$, displayed against all combinations of relatedness γ and return asymmetry $(R_{j1} - R_{i1})$ that are within the bounds specified earlier. The color coding in the figure represents the profit advantage of centralization relative to decentralization, ranging from no advantage (dark blue) to the strongest advantage (dark red), as indicated by the scale on the righthand side vertical axis. Panel B in Figure 2 shows the corresponding organizational arrangement that enables redeployment (if any) for each combination of relatedness and return asymmetry, again color coded according to the scale on the righthand side vertical axis. Then Panel C displays the corresponding organizational arrangement that is more profitable for the use of resource redeployment. Figure 3 shows the amount of effort that each of the units devotes to productive activity and to preparing resources for redeployment under centralization, for each combination of relatedness and return asymmetry, and Figure 4 shows the same thing under decentralization. The color coding in these figures represents the amount of effort on productive activity (in Panels A and C) and (cooperative) redeployment activity (in Panel B) by the units, as indicated by the scales on the righthand side vertical axes of the panels.

Insert Figures 2, 3, and 4 here

Area I in Panel A of Figure 2 represents a region in which redeployment does not take place because it does not increase firm profits or business unit utility. As shown in Panel A, when the return asymmetry $(R_{j1} - R_{i1})$ (the economic inducement for redeployment) is high but relatedness is relatively low (so adjustment costs are high), redeployment is less likely to occur. The same is true when the return asymmetry is low even if relatedness is high (so adjustment costs are low). Because no redeployment takes place, Panel B in Figure 2 denotes the organizational arrangement in Area I that enables redeployment as "None." In addition, Panel C in Figure 2 shows that neither centralization nor decentralization is profitable in Area I because redeployment is not profitable. In Area I, there is no difference between centralization (Figure 3) and decentralization (Figure 4) in the amount of effort expended by the units on productive and redeployment activity, because no redeployment takes place regardless of the organizational arrangement. The lower-performing business unit *i* commits no cooperative effort to prepare resources for an unprofitable redeployment of resources (as shown in Panel B in Figures 3 and 4) and devotes all of its effort to productive activity within the unit (as shown in Panel A in Figures 3 and 4). Similarly, the higher-performing business unit ***j*** receives no additional resources and commits the same amount of productive effort under centralization and decentralization (shown in Panel C in Figures 3 and 4).[16]

In contrast, when the combined effect of the return asymmetry and relatedness produces higher profits and business unit utility than in Area I, resource redeployment may occur. The combined effect of relatedness and the return asymmetry on profits and business unit utility is highest in the northeast corner of Panel A in Figure 2, which is part of Area III, because both the return asymmetry and relatedness are at their highest values. Holding the return asymmetry constant, the profits that can be gained from redeployment increase as relatedness increases, consistent with prior research (Sakhartov and Folta, 2014, 2015). However, because the effect of a low return asymmetry can partially or fully offset the effect of high relatedness on profits and vice versa, it is

[16] As indicated by the scales for the amount of productive effort on the righthand side of Panels A and C in Figures 3 and 4, the maximum amount of effort for the lower-performing unit is the same as the minimum amount of productive effort for the higher-performing unit. When there is no redeployment and the proportion of resources at the beginning and end of the period in each unit is 0.50, the amount of productive effort by both units is the same. Then, as indicated by equation 4, if the lower-performing unit redeploys resources to the higher-performing unit, the lower-performing unit reduces its productive effort below its maximum because it has fewer resources than before. The higher-performing unit also increases its productive effort above its minimum because it has more resources than before.

important that relatedness is not considered in isolation as a determinant of whether centralization or decentralization has an advantage.

Area III represents a region in which the profits that can be gained from redeployment are high enough to provide the lower-performing unit with an incentive to expend effort on redeployment activity that more than offsets the disutility of cooperative effort. In this area, the lower-performing unit voluntarily puts all of its effort into preparing resources for redeployment and exerts no productive effort (*cf.* Panel A in Figures 3 and 4). Moreover, because the higher-performing unit receives more resources, it increases its effort on productive activity (*cf.* Panel C in Figures 3 and 4).[17] In this case, the profits from resource redeployment are high enough that incentives from top management lead both units to commit their respective efforts voluntarily, and centralization cannot make this motivation stronger. Thus, in Area III resource redeployment takes place under both centralization and decentralization, as shown in Panel B in Figure 2, and there is no difference in the firm's profits (shown in Panel C in Figure 2) and the efforts of both units.

There is a remaining region in Figure 2, Area II, sandwiched in between Area I to the southwest and Area III to the northeast, where resource redeployment is profitable but centralization is required for the firm to obtain these profits. In Area I, as the values of the return asymmetry and/or relatedness increase in the northeast direction, resource redeployment eventually becomes profitable for the firm. The border between Area I and Area II indicates where this occurs. However, redeployment is not as profitable in Area II as in Area III to the northeast, because the combined effects of the return asymmetry and relatedness on profits is lower in Area II. Therefore, in Area II the share that the lower-performing unit would receive of the higher-performing unit's profits under decentralization is not high enough to incentivize cooperative effort, and the lower-

[17] This follows from the Nash equilibrium in equation 4, which shows that the productive effort of the higher-performing unit increases as more resources are redeployed to the unit.

performing unit instead devotes all of its effort to productive activity in its own unit (*cf.* Panels A and B in Figure 4). Only through centralization can top management compel the lower-performing unit to prepare resources for redeployment, and thereby ensure that resource redeployment occurs when it is profitable for the firm. Under centralization, the lower-performing unit devotes a positive amount of cooperative effort to redeployment (shown in Panel B in Figure 3), and the higher-performing unit devotes greater productive effort in Area II under centralization than under decentralization (*cf.* Panel C in Figures 3 and 4). This occurs because centralization provides the higher-performing unit with more resources through redeployment but decentralization does not. Thus, in Area II, redeployment occurs only when the decision is centralized, depicted in Panel B in Figure 2. Moreover, unlike in Areas I and III, in Area II centralization leads to greater profits than decentralization, shown in Panel C in Figure 2. As the profits from redeployment increase in the northeast direction in Area II, eventually the profits become large enough to provide sufficient incentives for redeployment that both units will commit their respective efforts voluntarily. The border between Area II and Area III indicates where this occurs.

Within Area II, the advantage of centralization increases as relatedness increases (holding the level of return asymmetry constant), as Panel A in Figure 2 indicates, because the profits from redeployment increase as relatedness increases. At the highest level of relatedness in the rightmost portion of Area II, resources are practically interchangeable between the two business units. As the return asymmetry increases at this level of relatedness, the advantage of centralization also increases because the profits from redeployment increase. As the return asymmetry continues to increase, so too do the profits from redeployment, which are shared with the lower-performing unit if it redeploys resources. At the border with Area III, the incentive provided by a share of the profits becomes strong enough that redeployment occurs under decentralization as well as centralization.

Next we introduce a nonzero cost of centralization, δ, and investigate how different values of δ together with lower values of the incentive for redeployment, β, affect the results of the model. Figure 5 displays the advantage of centralization for various combinations of the cost of centralization and business unit incentives, and Figure 6 displays the corresponding corporate structure that enables redeployment. Figure A1 in the Online Appendix displays the corresponding corporate structure that is most profitable for the use of redeployment and Figures A2-A7 display the corresponding productive and cooperative efforts of each of the business units. (Note that the scales for the righthand side axes differ between panels in each figure.)

Insert Figures 5 and 6 here

To illustrate the effect of a nonzero cost of centralization, we consider the effect when the value of β remains at 0.35. When there is a modest cost of centralization such that $\delta = 0.2$, the lower bound of Area II (see Panel F in Figures 5 and 6) shifts to the northeast (relative to $\delta = 0$ in Panel C in Figures 5 and 6). The shift occurs because the cost of centralization reduces the profits from redeployment so a higher level of return asymmetry and/or relatedness is required for profitable redeployment. Then, in Area III, the advantage of centralization turns negative (see Panel F in Figure 5). That is, decentralization is the more profitable structure (shown in Panel F in Figure A1) because the cost of centralization reduces firm profits under centralization.

When δ increases to 0.5, Area II no longer appears in the figures because the levels of return asymmetry and/or relatedness in that region are no longer high enough to offset the increased cost of centralization. Instead, a new Area IV, where decentralization has an advantage, appears in the general location where Area II had been (shown in Panel 5 in Figure 5). In Area IV, redeployment occurs only under decentralization (shown in Panel I in Figure 6). This switch illustrates the tradeoff between centralization and decentralization: in Area IV, an increase in the return asymmetry and/or relatedness causes profits to increase by enough relative to Area I that the incentives to the business units are large enough to offset the agency costs of redeployment effort under decentralization, but the costs of centralization are too high to make redeployment profitable under centralization. When the cost of centralization increases even further to $\delta = 0.8$, Area III disappears entirely because redeployment is not profitable under centralization, but Area IV where decentralization has an advantage remains (see Panel L in Figures 5 in 6).

The figures also depict the effects of lower levels of the incentive for redeployment, when β equals 0.2 and 0.1, for each level of δ. The results are qualitatively similar to those for the higher level of $\beta = 0.35$, but the locations of the boundaries between the areas change. As β decreases, the business units have less incentive to expend effort on redeployment, and this motivation is further weakened when the combined effects of the return asymmetry and relatedness lead to lower profits from redeployment. Thus, as β decreases, moving from right to left in the panels in Figure 5 when $\delta = 0$ (Panels C, B, and A) and $\delta = 0.2$ (Panels F, E, and D), the lower bound of Area III, where both decentralization and centralization enable redeployment, shifts to the northeast. This occurs because higher profits from redeployment (due to a larger return asymmetry and/or greater relatedness) are required to offset the lower incentives for collaborative effort, and for decentralization therefore to enable redeployment (shown in Figure 6). For similar reasons, as β decreases, the upper bound of Area I also shifts to the northeast. As the boundaries of Areas I and III both shift to the northeast, Area II shifts to the northeast as well. When δ takes on higher values of 0.5 and 0.8, as β decreases, the lower bound of Area IV shifts to the northeast because once again higher profits are required to offset the lower incentives for collaborative effort, and the upper bound of Area I therefore shifts northeast as well (shown in Figures 5, 6, and A1). (Recall that Area II no longer appears at higher costs of centralization and Area III no longer appears when $\delta = 0.8$.)

Summary of the Results

Overall, there are four possible outcomes of the model: 1) neither centralization nor decentralization leads to redeployment because redeployment is not profitable under either organizational arrangement; 2) redeployment occurs only under centralization; 3) redeployment occurs only under decentralization; 4) redeployment occurs under both centralization and decentralization. These findings are robust to different values of β (the incentive for redeployment) and δ (the cost of centralization), and to the optimal choice of k (the share of profits given to the business units) and β. In all cases, there are four areas that have the characteristics just noted.

The different outcomes of the model depend on the two standard determinants of profits from resource redeployment, namely the return asymmetry between the business units and relatedness, and two additional factors, namely agency costs of effort by the business units and the communication and monitoring costs of centralization. Although agency and centralization costs affect the tradeoff between centralization or decentralization, the tradeoff also depends on the other determinants of profits. In contrast to prior research on contemporaneous economies of scope, the model shows that centralization of the resource redeployment decision does not necessarily lead to higher performance for more related diversified firms, and decentralization does not necessarily lead to higher performance for less related diversified firms.

For example, at a moderate level of relatedness when the cost of centralization is high, the model shows that decentralization may be required for profitable redeployment (depicted as Area IV in the figures). This result accords with earlier research on diversification in which decentralization was thought to improve performance when relatedness is not high. However, at a moderate level of relatedness when the cost of centralization is lower, the model shows that centralization may be required to maximize the profits of the firm by ensuring that redeployment takes place (depicted as

Area II in the figures). In this case, the profits from redeployment (due to the level of return asymmetry and extent of relatedness) are not high enough to provide a sufficient incentive to offset the lower-performing unit's disutility of effort on redeployment activity, so the lower-performing unit will not voluntarily prepare resources for redeployment. This result does not accord with earlier research in which decentralization, and not centralization, was thought to improve performance when relatedness is not high. In addition, the model shows that when the level of relatedness is higher and profits are therefore higher (all else being equal), decentralization may be more profitable than centralization because the incentive to the units to redeploy resources is higher (in Areas III and IV when the cost of centralization is positive). This result does not accord with prior research in which centralization was thought to improve performance when relatedness is high. Overall, the results indicate that the effect of relatedness cannot be considered in isolation and that other factors including the return asymmetry affect whether centralization or decentralization of the redeployment decision is more profitable.

CONCLUSION

In this study, we have utilized a formal model to investigate the conditions under which it is more profitable to centralize versus decentralize a decision to redeploy resources in a multi-business firm. The model incorporates agency costs of effort that were featured in earlier research on organizational arrangements for related and unrelated diversification. That research, in which the logic of related diversification often rested on contemporaneous economies of scope, argued that more related diversified firms benefited from centralization and less related diversified firms benefited from decentralization. In contrast, the model presented here shows that this conclusion does not necessarily hold for resource redeployment. Instead, the tradeoff between centralization and decentralization depends on how the standard determinants of the profits from redeployment –

which include not only relatedness but also the return asymmetry – interact with agency costs of decentralization and the costs of centralization.

The conclusions of the model suggest the importance of empirically studying the organizational arrangements that firms employ when making redeployment decisions. Future research could examine the conditions under which firms centralize or decentralize resource redeployment. To obtain the necessary data, researchers could conduct a survey to obtain information about the centralization or decentralization of redeployment decisions, the extent of agency costs, the incentives given to the business units, and the cost of centralization. These data could be combined with financial information on business unit profitability (to estimate return asymmetries) and data on industry participation by business units (to estimate relatedness).

Future research could also investigate other potential determinants of centralization and decentralization in resource redeployment. For example, information asymmetry about a potential redeployment opportunity might affect whether centralization or decentralization is more profitable. Under some conditions, top management may acquire superior information by broadly scanning or searching the external environment (Helfat and Eisenhardt, 2004; Chandler, 1962), and under other conditions the business units may acquire superior information from their local environments about opportunities in closely related markets. If top management has an information advantage relative to the business units, the redeployment decision is more likely to be centralized because one business unit can't offer another business unit a payment for an unknown opportunity. In contrast, if the business units have superior information, top management can't supervise what it doesn't know (Harris and Raviv, 1996) and the redeployment decision is more likely to be decentralized.

Finally, future research could investigate whether some firms have a capability for resource redeployment and the effects of such a capability on the advantage of centralization versus decentralization. A redeployment capability would enable firms to repurpose resources more quickly and efficiently, thereby reducing adjustment costs and raising the profits from redeployment. This would help to offset the agency costs of redeployment, providing more leeway for decentralization (holding the cost of centralization constant). A redeployment capability could also reduce the cost of centralization by reducing communication needs between top management and the business units, thereby raising profits under centralization. The net effect of a resource redeployment capability could influence whether centralization or decentralization is more profitable.

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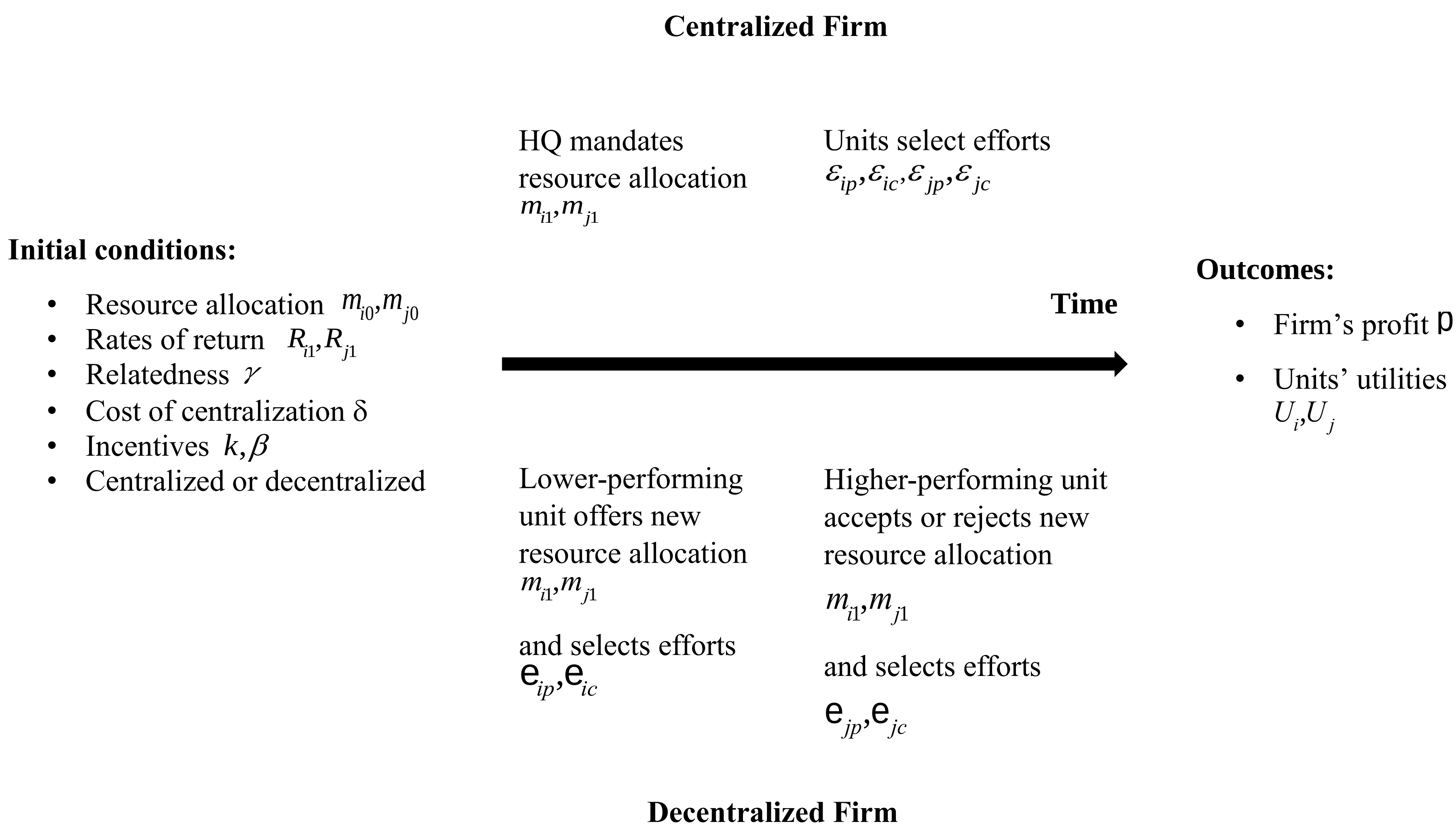
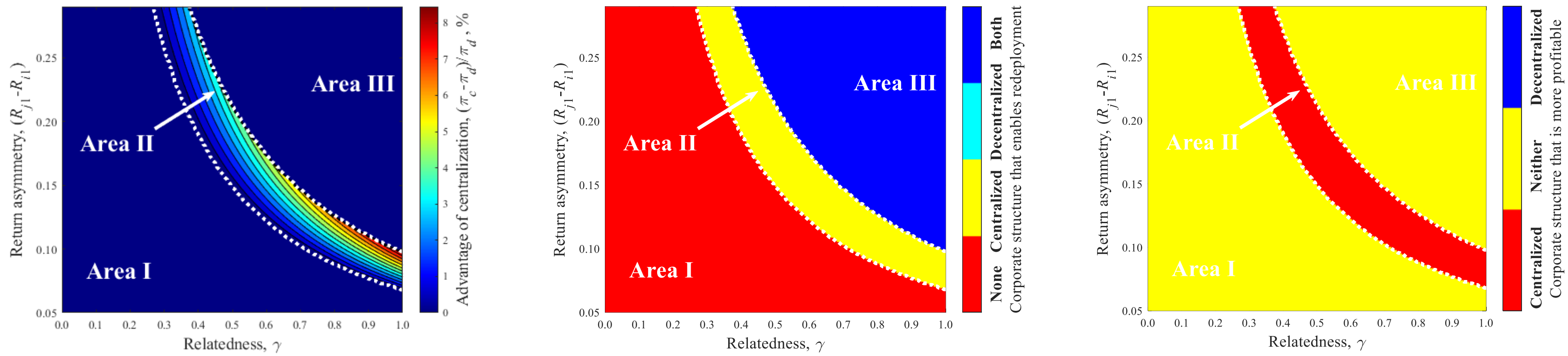


Figure 1. Model Timeline

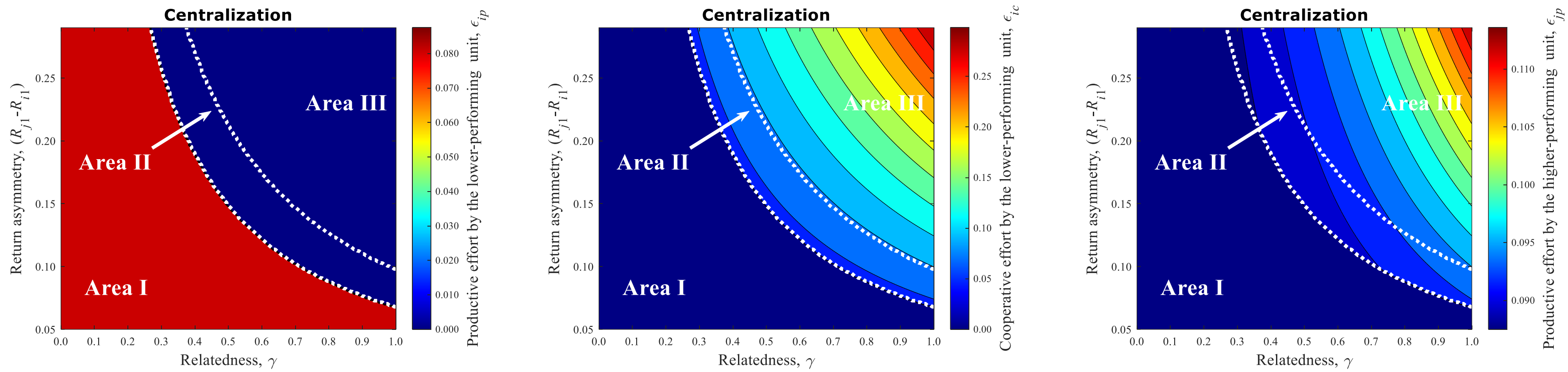


A. **Advantage of centralization**

B. **Corporate structure that enables redeployment**

C. **Corporate structure that is more profitable for the use of resource redeployment**

Figure 2. Centralization *versus* decentralization of resource redeployment ($\delta = 0.0$, $\beta = k/2 = 0.35$)

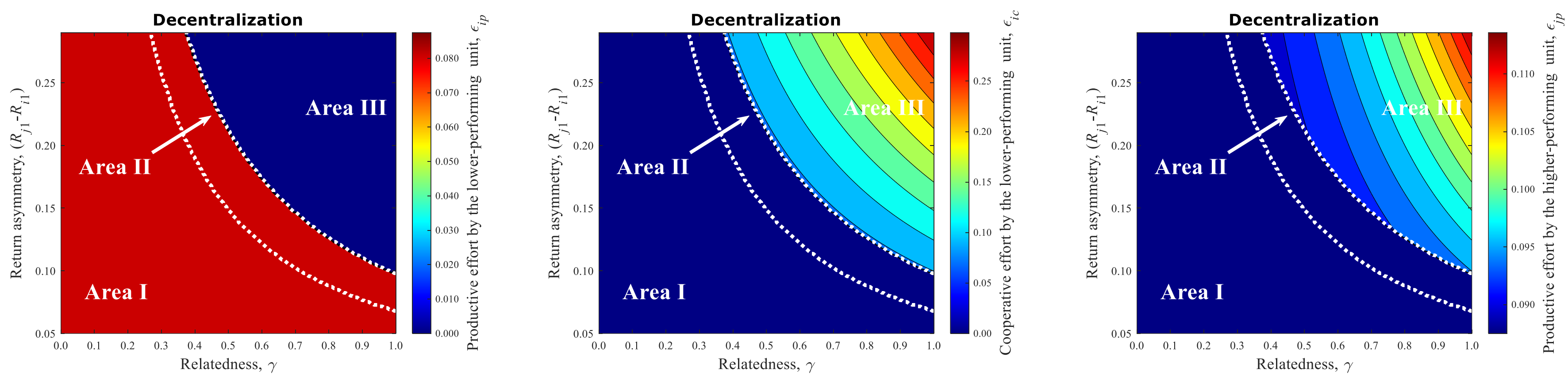


A. Productive effort by the lower-performing unit

B. Cooperative (redeployment) effort by the lower-performing unit

C. Productive effort by the higher-performing unit

Figure 3. Allocation of effort by business units in the firm with centralized resource redeployment ($\delta = 0.0$, $\beta = k/2 = 0.35$)



A. Productive effort by the lower-performing unit

B. Cooperative (redeployment) effort by the lower-performing unit

C. Productive effort by the higher-performing unit

Figure 4. Allocation of effort by business units in the firm with decentralized resource redeployment ($\delta = 0.0$, $\beta = k/2 = 0.35$)

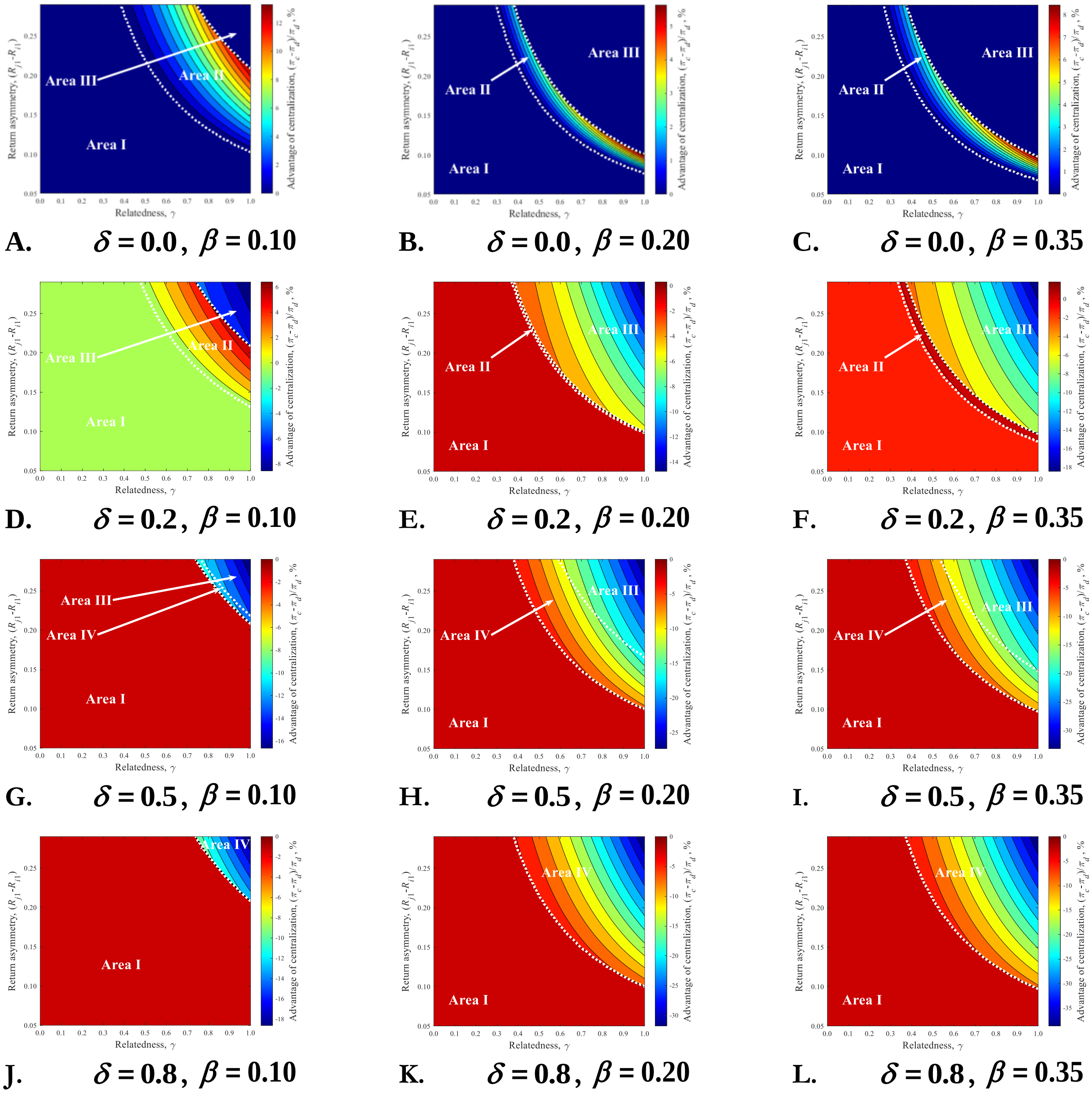


Figure 5. Advantage of centralization, for various combinations of the cost of centralization δ and the incentive for redeployment β

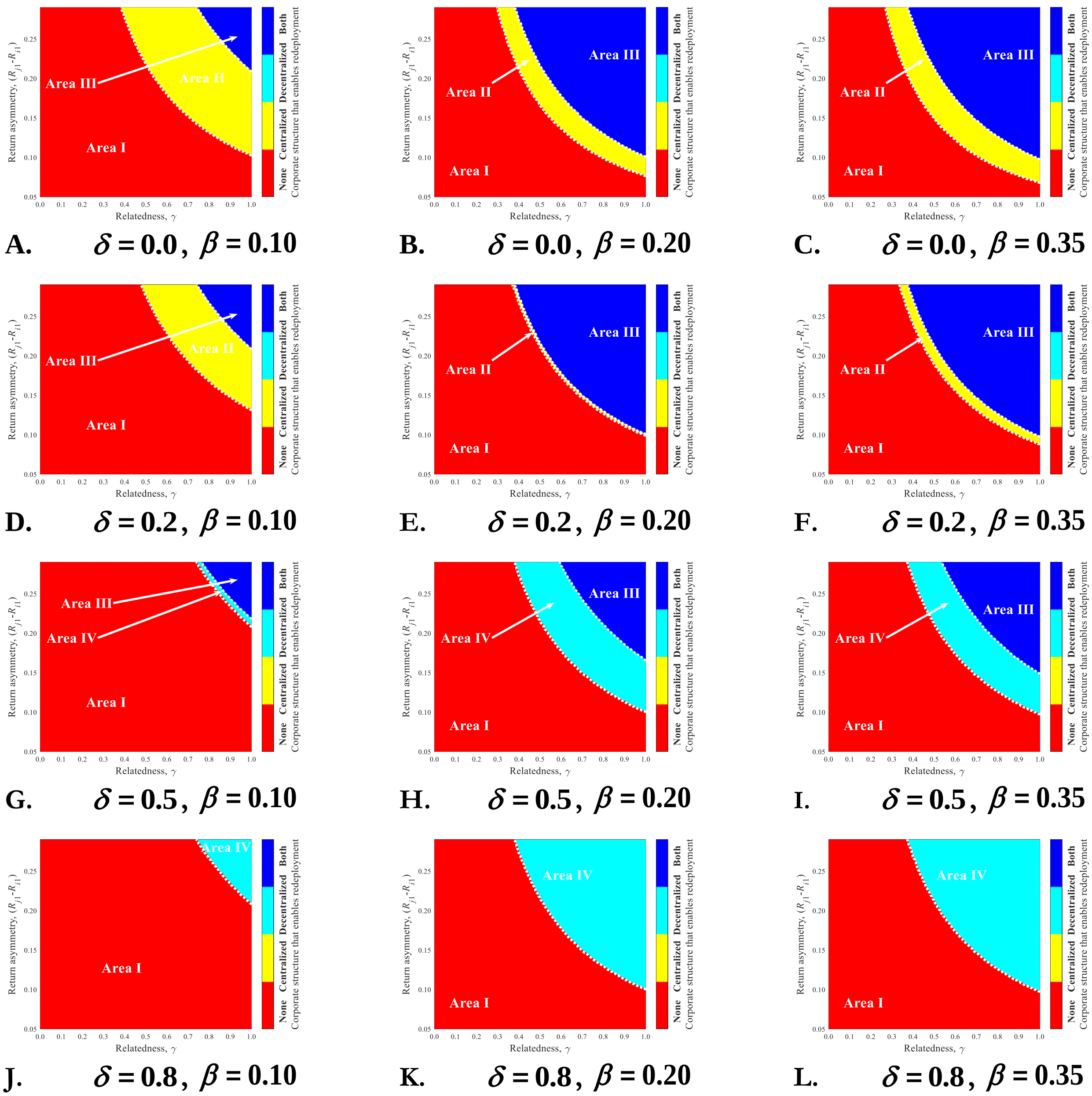


Figure 6. Corporate structure that enables redeployment, for various combinations of the cost of centralization δ and the incentive for redeployment β

ONLINE APPENDIX

Formal Solution for the Optimal Commitment of Effort by the Units

When resources are redeployed from business i to j, the differentiation of Equations 2.1 and 3.1 with respect to each type of effort involved in these equations and the requirement that all resulting derivatives equal zero, such that $\frac{\partial U_i}{\partial \varepsilon_{ip}} = 0$, $\frac{\partial U_i}{\partial \varepsilon_{ic}} = 0$, $\frac{\partial U_j}{\partial \varepsilon_{jp}} = 0$, and $\frac{\partial U_j}{\partial \varepsilon_{jc}} = 0$, lead to the following four respective equations, whose joint solution represents the Nash equilibrium:

$$\begin{cases} (k-\beta)m_{i1}R_{i1} - 2R_{i1}\varepsilon_{ip} = 0 \\ \beta\gamma\left(m_{j1} - m_{j0}\right)R_{j1}\varepsilon_{jp} - 2R_{i1}\varepsilon_{ic} = 0 \\ (k-\beta)m_{j0}R_{j1} + (k-\beta)\gamma\left(m_{j1} - m_{j0}\right)R_{j1}\varepsilon_{ic} - 2R_{j1}\varepsilon_{jp} = 0 \\ -2R_{j1}\varepsilon_{jc} = 0 \end{cases}. \qquad \text{(A.1)}$$

The last line in A.1 results in a direct solution for ε_{jc}, which is $\varepsilon_{jc}^* = 0$. The first line in A.1 can be restated as a direct solution for ε_{ip}, which is $\varepsilon_{ip}^* = \frac{(k-\beta)m_{i1}}{2}$. The second line in A.1 can be used to express ε_{ic} as a function of ε_{jp} such that $\varepsilon_{ic} = \frac{\beta\gamma\left(m_{j1} - m_{j0}\right)R_{j1}}{2R_{i1}}\varepsilon_{jp}$. The latter expression can be plugged into the third-line equation of A.1 in lieu of ε_{ic}, resulting in the following equation with a single unknown, ε_{jp}: $(k-\beta)m_{j0}R_{j1} + \frac{\beta(k-\beta)\gamma^2\left(m_{j1} - m_{j0}\right)^2 R_{j1}^2}{2R_{i1}}\varepsilon_{jp} - 2R_{j1}\varepsilon_{jp} = 0$, which can be further simplified by dividing by R_{j1} to become $(k-\beta)m_{j0} + \frac{\beta(k-\beta)\gamma^2\left(m_{j1} - m_{j0}\right)^2 R_{j1}}{2R_{i1}}\varepsilon_{jp} - 2\varepsilon_{jp} = 0$. The latter equation has only one unknown, ε_{jp}, and is linear in ε_{jp}, leading to a direct solution for ε_{jp}:

$\varepsilon_{jp}^* = \frac{2(k-\beta)m_{j0}R_{i1}}{4R_{i1} - \beta(k-\beta)\gamma^2(m_{j1} - m_{j0})^2 R_{j1}}$. This solution for ε_{jp} can be plugged back into the expression of ε_{ic} as a function of ε_{jp}, leading to the following solution for ε_{ic}:

$\varepsilon_{ic}^* = \frac{\beta(k-\beta)\gamma(m_{j1} - m_{j0})m_{j0}R_{j1}}{4R_{i1} - \beta(k-\beta)\gamma^2(m_{j1} - m_{j0})^2 R_{j1}}$. The resulting expressions for the optimal levels of the four types of effort are summarized as Equation 4 in the main text.

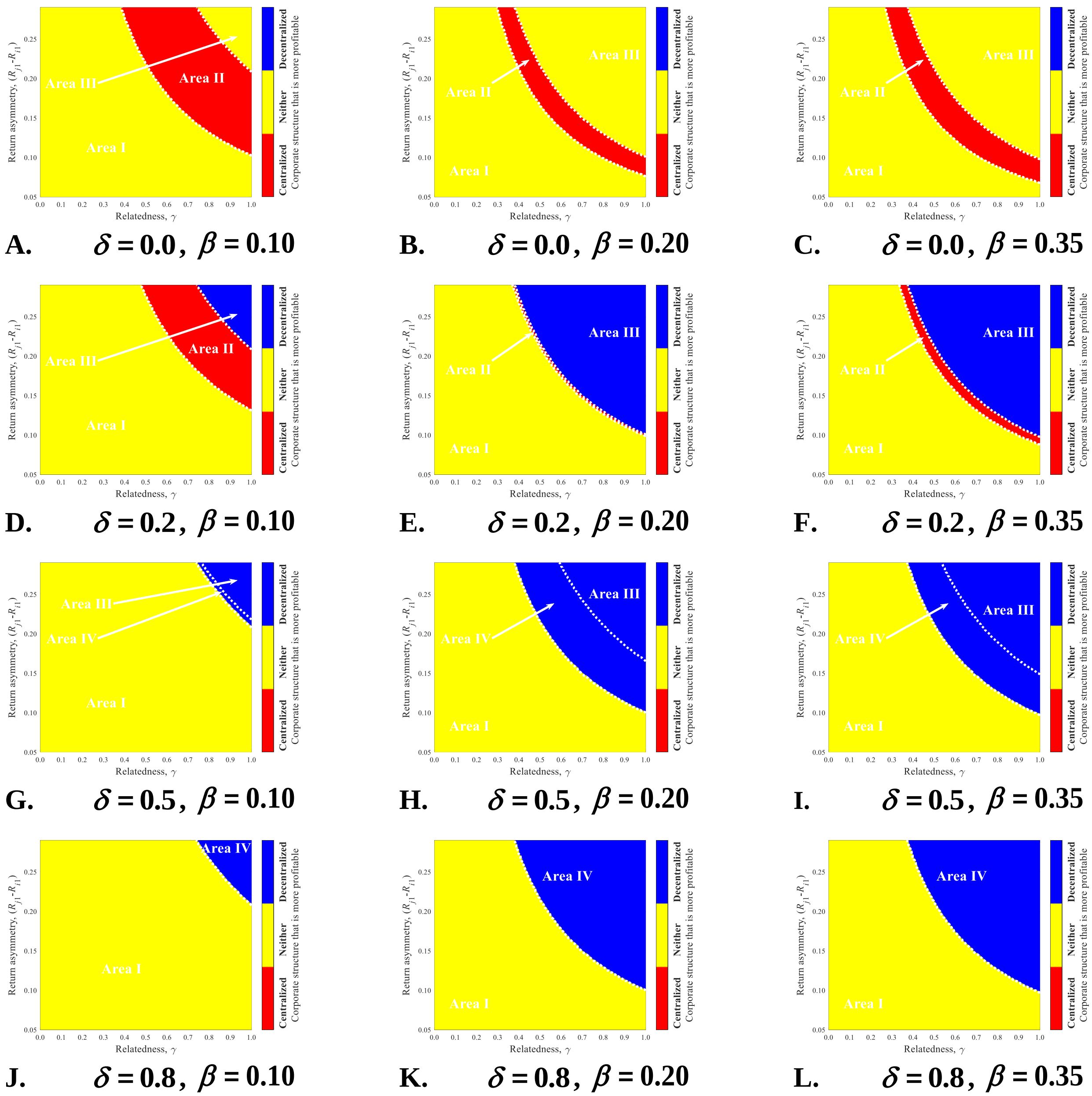


Figure A1.

Corporate structure that is more profitable for the use of resource redeployment, for various combinations of the cost of centralization δ and the incentive for redeployment β

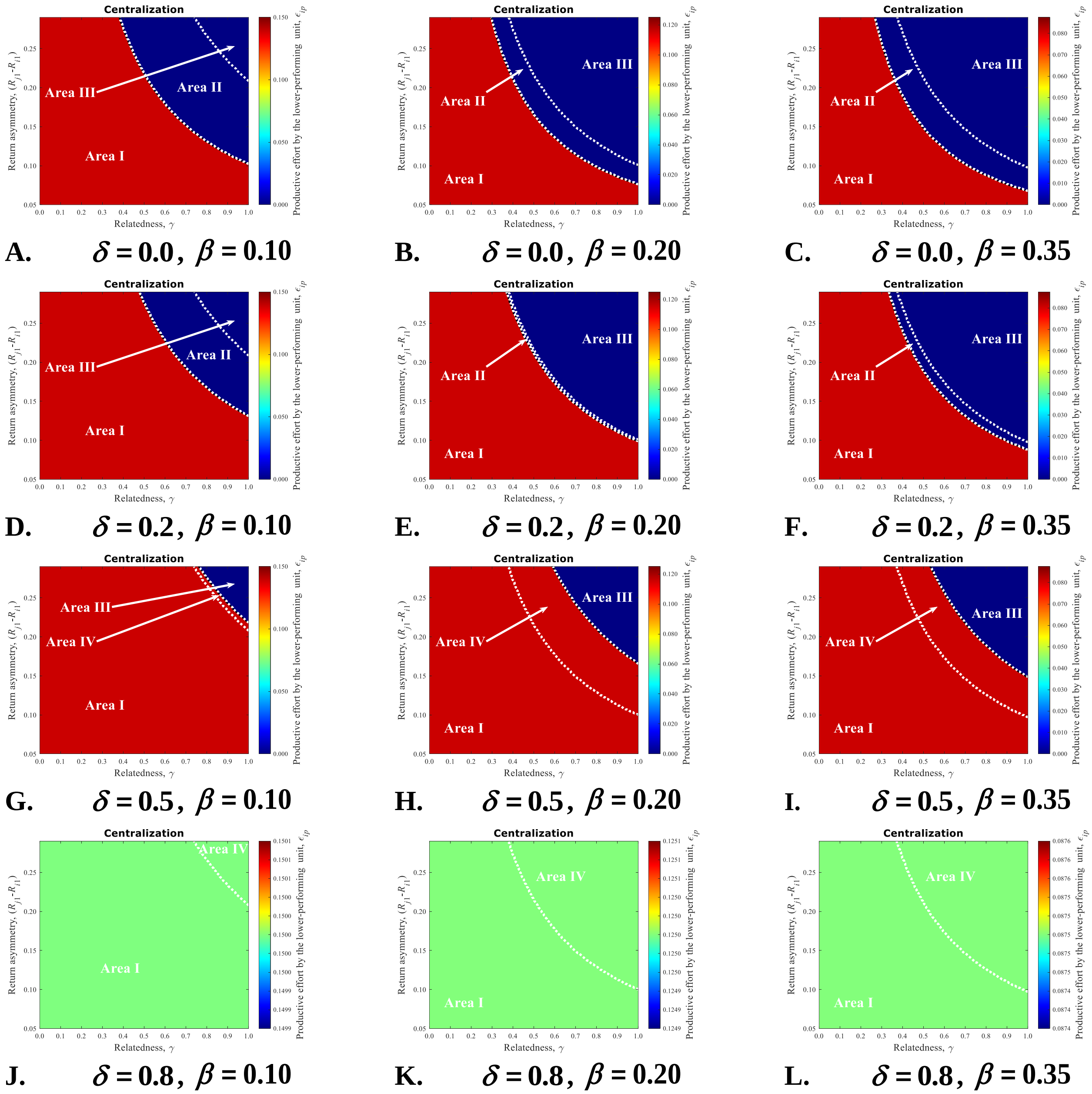


Figure A2. Productive effort by the lower-performing unit in the centralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β

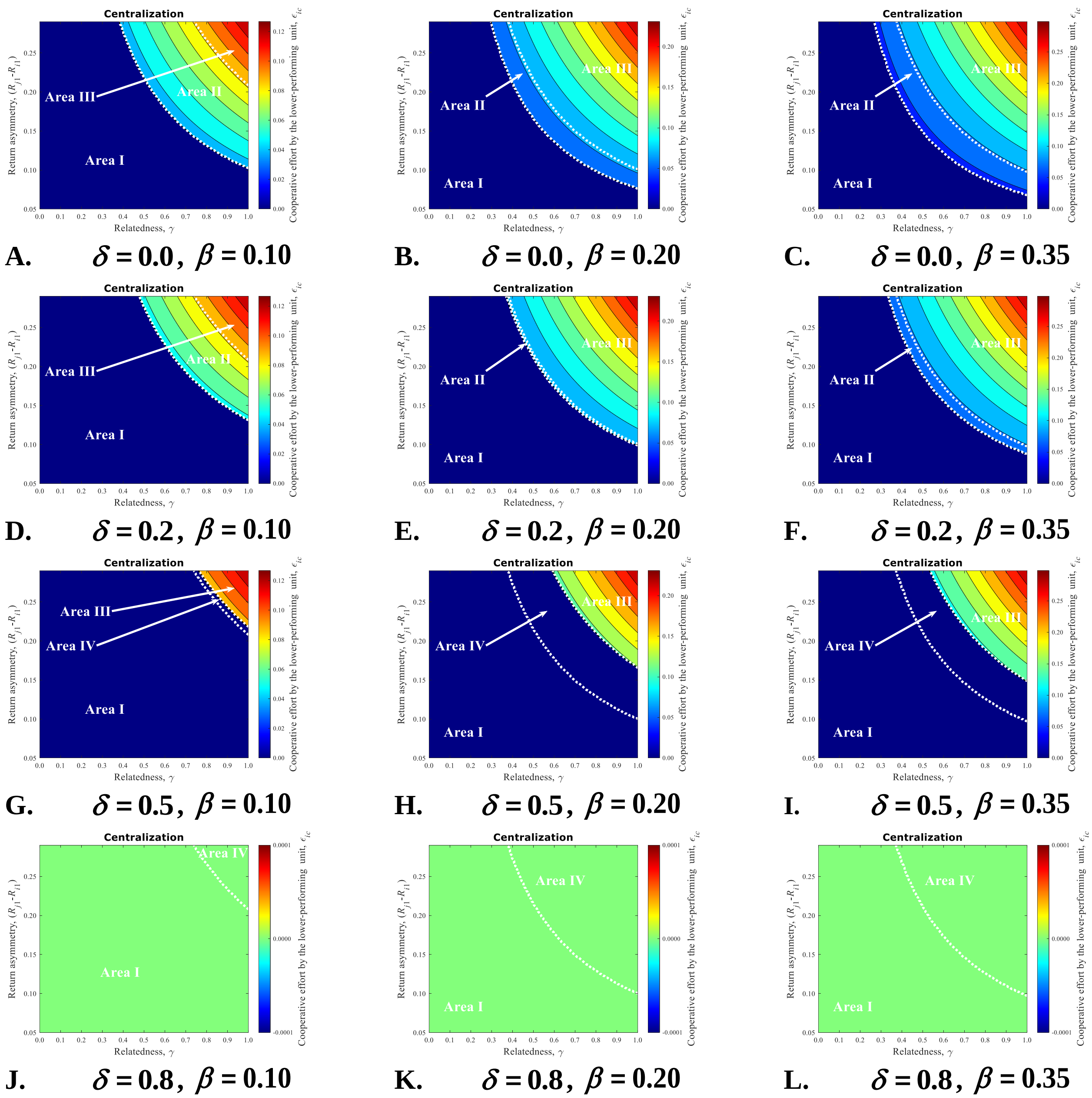


Figure A3. Cooperative (redeployment) effort by the lower-performing unit in the centralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β

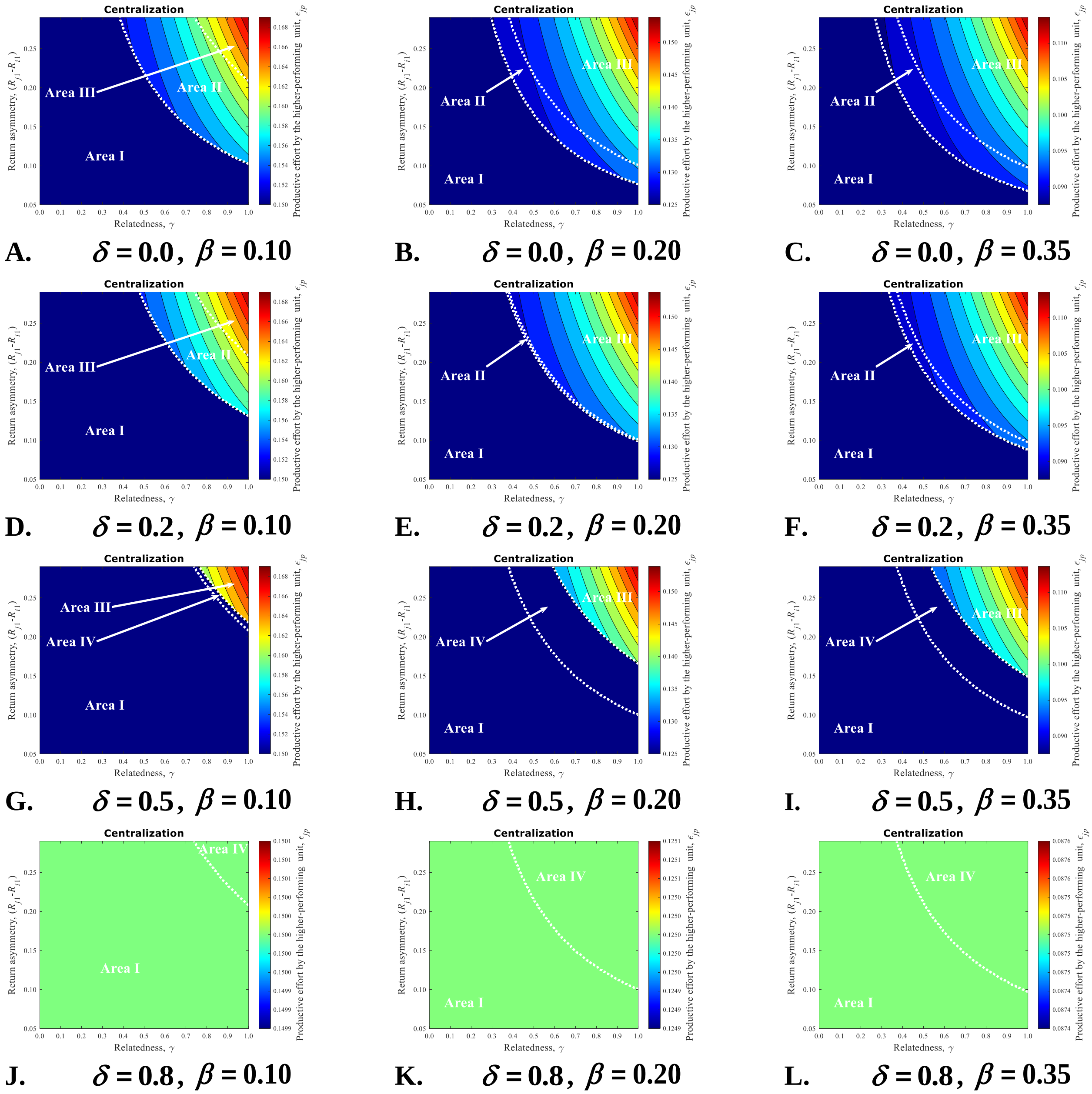


Figure A4. Productive effort by the higher-performing unit in the centralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β

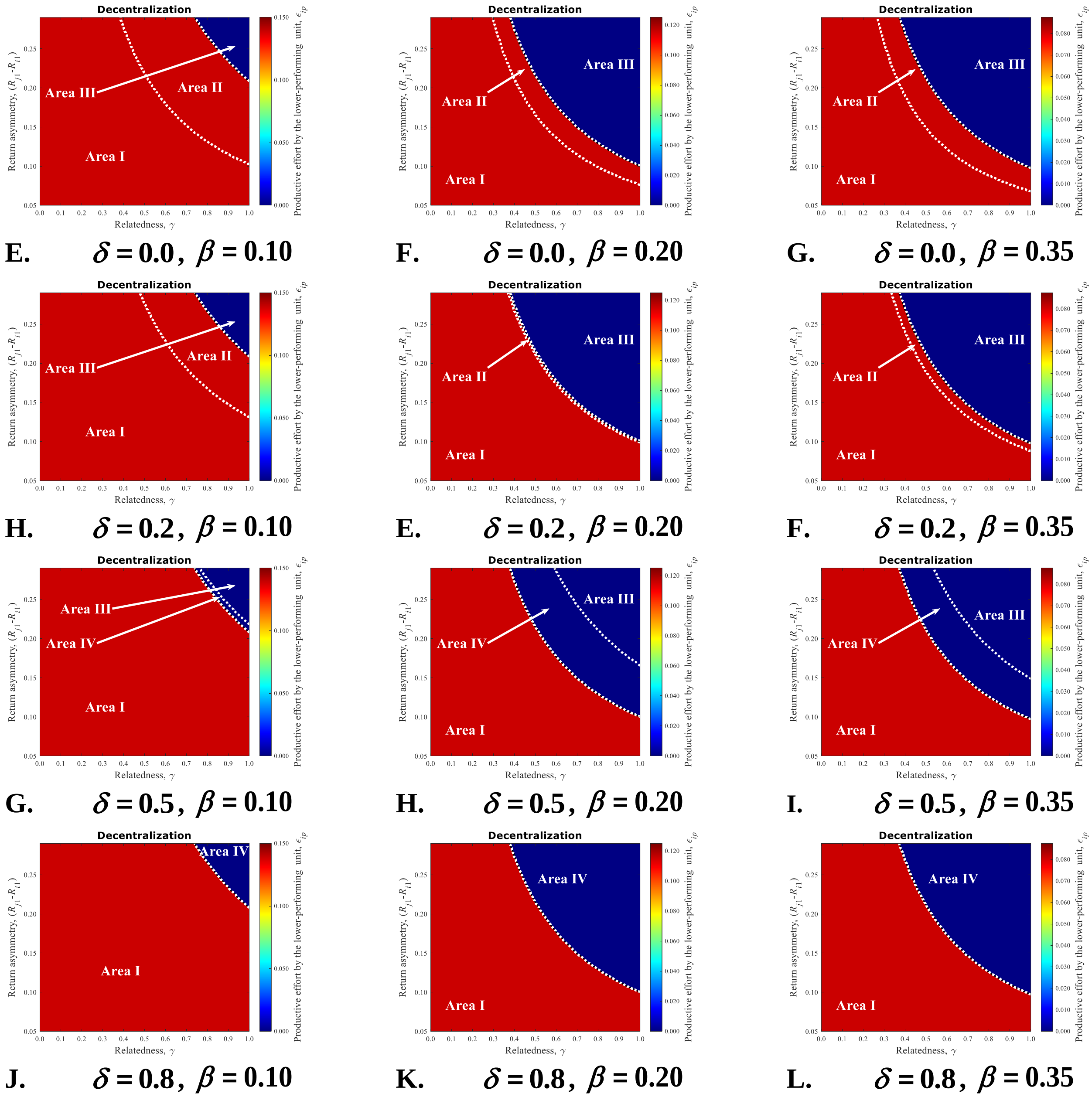


Figure A5. Productive effort by the lower-performing unit in the decentralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β

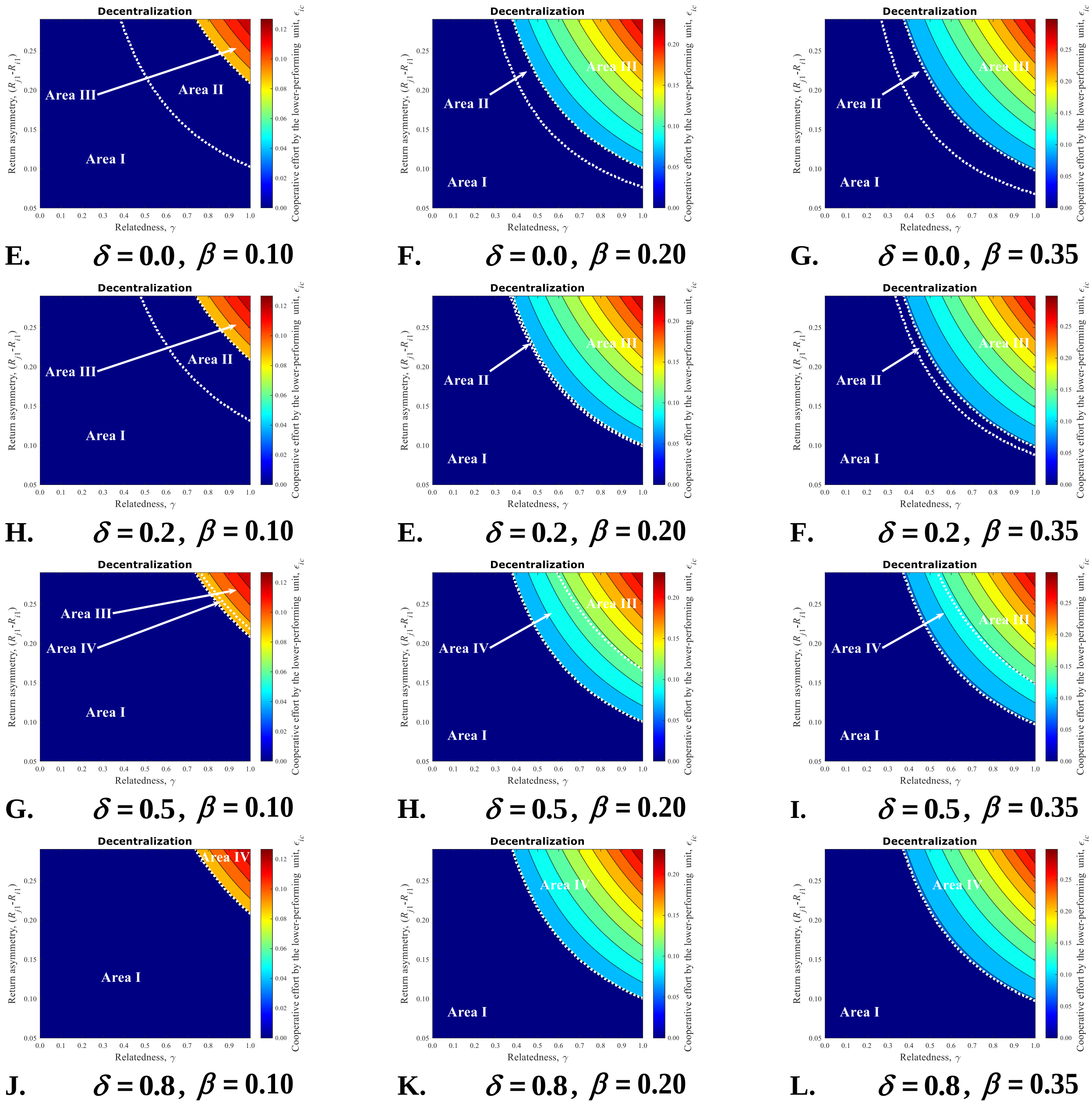


Figure A6. Cooperative (redeployment) effort by the lower-performing unit in the decentralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β

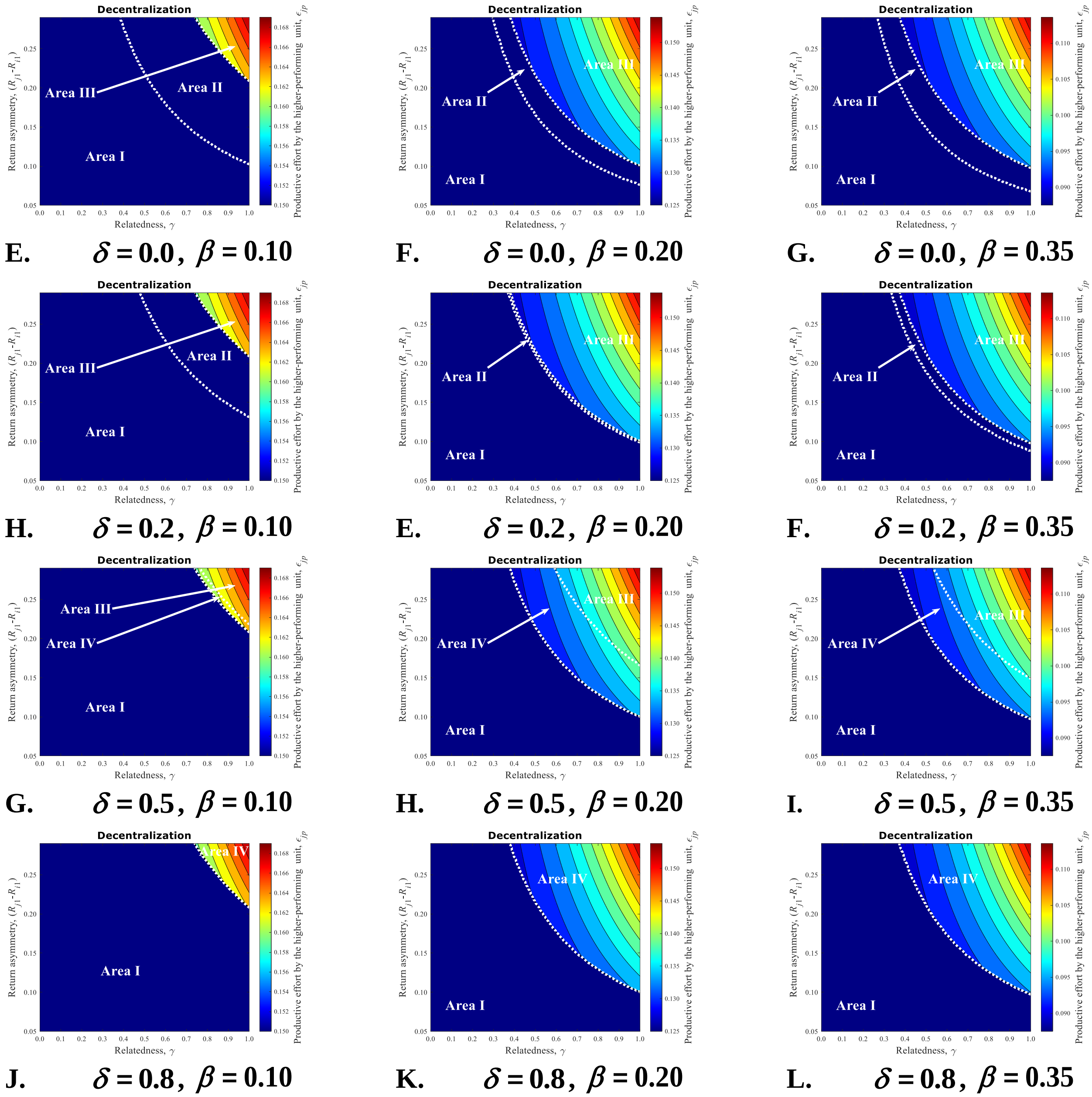


Figure A7. Productive effort by the higher-performing unit in the decentralized firm, for various combinations of the cost of centralization δ and the incentive for redeployment β