Boundary of the firm with endogenous firm structure

Qing Ma[1], Susheng Wang[2]

[1]Nottingham University Business School, University of Nottingham, Nottingham, United Kingdom

[2]Department of Economics, Hong Kong University of Science and Technology, Hong Kong, China

Correspondence

Susheng Wang, Department of Economics, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, China.

Email: s.wang@ust.hk

Abstract

We study the boundary of the firm with endogenous firm structure. The firm has two restructuring options: internal restructuring by which the firm centralizes or decentralizes decision making, or external restructuring by which the firm spins off a division. We investigate the firm's restructuring options to determine its boundary based on the optimal firm structure. Our conclusion depends on market uncertainty, market size, market competition, synergy among divisions, and coordination costs. We find that when market uncertainty rises, a decentralized firm (D-firm) conducts internal restructuring, whereas a centralized firm (C-firm) conducts external restructuring. A D-firm chooses to stay put when market competition intensifies, whereas a C-firm chooses to conduct either internal or external restructuring depending on whether a positive synergy exists among its divisions.

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1 INTRODUCTION

In a changing market, firms may decide to alter their decision-making process (e.g., centralize or decentralize decision making) and/or the firm boundary (e.g., spin off divisions). In this article, we focus on four restructuring options when firms adapt to a changing business environment: stay put, decentralize if centralization is the rule, centralize if decentralization is the rule, and divest. We treat the boundary and structure of the firm as two interdependent factors.

Research on the choice between internal and external restructuring is rare. Levine and Smith (2004) investigate the effect of the organizational structure and of horizontal disintegration on information sharing among divisions. They find that a free-rider problem may appear in which a division invests in an uninformative project and free-rides on the information from an informative project that another division has undertaken. They propose centralization or divestiture as possible remedies to the problem. Renucci (2008) considers conditions under which a firm is better off decentralizing decisions. He assumes a capacity constraint for a centralized structure in terms of decision making and considers two independent projects. He shows that a centralized structure allows the firm's overall investment capacity to increase but forces the headquarters to leave division managers with agency rents. Alonso et al. (2015) focus on centralization versus decentralization. They show that increased market competition (as reflected by increased price sensitivity of demand) implies a preference for centralization. We depart from the literature in several ways.

Our model works as follows. Building on Harford's (2012, p.81) argument that *"the traditional purpose of centralization is to make sure every business unit is coordinated and nobody is duplicating anyone else's effort,"* centralization in our model offers better coordination among divisions and better information to guide decision making than decentralization. Yet, centralization has drawbacks: A coordination cost is incurred, and incentives for division managers are low. Internal restructuring consists of providing the control rights of outputs to division managers when the firm was previously centralized, and providing the control rights of outputs to the chief executive officer (CEO) when the firm was previously decentralized. As

Williamson (1985) points out, internal restructuring aims at low-powered incentives, whereas external restructuring aims at high-powered incentives. The firm in our model can also conduct external restructuring by divesting one of its divisions. The divisions have positive or negative synergies. Divestiture offers high-powered incentives for managers and saves coordination costs, but it foregoes potential synergy among divisions.

We analyze these options based on market uncertainty, market size, market competition, synergy, and coordination costs. We obtain the following results. Increasing market uncertainty induces firms to centralize for the benefit of coordination. An expanding market induces firms to decentralize or divest for the benefit of higher incentives. Increasing market competition induces firms to decentralize for the benefit of low-powered incentives and competitive pricing. Lower synergy among divisions induces firms to divest for the benefit of high-powered incentives. A high coordination cost induces firms to divest to avoid coordination costs.

Essential to our results is the fact that we endogenize the choice of structure and that of the firm boundary. Our results would be affected if, for instance, structural change were not allowed. To see this, suppose that market competition drives down firm profit. It has a negative effect on managerial incentives if firm structure is not adjusted. However, managerial incentives may actually increase if firms can decentralize their control structure or divest some of their divisions. This simultaneous investigation of firm structure and firm boundary makes our article an original contribution to the literature.

2 MODEL

2.1 Firm

Consider a firm with two divisions $i = 1, 2$. Each division produces its own unique product. Division i produces output x_i and faces the following inverse demand:

$$p_i = P_i(x_i, \tilde{a}_i),$$

where p_i is the price and $\tilde{a}_i$ is a random factor. Division i's cost of production is

$$C_i(x_i, x_j),$$

where x_j is the other division's output. This cost function allows division j's output x_j to have a positive or negative effect on the production cost of division i, implying an externality or synergy between the two divisions.

2.2 Control structure

Following the incomplete contract approach, we focus on control rights or decision-making rights in a contractual relationship. Division i's output x_i is a control variable, which may be decided by the manager of division i or by the CEO. We consider the firm a decentralized firm (D-firm) when the control rights of all outputs are situated at the division level; alternately, we consider the firm a centralized firm (C-firm) when the control rights of all outputs are situated at the firm level.[1]

The relationships between the CEO and division managers are defined by contracts. The sequence of events is illustrated in the timeline shown in Figure 1. The CEO offers a contract to each division manager ex ante at $t = 0$, and then the division managers decide to accept or reject the contracts. The CEO is the principal, and a division manager is an agent in this contractual relationship. The contract for division i's manager is denoted by $S_i(x_i)$, specifying the payment $S_i(x_i)$ to the division manager when output is x_i.[2] The principal aims to maximize the

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[1]In a complete contract, the parties can negotiate to decide the values of x_1 and x_2 ex ante; that is, the values of x_1 and x_2 are predetermined in the contract. If so, it does not matter who has the control rights; that is, the control structure does not matter. However, we do not have such a contract, meaning that we have an incomplete contract. Although x_1 and x_2 are not contractable in our incomplete contract, their control rights are contractable. Accordingly, the values of x_1 and x_2 are determined ex post by those who have the control rights. In this case, the control structure matters.

[2]We use a simple contract form $S_i(x_i)$. The contract can also be of the form $S_i\big(P_i(x_i, a)x_i\big)$,

firm's overall profit when she designs the contracts. A division manager aims to maximize his own income when he decides on a division's output. We assume that a division's output x_i is verifiable, but the random factor $\tilde{a}_i$ and the division's cost C_i are not verifiable.

The project/cooperation proceeds after the contracts are accepted/signed by both parties. If the control rights are situated at the firm level (centralized control), the CEO decides on x_1 and x_2 ex post after the random factor $\tilde{a}_i$ is realized. The coordination cost $K(x_1, x_2)$ is observed when decisions are made at the firm level. The coordination cost may arise from asymmetric information as shown by Alonso et al. (2015), or bureaucratic inefficiency as shown by Wang and Xiao (2007). The manager of division i decides on x_i ex post when the control rights are situated at the division level (decentralized control). The division managers decide on x_1 and x_2 simultaneously in Nash equilibrium in the ex post subgame. Thus, the solution in each case is a subgame perfect Nash equilibrium. The revenue is divided based on the contracts at the end of the project at $t = 1$.

We assume that the division managers cannot observe $\tilde{a}_i$, whereas the CEO can when $\tilde{a}_i$ realizes its value ex post. In practice, the CEO tends to have resources in acquiring and studying market information. For example, large companies, such as the US Federal Reserve (Fed), World Bank, and Samsung, often have an office that conducts research on markets. This investment is more justifiable at the top level of a company than at a lower level. Various market reports proceed directly to the CEO. The chief information officer reports directly to the CEO. The chief operating officer, who supervises day-to-day activities, including marketing and sales, also provides feedback to the CEO. These resources are part of the coordination cost. A

$S_i\big(P_i(x_i, a)x_i - C_i(x_1, x_2)\big)$ or $S_i\big(x_i, C_i(x_1, x_2)\big)$ if the cost $C_i(x_1, x_2)$ is verifiable. The form of the contract itself does not influence our results. The contractual solution is efficient (maximizing the total surplus) in each case (centralized structure, decentralized structure, or spinoff), implying that a more complicated/sophisticated contract cannot improve firm profits.

division manager typically knows his/her own market well, but not the markets of other divisions. The CEO has the advantage of knowing all markets, especially for firms with synergy among their divisions. However, this assumption may not fit all companies. For example, the division managers may have better local information than the CEO if the two divisions are in significantly different physical locations. In Remark 1, we discuss the scenario if we alternatively assume that the division managers can also observe $\tilde{a}_i$.

2.3 Internal versus external restructuring

The CEO can adjust contractual relationships defined by $S_1(\cdot)$ and $S_2(\cdot)$ when coping with a changing business environment. The CEO can also implement a structural change when the changes are substantial. The CEO can proceed in several ways. She may decentralize or centralize the divisions or divest one of them. Divesting a division is considered external restructuring, whereas decentralizing or centralizing the control structure within a firm is considered internal restructuring. Internal restructuring may be better than external restructuring or vice versa, depending on the business environment. For example, divestiture may prove to be the best coping strategy when the market expands substantially.

A firm in practice makes one structural change at a time. A structural change is a complicated process that requires considerable time and effort. Each structural change in practice typically takes a few months to accomplish. Hence, a firm in our model makes one structural change only.

2.4 Parametric functions

We use the following set of parametric functions to analyze our solution:

$$P_i(x_i, \tilde{a}) = \tilde{a} - \rho x_i, \qquad C_i\left(x_i, x_j\right) = c x_i - \theta x_i x_j, \qquad K(x_1, x_2) = 2k x_1 x_2, \tag{1}$$

where $\rho, c, k > 0$ and $\theta \in \mathbb{R}$ are constants. Here, k represents the coordination cost, c represents the marginal cost of production, and θ represents synergy between the two divisions. A positive synergy exists if $\theta > 0$; conversely, a negative synergy exists if $\theta < 0$. We have a linear demand function for each product, where ρ is the slope of the demand curve and $\tilde{a}$ is the intercept. The demand curve shifts out (shifts in) if $\tilde{a}$ increases (decreases). For a larger (smaller) ρ, demand is less (more) sensitive to the price. Given that competition may cause price sensitivity, $1/\rho$ is used as a measure of market competitiveness. The density function of $\tilde{a}$ is denoted by $f(a)$, the mean value of $\tilde{a}$ is denoted by $\bar{a} \equiv E(\tilde{a})$, and demand uncertainty is denoted by $\sigma^2 \equiv \mathrm{Var}(\tilde{a})$. Synergy disappears if one division is divested, and the cost and coordination functions for the two divisions become

$$C_i(x_i) = cx_i, \qquad K(x_i) = 2kx_i. \tag{2}$$

With these parametric functions, we have symmetric divisions with identical parametric functions.

3 SOLUTION

3.1 Decentralization

The division managers in a firm with a decentralized control structure have the right to decide on outputs. After accepting contracts $S_1(x_1)$ and $S_2(x_2)$, the two division managers choose outputs in an ex post subgame. Given Division 2's output, Division 1's problem is

$$\max_{x_1} \; S_1(x_1) - C_1(x_1, x_2).$$

Its first-order condition (FOC) implies an incentive compatibility (IC) condition IC_1. Symmetrically, Division 2's FOC implies a second IC condition IC_2. The two IC conditions imply a Nash equilibrium $(\hat{x}_1, \hat{x}_2)$ in the ex post subgame. After considering the ex post individual rationality (IR) conditions IR_1 and IR_2, the CEO's ex ante problem is

$$\begin{aligned} \Pi_d^* \equiv \max_{S_1(\cdot),\, S_2(\cdot),\, x_1,\, x_2} \; & \int \big[P_1(x_1, a)x_1 + P_2(x_2, a)x_2 - S_1(x_1) - S_2(x_2)\big] f(a)\, da \\ \text{s.t.} \quad & IC_1\!: \; S_1'(x_1) = C_{1x_1}'(x_1, x_2) \\ & IC_2\!: \; S_2'(x_2) = C_{2x_2}'(x_1, x_2) \\ & IR_1\!: \; S_1(x_1) \geq C_1(x_1, x_2) \\ & IR_2\!: \; S_2(x_2) \geq C_2(x_1, x_2), \end{aligned} \tag{3}$$

where Π_d^* is the expected profit, and the subscript d stands for decentralization. Here, x_1 and x_2 are independent of a given that the division managers cannot observe $\tilde{a}$. With the parametric functions in (1), the solution is

$$x_i^* = \frac{\bar{a} - c}{2(\rho - \theta)}, \qquad S_i^*(x) = \frac{2c\rho - \theta\bar{a} - \theta c}{2(\rho - \theta)} x, \qquad \Pi_d^* = \frac{(\bar{a} - c)^2}{2(\rho - \theta)}. \tag{4}$$

3.2 Centralization

The CEO of the firm with centralized control structure has the right to decide on outputs. After the two division managers have accepted contracts $S_1(x_1)$ and $S_2(x_2)$, the CEO decides on x_1 and x_2 by considering the following ex post problem:

$$\max_{x_1,\, x_2} \; P_1(x_1, a)x_1 + P_2(x_2, a)x_2 - S_1(x_1) - S_2(x_2) - K(x_1, x_2).$$

The two FOCs of this problem imply two IC conditions IC_1 and IC_2, which determine outputs $\left(\hat{x}_1(a), \hat{x}_2(a)\right)$. After taking into account the ex ante IR conditions IR_1 and IR_2, the CEO's ex ante problem is

$$\begin{aligned} \Pi_c^* \equiv \max_{S_1(\cdot), S_2(\cdot), x_1, x_2} & \int [P_1(x_1, a)x_1 + P_2(x_2, a)x_2 - S_1(x_1) - S_2(x_2) - K(x_1, x_2)] f(a) da \\ \text{s.t.} \quad & IC_1\!: \; P'_{1x_1}(x_1, a)x_1 + P_1(x_1, a) = S'_1(x_1) + K'_{x_1}(x_1, x_2) \\ & IC_2\!: \; P'_{2x_2}(x_2, a)x_2 + P_2(x_2, a) = S'_2(x_2) + K'_{x_2}(x_1, x_2) \\ & IR_1\!: \int [S_1(x_1) - C_1(x_1, x_2)] f(a)\, da \geq 0 \\ & IR_2\!: \int [S_2(x_2) - C_2(x_1, x_2)] f(a)\, da \geq 0, \end{aligned} \tag{5}$$

where x_1 and x_2 are functions of a, and Π_c^* is the expected profit. With the parametric functions in (1), the solution is

$$x_i^*(a) = \frac{a - c}{2(\rho - \theta + k)}, \qquad S_i^*(x) = cx - \theta x^2, \qquad \Pi_c^* = \frac{(\bar{a} - c)^2 + \sigma^2}{2(\rho - \theta + k)}. \tag{6}$$

3.3 Divestiture

The firm may acquire great results by spinning off one of its divisions. Because the two divisions are symmetric, we let Division 1 be divested. After spinning off, Division 1 becomes an independent firm and decides on its own output x_1. Because division 1 is now a firm, the manager of division 1 can observe a. Thus, Division 1's problem is

$$\max_{x_1} P_1(x_1, a)x_1 - C_1(x_1), \tag{7}$$

which implies an optimal output $x_1^*(a)$. Then, the ex ante profit is

$$\Pi_1^* \equiv \int \{P_1[x_1^*(a), a]x_1^*(a) - C_1\big(x_1^*(a)\big)\}f(a)\,da.$$

With the parametric functions in (1), the solution is

$$x_1^*(a) = \frac{a-c}{2\rho}, \qquad \Pi_1^* = \frac{(\bar{a}-c)^2 + \sigma^2}{4\rho}.$$

3.3.1 Decentralized spinoff

After spinning off Division 1, the firm still has Division 2. The manager of Division 2 with decentralized control structure has the right to decide on Division 2's output as follows:

$$\max_{x_2} S_2(x_2) - C_2(x_2).$$

Its FOC implies an IC condition IC. After considering the ex post IR condition IR, the CEO's ex ante problem is

$$\begin{aligned} \Pi_{2d}^* \equiv \max_{S_2(\cdot), x_2} & \int [P_2(x_2, a)x_2 - S_2(x_2)]f(a)\,da \\ \text{s.t.} \quad & IC\colon\ S_2'(x_2) = C_2'(x_2) \\ & IR\colon\ S_2(x_2) \geq C_2(x_2). \end{aligned} \tag{8}$$

x_2 is independent of a because the division manager cannot observe a. With the parametric functions in (1), the solution is

$$x_2^* = \frac{\bar{a}-c}{2\rho}, \qquad S_2^*(x) = cx, \qquad \Pi_{2d}^* = \frac{(\bar{a}-c)^2}{4\rho}.$$

Then, the total expected profit is

$$\Pi_{ds}^* \equiv \Pi_1^* + \Pi_{2d}^* = \frac{2(\bar{a}-c)^2 + \sigma^2}{4\rho}. \tag{9}$$

3.3.2 Centralized spinoff

The CEO of the firm with centralized control structure has the right to decide on Division 2's output. With coordination cost $K(x_2)$, the CEO's ex post problem is

$$\max_{x_2} P_2(x_2, a)x_2 - S_2(x_2) - K(x_2).$$

Its FOC implies an IC condition IC. After taking into account the ex ante IR condition IR, the CEO's ex ante problem is

$$\begin{aligned}\Pi_{2c}^* \equiv \max_{S_2(\cdot),x_2} & \int [P_2(x_2,a)x_2 - S_2(x_2) - K(x_2)]f(a)\,da \\ \text{s.t.} \quad & IC\colon\ P'_{2x_2}(x_2,a)x_2 + P_2(x_2,a) = S'_2(x_2) + K'(x_2) \\ & IR\colon \int [S_2(x_2) - C_2(x_2)]f(a)\,da \geq 0,\end{aligned} \tag{10}$$

where x_2 is a function of a. With the parametric functions in (1), the solution is

$$x_2^*(a) = \frac{a - c - 2k}{2\rho}, \qquad S_2^*(x) = cx, \qquad \Pi_{2c}^* = \frac{(\bar{a} - c - 2k)^2 + \sigma^2}{4\rho}.$$

Then, the total expected profit is

$$\Pi_{cs}^* \equiv \Pi_1^* + \Pi_{2c}^* = \frac{(\bar{a} - c)^2 + (\bar{a} - c - 2k)^2 + 2\sigma^2}{4\rho}. \tag{11}$$

4 ANALYSIS

When coping with a changing business environment, firms may conduct restructuring besides adjusting contractual relationships among managers. We now investigate why firms prefer external restructuring to internal restructuring and vice versa. We focus on a few influencing factors, including market uncertainty σ^2, market competition measured by price sensitivity $1/\rho$, synergy θ between two divisions, market size $\bar{a}$, and the coordination cost k. For convenience, we assume that

$$\rho > \theta, \qquad \bar{a} > c + 2k.$$

The firm has four restructuring options: stay put, centralization, decentralization, and divestiture. From the solutions of Section 3, we can derive conditions for the firm's choice on each option. The conditions for the firm's decision are as follows:

A D-firm will choose to centralize if

$$k(\bar{a}-c)^2 < (\rho-\theta)\sigma^2, \qquad 2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2 > 0; \tag{12}$$

A D-firm will choose to divest if

$$2\theta(\bar{a}-c)^2 < (\rho-\theta)\sigma^2, \qquad 2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2 < 0; \tag{13}$$

A C-firm will choose to decentralize if

$$k(\bar{a}-c)^2 > (\rho-\theta)\sigma^2, \qquad \frac{\rho+\theta}{\rho-\theta}(\bar{a}-c)^2 > (\bar{a}-c-2k)^2 + 2\sigma^2; \tag{14}$$

A C-firm will choose to divest if

$$\begin{aligned} &\frac{\theta-k}{\rho-\theta+k}[(\bar{a}-c)^2+\sigma^2] + 2k(\bar{a}-c-k) < 0, \\ &\frac{\rho+\theta}{\rho-\theta}(\bar{a}-c)^2 < (\bar{a}-c-2k)^2 + 2\sigma^2. \end{aligned} \tag{15}$$

See the Appendix for the derivation. To explain these conditions, we take (12) as an example. A D-firm conducts centralization if it perceives this choice as better than its current control structure and divestiture, that is, $\Pi_c^* > \Pi_d^*$ and $\Pi_c^* > \Pi_{ds}^*$, or the two conditions in (12) are satisfied. Alternately, a D-firm chooses to stay put if it perceives its current control structure as the best option. For convenience, we list the conditions in Table 1.

Proposition 1 (Uncertainty).

(a) When market uncertainty σ^2 rises, a D-firm conducts internal restructuring (centralization) if $\rho+\theta > k$, a D-firm conducts external restructuring (divestiture) if $\rho+\theta < k$, and a C-firm conducts external restructuring if $\theta < k$.

(b) When market uncertainty σ^2 drops, a D-firm chooses to stay put, whereas a C-firm conducts internal restructuring (decentralization).

In addition to a coordinating role of contracts, a centralized control structure offers better coordination among divisions and hence can deal with uncertainty more effectively. Thus, a D-firm conducts centralization when market uncertainty rises. However, centralization incurs a coordination cost. Condition $\rho + \theta > k$ ensures that the coordination cost is sufficiently small so that centralization is the best option. Alternately, a D-firm may consider conducting external restructuring if the coordination cost is high. Condition $\rho + \theta < k$ ensures that the coordination cost is sufficiently high or the synergy among divisions is sufficiently small to make external restructuring the best option. However, a division with more demand uncertainty is less valuable to the firm. Thus, a C-firm may consider conducting external restructuring when the rising uncertainty is coupled with a high coordination cost or a low synergy among divisions such that $\theta < k$.

The advantage of centralization in dealing with uncertainty diminishes when market uncertainty drops. Because a decentralized control structure offers the benefit of higher incentives for division managers, a C-firm may conduct internal restructuring when market uncertainty drops.

Proposition 2 (Competition).

(a) When market competition intensifies (ρ drops), a D-firm chooses to stay put, a C-firm conducts internal restructuring if $\theta > 0$*, and a C-firm conducts external restructuring if* $\theta < 0$.

(b) When market competition subsides (ρ rises), a D-firm conducts internal restructuring, whereas a C-firm chooses to stay put.

In line with our expectations, a C-firm's equilibrium output is on average lower than a D-firm's equilibrium output, as shown in Solutions (4) and (6). This finding implies that a C-firm's equilibrium price is on average higher than a D-firm's equilibrium price. A higher price becomes a profitable option when market competition subsides or demand becomes less sensitive to the price, inducing a D-firm to centralize its control structure. Symmetrically, centralization has a clear disadvantage when market competition intensifies or demand becomes more sensitive to the price because of lower incentives and a higher price. Hence, a C-firm may prefer to decentralize its control structure. However, a firm may consider conducting external restructuring if negative synergy exists among divisions. Our finding that market competition implies a preference for decentralization is consistent with the literature but contradicts Alonso et al. (2015).

We find that the effects of market competition differ substantially between firms with fixed and flexible structures. Schmidt (1997), Raith (2003), and Vives (2008) discuss the effects of market competition on firms with fixed structures. If a firm has a fixed structure, market competition has a negative effect on managerial incentives because market competition drives down the firm's profit. However, a firm in our model can decentralize its structural control or divest a division to alleviate the incentive problem. In fact, our model shows that a structural change can reverse the effect on incentives, so that market competition has a positive effect on managerial incentives.

Proposition 3 (Synergy).

(a) When synergy θ rises, a D-firm chooses to stay put, whereas a C-firm conducts internal restructuring.

(b) When synergy θ drops, both types of firms conduct external restructuring.

Decentralization is the best control structure when synergy θ rises. A divestiture foregoes synergy, whereas a D-firm structure captures synergy without incurring a coordination cost. Hence, a C-firm chooses to conduct decentralization. However, when synergy θ drops, the benefit of keeping both divisions within the firm diminishes, making divestiture a more attractive option.

Proposition 4 (Expansion).

(a) When the market expands ($\bar{a}$ rises), a D-firm chooses to stay put if $\theta > 0$, a D-firm conducts external restructuring if $\theta < 0$, and a C-firm conducts internal restructuring.

(b) *When the market shrinks ($\bar{a}$ drops), both types of firms choose to stay put if $\theta > k$, whereas a D-firm conducts internal restructuring if $\theta < k$.*

The benefit of a decentralized structure in stimulating incentives increases when the market expands, inducing a C-firm to conduct internal restructuring. Conversely, centralization offers coordination to cope with a difficult time when the market shrinks, inducing a D-firm to conduct centralization.

Proposition 5 (Coordination).

(a) *When the coordination cost k rises, a D-firm conducts external restructuring, whereas a C-firm conducts internal restructuring.*

(b) *When the coordination cost k drops, a D-firm conducts internal restructuring.*

The effect of coordination costs is straightforward. An increase in coordination costs makes centralization a less attractive option than decentralization, inducing a C-firm to conduct internal restructuring. This situation can also make external restructuring a more attractive option, inducing a D-firm to conduct external restructuring.

In sum, when market uncertainty rises, a D-firm conducts internal restructuring, whereas a C-firm conducts external restructuring. A D-firm chooses to stay put when market competition intensifies, whereas a C-firm chooses to conduct either internal or external restructuring depending on whether the synergy is positive. When synergy rises, a D-firm chooses to stay put, whereas a C-firm conducts internal restructuring. When the market expands, a D-firm chooses to stay put or conduct external restructuring, whereas a C-firm conducts internal restructuring. When coordination costs rise, a D-firm conducts external restructuring, whereas a C-firm conducts internal restructuring.

Remark 1. In our model, the CEO can observe $\tilde{a}$ when it is realized, but the division managers cannot. If we instead assume that both the CEO and the division managers can observe $\tilde{a}$ when it is realized, the payoff of a D-firm in (4) becomes $\Pi_d^* = (\bar{a} - c)^2 + \sigma^2/2(\rho - \theta)$, the payoff of a decentralized spinoff in (9) becomes $\Pi_{ds}^* = (\bar{a} - c)^2 + \sigma^2/2\rho$, and no changes occur to the payoffs of the other two cases. Then, we always have

$$\Pi_d^* > \Pi_c^*, \quad \Pi_{ds}^* > \Pi_{cs}^*, \quad \Pi_d^* > \Pi_{ds}^*,$$

implying that a D-firm will always choose to stay put, a C-firm will always conduct decentralization, and no spinoff will occur. In other words, a decentralized structure is always more efficient than a centralized structure and a spinoff. Hence, in this case, only D-firms are left in the end. In practice, divisions at vastly different locations tend to have a decentralized structure, consistent with this theoretical prediction.

Remark 2. Many kinds of information exist in practice. The assumption that the CEO knows a whereas the division managers do not represents a situation in which the CEO knows better than the division managers. Hence, the alternative assumption of both parties knowing a in Remark 1 is an extreme case in which everyone has exactly the same amount of information.

Remark 3. In our analysis, firms conduct one restructuring at a time when necessary. If a further restructuring is needed, our analysis provides guidance on each step. We assume that firms conduct one restructuring at a time when multiple restructuring is needed. Firms in practice are likely to conduct one restructuring at a time, considering a large amount of uncertainty and knowledge involved in each restructuring.

5 EXAMPLES

In this section, we offer a few practical examples. In practice, consistent with our theory, divestiture has often been a strategy to spin off noncore or poorly performing divisions, centralization has often been a strategy to streamline operations, and decentralization has often been a strategy to improve managerial incentives.

5.1 US Federal Reserve (Fed)

The Fed implemented several major restructuring programs in its history. It decentralized some of its control rights to its departmental level in 1919 because of the expanding demand for US banking services during World War I, consistent with our Proposition 4(a). However, the Fed centralized many of its control rights in 1935 (Wheelock, 1999) amid shrinking demand for banking services during the 10 years of economic recession after the 1929 stock market crash, consistent with our Proposition 4(b). US banks have been suffering from competition with nonbank financial intermediaries in the last 20 to 30 years. Consequently, examples of external restructuring abound among US banks, consistent with our Proposition 2(a).

5.2 Alfa Corporation

Alfa was a Mexican business group teetering on the edge of collapse in 1982 amid an economic crisis in Mexico. The company conducted restructuring in that same year and is today the fourth largest privately owned company in Mexico. The restructuring program centralized decision making, strengthened the core business, regrouped management control of those subsidiaries with synergy, and divested nonproductive or nonessential subsidiaries. This experience is consistent with our Propositions 1(a), 2(a), and 4(b). Furthermore, following the recovery of the Mexican economy in 1987, Alfa conducted a decentralization program, consistent with our Propositions 1(b) and 4(a).

5.3 Hewlett-Packard (HP)

HP performed well and repeatedly decentralized its organizational structure until 1996, consistent with our Proposition 4(a). However, HP centralized its 83 divisions into 6 centralized divisions in the early 2000s following stagnant revenues and a declining profit rate. HP again centralized management of its product lines in March 2012 following its declining profits, consistent with our Proposition 4(b). HP tried to sell off its PC division in 2014 (but failed), given the intensified competition in the PC market, consistent with our Proposition 2(a). HP divested its Snapfish division in 2015 to sharpen its focus, resulting in two entities: HP Inc. and HP Enterprise, consistent with our Propositions 2(a) and 3(b).

5.4 Microsoft Corporation

Microsoft started to face a shrinking market in 2005 because of the growing popularity of tablets. Consequently, Microsoft centralized its decision making in September 2005, and it further centralized its technology decisions and combined eight divisions into four in July 2013, consistent with our Proposition 4(b).

5.5 Sony Corporation

Sony started to face a shrinking market share in 2005 because of the fierce competition with Samsung and Apple. Consequently, Sony centralized its decision making in September 2005, consistent with our Proposition 4(b). Sony conducted another major restructuring program in March 2012 to centralize its decision making and close down or sell off some divisions, consistent with our Propositions 4(b) and 2(b).

5.6 Acer Inc.

As a fast-growing company, Acer decentralized many decision-making rights in 1991, consistent with our Proposition 4(a). However, Acer centralized its product management, manufacturing, customer services, and brand management functions in 1998 and December 2000 because of the shrinking PC market, consistent with our Proposition 4(b). Acer spun off Wistron and BenQ in 2001 because of the fast-growing market in mainland China, consistent with our Proposition 4(a).

6 CONCLUSION

A centralized control structure offers better coordination among divisions and better information to aid decision making, but it incurs coordination costs and lower incentives for division managers. A decentralized control structure offers higher incentives and lower decision-making cost, but no coordination exists among decision makers, and no overall market information is available to guide their decisions. Divestiture offers high-powered incentives and saves coordination costs, but it foregoes synergy among divisions. Consequently, the general tendencies are indicated as follows: Increasing market uncertainty induces firms to centralize (for the benefit of coordination), increasing market competition induces firms to decentralize (for higher incentives and competitive pricing), lower synergy among divisions induces firms to divest (for high-powered incentives), an expanding market induces firms to decentralize or divest (for higher incentives), and high coordination costs induce firms to divest (to avoid coordination costs).

Globalization has been a strong trend in recent years. Multinationals have been the driving force behind globalization. However, little is known about the boundary of these multinationals (see the survey conducted by Antràs & Rossi-Hansberg, 2009). Multinationals often (but not always) choose external restructuring over internal restructuring. Thus, identifying the factors that limit a multinational's size and determine its internal control structure is significant. The breakup of DaimlerChrysler provides an example of external restructuring in a troubled time. Our article offers an understanding of how multinationals develop and evolve.

Internal restructuring is a reorganization of the firm, whereas external restructuring redefines the firm's boundary. This article offers insight into the dependence of the firm's boundary on its internal control structure. It also presents a theory of the boundary of the firm with endogenous firm structure.

APPENDIX

A.1 The Decentralization Solution

For Problem (3), if the individual rationality (IR) conditions are not binding in equilibrium, given optimal contracts $S_1(x_1)$ and $S_2(x_2)$, the chief executive officer (CEO) can always offer $S_1(x_1) - \varepsilon$ and $S_2(x_2) - \varepsilon$ for some $\varepsilon > 0$ to satisfy the IR conditions. Contracts $S_1(x_1) - \varepsilon$ and $S_2(x_2) - \varepsilon$ also satisfy the incentive compatibility (IC) conditions. These contracts raise the firm's profit, which contradicts the fact that contracts $S_1(x_1)$ and $S_2(x_2)$ are optimal. Hence, the IR conditions must be binding in equilibrium. By the binding IR conditions, Problem (3) becomes

$$\begin{aligned}\Pi_d^* = \max_{S_1(\cdot),\, S_2(\cdot),\, x_1,\, x_2} & \int \left[P_1(x_1,a)x_1 + P_2(x_2,a)x_2 - C_1(x_1,x_2) - C_2(x_1,x_2)\right] f(a)\, da \\ \text{s.t.} \quad & IC_1\colon\ S_1'(x_1) = C'_{1x_1}(x_1,x_2) \\ & IC_2\colon\ S_2'(x_2) = C'_{2x_2}(x_1,x_2) \\ & IR_1\colon\ S_1(x_1) = C_1(x_1,x_2) \\ & IR_2\colon\ S_2(x_2) = C_2(x_1,x_2).\end{aligned} \tag{A1}$$

Because $S_1(x_1)$ and $S_2(x_2)$ do not appear in the objective function of Problem (A1), the problem can be solved in two steps. First, we solve the following problem for optimal outputs (x_1^*, x_2^*) without referring to contracts S_1 and S_2:

$$\Pi_d^* = \max_{x_1,\, x_2} \int \left[P_1(x_1,a)x_1 + P_2(x_2,a)x_2 - C_1(x_1,x_2) - C_2(x_1,x_2)\right] f(a)\, da. \tag{A2}$$

Second, given (x_1^*, x_2^*), we find optimal contracts S_1 and S_2 that satisfy:

$$\begin{aligned} S_1'(x_1^*) &= C'_{1x_1}(x_1^*, x_2^*) \\ S_2'(x_2^*) &= C'_{2x_2}(x_1^*, x_2^*) \\ S_1(x_1^*) &= C_1(x_1^*, x_2^*) \\ S_2(x_2^*) &= C_2(x_1^*, x_2^*). \end{aligned} \tag{A3}$$

Because the division managers cannot observe a, their Nash equilibrium in output cannot be dependent on a. Suppose that the Nash equilibrium is $(\bar{x}_1, \bar{x}_2)$. If the CEO proposes $\left(x_1^*(a), x_2^*(a)\right)$ that is dependent on a, if $\left(x_1^*(a), x_2^*(a)\right) \neq (\bar{x}_1, \bar{x}_2)$, the division managers will ignore $\left(x_1^*(a), x_2^*(a)\right)$ and choose $(\bar{x}_1, \bar{x}_2)$. Hence, the CEO has to propose $(\bar{x}_1, \bar{x}_2)$, which is independent of a. Then, with functions in (1) and fixed x_1 and x_2, Problem (A2) becomes

$$\Pi_d^* = \max_{x_1,\, x_2}\ (\bar{a} - \rho x_1)x_1 + (\bar{a} - \rho x_2)x_2 - (c x_1 - \theta x_1 x_2) - (c x_2 - \theta x_1 x_2).$$

The first-order conditions (FOCs) are

$$\bar{a} - 2\rho x_1 - c + 2\theta x_2 = 0, \qquad \bar{a} - 2\rho x_2 - c + 2\theta x_1 = 0,$$

which imply

$$x_1^* = x_2^* = \frac{(\theta + \rho)(\bar{a} - c)}{2(\rho^2 - \theta^2)} = \frac{\bar{a} - c}{2(\rho - \theta)}.$$

Then, by (A3), we need to find $S_1(x)$ such that

$$S_1'(x_1^*) = c - \theta x_2^*, \qquad S_1(x_1^*) = cx_1^* - \theta x_1^* x_2^*. \tag{A4}$$

Consider a linear contract of the form $S_1 = \alpha x_1 + \beta$. Then, (A4) implies

$$\alpha = c - \theta x_2^* = c - \theta \frac{\bar{a} - c}{2(\rho - \theta)},$$

and

$$(c - \theta x_2^*) x_1^* + \beta = cx_1^* - \theta x_1^* x_2^*,$$

implying $\beta = 0$. Hence,

$$S_1^*(x) = \frac{2c\rho - \theta\bar{a} - \theta c}{2(\rho - \theta)} x.$$

Then,

$$p_i^* = \tilde{a} - \rho x_i^* = \tilde{a} - \frac{\rho(\bar{a} - c)}{2(\rho - \theta)},$$

and

$$\Pi_d^* = 2(\bar{a} - \rho x^*)x^* - 2[cx^* - \theta(x^*)^2] = \frac{(\bar{a} - c)^2}{2(\rho - \theta)}.$$

A.2 The Centralization Solution

For Problem (5), by the same argument on Problem (3), the IR conditions must be binding in equilibrium. By the binding IR conditions, Problem (5) becomes

$$\begin{aligned}
\Pi_c^* = \max_{S_1(\cdot), S_2(\cdot), x_1, x_2} & \int \{P_1(x_1, a)x_1 + P_2(x_2, a)x_2 - C_1(x_1, x_2) - C_2(x_1, x_2) - K(x_1, x_2)\} f \\
\text{s.t.} \quad & IC_1 \colon P'_{1x_1}(x_1, a)x_1 + P_1(x_1, a) = S_1'(x_1) + K'_{x_1}(x_1, x_2) \\
& IC_2 \colon P'_{2x_2}(x_2, a)x_2 + P_2(x_2, a) = S_2'(x_2) + K'_{x_2}(x_1, x_2) \\
& IR_1 \colon \int S_1(x_1) f(a)\, da = \int C_1(x_1, x_2) f(a)\, da \\
& IR_2 \colon \int S_2(x_2) f(a)\, da = \int C_2(x_1, x_2) f(a)\, da.
\end{aligned} \tag{A5}$$

Because $S_1(x_1)$ and $S_2(x_2)$ do not appear in the objective function of Problem (A5), the problem can be solved in two steps. First, we solve the following problem for optimal outputs $\big(x_1^*(a), x_2^*(a)\big)$ without referring to contracts S_1 and S_2:

$$\Pi_c^* = \max_{x_1, x_2} \int \{P_1(x_1, a)x_1 + P_2(x_2, a)x_2 - C_1(x_1, x_2) - C_2(x_1, x_2) - K(x_1, x_2)\} f(a)da \quad \text{(A6)}$$

Second, given (x_1^*, x_2^*), we find optimal contracts S_1 and an S_2 that satisfy:

$$\begin{aligned}
&P'_{1x_1}(x_1^*, a)x_1^* + P_1(x_1^*, a) = S'_1(x_1^*) + K'_{x_1}(x_1^*, x_2^*) \\
&P'_{2x_2}(x_2^*, a)x_2^* + P_2(x_2^*, a) = S'_2(x_2^*) + K'_{x_2}(x_1^*, x_2^*) \\
&\int S_1(x_1^*) f(a)\, da = \int C_1(x_1^*, x_2^*) f(a)\, da \\
&\int S_2(x_2^*) f(a)\, da = \int C_2(x_1^*, x_2^*) f(a)\, da.
\end{aligned} \quad \text{(A7)}$$

Note that although a is not verifiable, because $\left(x_1^*(a), x_2^*(a)\right)$ is optimal for the CEO, the division managers know that $\left(x_1^*(a), x_2^*(a)\right)$ is truthful.

With functions in (1), Problem (A6) becomes

$$\Pi_c^* = \max_{x_1, x_2} \int \{(a - \rho x_1)x_1 + (a - \rho x_2)x_2 - (cx_1 - \theta x_1 x_2) - (cx_2 - \theta x_1 x_2) - 2k x_1 x_2\} f(a)da.$$

By the Hamiltonian method, the Euler equations are

$$a - 2\rho x_1 - c + 2(\theta - k)x_2 = 0, \qquad a - 2\rho x_2 - c + 2(\theta - k)x_1 = 0,$$

implying

$$x_1^*(a) = x_2^*(a) = \frac{a - c}{2(\rho - \theta + k\ )}.$$

Then,

$$p_i^* = a - \frac{\rho(a - c)}{2(\rho - \theta + k)}.$$

Consider a simple contract of the form $S_1(x) = \alpha x^2 + \beta x + \gamma$. (A7) implies

$$\begin{aligned}
&a - 2\rho x_1^* = 2\alpha x_1^* + \beta + 2k x_1^*, \\
&\alpha E\left([x_1^*(\tilde{a})]^2\right) + \beta E\left(x_1^*(\tilde{a})\right) + \gamma = cE\left(x_1^*(\tilde{a})\right) - \theta E\left([x_i^*(\tilde{a})]^2\right),
\end{aligned}$$

implying

$$\begin{aligned}
&\left(1 - \frac{\alpha + k + \rho}{\rho - \theta + k}\right) a = \beta - \frac{\alpha + k + \rho}{\rho - \theta + k} c, \\
&(\alpha + \theta) \frac{\sigma^2 + (\bar{a} - c)^2}{4(\rho - \theta + k)^2} + \frac{(\beta - c)(\bar{a} - c)}{2(\rho - \theta + k)} + \gamma = 0.
\end{aligned} \quad \text{(A8)}$$

Let

$$\frac{\alpha+k+\rho}{\rho-\theta+k}=1,$$

implying $\alpha=-\theta$. Then, conditions in (A8) imply $\beta=c$ and $\gamma=0$. Hence,

$$S_1^*(x)=cx-\theta x^2.$$

Then,

$$\Pi_c^*=E\{2(a-\rho x_i^*)x_i^*-2(cx_i^*-\theta(x_i^*)^2)-2k(x_i^*)^2\}=\frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)}.$$

A.3 The Divestiture Solution

With functions in (1), Problem (7) becomes

$$\max_{x_1}\ (a-\rho x_1)x_1-cx_1,$$

which implies

$$x_1^*(a)=\frac{a-c}{2\rho}.$$

We then have

$$\Pi_1^*=E\left[\frac{(\tilde{a}-c)^2}{4\rho}\right]=\frac{(\bar{a}-c)^2+\sigma^2}{4\rho}.$$

A.3.1 A decentralized spinoff

For Problem (8), if the IR condition is not binding in equilibrium, given the optimal contract $S_2(x_2)$, the CEO can always offer $S_2(x_2)-\varepsilon$ for some $\varepsilon>0$ to satisfy the IR condition. Contract $S_2(x_2)-\varepsilon$ also satisfies the IC condition. This contract raises the firm's profit, which contradicts the fact that contract $S_2(x_2)$ is optimal. Hence, the IR condition must be binding in equilibrium. By the binding IR condition, Problem (8) becomes

$$\begin{aligned}\Pi_{2d}^{*} = \max_{S_2(\cdot),x_2} & \int [P_2(x_2,a)x_2 - C_2(x_2)]f(a)\,da \\ \text{s.t.} \quad & IC\colon\ S_2'(x_2) = C_2'(x_2) \\ & IR\colon\ S_2(x_2) = C_2(x_2).\end{aligned} \tag{A9}$$

Because $S_2(x_2)$ does not appear in the objective function of Problem (A9), the problem can be solved in two steps. First, we solve the following problem for optimal output x_2^* without referring to S_2:

$$\Pi_{2d}^{*} = \max_{x_2} \int [P_2(x_2,a)x_2 - C_2(x_2)]f(a)\,da. \tag{A10}$$

Second, given x_2^*, we find an S_2 that satisfies:

$$S_2'(x_2^*) = C_2'(x_2^*), \qquad S_2(x_2^*) = C_2(x_2^*). \tag{A11}$$

With functions in (1), problem (A10) becomes

$$\Pi_{2d}^{*} = \max_{x_2} \int \left[(a - \rho x_2)x_2 - c x_2\right] f(a)\,da.$$

Because the manager of Division 2 does not observe a, x_2 cannot depend on a in this case. Then, the problem becomes

$$\Pi_{2d}^{*} = \max_{x_2}\ (\bar{a} - c)x_2 - \rho x_2^2,$$

which implies

$$x_2^* = \frac{\bar{a} - c}{2\rho}.$$

Given x_2^*, we try to find an $S_2(x_2)$ that satisfies (A11). Consider a linear contract of the form $S_2(x_2) = \alpha x_2 + \beta$. Then, (A11) becomes

$$\alpha = c, \qquad \alpha \frac{\bar{a} - c}{2\rho} + \beta = c \frac{\bar{a} - c}{2\rho},$$

implying $\alpha = c$ and $\beta = 0$. That is, there is indeed an optimal linear contract, which is

$$S_2^*(x) = cx.$$

Then,

$$\Pi_{2d}^{*}=\frac{(\bar{a}-c)^2}{4\rho}.$$

Thus,

$$\Pi_{ds}^{*}=\frac{2(\bar{a}-c)^2+\sigma^2}{4\rho}.$$

A.3.2 A centralized spinoff

For Problem (10), by the same argument on Problem (8), the IR condition must be binding in equilibrium. By the binding IR condition, Problem (10) becomes

$$\begin{aligned}\Pi_{2c}^{*}=\max_{S_2(\cdot),x_2}&\int[P_2(x_2,a)x_2-C_2(x_2)-K(x_2)]f(a)\,da\\ \text{s.t.}\quad & IC: P'_{2x_2}(x_2,a)x_2+P_2(x_2,a)=S'_2(x_2)+K'(x_2)\\ & IR: \int S_2(x_2)f(a)\,da=\int C_2(x_2)f(a)\,da.\end{aligned}\tag{A12}$$

Because $S_2(x_2)$ does not appear in the objective function of Problem (A12), the problem can be solved in two steps. First, we solve the following problem for optimal output $x_2^*(a)$ without referring to S_2:

$$\Pi_{2c}^{*}=\max_{x_2}\int[P_2(x_2,a)x_2-C_2(x_2)-K(x_2)]f(a)\,da\,.\tag{A13}$$

Second, given x_2^*, we find an S_2 that satisfies:

$$\begin{aligned}&P'_{2x_2}(x_2^*,a)x_2^*+P_2(x_2^*,a)=S'_2(x_2^*)+K'(x_2^*)\\ &\int S_2(x_2^*)f(a)\,da=\int C_2(x_2^*)f(a)\,da.\end{aligned}\tag{A14}$$

With functions in (1), Problem (A13) becomes

$$\Pi_{2c}^{*}=\max_{x_2}\int\big[\big(a-\rho x_2(a)\big)x_2(a)-cx_2(a)-2kx_2(a)\big]f(a)da.$$

The Hamiltonian function can be defined as

$$H(x_2,a)=(a-c-2k)x_2-\rho x_2^2.$$

The Euler equation implies

$$x_2^*(a)=\frac{a-c-2k}{2\rho}.$$

Given x_2^*, we try to find an S_2 that satisfies (A14). Consider a linear contract of the form $S_2(x_2) = \alpha x_2 + \beta$. Then, (A14) becomes

$$-\rho\frac{a-c-2k}{2\rho} + a - \rho\frac{a-c-2k}{2\rho} = \alpha + 2k$$
$$E\left(\alpha\frac{\tilde{a}-c-2k}{2\rho} + \beta\right) = E\left(c\frac{\tilde{a}-c-2k}{2\rho}\right),$$

implying $\alpha = c$ and $\beta = 0$. That is, there is indeed an optimal linear contract, which is

$$S_2^*(x) = cx.$$

Then,

$$\Pi_{2c}^* = \frac{(\bar{a}-c-2k)^2 + \sigma^2}{4\rho}.$$

Thus,

$$\Pi_{cs}^* = \Pi_1^* + \Pi_{2c}^* = \frac{(\bar{a}-c)^2 + (\bar{a}-c-2k)^2 + 2\sigma^2}{4\rho}.$$

A.4 Derivation of Conditions (12)–(15)

A.4.1 A D-firm chooses to centralize

A decentralized firm (D-firm) will switch to a centralized structure if and only if $\Pi_d^* < \Pi_c^*$ and $\Pi_{ds}^* < \Pi_c^*$, that is,

$$\frac{(\bar{a}-c)^2}{2(\rho-\theta)} < \frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)}, \qquad \frac{2(\bar{a}-c)^2+\sigma^2}{4\rho} < \frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)},$$

implying

$$\frac{k(\bar{a}-c)^2 - (\rho-\theta)\sigma^2}{(\rho-\theta)(\rho-\theta+k)} < 0, \qquad \frac{2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2}{2\rho(\rho-\theta+k)} > 0.$$

With $\rho > \theta$, the conditions become

$$k(\bar{a}-c)^2 < (\rho-\theta)\sigma^2, \qquad 2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2 > 0.$$

A.4.2 A D-firm chooses to divest

A D-firm will spin off one division if and only if $\Pi_d^* < \Pi_{ds}^*$ and $\Pi_c^* < \Pi_{ds}^*$, that is,

$$\frac{(\bar{a}-c)^2}{2(\rho-\theta)} < \frac{2(\bar{a}-c)^2+\sigma^2}{4\rho}, \qquad \frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)} < \frac{2(\bar{a}-c)^2+\sigma^2}{4\rho},$$

implying

$$2\theta(\bar{a}-\mathrm{c})^2 < (\rho-\theta)\sigma^2, \quad 2(\theta-k)(\bar{a}-\mathrm{c})^2 + (\rho+\theta-k)\sigma^2 < 0.$$

A.4.3 A C-Firm Chooses to Decentralize

A centralized firm (C-firm) will switch to a decentralized structure if and only if $\Pi_c^* < \Pi_d^*$ and $\Pi_{cs}^* < \Pi_d^*$, that is,

$$\frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)} < \frac{(\bar{a}-c)^2}{2(\rho-\theta)}, \qquad \frac{(\bar{a}-c)^2+(\bar{a}-c-2k)^2+2\sigma^2}{4\rho} < \frac{(\bar{a}-c)^2}{2(\rho-\theta)},$$

implying

$$k(\bar{a}-c)^2 > (\rho-\theta)\sigma^2, \qquad (\rho+\theta)(\bar{a}-c)^2 > (\rho-\theta)(\bar{a}-c-2k)^2 + 2(\rho-\theta)\sigma^2.$$

A.4.4 A C-firm chooses to divest

A C-firm will spin off one division if and only if $\Pi_c^* < \Pi_{cs}^*$ and $\Pi_d^* < \Pi_{cs}^*$, that is,

$$\frac{(\bar{a}-c)^2+\sigma^2}{2(\rho-\theta+k)} < \frac{(\bar{a}-c)^2+(\bar{a}-c-2k)^2+2\sigma^2}{4\rho},$$
$$\frac{(\bar{a}-c)^2}{2(\rho-\theta)} < \frac{(\bar{a}-c)^2+(\bar{a}-c-2k)^2+2\sigma^2}{4\rho},$$

implying

$$(\rho+\theta-k)(\bar{a}-c)^2 + 2(\theta-k)\sigma^2 < (\rho-\theta+k)(\bar{a}-c-2k)^2,$$
$$(\rho+\theta)(\bar{a}-c)^2 < (\rho-\theta)(\bar{a}-c-2k)^2 + 2(\rho-\theta)\sigma^2.$$

A.5 Proof of Propositions

If $\theta \geq k$, the first condition of (15) and the second condition of (13) cannot hold. This makes sense: If synergy among the divisions is strong enough, neither type of the firm would consider external restructuring. Hence, when we discuss conditions in (13) and (15), we need to assume $\theta < k$.

Proof of Proposition 1

When $\boldsymbol{\sigma^2}$ rises, the first conditions in (12) and (13) are more likely to hold, but the second conditions in (12) and (13) depend on the sign of $\boldsymbol{\rho+\theta-k}$. If $\boldsymbol{\rho+\theta>k}$, conditions in (12) are more likely to hold, implying that a D-firm is more likely to carry out internal restructuring; if $\boldsymbol{\rho} + \boldsymbol{\theta} < \boldsymbol{k}$, conditions in (13) are more likely to hold, implying that a D-firm is more likely to carry out external restructuring. Also, when $\boldsymbol{\sigma^2}$ rises, conditions in (14) are less likely to hold, and if $\boldsymbol{\theta} < \boldsymbol{k}$, conditions in (15) are more likely to hold.

When σ^2 drops, conditions in (12) and (13) are less likely to hold, but conditions in (14) are more likely to hold.

Proof of Proposition **2**

If $\boldsymbol{\rho}$ drops, conditions in (12) and (13) are less likely to hold; if $\boldsymbol{\theta} > \mathbf{0}$, conditions in (14) are more likely to hold; and if $\boldsymbol{\theta} < \mathbf{0}$, conditions in (15) are more likely to hold.

For a D-firm, if ρ rises, conditions in (12) are more likely to hold, but for a C-firm, conditions in (14) and (15) are less likely to hold, whereas for conditions in (15) we need to assume $\theta < k$.

Proof of Proposition **3**

When $\boldsymbol{\theta}$ rises, conditions in (12) and (13) are less likely to hold, implying that a D-firm will stay put. However, conditions in (14) are more likely to hold.

When θ drops, conditions in (13) and (15) are more likely to hold.

Proof of Proposition 4

When $\bar{\boldsymbol{a}}$ rises, conditions in (12) are less likely to hold. If $\boldsymbol{\theta} > \mathbf{0}$, conditions in (13) are less likely to hold, but if $\boldsymbol{\theta} < \mathbf{0}$, conditions in (13) are more likely to hold. Furthermore, we have

$$\frac{\partial\left[\frac{\rho+\theta}{\rho-\theta}(\bar{a}-c)^2-(\bar{a}-c-2k)^2-2\sigma^2\right]}{\partial(\bar{a}-c)} = 2\frac{2\theta}{\rho-\theta}(\bar{a}-c)+4k > 0.$$

Hence, conditions in (14) are more likely to hold.

When $\bar{a}$ drops, if $\theta > k$, the second condition in (13) and the first condition in (15) simply cannot hold, and conditions in (12) and (14) are less likely to hold. If $\theta < k$, conditions in (12) are more likely to hold.

Proof of Proposition 5

When $\boldsymbol{k}$ rises, conditions in (13) and (14) are more likely to hold. When $\boldsymbol{k}$ drops, conditions in (12) are more likely to hold.

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TABLE 1 Internal versus external restructuring

	Internal restructuring	External restructuring
D-firm	Conditions (12) $k(\bar{a}-c)^2 < (\rho-\theta)\sigma^2,$ $2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2 > 0$	Conditions (13) $2\theta(\bar{a}-c)^2 < (\rho-\theta)\sigma^2,$ $2(\theta-k)(\bar{a}-c)^2 + (\rho+\theta-k)\sigma^2 < 0$
C-firm	Conditions (14) $k(\bar{a}-c)^2 > (\rho-\theta)\sigma^2,$ $\frac{\rho+\theta}{\rho-\theta}(\bar{a}-c)^2 > (\bar{a}-c-2k)^2 + 2\sigma^2$	Conditions (15) $\frac{\theta-k}{\rho-\theta+k}[(\bar{a}-c)^2+\sigma^2] + 2k(\bar{a}-c-k) < 0,$ $\frac{\rho+\theta}{\rho-\theta}(\bar{a}-c)^2 < (\bar{a}-c-2k)^2 + 2\sigma^2$

Abbreviations: D-firm, decentralized firm; C-firm, centralized firm.

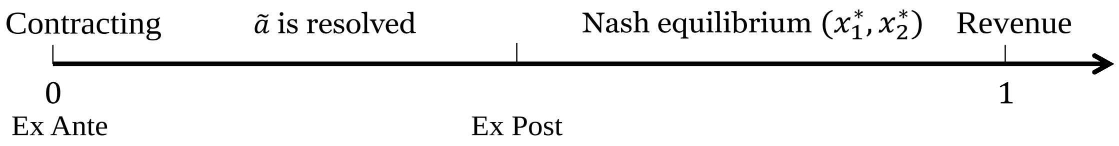

FIGURE 1 Timing of events