Performance Measurement, Compensation Schemes, and the Allocation of Interdependence Effects

Michael Krapp, Wolfgang Schultze, and Andreas Weiler

University of Augsburg, Faculty of Business Administration and Economics, D-86135 Augsburg
{quantitative-methoden|wpc}@wiwi.uni-augsburg.de

1 Introduction

In practice, firms often exhibit divisionalized structures in which headquarters delegate decision rights to divisional managers. In this paper, we examine the problem of allocating interdependence effects stemming from interdivisional trade. For this, we analyze a model in which a divisionalized firm contracts with two managers to operate their divisions and to make relationship-specific investment decisions. Contracts can be based on both divisional profits and hence depend on the allocation of interdependence effects. In line with transfer pricing literature, we discuss a centralized as well as a decentralized setting with respect to the allocation authority.

Issues of mechanism design concerning divisional trade are extensively discussed in the literature.[1] Most related to our paper is [1] which shows that profit sharing induces managers to make first-best investment decisions in a decentralized setting. However, profit sharing imposes extra risk on the managers and therefore may not be optimal. Our paper extends the analysis of [1] by incorporating moral hazard problems with respect to investment decisions. Further, we distinguish between different organizational designs.

[1] Cf., for instance, [1], [2], [3], [4], [6], and [7]. With respect to relation-specific investments, it was shown that negotiated transfer prices result in efficient trade as long as information is symmetric between divisional managers. However, this does not imply first-best investment decisions in general. Edlin/Reichelstein [5] show that efficient investment decisions are attainable when both managers can commit to contracts prior to making their investment decisions. However, in line with [1], we assume that not all necessary parameters can be specified in advance.

2 The Model and Benchmark Solution

We analyze the performance measurement problem of a two-divisional firm with a risk-neutral principal, a downstreaming division (division 1), and an upstreaming division (division 2). Both divisional managers are risk-averse and effort-averse with respect to their relationship-specific investment decisions. Further, in line with [3] and [6], we consider a linear-quadratic scenario and adopt the well-known LEN assumptions. Then, division manager i ($i = 1, 2$) strives to maximize $\mathrm{E}(w_i) - \frac{\alpha_i}{2}\mathrm{Var}(w_i) - \frac{1}{2}v_i I_i^2$, where w_i denotes the compensation, α_i the coefficient of risk-aversion, and I_i the relationship-specific investment decision of manager i; v_i measures her effort-aversion. W.l.o.g. we set the reservation utilities of both managers to zero.

We assume that both divisional profits π_i depend on the allocation of the interdependence effect t: $\pi_1 = R(\vartheta, q, I_1) - t - \frac{1}{2}I_1^2 + \varepsilon_1$ and $\pi_2 = t - C(\vartheta, q, I_2) - \frac{1}{2}I_2^2 + \varepsilon_2$, where $R(\vartheta, q, I_1) = (a(\vartheta) - \frac{1}{2}bq + I_1)q$ and $C(\vartheta, q, I_2) = (c(\vartheta) - I_2)q$. Further, $\varepsilon = (\varepsilon_1, \varepsilon_2)$ denotes the vector of noise terms, where $\varepsilon_i \sim N(0, \sigma_i^2)$ and $\mathrm{Cov}(\varepsilon_1, \varepsilon_2) = \varrho\sigma_1\sigma_2$.[2] The variable q denotes the quantity transfered from division 2 to division 1. To avoid trivial solutions, we assume $a(\vartheta) > c(\vartheta)$ for all feasible values of ϑ. The state variable ϑ can be observed ex post (after contracting and making investment decisions) by the division managers only. In contrast, the distribution of ϑ is ex ante common knowledge. For convenience, we assume $\mathrm{Cov}(a(\vartheta), \varepsilon_i) = \mathrm{Cov}(c(\vartheta), \varepsilon_i) = 0$ and $\mathrm{Var}(a(\vartheta)) = \mathrm{Var}(\mathrm{c}(\vartheta)) = \mathrm{Cov}(a(\vartheta), c(\vartheta)) = \sigma_\vartheta^2$.

In line with the LEN model, we restrict our analysis to linear compensation contracts, i.e. $w_i = \underline{w}_i + w_{i1}\pi_1 + w_{i2}\pi_2$. Note that contracts placing equivalent weights on both divisional profits ($w_{ii} = w_{ij}$) implicate profit sharing. Since we aim at studying the allocation of interdependence effects, it is appropriate to distinguish between a centralized and a decentralized setting. Figures 1 and 2 depict the event sequences for both designs. In the centralized setting, central management allocates the interdependence effect by determining t as well as q at date 1 subject to incomplete information w.r.t. ϑ.

In contrast, in the decentralized setting, central management delegates allocation authority as well as the determination of the transfer quantity to the divisions. Here we assume the divisional managers to bargain about the allocation after observing ϑ. Divisional managers are hence able to respond to the realization of the state variable ϑ. Therefore, a

[2] In contrast to [1], we allow for a possible risk interdependence between both divisions.

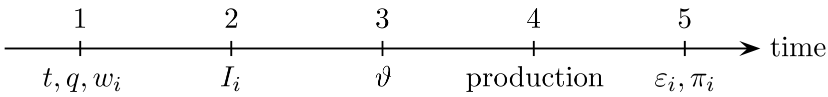

Fig. 1. Sequence of events in the centralized setting

flexibility gain is attained from the perspective of central management.[3] Since information is symmetric between the divisional managers, we re-

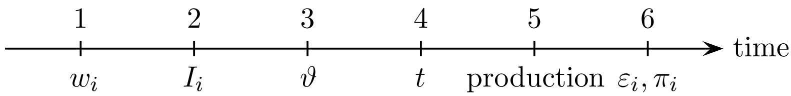

Fig. 2. Sequence of events in the decentralized setting

strict our analysis w.l.o.g. to the case in which both managers possess equal bargaining power and therefore to the Nash bargaining solution:[4]

$$t = \tfrac{1}{2}[q(a(\vartheta) + c(\vartheta) - \tfrac{1}{2}bq + I_1 - I_2) + \varepsilon_1 - \varepsilon_2] \ . \tag{1}$$

Based on the negotiated allocation, the downstreaming division 1 determines the transfer quantity. Provided this allocation mechanism, the divisional profits

$$\pi_i = \tfrac{1}{2}[q(a(\vartheta) - c(\vartheta) - \tfrac{1}{2}bq + I_1 + I_2) + \varepsilon_1 + \varepsilon_2] - \tfrac{1}{2}I_i^2 \tag{2}$$

will be realized at date 6.

Before we examine these settings in detail, we derive some benchmark results by abstracting from agency problems. Then, the efficient trade (given investments I_1 and I_2),

$$\hat{q}(I_1, I_2) \in \arg\max_{q \geq 0} \{R(q, \vartheta, I_1) - C(q, \vartheta, I_2)\} \ , \tag{3}$$

is given by

$$\hat{q}(I_1, I_2) = \frac{a(\vartheta) - c(\vartheta) + I_1 + I_2}{b} \ . \tag{4}$$

Our assumptions assure that $\hat{q}$ is unique and interior for all I_1 and I_2. The firm's investment choice can now be characterized as follows: Let $\hat{I} = (\hat{I}_1, \hat{I}_2)$ denote the vector of efficient investment decisions. Thus, $\hat{I}$ satisfies the condition

[3] However, this advantage is reduced by a control loss, cf. [8].

[4] A similar assumption is made in [1].

$$\hat{I} \in \arg\max_{I_1,I_2} \{\mathrm{E}[R(\hat{q},\vartheta,I_1) - C(\hat{q},\vartheta,I_2)] - \tfrac{1}{2}I_1^2 - \tfrac{1}{2}I_2^2\} \ . \qquad (5)$$

The Envelope Theorem implies that the first-best investments $\hat{I}$ exist and backward induction yields $\hat{I}_i = \mathrm{E}(\hat{q})$.
In the following section, we solve the performance evaluation problem in the context of different mechanism designs.

3 Centralized vs. Decentralized Allocation Authority

We start with the case in which the allocation of the interdependence effect is determined by central management. That is, at date 1, central management fixes the underlying performance evaluation system, the allocation rule t and the transfer quantity q by solving the program

$$\max_{w_i,q,t} (1-w_{11}-w_{21})\mathrm{E}(\pi_1|q,t) + (1-w_{22}-w_{12})\mathrm{E}(\pi_2|q,t) - (\underline{w}_1 + \underline{w}_2) \quad (6)$$

$$\text{s.t.} \ \ I_i \in \arg\max_{\tilde{I}} \{\mathrm{E}_{\vartheta,\varepsilon}(w_i|q,t) - \tfrac{v_i}{2}\tilde{I}_i^2 - \tfrac{\alpha_i}{2}\mathrm{Var}_{\vartheta,\varepsilon}(w_i|q,t)\}, i = 1,2 \quad (7)$$

$$\mathrm{E}_{\vartheta,\varepsilon}(w_i|q,t) - \tfrac{v_i}{2}I_i^2 - \tfrac{\alpha_i}{2}\mathrm{Var}_{\vartheta,\varepsilon}(w_i|q,t) \geq 0, \ i = 1,2 \ , \quad (8)$$

where constraints (7) ensure that the managers' investment choices are incentive compatible and the constraints (8) guarantee the managers their reservation utility. Obviously, the participation constraints hold in equality when choosing an appropriate fixed compensation.
The following proposition summarizes our main results regarding the centralized setting.[5]

Proposition 1 (Centralized Allocation Authority).

i) First-best investment decisions can only be induced if $v_i = 0$.
ii) Investment decisions are independent of t and w_{ij}.
iii) Investment decisions are independent of w_{ii} iff $v_i = 0$ and $w_{ii} \neq 0$.

From the perspective of performance evaluation, there is no need to base w_i also on the profit of division $j \neq i$. Further, note that investment decisions are independent of the allocation t if central management is equipped with allocation authority. Additionally, central management can fix the optimal transfer quantity by backward induction and making use of the Envelope Theorem:

$$q = \frac{\mathrm{E}[a(\vartheta) - c(\vartheta)] + I_1 + I_2}{b + \alpha_1\sigma_\vartheta^2(w_{11} - w_{12})^2 + \alpha_2\sigma_\vartheta^2(w_{22} - w_{21})^2} \ . \qquad (9)$$

[5] We omit the proofs. The authors will provide all proofs upon request.

As a consequence, even under full information, central management will only choose the first-best efficient trade if (i) both agents are risk-neutral ($\alpha_i = 0$) or (ii) by implementing full profit sharing ($w_{ii} = w_{ij}$). Both cases are equivalent. Therefore, profit sharing itself does not provide any incentives for investment decisions, however, it mitigates distortions in q caused by the trade-off between risk sharing and investment incentives.

We now turn to the analysis of the decentralized setting. In this case, central management delegates decision rights to the divisional managers and determines the performance evaluation system by solving the program

$$\max_{w_i}(1 - w_{11} - w_{21})\mathrm{E}(\pi_1) + (1 - w_{22} - w_{12})\mathrm{E}(\pi_2) - (\underline{w}_1 + \underline{w}_2) \quad (10)$$

$$\text{s.t.} \quad q \in \arg\max_{\tilde{q}}\{\mathrm{E}_\varepsilon(w_1) - \tfrac{v_1}{2} I_1^2 - \tfrac{\alpha_1}{2}\mathrm{Var}_\varepsilon(w_1)\} \quad (11)$$

$$I_i \in \arg\max_{\tilde{I}}\{\mathrm{E}_{\vartheta,\varepsilon}(w_i) - \tfrac{v_i}{2} \tilde{I}_i^2 - \tfrac{\alpha_i}{2}\mathrm{Var}_{\vartheta,\varepsilon}(w_i)\}, \; i = 1, 2 \quad (12)$$

$$\mathrm{E}_{\vartheta,\varepsilon}(w_i) - \tfrac{v_i}{2} I_i^2 - \tfrac{\alpha_i}{2}\mathrm{Var}_{\vartheta,\varepsilon}(w_i) \geq 0, \; i = 1, 2\,, \quad (13)$$

where (11) and (12) are the incentive compatibility constraints and (13) are the participation constraints.

Since both divisional managers bargain about the allocation under symmetric information, it is straightforward to see that this bargaining process leads to first-best efficient trade $\hat{q}(I)$ given investments I. The following proposition states our results for the decentralized setting.

Proposition 2 (Decentralized Allocation Authority).

i) Divisional managers will always make efficient trade decisions if the allocation is based on a bargaining process under symmetric information.

ii) Investment decisions depend on the expected allocation process and are first-best iff $v_i = 0$ and a full profit sharing policy is applied.

These results are in line with [1] if we abstract from moral hazard issues. However, from an optimal contracting perspective, a firm-wide performance evaluation system imposes extra risk on the managers. In contrast to the centralized setting in which central management is able to trade-off risk sharing and to control investment decisions by fixing trade quantities, central management looses degrees of freedom to solve this problem within a decentralized setting. On the other hand, divisional managers are able to directly respond to the realization of the state variable. Hence, a flexibility gain is attained.

4 Concluding Remarks

We have shown that the allocation process for interdependence effects between divisions usually cannot be substituted by performance evaluation systems. In centralized settings, however, allocation processes and fixed payments interact. Then, central management can allocate the interdependence effect in order to influence decision making and adjust the divisional managers' compensations accordingly. Furthermore, we have shown that the design of optimal performance evaluation systems essentially depend on the underlying allocation authority.

Our results suggest that different allocation procedures (given optimal performance evaluation systems) dominate each other depending on certain conditions. In particular, these are the disutilities of effort, the variance of the state parameter, the parameters of risk-aversion of the managers, and the risk interdependence between both divisions. Further analyses concerning these issues are on our research agenda.

References

1. Anctil MA, Dutta S (1999) Negotiated transfer pricing and divisional vs. firm-wide performance evaluation. Accounting Review 74:87–104
2. Baldenius T (2000) Intrafirm Trade, Bargaining Power, and Specific Investments. Review of Accounting Studies 5:27–56
3. Baldenius T, Reichelstein SJ (1998) Alternative Verfahren zur Bestimung innerbetrieblicher Verrechnungspreise. Zeitschrift für betriebswirtschaftliche Forschung 50:236–259
4. Baldenius T, Reichelstein SJ, Sahay SA (1999) Negotiated versus cost-based transfer pricing. Review of Accounting Studies 4:67–91
5. Edlin AS, Reichelstein SJ (1995) Specific investment under negotiated transfer pricing: An efficiency result. Accounting Review 70:275–291
6. Pfeiffer T (2003) Corporate-Governance-Strukturen interner Märkte. Deutscher Universitäts-Verlag, Wiesbaden
7. Pfeiffer T, Wagner J (2007) Die Rekonstruktion interner Märkte, das Dilemma der pretialen Lenkung und spezifische Investitionsprobleme. Zeitschrift für betriebswirtschaftliche Forschung 59:958–981
8. Williamson OE (1985) The economic institutions of capitalism. Free Press, New York