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Abstract

We study interfirm price competition in the presence of horizontal and vertical intrafirm conflicts in each firm. Intrafirm conflicts are captured by a principal-agent framework with firms employing more than one agent and implementing a tournament incentive scheme. The principals offer premium incentives in the sense of revenue shares to which agents react by proposing a sales price. Introducing such intrafirm conflicts results in higher prices and lower effort levels. Increasing the number of agents lowers the optimal surplus share of the agents as well as the individual effort and the sales prices. Firm profits first increase and then decrease when employing more and more agents suggesting that principals should employ an intermediate number of agents.

Keywords: Price competition; Agency theory

JEL Classification: C72, L22, M52

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1 Introduction

Whereas principal-agent theory typically restricts itself to the analysis of intrafirm conflicts by neglecting interfirm competition, most of the theoretical IO literature focusses purely on interfirm competition by assuming a unitary firm decision maker. While studying only one of these two basic conflicting lines, intrafirm or interfirm conflicts, will certainly be enlightening for the analysis of many questions, in some cases it may suggest questionable implications concerning real-world behavior where both conflicting lines usually coexist. For instance, neglecting interfirm competition in a simple principal-agent framework (the LEN-model, see e.g. Spreemann 1987 and Hart, Holmström 1987) will typically suggest a generally positive relationship between CEO-earnings and firm performance. In the real world, however, interfirm competition on the markets for top managers may lead to a situation where a low-performing firm has to pay a lot in order to recruit a high-level CEO with the potential to help the firm out of its crisis. Moreover, a generally positive relationship between firm performance and CEO pay is also questioned by empirical studies (see, e.g. Jensen, Murphy 1990). Similarly, assuming a unitary decision maker in IO models of interfirm competition may miss the decisive reason why firms abstain from profit maximization.

Of course, one may assume that principals are the only ones who are concerned about both, intrafirm and interfirm conflicts. If principals, for instance, confront their agents with piece rates, all what their agents will have to do is to match their efforts with the given piece rates, i.e., there is neither a conflict between the agents in a single firm nor between those working in different firms. In our paper, we do not only burden the principals with the coexistence of intrafirm conflicts and interfirm competition, but also the agents. In our analysis, principals first determine the incentive schemes for their agents who then determine their firm's sales policy. Hence, there is strategic interaction within and between firms also on the second stage. Thus principals, when determining the incentive schemes, must be aware of the fact that their agents are competing with fellow agents as well as with colleagues in competing firms.

Our analysis is related to the studies of Vickers (1985), Fershtman, Judd (1987) as well as Sklivas (1987) who discuss the optimal intrafirm incentives for managers in a situation of interfirm quantity or price competition respectively. Kräkel (2005) further regards tournament-like interfirm competition in a principal- (one) agent framework. To the best of our knowledge, however, only Güth, Pull, Stadler (2010) avoid the restriction to one principal and one agent in each firm. Whereas Güth,

Pull, Stadler (2010) analyze a homogeneous oligopoly market with quantity competition, we are concerned with a heterogeneous duopoly market with price competition. In our view, quantity competition can either be justified by special institutional arrangements like commodity exchanges or be interpreted as a shortcut of analyzing more complex market decision processes involving capacities, e.g. in the sense of Kreps, Scheinkman (1983), or as an approximation of price competition of heterogeneous markets. In the latter sense the present study explores the "continuity" when modeling and analyzing intra- and interfirm conflicts either by quantity or price competition on more or less heterogeneous markets.

The remainder of this paper is structured as follows: Section 2 describes the benchmark case without intrafirm conflict. Section 3 adds intrafirm conflicts to study the combined effects of interfirm competition and intrafirm conflicts. Section 4 concludes and compares our results with the related literature.

2 The Benchmark Case: Price Competition in Duopoly

We restrict ourselves to the case of two competing firms $i = 1, 2$ in a heterogeneous market with firm specific sales amounting to $q_i = \sum_k e_{i,k},\ i = 1, 2;\ k = 1, ..., n$, where $e_{i,k}$ denotes the effort level of worker k employed in firm i. Sales are assumed to serve demand for the differentiated products. To make the model analytically tractable, we further assume linear demand functions of the form

$$q_i(p_1, p_2) = 1 - 2p_i + p_j \quad i = 1, 2,\ i \neq j$$

for the two substitute goods. Effort costs are private costs of each agent, but commonly known. For simplicity, let all agents have the same quadratic effort cost function

$$c(e_{i,k}) = e_{i,k}^2/2\ .$$

To provide a benchmark solution without intrafirm conflict, we first assume that both firms maximize their firm surplus, i.e. we assume a unitary decision maker for each firm who could dictate effort levels and possibly compensate the firm's n workers for their effort costs by fixed wages. Due to the strictly convex cost function each firm will do so by imposing the same effort level e_i for all its n workers. Thus the surplus of each firm can be expressed by

$$S_i(p_i, p_j) = p_i(1 - 2p_i + p_j) - (1 - 2p_i + p_j)^2/(2n); \quad i = 1, 2,\ i \neq j.$$

From the first-order conditions the equilibrium benchmark solution without intrafirm conflicts can be derived as

$$p^* = \frac{n+2}{3n+2}$$

and

$$S^* = \frac{2n(n+1)}{(3n+2)^2} \, .$$

Some numerical calculations are summarized in Table 1. All outcome variables react monotonically to an increasing number n of employees in each firm. Prices decrease, individual efforts converge to 0, and the sales amounts and surplus levels increase.

n	1	2	3	...	100	...	$n \to \infty$
p^*	0.600	0.500	0.455	...	0.338	...	0.333
q^*	0.400	0.500	0.555	...	0.662	...	0.667
e^*	0.400	0.250	0.185	...	0.007	...	0.000
S^*	0.160	0.188	0.198	...	0.221	...	0.222

Table 1: Results in the case of only interfirm competition.

3 Introducing Intrafirm Conflicts

Rather than assuming that all members (principal and agents) of each firm i are interested in maximizing firm surplus, we now include vertical and horizontal intrafirm conflicts and hence analyze both, strategic interactions within firms as well as between firms. In order to demonstrate the combined effects of intrafirm and interfirm competition, we assume that principals share revenues with their agents. Let s_i denote the revenue share for the whole labor force of a firm. Thus each of the agents, $k = 1, ..., n$, employed by firm $i = 1, 2$ earns

$$\begin{aligned} U_{i,k}(p_{i,k}) &= s_i p_{i,k} q_i(p_{i,k}, p_{j,\ell})/n - q_i(p_{i,k}, p_{j,\ell})^2/(2n^2) \\ &= s_i p_{i,k}(1 - 2p_{i,k} + p_{j,\ell})/n - (1 - 2p_{i,k} + p_{j,\ell})^2/(2n^2), \end{aligned}$$

where $p_{i,k}$ ($p_{j,\ell}$) is the price suggestion made by agent $k(\ell)$ in firm i (j). While it may appear unusual that agents choose prices, this corresponds to the usual assumption in the case of quantity competition where agents via their effort choices determine

their firm's sales quantity and hence their firms' market policy.[1] In principle, in case of $n > 1$, different agents $k = 1, ..., n$ in firm i could propose different prices $p_{i,k}$. Due to their symmetry, however, this does not occur in case of general optimality on which our analysis is based. Off the equilibrium play one could impose that p_i is given by the minimal price $p_{i,k}$, i.e. the most aggressive price proposal or by the maximal $p_{i,k}$ yielding the smallest effort level.

Maximization of $U_{i,k}$ with respect to the price $p_{i,k}$ and solving for the equilibrium price choices yields

$$p_i = \frac{12 + 6ns_i + 10ns_j + 5n^2 s_i s_j}{12 + 14ns_i + 14ns_j + 15n^2 s_i s_j}; \quad i = 1, 2,\ i \neq j,$$

for all agents in the second stage as functions of the incentive constellation (s_i, s_j), chosen by the two principals on the first stage. Anticipating the equilibrium effort, the profit functions of the two principals are given by

$$\begin{aligned}\pi_i(s_1, s_2) &= (1 - s_i)p_i q_i \\ &= N/(12 + 14ns_i + 14ns_j + 15n^2 s_i s_j)^2, \quad i = 1, 2,\ i \neq j,\end{aligned}$$

where $N = 2n(72s_i + 36ns_i^2 + 120ns_i s_j + 60n^2 s_i^2 s_j + 50n^2 s_i s_j^2 + 25n^3 s_i^2 s_j^2 - 72s_i^2 - 36ns_i^3 - 120ns_i^2 s_j - 60n^2 s_i^3 s_j - 50n^2 s_i^2 s_j^2 - 25n^3 s_i^3 s_j^2)$.

The first-order condition for maximizing $\pi_i(s_1, s_2)$ with respect to $s_i,\ i = 1, 2$, and the obvious symmetry of the solution imply a polynomial equation for each number $n = 1, 2, ...$ of a firm's agents, namely $s^{**} = s^{**}(n) \in (0, 1)$ implying the identical prices

$$p^{**} = \frac{12 + 16ns^* + 5n^2 s^{*2}}{12 + 28ns^* + 15n^2 s^{*2}},$$

demand levels $q_i(p^{**}, p^{**}) = q^{**}$ with

$$q^{**} = \frac{12ns^* + 10n^2 s^{*2}}{12 + 28ns^* + 15n^2 s^{*2}},$$

and effort levels $e_{k,i} = e^*$ for $k = 1, ..., n$ and $i = 1, 2$ with

$$e^{**} = \frac{12s^* + 10ns^{*2}}{12 + 28ns^* + 15n^2 s^{*2}}.$$

[1] If we think of agents as being high-level managers the assumption that they determine prices is of course rather intuitive and natural.

Finally, firm profits are given by

$$\pi^{**} = (1 - s^{**})p^{**}q^{**}.$$

Table 2 illustrates how the solution $(s^{**}, e^{**}, p^{**}, q^{**}, \pi^{**})$ depends on the number $n = 1, 2, ...$ of agents employed by each duopoly seller. Interestingly, the variables in the upper four rows of Table 2 react monotonically to a rise in n with s^{**}, p^{**}, q^{**} and e^{**} increasing in n whereas π^{**} depends on n in a hump-shaped fashion with π^{**} first increasing and then decreasing in the number of agents.

n	1	2	3	...	100	...	$n \to \infty$
s^{**}	0.363	0.363	0.259	...	0.040	...	0.000
p^{**}	0.765	0.652	0.641	...	0.429	...	0.333
q^{**}	0.235	0.348	0.359	...	0.571	...	0.667
e^{**}	0.235	0.174	0.120	...	0.006	...	0.000
π^{**}	0.115	0.145	0.171	...	0.235	...	0.222

Table 2: Solution results with intrafirm and interfirm competition.

A comparison of the results with those of the benchmark case shows that the inclusion of intrafirm conflicts results in higher prices and lower effort levels. Whereas the popular single decision maker framework, based on firm specific surplus maximization, suggests to employ more and more workers in order to lower the marginal costs of effort, additionally capturing intrafirm conflicts first also encourages such attempts but then induces principals to limit their labor force. Thus, even in the case of huge labor supply, principals would refrain from hiring all workers what provides a novel justification of natural unemployment, namely one based on the coexistence of intra- and interfirm conflicts for heterogenous oligopoly markets.

4 Conclusion

Why did we care to extend our analysis for homogeneous markets with sales competition to heterogeneous markets with price competition? Except for special institutions like commodity exchanges, homogeneous markets with sales competition are at best a border case of heterogeneous markets with price competition. One may even argue that such markets should not be considered directly but rather via studying heterogeneous markets with price competition and taking the limit when heterogeneity vanishes (see Brennen, Güth, Kliemt 2008 for a general discussion of such an approximative truth principle). In many markets, at least restricted

price choices by agents are usual. The argument that modeling price competition by agents is rather unusual in agency theory does not question our study but the continuity between the analysis of homogeneous and heterogeneous markets. What seems so obvious for the homogeneous market should be even more reasonable for the heterogeneous market. Either agents can influence their firm's sales strategy, regardless of whether the market is homogeneous or heterogeneous, or not.

Here, as in our earlier study, we have assumed the former and as a matter of fact performed a complementary analysis of intra- and interfirm conflicts for heterogeneous markets. If this appears to be a somewhat strange exercise, one must ask: do we want to deny that agents can influence their firm's sales strategy? If not, the next question would be: are there more adequate models for capturing intrafirm and interfirm conflicts on heterogeneous markets with price competition?

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