CROSS-FIRM REAL EARNINGS MANAGEMENT

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Cross-firm real earnings management*

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Abstract: There is ample empirical evidence documenting that stockholders can learn about the fundamental value of any particular firm from observing the earnings announcements of other firms that operate in the same industry. We argue that such intra-industry information transfers may motivate managers to mislead stockholders about the value of their firm not only by manipulating their own earnings report but also by influencing the earnings reports of rival firms. Managers obviously do not have access to the accounting system of peer firms, but they can nevertheless influence the earnings reports of rival firms by distorting real transactions that relate to the product market competition. We demonstrate such managerial behavior, which we refer to as cross-firm real earnings management, and explore its potential consequences within an industry setting with imperfect (non-proprietary) accounting information. Our analysis interestingly suggests that the practice of cross-firm real earnings management, although involving the distortion of real production decisions in the direction that promotes stock prices at the expense of economic profits, may nevertheless increase the firms' fundamental value in equilibrium.

Keywords: accounting; financial reporting; earnings management; real earnings management; non-proprietary information; product market competition; managerial myopia.

JEL classification: D82, M41, M43.

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1. Introduction

Our study is rooted in the observation that stockholders can learn about the fundamental value of any particular firm from observing the earnings announcements of other firms that operate in the same industry. For instance, favorable earnings announcement of a certain firm may allude to a reduction in the market share of its rivals or may alternatively reflect some industry-wide shock, such as an increase in the consumer demand or a decrease in the input prices, which is likely to affect favorably all firms in the industry. There is ample empirical evidence documenting that stock prices indeed reflect such intra-industry information transfers (e.g., Foster, 1981; Han, Wild, and Ramesh, 1989; Han and Wild, 1990; Freeman and Tse, 1992; Lang and Lundholm, 1996; Ramnath, 2002; Thomas and Zhang, 2007; Kim, Lacina and Park, 2008). Therefore, capital markets concerns of managers may induce them to mislead stockholders about the value of their firm not only by managing their own earnings report but also by influencing the earnings reports of rival firms. Managers obviously do not have access to the accounting system of peer firms, but they can nevertheless influence the economic profits of rival firms, and thereby also their earnings reports, by distorting real transactions that relate to the product market competition. So, while the target of earnings management is conventionally perceived in the literature as being the accounting report of the managers' own firm (e.g., Dye, 1988; Stein, 1989; Arya, Glover and Sunder, 1998; Fischer and Verrecchia, 2000; Kirschenheiter and Melumad, 2002; Fischer and Stocken, 2004; Demski, 2004; Ewert and Wagenhofer, 2005; Guttman, Kadan, and Kandel, 2006; Einhorn and Ziv, 2012; Amir, Einhorn and Kama, 2014), we draw attention to another practice of earnings management, which aims to influence the reported earnings of other firms.[1] We refer to this practice as cross-firm real earnings management.

We demonstrate the potential for the practice of cross-firm real earnings management to exist and study its consequences within a Cournot competition game between two firms that operate in the same product market and their stocks are publicly traded in the same capital market. Managers in this game are

[1] See Ewert and Wagenhofer (2012) for a recent survey of the earnings management literture.

myopic in the sense that they care not only about the long-term fundamental value of their firms but also about the short-term price of their stock, as determined by the capital market investors based on the content of noisy accounting earnings reports that the two firms release after their profits are set in the product market. The production decisions serve in our setting as the vehicle through which the two managers carry out their real activities of cross-firm earnings management. Consistent with the conventional perception that real earnings management requires incomplete information about the underlying real action (e.g., Stein, 1989), the production decisions of the managers are assumed unobservable to the capital market investors. In equilibrium, both managers distort the production levels relative to the benchmark set by the classical setting of Cournot competition. Such real distortions in production emerge in equilibrium even though information in our model is non-proprietary in nature, as it is released to the markets after profits have already been determined.[2] They are thus not triggered by product market considerations of the managers, but rather stem from their capital market concerns.

To understand our results, it should be noted that, although investors in the capital market can rationally form expectations for the production quantities of the two firms and the implied retail price of their products in equilibrium, they cannot perfectly deduce the resulting profits of the firms, as those are additionally subject to various business shocks. The accounting reports of the two firms serve investors to imperfectly resolve their uncertainties about these business shocks and thereby allow them to more accurately evaluate the firms and price their stocks. As the two competing firms are likely to face correlated business shocks, and since the accounting earnings report of each firm only noisily reflects its true profit, the investors price the stocks of each firm based not only on its own accounting report but also on the basis of the accounting report of the rival firm. This motivates the two managers to distort their production decisions in order to affect the accounting earnings report of the rival firm (via the effect on its economic

[2] For studies that demonstrate direct consequences of proprietary accounting information on the competition between firms in the product market see, for example, Dontoh (1989), Darrough and Stoughton (1990), Wagenhofer (1990), Feltham and Xie (1992), Darrough (1993), Arya, Frimor and Mittendorf (2010), Bagnoli and Watts (2010).

profit) and thereby mislead the capital market investors about the value of their own firm.[3] Taking the conjectures of the investors as fixed, the myopic managers in our model end up in distorting production even though they know that they cannot fool the capital market in equilibrium. This result is consistent with Stein (1989). Here, however, despite the fact that, from the narrow perspective of the firm's value, the myopic managers choose sub-optimal production levels, we show that the equilibrium expected values of the firms might nevertheless increase with managerial myopia.

When the profits of the two firms are subject to positively correlated business shocks (e.g., fluctuations in downstream consumer demand or in upstream input prices), the market price of each firm positively responds to the earnings report of the rival firm. The manager of each firm thus obtains an added cross benefit from a high profit of the rival firm, which induces him/her to compete less aggressively, cutting back on his/her production level. Interestingly, despite the seemingly altruist willingness of the managers to cut the profit of their own firm in order to increase the profit of the rival firm, the two firms may nevertheless end up with higher profits in equilibrium as a result of the reduction in the aggressiveness of the product market competition. This suggests that myopic preferences of managers, which bring capital market considerations into their production choice, may serve as an effective commitment device to create collaboration between competing firms, which eventually results in lower quantities of production and higher profits.[4] In extreme cases where the two firms confront highly correlated business shocks and their managers are highly myopic, the collaboration may be so profound that the two firms essentially behave like a monopoly and divide the monopolist profit between them. The increment in the aggregate profit in the industry due to reduction in the aggressiveness of the competition

[3] Our model therefore points to the role of capital market concerns of managers in implicitly causing them to be concerned not only about their own reported performance but also about the reported performance of their rivals, even when relative performance measures are not expilicitely employed in the managerial compensation contract. These inherent relative-performnce concerns of managers, which naturally arise from their capital market concerns, should be thus taken into considration when desiging relative-performance compensation contracts of managers.

[4] The literature points to several other commitement devices employed by firms to shape their aggresiveness in the product market competition, such as capital investment (e.g., Dixit, 1980), financial leverage (e.g., Brander and Lewis, 1986) and managerial compensation contracts (e.g., Aggarwal and Samwick, 1999; Miller and Pazgal, 2001).

is, however, not necessarily equally divided between the individual firms. This is because managers might vary in their myopic preferences. When the levels of myopia of the two managers do not differ a lot, each firm receives benefit from the myopia of the rival manager, which compensates for the cost imposed by the myopic behavior of its own manager. Consequently, the two firms share the increment in their aggregate profit, though the firm with the less myopic manager takes a larger share. On the other hand, when there is a considerable difference in the myopia levels of the managers, the cross-firm real earnings management activities of the two managers work to increase only the profit of the firm with the less myopic manager while decreasing the profit of the other firm.

Opposite equilibrium outcomes arise from the model in circumstances where the firms face negatively correlated business shocks (e.g., fluctuations in the market share of the two firms). Here, the market price of each firm responds negatively to the earnings report of the rival firm. So, the manager of each firm obtains added cross benefit from a low profit of the rival firm, which urges him/her to compete more aggressively and increase the production level above the otherwise optimal level. This works to lower the aggregate profit of the firms. At the extreme, when the two firms face business shocks with extremely negative correlation and their managers are highly myopic, the competition between them becomes so aggressive that their profits converge to zero. The decline in the aggregate profit in the industry due to the increase in the aggressiveness of the product market competition does not necessarily apply equally to both firms, unless their managers are equally myopic. When the difference in the myopia levels of the two managers is relatively small, the two firms suffer from the decline in their profits, though the firm with the less myopic manager (who draws back and concedes market share to the more aggressive rival) incurs a larger cost. Otherwise, the cross-firm real earnings management activities of the two managers work to decrease only the profit of the firm with the less myopic manager while increasing the profit of the other firm.

While the direction of the distortion in the product market equilibrium outcomes from those of the classical Cournot competition depends on whether the two firms face positively or negatively correlated business shocks, the magnitude of the distortion is determined by the absolute value of the correlation between the business shocks. The greater is the correlation between the business shocks that the two firms confront, in absolute terms, the stronger is the response of the stock price of each firm to the accounting report of the rival firm, and consequently the more salient is the managerial motivation to engage in cross-firm earnings management and the more significant is the resulting distortion in the product market outcomes. The magnitude of the distortion in the product market outcomes is obviously also increasing in the level of managerial myopia. As the managers become more myopic, they care more about the price at which the stocks of their firm are traded in the capital market. This works to enhance their incentives to engage in cross-firm earnings management activities and increase the resulting distortion in their production choice. Two additional important parameters that influence the magnitude of the distortion in the product market outcomes, albeit in a non-monotonic manner, are the extent to which the profits of the firms are exposed to business shocks and the extent to which their accounting system is noisy.

The paper proceeds as follows. The next section describes the model underlying the analysis. Sections 3 and 4 present the equilibrium outcomes that the model yields and discuss their implications. Section 3 sheds light on the variation of cross-firm earnings management across different industries under the premise that firms operating in the same industry are symmetric. Section 4 analyzes the consequences of introducing asymmetry between firms, thereby exploring the variation in cross-firm earnings management within a given industry. The final section summarizes and offers concluding remarks. Proofs appear in the appendix.

2. Model

Our model is designed to demonstrate the effect of capital market concerns of managers on the competition between firms in the product market. It thus depicts a game between two firms, denoted A and

B, which operate in the same product market and their stocks are publicly traded in the same capital market. The managers of the two firms compete in the product market on the quantity of their production, making their production decision in light of the wish to maximize both the profit of their firm and the price at which its stocks are traded in the capital market following earnings announcements. For simplicity, we model the two firms in a symmetric way. We keep the symmetric structure throughout the analysis in Section 3, but later on consider the consequences of introducing asymmetry between the two firms in Section 4. The rest of this section details the parameters and assumptions of the model, which are all assumed to be common knowledge unless otherwise indicated.

The two firms in our model produce and sell the same product. The firms face a Cournot competition, competing on the quantity of units they produce and sell, which they decide on simultaneously and independently of each other.[5] Denoting the number of units produced and sold by each firm i ($i = A, B$) by q_i and assuming a standard linear demand function for the products, we represent the retail price for each unit of product that the firms sell by $p(q_A, q_B) = a - q_A - q_B$, where $a > 0$.[6] In this formulation, the parameter a is the familiar demand intercept that reflects the overall level of demand for the product. The marginal cost of production is assumed to be fixed and identical across firms and is given by the parameter c, where $a > c \geq 0$. To introduce a role for an accounting system, we allow for uncertainty regarding the realized profits of the firms. Thus, given the production quantities q_A and q_B of the two firms, we represent the profit of each firm i ($i = A, B$) by the random variable $\tilde{\pi}_i(q_A, q_B)$, which follows the structure $q_i(p(q_A, q_B) - c) + \tilde{\eta}_i$, where $\tilde{\eta}_i$ captures a business shock and is assumed to

[5] The Cournot competition is employed in our model only as a demonstration of instances where cross-firm earnings management might occur. We note, however, that cross-firm earnings management also arise under other competition structures, like Stackelberg competition or Bertrand competition.

[6] Our results hold qualitatively in a setting with substitute products, in which the retail prices of the products of firms A and B are given by $a - q_A - \gamma q_B$ and $a - \gamma q_A - q_B$, respectively, where $0 < \gamma \leq 1$ is the substitutability coefficient that reflects the degree of competitive intensity between the two products.

be normally distributed with zero mean and variance $\sigma_\eta^2 \in (0,\infty)$.[7] The business shock $\tilde{\eta}_i$ that each firm i ($i = A, B$) faces represents uncertainties about firm-specific prospects, as well as uncertainties about the overall business environment.

We allow the random variables $\tilde{\eta}_A$ and $\tilde{\eta}_B$ to be correlated and denote their covariance by $\rho\sigma_\eta^2$, where $-1 < \rho < 1$ and $\rho \neq 0$. The correlation ρ between $\tilde{\eta}_A$ and $\tilde{\eta}_B$, which plays a crucial role in our analysis, is allowed to be either positive or negative. We only preclude from the model the case of $\rho = 0$, where the profits of the two firms are subject to uncorrelated business uncertainties, which is clearly a less likely case for firms operating in the same industry. Positive values of ρ capture situations where the two firms face common shocks in upstream input prices or in downstream consumer taste, such as the increase in consumer demand for smart-phones, the fall in consumer demand for non-digital cameras at the turn of the century, or the sharp rise in internet backbone capacity in the late l990s. Negative values of ρ, on the other hand, might arise from fluctuations in the market share of the two firms due to firm-specific shocks attributable to the effectiveness of marketing campaigns, deficiencies in production processes, quality of management teams and so forth. Since it is reasonable to assume that in reality business uncertainties arise both from industry-wide shocks that are common to all firms in a given industry and from firm-specific shocks that alter the competition for market share between firms in the industry, the correlation ρ can be seen as reflecting the net effect of these uncertainties.

After the production quantities are determined in the product market, but before the profits are realized and distributed as a liquidating dividend to stockholders, both firms mandatorily provide the capital market with their accounting earnings report. The earnings report of each firm i ($i = A, B$), denoted r_i, is modeled as the realization of a noisy estimator of the profit variable $\tilde{\pi}_i(q_A, q_B)$, which takes

[7] Our results hold qualitatively when the business shock stems from uncertainty regarding the demand intercept a or the production cost c. This alternative modeling choice, however, makes the analysis less tractable and introduces more complexity into the exposition of the results.

the form $\tilde{\pi}_i(q_A, q_B) + \tilde{\varepsilon}_i$, where $\tilde{\varepsilon}_i$ is an independent normally distributed random variable with zero mean and variance $\sigma_\varepsilon^2 \in (0, \infty)$. The random variable $\tilde{\varepsilon}_i$ depicts the noise in the accounting system, whereas the extent to which the accounting system is noisy is captured by the parameter σ_ε^2. To emphasize our focus on cross-firm earnings management, we preclude from the model any managerial discretion in the process of accounting measurement and reporting.[8] Accounting information in our model is non-proprietary, because it is reported after the two firms have already chosen their production level. The only role that the accounting reports of the two firms serve in our model is in assisting the capital market investors to better evaluate and price the firms' equity.

Even though the production quantity of each firm is observable only to its manager, in equilibrium the investors rationally infer the production quantities of the two firms and the implied retail price of their products. They are, nevertheless, incapable of perfectly deducing the profits of the firms, as those are additionally subject to the business shocks $\tilde{\eta}_A$ and $\tilde{\eta}_B$. The earnings reports thus help them to imperfectly estimate the extent to which the business shocks have affected the profits of the two firms. The investors are assumed to be risk neutral. Accordingly, they set the market equity price of each firm equal to their expectations regarding the firm's profit conditional on all the publicly available information. Since the profits of the two firms are subject to correlated business shocks (i.e., $\rho \neq 0$) and the accounting earnings report of each firm only noisily reflects its profit (i.e., $\sigma_\varepsilon^2 > 0$), the set of information relevant to the investors in pricing each firm includes both the earnings report provided by the firm itself and the earnings report provided by its rival. We accordingly use the functions $P_A, P_B : \Re^2 \to \Re$ to represent the pricing rule of the capital market investors, where $P_i(r_A, r_B)$ is the market price of the equity of firm i ($i = A, B$), given that r_A and r_B are the earnings reports provided by firm A and firm B, respectively.

[8] Our analysis and results can be generalized to the case where the managers exercise discretion in reporting, which allows them to engage in traditional earnings management of biasing their own report, in addition to their real activities of cross-firm earnings management.

While perfect information about the true level of performance normally becomes available to the market in the long run, performance is noisily reported in the financial statement and embedded in equity prices much earlier. We therefore allow the managers to be myopic in the sense that, in addition to their interest in the true performance of their firm, they also care about the firm's stock price as determined by the level of performance reported in the accounting system.[9] This assumption, which has been previously employed by other models (e.g., Einhorn and Ziv, 2007; Langberg and Sivaramakrishnan, 2010), is reasonable in a variety of prevalent situations. This is the case, for example, when managers are compensated based on the stock market price and at the same time are concerned about their future professional reputation. It is also the case when there are different types of shareholders, some needing to sell their holdings quickly and others intending to hold their shares for the long run. Accordingly, we assume that the payoff of the manager of firm i $(i = A, B)$ is given by the weighted average $U_i(P_i(r_A, r_B), \pi_i) = \lambda P_i(r_A, r_B) + (1-\lambda)\pi_i$, which assigns a weight $1-\lambda$ to the firm's true profit π_i and a weight λ to the firm's stock price $P_i(r_A, r_B)$ as determined by the reported earnings of the firm and its rival, where $0 < \lambda \leq 1$. The parameter λ represents the level of managerial myopia.[10] The assumption that managers are myopic to some extent (i.e., $\lambda > 0$) is critical to our analysis as it brings capital market considerations into managers' production choice.

[Figure 1]

Figure 1 provides a timeline depicting the sequence of events in the model. It follows from the timeline that equilibrium in the model consists of the two production decisions, q_A and q_B,

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[9] Studies that analyze product market competition under managerial myopia conventionally assume that managers are myopic in the sense that they promote current profits at the expense of future profits. In our model, the myopia of managers stems from their capital market concerns, which induce them to promote stock prices at the expense of economic profits.

[10] To keep the exposition simple, we assume a homogenous level of myopia for the two managers throughout our main analysis in Section 3. We, however, extend our analysis to consider the consequences of heterogeneity in the managerial myopia in Section 4.

simultaneously made in the product market by the managers of the two firms, and the two subsequent pricing rules, $P_A, P_B : \Re^2 \to \Re$, applied by the investors in the capital market with respect to the equity of the two firms. We look for a Bayesian equilibrium, in which all players make optimal decisions that maximize their utility on the basis of all their available information, as well as their rational expectations about the strategic behavior of all other players, utilizing Bayes' rule to make inferences and update their beliefs. Denoting by $\hat{q}_A$, $\hat{q}_B$ and $\hat{P}_A, \hat{P}_B : \Re^2 \to \Re$ the conjectures of the players about q_A, q_B and $P_A, P_B : \Re^2 \to \Re$, respectively, any Bayesian equilibrium ($q_A, q_B, P_A, P_B : \Re^2 \to \Re$) must satisfy the following five conditions for any levels of reported earnings $r_A, r_B \in \Re$:

(i) $$q_A \in \underset{q_A \geq 0}{\arg\max}\, \mathrm{E}\Big[U_A\Big(\hat{P}_A(\tilde{\pi}_A(q_A, \hat{q}_B) + \tilde{\varepsilon}_A, \tilde{\pi}_B(q_A, \hat{q}_B) + \tilde{\varepsilon}_B)\ ,\ \tilde{\pi}_A(q_A, \hat{q}_B)\Big)\Big]$$

(ii) $$q_B \in \underset{q_B \geq 0}{\arg\max}\, \mathrm{E}\Big[U_B\Big(\hat{P}_B(\tilde{\pi}_A(\hat{q}_A, q_B) + \tilde{\varepsilon}_A, \tilde{\pi}_B(\hat{q}_A, q_B) + \tilde{\varepsilon}_B)\ ,\ \tilde{\pi}_B(\hat{q}_A, q_B)\Big)\Big]$$

(iii) $$P_A(r_A, r_B) = E\left[\tilde{\pi}_A(q_A, q_B) \,\middle|\, \tilde{\pi}_A(\hat{q}_A, \hat{q}_B) + \tilde{\varepsilon}_A = r_A\ ,\ \tilde{\pi}_B(\hat{q}_A, \hat{q}_B) + \tilde{\varepsilon}_B = r_B\right]$$

(iv) $$P_B(r_A, r_B) = E\left[\tilde{\pi}_B(q_A, q_B) \,\middle|\, \tilde{\pi}_A(\hat{q}_A, \hat{q}_B) + \tilde{\varepsilon}_A = r_A\ ,\ \tilde{\pi}_B(\hat{q}_A, \hat{q}_B) + \tilde{\varepsilon}_B = r_B\right]$$

(v) $\hat{q}_A = q_A$, $\hat{q}_B = q_B$, $\hat{P}_A(r_A, r_B) = P_A(r_A, r_B)$ and $\hat{P}_B(r_A, r_B) = P_B(r_A, r_B)$.

Conditions (i) and (ii) pertain to the simultaneous production decisions of the two managers. According to these two conditions, each manager chooses the production quantity that maximizes his/her expected utility, utilizing his/her rational expectations about the simultaneously chosen production quantity of the rival manager and about the forthcoming pricing rule applied by the capital market investors. Conditions (iii) and (iv) describe the pricing rule applied by the capital market investors subsequent to the earnings announcements of the firms. They require the risk-neutral investors to set the market equity price of each firm to be equal to their expectations about the firm's profit based on all the publicly available information, which includes the earnings announcements of the two firms, and utilizing their rational conjectures about the managers' production quantities. The fifth, and last, equilibrium condition is that all players have rational expectations regarding each other's behavior.

3. *Equilibrium Analysis*

We derive the interrelated equilibrium outcomes in the product market and the capital market using backward induction. We start with the capital market and derive the pricing functions applied by the investors under the assumption that the production levels for the two firms in the product market are exogenously given. We then move backward to the product market and derive the managers' optimal production quantities. Along this tack, Lemma 1 presents the pricing functions $P_A, P_B : \Re^2 \to \Re$ applied by the capital market investors in a sub-game given their conjectures about the production quantities q_A and q_B of the two firms.

LEMMA 1. *In the sub-game subsequent production, with conjectured production quantities* $\hat{q}_A$ *and* $\hat{q}_B$, *for any* $i, j \in \{A, B\}$ *such that* $i \neq j$, *the pricing function* $P_i : \Re^2 \to \Re$ *applied by the capital market investors takes the following form:* $P_i(r_A, r_B) = \mu_i + \alpha\,(r_i - \mu_i) + \beta\left(r_j - \mu_j\right)$, *where* $\mu_i = \hat{q}_i(a - \hat{q}_A - \hat{q}_B - c)$,

$\alpha = \dfrac{\varphi + (1-\rho^2)\varphi^2}{1 + 2\varphi + (1-\rho^2)\varphi^2}$, $\beta = \dfrac{\rho\varphi}{1 + 2\varphi + (1-\rho^2)\varphi^2}$ *and* $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$.

In the presence of business uncertainties (as captured by our assumption that $\sigma_\eta^2 > 0$), the capital market investors cannot precisely infer the firms' profits, $\tilde{\pi}_A(q_A, q_B) = q_A(a - q_A - q_B - c) + \tilde{\eta}_A$ and $\tilde{\pi}_B(q_A, q_B) = q_B(a - q_A - q_B - c) + \tilde{\eta}_B$, despite their rational expectations about the firms' optimal production quantities, q_A and q_B. They thus find the accounting system useful. However, due to the imprecision of the accounting system (as captured by our assumption that $\sigma_\varepsilon^2 > 0$), the investors consider the accounting report of each firm only as a noisy estimator of its underlying true profit. The accounting report of the rival firm may serve them as an additional noisy estimator, provided that the profits of the two firms are subject to correlated business uncertainties (as captured by the assumption $\rho \neq 0$). Therefore, as formally stated by Lemma 1, not only does the market price of each firm respond to its own reported earnings, it also responds to the reported earnings of its rival. The pricing coefficient α captures the extent to which the stock price of each firm relies on its own earnings report. The pricing coefficient β captures the extent to which the stock price of each firm relies on the earnings report of the rival firm. While the market price of each firm always positively responds to its own earnings report (i.e., $\alpha > 0$), it might either positively (i.e., $\beta > 0$) or negatively (i.e., $\beta < 0$) respond to the earnings report of the rival firm, depending on whether $\rho > 0$ or $\rho < 0$. The magnitude of the correlation ρ is also an important determinant underlying the pricing procedure of investors. It immediately follows from Lemma 1 that, the higher the correlation between the business uncertainties of the two firms, in absolute terms, the higher is the absolute value of the pricing coefficient β, the lower is the value of the pricing coefficient α, and the stronger therefore is the reliance of the market price of each firm on the earnings reported by its rival. The pricing coefficients α and β also depend upon the parameters σ_η^2 and σ_ε^2, but in a non-monotonic manner.

The structure of the pricing functions P_A and P_B, as given in Lemma 1, is consistent with extant empirical evidence. Many empirical studies document the response of stock prices to earnings announcements of peer firms (e.g., Foster, 1981; Han, Wild, and Ramesh, 1989; Han and Wild, 1990; Freeman and Tse, 1992; Lang and Lundholm, 1996; Ramnath, 2002; Thomas and Zhang, 2007; Kim, Lacina and Park, 2008). Some of them further shed light on the determinants of the direction of the price response to intra-industry information transfers. In particular, Lang and Lundholm (1996) find that in industries in which industry-wide shocks constitutes the primary source of business uncertainty (as captured in our model by a positive ρ), the relation between a firm's stock price and the reported earnings of other firms in the same industry tends to be positive. On the other hand, in industries where the primary source of uncertainty is firm-specific competitive advantage (as captured in our model by a negative ρ), they find that the relation between a firm's stock price and the reported earnings of other firms in the same industry tends to be negative. Relatedly, Kim, Lacina and Park (2008) find a negative (positive) relation between a firm's stock price and managerial earnings and revenue forecasts of other rival (non-rival) firms in the same industry.

Utilizing our results about the pricing functions applied by the investors in the capital market, as presented in Lemma 1, we now move backward and derive the managers' optimal production strategy in the product market. In making his/her production decision, the manager of each firm cares not only about the firm's true profit, as conventionally assumed in models of product market competition. Being myopic, he/she also cares about the price at which the stocks of the firm are traded in the capital market, knowing that the stock price responds to the reported earnings of the rival firm, as indicated by Lemma 1. Hence, due to their myopic preferences (as captured by the assumption $\lambda > 0$), managers are interested not only in the effect of their production choice on the expected profit of their own firm. They also take into consideration the effect of their production choice on the expected profit of the rival firm. It specifically follows from Lemma 1 that each manager i ($i = A, B$) aims at maximizing a linear combination, $E[U_i] = (\lambda\alpha + 1 - \lambda)\pi_i + \lambda\beta\pi_j$, which assigns a weight $\lambda\alpha + 1 - \lambda$ to the profit π_i of his/her own firm and a weight $\lambda\beta$ to the profit π_j of the rival firm j ($j \neq i$). Equivalently, each manager i chooses the production decision that maximizes $\pi_i + \delta\pi_j$, where $\delta = \dfrac{\lambda\beta}{\lambda\alpha + 1 - \lambda}$ is his/her marginal rate of substitution of the profit π_j of the rival firm for the profit π_i of his/her own firm. The substitution rate δ therefore serves in our analysis as a summary measure that condenses all the relevant information embedded in the modeling parameters ρ, λ, σ_η^2 and σ_ε^2 into a single measure of the manager's preferences over the profit of his/her own firm and that of the rival firm.

Based on Lemma 1, it is easy to see that the substitution rate δ may vary from -1 to $+1$. When δ is positive (negative), the manager is willing to sacrifice $|\delta|<1$ dollars of his/her own profit in order to increase (decrease) the profit of the rival by one dollar. So, while the sign of the substitution rate δ reflects the direction of the managerial incentives for cross-firm real earnings management, its absolute value captures the magnitude of these incentives. The presentation of the substitution rate $\delta=\frac{\lambda\beta}{\lambda\alpha+1-\lambda}$ in terms of the equilibrium pricing coefficients α and β is useful in designing an empirical proxy that indicates circumstances where the practice of cross-firm real earnings management is more likely to occur. We, however, additionally provide in Lemma 2 the presentation of δ in terms of the primitive modeling parameters in order to explore the fundamental determinants underlying the practice of cross-firm real earnings management.

LEMMA 2. *The marginal rate of substitution* $\delta=\frac{\lambda\beta}{\lambda\alpha+1-\lambda}$, *where* α *and* β *are the pricing coefficients given in Lemma 1, equals* $\frac{\lambda\rho\varphi}{1-\lambda+(2-\lambda)\varphi+(1-\rho^2)\varphi^2}$, *where* $\varphi=\sigma_\eta^2/\sigma_\varepsilon^2$. *The rate* δ *varies between* -1 *and* $+1$. *The sign of* δ *is identical to that of* ρ. *The absolute value of* δ *is increasing in* $|\rho|$, *increasing in* λ, *and non-monotonic in* φ *- initially increasing in* φ, *reaching its maximum at* $\varphi=\sqrt{\frac{1-\lambda}{1-\rho^2}}$, *and then decreasing in* φ. *Also,* $\lim_{\rho\to 0}\delta=\lim_{\lambda\to 0}\delta=\lim_{\varphi\to 0}\delta=\lim_{\varphi\to\infty}\delta=0$.

Lemma 2 indicates that the sign of the substitution rate δ is identical to that of the parameter ρ. Intuitively, when the two firms are subject to positively (negatively) correlated business shocks, the stock price of each firm positively (negatively) relies on the earnings report of the rival firm, implying that the goal of the cross-firm earnings management activities of each manager is inflating (deflating) the profit of the rival firm. Not only does the sign of the correlation ρ play a major role in shaping the managerial incentives for cross-firm earnings management as reflected by the marginal rate of substitution δ. Its absolute value does so too. The more correlated are the business shocks that the two firms face, in absolute terms, the more significantly does the stock price of each firm reflect the earnings report of the rival firm, and the more eager are the managers to engage in cross-firm earnings management. Therefore, as formally stated in Lemma 2, the absolute value of δ, which depicts the magnitude of the managerial motivation to engage in cross-firm earnings management, is increasing in the absolute value of ρ.

Lemma 2 also suggests that the absolute value of the marginal rate of substitution δ is increasing in the parameter λ, alluding to the role of the managerial level of myopia as another important determinant that shapes the incentives of the managers to engage in real activities of cross-firm earnings management. The managerial myopia, as captured by the parameter λ, brings capital market concerns of managers into their production decisions. The two managers, both of whom care mostly about the true profit of their firm when λ is close to zero, become more and more concerned with capital market considerations in making their production choice as λ increases, and therefore their motivation to engage in cross-firm earnings management is increasing in λ.

Lemma 2 further points to the non-monotonic reliance of the absolute value of the marginal rate of substitution δ on the ratio $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$ of the business uncertainty σ_η^2 to the accounting noisiness σ_ε^2, which reflects the usefulness of the accounting report of each firm in estimating the profit of that particular firm. When the ratio $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$ converges to zero, δ also converges to zero, because the accounting reports of the firms are either not necessary to investors due to the absence of business uncertainties (i.e., σ_η^2 approaches zero) or extremely noisy and thus not at all informative to investors (i.e., σ_ε^2 approaches infinity). Once the business environment becomes uncertain and the accounting reports become informative (i.e., $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2 > 0$), capital market prices turn to be dependent on the accounting reports of the two firms, evoking the managerial incentive for cross-firm earnings management. The absolute value of δ thus initially increases in φ, but it reaches a maximum at $\varphi = \sqrt{(1-\lambda)/(1-\rho^2)}$, and afterwards it decreases in φ. This is because intra-industry information transfers diminish when the business environment becomes highly uncertain or the accounting reports become highly accurate. At the extreme, when the ratio $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$ converges to infinity, δ converges to zero again, because the stock price of each firm relies solely on its own accounting report and is independent of the accounting report of the rival firm, which becomes either uninformative to investors due to a huge business uncertainty (i.e., σ_η^2 approaches infinity) or redundant due to a perfect accounting system (i.e., σ_ε^2 approaches zero).

Managerial incentives for cross-firm real earnings management are absent only when the substitution rate δ is zero. The case of $\delta = 0$ therefore provides a natural point of reference to the analysis and serves as our benchmark. In this context, it should be noted that the substitution rate δ is always different from zero under our modeling assumptions, but it does converge to zero under some extreme circumstances. Such circumstances occurs in the model when the two firms face business shocks that are nearly uncorrelated (i.e., ρ converges to zero), or when the managers are not at all myopic (i.e., λ converges to zero), or in the absence of any business uncertainties (i.e., σ_η^2 converges to zero), or in the presence of infinite business uncertainties (i.e., σ_η^2 converges to infinity), or under a perfect accounting system (i.e., σ_ε^2 converges to zero), or under totally uninformative accounting system (i.e., σ_ε^2 converges to infinity). Lemma 3 indicates that, in the benchmark case of $\delta = 0$, where managerial incentives for cross-firm earnings management do not exist, each firm responds to the production level of the rival firm with a level of production that maximizes its own profit, as in the classical Cournot competition. Lemma 3 further explores the deviation of the managers from the profit maximizing production decisions when $\delta \neq 0$ and states the direction and magnitude of their deviation in the concise terms of the marginal rate of substitution δ.

LEMMA 3. *The best production level response q_i of firm i ($i = A, B$) to a given production level q_j of the rival firm j ($j \neq i$) is $q_i = \dfrac{a - q_j - c}{2} - \dfrac{\delta q_j}{2}$, where δ is the marginal rate of substitution, as defined in Lemma 2.*

In the benchmark case of $\delta = 0$, each manager i ($i = A, B$) responds to the production level q_i of the rival firm j ($j \neq i$) with a level of production $\dfrac{a - q_j - c}{2}$ that maximizes its own profit, as in the classical Cournot competition. When $\delta \neq 0$, however, the two managers distort production in the direction that promotes capital market prices at the expense of economic profits. Specifically, for $\delta > 0$ ($\delta < 0$), each manager i responds to the production level q_j of the rival firm j with a level that is lower (higher) than the benchmark optimal response of $\dfrac{a - q_j - c}{2}$ by an amount equal to $\dfrac{|\delta| q_j}{2}$. This distortion in the unobservable real production level from the profit-maximizing level, which reflects the cross-firm earnings management activities of the managers, becomes stronger in its magnitude as the absolute value of the substitution rate δ increases. Its direction is determined by the sign of the substitution rate δ. A positive marginal rate of substitution δ induces the two managers to compete less aggressively and cut back on production due to the cross-benefit from increasing the profit of the rival firm. On the other hand, a negative marginal rate of substitution δ urges the managers to compete more aggressively and increase the production level due to the added cross-benefit from a low profit of the rival firm. The resulting equilibrium outcomes are given in Proposition 4.

PROPOSITION 4. *The model yields a unique Bayesian equilibrium ($q_A, q_B, P_A, P_B : \Re^2 \to \Re$). In the product market, the equilibrium production quantity of each firm i ($i = A, B$) equals $q_i = \dfrac{a - c}{3 + \delta}$ and is* *decreasing in the marginal rate of substitution δ given by Lemma 2. The implied expected profit of each firm i ($i = A, B$) equals $E[\tilde{\pi}_i(q_A, q_B)] = (1+\delta)\left(\frac{a-c}{3+\delta}\right)^2$ and is increasing in the marginal rate of substitution δ. In the capital market, the equilibrium pricing functions are as given by Lemma 1, where the above equilibrium production levels are conjectured by investors.*

The product market equilibrium outcomes, as formally given in Proposition 4, are graphically illustrated in Figure 2, where the left plot pertains to the case of $\delta > 0$ and the right plot pertains to the case of $\delta < 0$. In both plots, the production quantity of firm A is illustrated on the vertical axis, while the production quantity of firm B is illustrated on the horizontal axis. The blue solid line in both plots is the production level response of manager A to any given production level of the rival firm B. The orange solid line in both plots is the production level response of manager B to any given production level of the rival firm A. The blue and orange dotted lines are the response functions of managers A and B, respectively, in the benchmark of $\delta = 0$, which coincides with the classical Cournot competition. In the left plot, the positive marginal rate of substitution δ leads the two managers to compete less aggressively and thus their response lines are below the benchmark dotted lines. On the other hand, in the right plot, the negative marginal rate of substitution δ causes the two managers to compete more aggressively and thus their response lines are above the benchmark dotted lines. The equilibrium production quantities are captured by the intersection point of the blue and the orange solid lines. The equilibrium point reflects lower (higher) production quantities for $\delta > 0$ ($\delta < 0$) relative to the benchmark production quantities captured by the intersection point of the blue and orange dotted lines. Capital market concerns therefore work to shift the equilibrium production quantities in the direction of the monopolist quantities (as captured in the plots by the green point) when $\delta > 0$. However, they have the opposite effect of shifting the equilibrium production quantities in the direction of the competitive quantities of zero profits (as captured in the plots by the pink point) when $\delta < 0$. In both cases, the higher is the absolute value of the marginal rate of substitution δ, the larger is the distance of the equilibrium point from the benchmark point. The equilibrium point converges to the monopolist green point in the extreme case where δ approaches $+1$, and it coincides with the competitive pink point in the extreme case of δ approaching -1.

[Figure 2]

In spite of the myopic preferences of the two managers, which motivate them to distort production in the direction that promotes capital market prices at the expense of economic profits, the resulting profits of the two firms increase beyond the benchmark profits for positive values of δ. This is because a positive marginal rate of substitution δ has the interesting effect of spurring firms to collaborate with their rivals. Even though such collaboration is driven by capital market considerations, and not by the motivation of managers to maximize the economic profits of their own firms, it eventually results in higher profits for both firms in equilibrium. As δ increases from zero toward $+1$, the managers become more concerned about the profit of the rival and care less about the profit of their own firm, and therefore the collaboration between them is enhanced. At the extreme, when δ approaches $+1$, the collaboration is so profound that the two firms essentially behave like a monopoly and divide the monopolist profit between them.[11] A negative marginal rate of substitution δ has the opposite effect of escalating the aggressiveness of the product market competition and consequently decreasing the profits of both firms. As δ decreases from zero toward -1, the managers become more concerned about the profit of the rival and care less about the profit of their own firm, making the product market competition even more aggressive, so that the resulting decline in the profits of the firms becomes even steeper. At the extreme, when δ approaches

[11] When δ approaches $+1$ (i.e., both ρ and λ converges to $+1$), the total quantity $q_A + q_B$ produced by the two firms converges to the monopolist production quantity $\frac{a-c}{2}$ and the sum $E[\tilde{\pi}_A(q_A, q_B)] + E[\tilde{\pi}_B(q_A, q_B)]$ of their expected profits accordingly converges to the monopolist profit $\left(\frac{a-c}{2}\right)^2$, which is equally divided between them.

-1, the competition between the two rival firms becomes so aggressive that it results in zero profits for the firms, as in the case of a competitive market with an infinite number of firms.[12]

In equilibrium, the capital market investors rationally infer the distortion in the production decisions of the two managers, and therefore perfectly adjust for the resulting bias in their earnings reports. Even though the managers know that they cannot fool the capital market, they still choose to distort their production decisions. They are trapped into such behavior because they take the conjectures of the capital market investors as fixed, knowing that the investors would ascribe to them the production distortion in any case. This result is consistent with Stein (1989). Here, however, despite the fact that, from the narrow perspective of the firm's value, the myopic managers choose sub-optimal production levels, it appears that the equilibrium expected values of the firms might nevertheless increase with managerial myopia.

Figure 3 graphically illustrates how the deviations of the equilibrium production outcomes from the benchmark outcomes vary with the marginal rate of substitution δ. The blue curve in the left plot describes the equilibrium production quantity q_i of firm i ($i = A, B$) as a decreasing function of the parameter δ. This decreasing curve goes through the benchmark production level $\frac{a-c}{3}$ at $\delta = 0$. It is above the benchmark production level when δ is negative and below it when δ is positive. The blue curve in the right plot similarly describes the expected equilibrium profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i ($i = A, B$) as an increasing function of the parameter δ. This increasing curve goes through the benchmark expected profit $\left(\frac{a-c}{3}\right)^2$ at $\delta = 0$, and it is below (above) this benchmark when δ is negative (positive). Both plots demonstrate that the higher is the absolute value of δ, the more

[12] When δ approaches -1 (i.e., ρ converges to -1 and λ converges to $+1$), the total quantity $q_A + q_B$ produced by the two firms converges to the competitive production quantity $a - c$ and the expected profits $E[\tilde{\pi}_A(q_A, q_B)]$ and $E[\tilde{\pi}_B(q_A, q_B)]$ of both firms converge to zero.

significant is the deviation from the benchmark production outcomes.

[Figure 3]

Having established how the equilibrium profits of the two firms vary with the substitution rate δ (Proposition 4) and how the substitution rate δ varies with the modeling parameters (Lemma 2), it is now easy to obtain the relationships between the equilibrium profits of the firms and the primitive parameters ρ, λ, σ_η^2 and σ_ε^2. These relationships, which result immediately from Proposition 4 and Lemma 2, are formally stated in Corollary 5.

COROLLARY 5. *In equilibrium, the expected profit* $E[\tilde{\pi}_i(q_A, q_B)]$ *of each firm* i *(*$i = A, B$*) is increasing in* ρ. *When* $\rho > 0$ *(*$\rho < 0$*),* $E[\tilde{\pi}_i(q_A, q_B)]$ *is above (below) the benchmark profit of* $\left(\frac{a-c}{3}\right)^2$*, it is increasing (decreasing) in* λ*, and it is non-monotonic in* $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$ *- initially increasing (decreasing) in* φ*, reaching its maximum (minimum) at* $\varphi = \sqrt{\frac{1-\lambda}{1-\rho^2}}$*, and then decreasing (increasing) in* φ.

The comparative statics results, as presented in Corollary 5, are graphically illustrated in Figure 4. The left plot describes how the expected equilibrium profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i ($i = A, B$) varies with the parameters ρ and λ. The blue curve in the left plot describes the expected equilibrium profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i as a decreasing function of the parameter ρ. This increasing curve goes through the benchmark expected profit of $\left(\frac{a-c}{3}\right)^2$, as obtained from the classical Cournot competition, at $\rho = 0$. It is below (above) the benchmark level when ρ is negative (positive). The higher is the absolute value of ρ, the more significant is the deviation of the equilibrium profit from the benchmark level. The equilibrium expected profit moves from the blue curve toward the orange curve as the managerial myopia λ increases. So, while the direction of the deviation of the equilibrium profit from the benchmark profit is determined by the sign of ρ, its magnitude is increasing in the absolute value of ρ and in λ. The right plot illustrates the sensitivity of the equilibrium expected profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i ($i = A, B$) to the ratio $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$. The blue and the orange curves in the right plot describe the expected profit as a function of φ for positive and negative values of ρ, respectively. Both curves intersect with the benchmark expected profit at $\varphi = 0$. As φ increases, the blue (orange) curve initially increases (decreases), reaching a maximum (minimum) at $\varphi = \sqrt{(1-\lambda)/(1-\rho^2)}$, and afterwards decreases (increases). The two curves converge again to the benchmark level as φ converges to infinity.

[Figure 4]

4. Extension – Introducing asymmetric managerial myopia

Till now we have emphasized how the practice of cross-firm earnings management is expected to vary across different industries under the premise that firms operating in the same industry are symmetric. In order to understand the variation in cross-firm earnings management within a given industry, we introduce asymmetry between firms into our setting by allowing their managers to exhibit different levels of myopia. This extension of our analysis is rooted in the notion that, while firms that operate in the same industry are likely to face similar business and informational environments, their managers may vary significantly in their myopic preferences because of differences in personal career concerns (e.g., Holmstrom, 1999). Accordingly, instead of assuming the same level λ of myopia for both managers, we now allow the manager of firm A to have a myopia level of λ_A, which may differ from the myopia level λ_B of the manager of the rival firm B, where $0 < \lambda_A, \lambda_B \leq 1$. As in the symmetric setting, we assume that the myopia levels of the two managers are publicly observable prior to their production decisions, possibly through their compensation contracts, which must be disclosed to the markets. Proposition 6 establishes the existence and uniqueness of equilibrium in the asymmetric setting and describes its structure.

PROPOSITION 6. *The asymmetric setting, where* λ_A *and* λ_B *are not necessarily the same, yields a unique Bayesian equilibrium (* $q_A, q_B, P_A, P_B : \Re^2 \to \Re$ *). In equilibrium, for any* $i, j \in \{A,B\}$ *such that* $i \neq j$ *,*

$$q_i = \frac{a-c}{3+\delta_i+(\delta_i-\delta_j)\frac{1+\delta_i}{1-\delta_i}}, \quad E[\tilde{\pi}_i(q_A,q_B)] = \frac{(a-c)^2(1-\delta_i)(1-\delta_i\delta_j)}{(4-(1+\delta_i)(1+\delta_j))^2} \text{ and } P_i(r_A,r_B) = \mu_i + \alpha(r_i-\mu_i) + \beta(r_j-\mu_j),$$

where $\alpha = \dfrac{\varphi+(1-\rho^2)\varphi^2}{1+2\varphi+(1-\rho^2)\varphi^2}$, $\beta = \dfrac{\rho\varphi}{1+2\varphi+(1-\rho^2)\varphi^2}$, $\varphi = \sigma_\eta^2/\sigma_\varepsilon^2$, $\mu_i = \hat{q}_i(a-\hat{q}_A-\hat{q}_B-c)$ *and*

$$\delta_i = \frac{\lambda_i\beta}{\lambda_i\alpha+1-\lambda_i} = \frac{\lambda_i\rho\varphi}{1-\lambda_i+(2-\lambda_i)\varphi+(1-\rho^2)\varphi^2}.$$

Each manager i ($i = A,B$) makes the optimal production decision in light of his/her own myopic preferences (as captured by the parameter λ_i) and on the basis of his/her rational conjectures about the production decision of the rival manager j ($j \neq i$), which in turn depends upon the (observable) myopic preferences of manager j (as captured by the parameter λ_j). Therefore, as indicated by Proposition 6, the optimal production decision of each manager i ($i = A,B$) depends upon both his/her own level λ_i of myopia and the myopia level λ_j of the rival manager j ($j \neq i$). Corollary 7 describes the sensitivity of the product market equilibrium outcomes, in both aggregate and disaggregate terms, to changes in the parameters λ_A and λ_B.

COROLLARY 7. *In the asymmetric setting, where* λ_A *and* λ_B *are not necessarily the same, for* $\rho > 0$ *(* $\rho < 0$ *), the equilibrium aggregate production quantity* $q_A + q_B$ *in the industry is decreasing (increasing) in* λ_A *and in* λ_B*, whereas the equilibrium expected aggregate profit* $E[\tilde{\pi}_A(q_A,q_B)] + E[\tilde{\pi}_B(q_A,q_B)]$ *in the industry is increasing (decreasing) in* λ_A *and in* λ_B*. When* $\rho > 0$*, for any* $i, j \in \{A,B\}$*, such that* $i \neq j$*, the expected profit* $E[\tilde{\pi}_i(q_A,q_B)]$ *of firm* i *is increasing* *in* λ_j *and is decreasing in* λ_i. *When* $\rho < 0$, *for any* $i, j \in \{A, B\}$, *such that* $i \neq j$, *the expected profit* $E[\tilde{\pi}_i(q_A, q_B)]$ *of firm* i *is decreasing in* λ_j *but it is not necessarily monotonic in* λ_i *(it is either increasing in* λ_i *or initially increasing and afterwards decreasing in* λ_i*).*

Corollary 7 implies that asymmetry in managerial myopia does not change the way in which managerial myopic behavior affects the product market in aggregate terms. It specifically indicates that the aggregate production quantity in the industry decreases (increases) for $\rho > 0$ ($\rho < 0$) as one of the managers becomes more myopic. Corollary 7, however, further reveals that the resulting increase (decrease) in the aggregate profit in the industry is not equally dispersed among the individual firms. Figure 5 graphically illustrates the effect of changing the level λ_A of managerial myopia in firm A on the expected profit $E[\tilde{\pi}_A(q_A, q_B)]$ of firm A (the blue curve) and the spill-over effect of such a change on the expected profit $E[\tilde{\pi}_B(q_A, q_B)]$ of the rival firm B (the orange curve), holding the myopia level λ_B of manager B fixed.[13] The left plot of Figure 5 pertains to a positive ρ, whereas the right plot pertains to a negative ρ. In both plots, the dotted horizontal line describes the benchmark expected profit $\left(\frac{a-c}{3}\right)^2$ obtained from the classical Cournot competition, which is independent of the managerial level of myopia and therefore identical across firms.

[Figure 5]

In the left plot, where ρ is positive, the blue curve of the expected profit $E[\tilde{\pi}_A(q_A, q_B)]$ of firm A is decreasing in λ_A, whereas the orange curve of the expected profit $E[\tilde{\pi}_B(q_A, q_B)]$ of firm B is increasing in λ_A. This is because, under a positive ρ, an increase in the myopia level λ_A of manager A

[13] Though not explicitly illustrated in Figure 5, the sensitivity of the profits of the two firms to changes in the myopia level λ_B of manager *B* is immediately implied from the figure using symmetric arguments.

augments his/her incentive to engage in cross-firm earnings management directed to improve the profit of the rival firm B, at the expense of decreasing the profit of his/her own firm A to some extent. In addition, as the change in the myopia level λ_A of manager A is observable, it serves as a commitment to compete less aggressively, allowing the rival manager to gain even more market share. The right plot depicts a different effect of a change in λ_A on the profits of the two firms when is ρ negative. In the right plot, where ρ is negative, the blue curve of $E[\tilde{\pi}_A(q_A, q_B)]$ is increasing in λ_A, whereas the orange curve of $E[\tilde{\pi}_B(q_A, q_B)]$ is decreasing in λ_A. Intuitively, under a negative ρ, an increase in the myopia level λ_A of manager A enhances his/her incentive to engage in cross-firm earnings management directed to decrease the profit of the rival firm B. Although manager A is willing to engage in these practices even at the cost of decreasing to some extent the profit of his/her own firm A, in equilibrium the profit of firm A might nevertheless increase due to a change in the response of the rival manager. This is because the observable increase in the myopia level λ_A of manager A serves as a commitment to compete more aggressively, which causes the rival manager to draw back and concede market share. With these two countervailing forces at work, the profit of firm A is not necessarily monotonic in λ_A, as indicated by Proposition 6. It is sometimes monotonically increasing in λ_A as in the special case depicted in Figure 5, but Proposition 6 indicates the existence of other cases where it is only initially increasing in λ_A, reaching a maximum, and afterward decreasing in λ_A.[14] Hence, changes in the myopia level of one manager do not always work to benefit one firm at the expense of the other.

Particular attention should be also paid to the intersection point of the blue and the orange curves, which reflects the symmetric case of $\lambda_A = \lambda_B$ where the two managers have the same level of myopia, as discussed in Section 3. As indicated by Proposition 4, the intersection of the two curves

[14] We note that $-1/3 < \rho < 0$ is a sufficient condition for the profit of each firm to be monotonically increasing in the myopia level of its manager. Such monotonic behavior also emerges in cases where $-1 < \rho \leq -1/3$ as long as the myopia levels λ_A and λ_B of the two managers are sufficiently low.

represents an identical profit for both firms, which is above (below) the benchmark profit as depicted by the dotted line in the left (right) plot. While both firms benefit (lose) in equilibrium from myopic managerial behavior when $\rho > 0$ ($\rho < 0$) relative to the benchmark of $\rho = 0$ under symmetric levels of myopia, this is not necessarily true under asymmetric managerial myopia. Both the left and the right plots in Figure 5 reflect cases where the profit of one firm is below the benchmark dotted line and the profit of the other firm is above it. To identify these cases, in Corollary 8 we contrast the profits of the individual firms against the profits obtained in the benchmark of $\rho = 0$.

COROLLARY 8. *In the asymmetric setting, where λ_A and λ_B are not necessarily the same, there exist two positive scalars Δ_1 and Δ_2, such that, if $-\Delta_1 < \lambda_A - \lambda_B < \Delta_2$, the expected profits $E[\tilde{\pi}_A(q_A, q_B)]$ and $E[\tilde{\pi}_B(q_A, q_B)]$ of both firms are above (below) the benchmark profit of $\left(\frac{a-c}{3}\right)^2$ when $\rho > 0$ ($\rho < 0$). Otherwise, if $\lambda_A - \lambda_B < -\Delta_1$ or $\lambda_A - \lambda_B > \Delta_2$, the expected profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm $i = \arg\min_{k \in \{A,B\}} \lambda_k$ is above (below) the benchmark profit and the expected profit $E[\tilde{\pi}_j(q_A, q_B)]$ of firm $j = \arg\max_{k \in \{A,B\}} \lambda_k$ is below (above) the benchmark profit when $\rho > 0$ ($\rho < 0$).*

Corollary 8 reveals that, when ρ is positive (negative), at least one firm benefits (loses) from myopic managerial behavior relative to the benchmark case where both managers are not myopic, and sometimes both firms are better off (worse off) in equilibrium. As long as the difference between the two levels of managerial myopia is sufficiently low, both firms benefit (lose) from managerial myopia when $\rho > 0$ ($\rho < 0$), as in the symmetric setting. However, under substantial asymmetry in managerial myopia, only the firm with the less myopic manager benefits (loses) from myopic managerial behavior, whereas the other firm loses (benefits) from such behavior, when $\rho > 0$ ($\rho < 0$). These results are graphically illustrated in Figure 5. In the left plot, where ρ is positive, the blue curve is decreasing, whereas the orange curve is increasing, and both curves go through the benchmark dotted line. The left plot thus demonstrates the existence of a non-empty region, where λ_A is around the fixed value of λ_B, in which both curves are above the benchmark line. Outside this region, only one of the two curves (the one representing the firm with the less myopic manager) is above the benchmark line, while the other curve is below it. The right plot depicts a similar effect, though in the opposite direction, for a negative correlation ρ. In the right plot, the blue curve is increasing and the orange curve is decreasing, but again both curves go through the benchmark dotted line. There thus exists a non-empty region, where λ_A is around the fixed value of λ_B, in which both curves are below the benchmark line. Outside this region, only one the two curves (the one representing the firm with the less myopic manager) is below the benchmark line, while the other curve is above it.

5. Summary and Conclusions

It is conventionally perceived in the literature that opportunistic earnings management occurs when managers use judgment in financial reporting and in structuring transactions to alter financial reports to either mislead some stockholders about the underlying economic performance of the company or to influence contractual outcomes that depend on the reported accounting numbers. In this classical definition of earnings management, originally provided by Healy and Wahlen (1999, page 368), as well as in other definitions that appear in the literature, the target of earnings management is the accounting report of the managers' own firm. We draw attention to another practice of earnings management, previously unexplored in the literature, which aims to influence the reported earnings of other firms. We refer to this practice as cross-firm earnings management. Such a practice can only exist if managers have both the incentives and the tools to affect the reported earnings of peer firms. We argue that managerial incentives for cross-firm earnings management can stem from capital market concerns of managers. In particular, knowing that stockholders can learn about the fundamental value of any particular firm from observing the earnings announcements of other firms that operate in the same industry, managers may have incentives to influence the earnings reports of rival firms in order to mislead the stockholders about the value of their own firm. Managers obviously do not have access to the accounting system of peer firms, but they can nevertheless influence the economic profits of rival firms, and thereby also their earnings reports, by distorting real transactions that relate to the product market competition. Hence, while the linkage between peer firms in the capital market provides their managers with the incentives to engage in cross-firm earnings management, the linkage between the firms in the product market equips their managers with the tools to do so.

We demonstrate such managerial behavior and study its consequences within a setting that depicts a game between two competing firms that operate in the same product market and their stocks are publicly traded in the same capital market. An analysis of our game suggests that capital market concerns of managers may evoke incentives for cross-firm earnings management and thereby affect the aggressiveness of their competition in the product market. Interestingly, it appears that cross-firm earnings management, even though it involves the distortion of real production decisions, is not necessarily costly to firms. Our analysis yields the prediction that in industries where competing firms face positively correlated business shocks (e.g., fluctuations in downstream consumer tastes and in upstream input prices), the practice of cross-firm earnings management is expected to increase the aggregate profits of the firms, because it works to diminish the aggressiveness of their product market competition and allow for collaboration between them. In such industries, cross-firm earnings management is expected to improve the profits of all firms as long as there are relatively small differences in the myopia level of their managers, but it is likely to increase only the profits of the firms whose managers are less myopic at the expense of their rivals when the cross-section variation in the level of managerial myopia across peer firms is relatively large. On the other hand, in industries where competing firms face negatively correlated business shocks (e.g., fluctuations in the market share of the competing firms), the practice of cross-firm earnings management is likely to result in lower aggregate profits for the firms, as it works to accelerate the aggressiveness of their competition in the product market.

Here, cross-firm earnings management is expected to decrease the profits of all firms when managers do not differ a lot in their level of myopia, but it is likely to decrease only the profits of the firms whose managers are less myopic, while increasing the profits of their rivals, when the level of managerial myopia varies considerably across the firms. Our analysis further alludes to the sensitivity of the product market competition to the ownership structure of the competing firms, and in particular to whether they are privately held or publically traded. In particular, it follows from our analysis that the competitive behavior of firms might significantly alter when peer firms in the industry go public or alternatively go private.

The analysis given in this study suggests several possibilities for future research. While it sheds light on the incentives of managers to affect the reported earnings of rival firms and explores some of the real activities that managers might employ in their attempt to do so, we believe that there is considerable potential for further investigating the consequences of such activities, as well as their underlying determinants, and in exploring other kinds of real activities of cross-firm earnings management. Extensions of our analysis could involve settings with different competitive structures (e.g., Stackelberg competition, Bertrand competition, or a repeated Cournot game instead of the single shot Cournot game), settings with more asymmetries between firms (e.g., asymmetry in production cost, business uncertainty or accounting noise, in addition to asymmetry in managerial myopia), or settings with an endogenous choice of some of the firms' characteristics (e.g., endogenous choice of managerial myopia or accounting noise).

APPENDIX – PROOFS

Proof of Lemma 1.

The third and fourth conditions of the equilibrium imply

$P_A\left(r_A,r_B\right)=E\left[\tilde{\pi}_A\left(q_A,q_B\right)\middle|r_A,r_B\right]=E\left[\mu_A+\tilde{\eta}_A\middle|\mu_A+\tilde{\eta}_A+\tilde{\varepsilon}_A=r_A,\mu_B+\tilde{\eta}_B+\tilde{\varepsilon}_B=r_B\right]$ and

$P_B\left(r_A,r_B\right)=E\left[\tilde{\pi}_B\left(q_A,q_B\right)\middle|r_A,r_B\right]=E\left[\mu_B+\tilde{\eta}_B\middle|\mu_A+\tilde{\eta}_A+\tilde{\varepsilon}_A=r_A,\mu_B+\tilde{\eta}_B+\tilde{\varepsilon}_B=r_B\right]$, where

$\mu_A=\hat{q}_A(a-\hat{q}_A-\hat{q}_B-c)$, and $\mu_B=\hat{q}_B(a-\hat{q}_B-\hat{q}_A-c)$. Employing our distributional assumptions we get

$P_A(r_A,r_B)=(1-\alpha)\mu_A-\beta\mu_B+\alpha\ r_A+\beta\ r_B$ and $P_B(r_A,r_B)=(1-\alpha)\mu_B-\beta\mu_A+\alpha\ r_B+\beta\ r_A$, where

$\alpha=\dfrac{\varphi+(1-\rho^2)\varphi^2}{1+2\varphi+(1-\rho^2)\varphi^2}$, $\beta=\dfrac{\rho\varphi}{1+2\varphi+(1-\rho^2)\varphi^2}$, and $\varphi=\dfrac{\sigma_\eta^2}{\sigma_\varepsilon^2}$. □

Proof of Lemma 2.

Using the expressions for α and β from Lemma 1 we have that

$\delta=\dfrac{\lambda\beta}{\lambda\alpha+1-\lambda}=\dfrac{\lambda\rho\varphi}{1-\lambda+\left(2-\lambda\right)\varphi+\left(1-\rho^2\right)\varphi^2}$, where $\varphi=\dfrac{\sigma_\eta^2}{\sigma_\varepsilon^2}$. The fact that $-1<\rho<1,\ 0<\lambda\leq1$,

$0<\varphi<\infty$, implies that $-1<\delta<1$ and $sign\left(\delta\right)=sign\left(\rho\right)$. Also, $\left|\delta\right|$ is increasing in $\left|\rho\right|$ because

$\dfrac{\partial\delta}{\partial\rho}=\dfrac{\lambda\varphi\left(1-\lambda\left(1+\varphi\right)+\varphi\left(2+\varphi+\varphi\rho^2\right)\right)}{\left[1-\lambda+\left(2-\lambda\right)\varphi+\left(1-\rho^2\right)\varphi^2\right]^2}>0$, and it is increasing in λ because

$\dfrac{\partial\delta}{\partial\lambda}=\dfrac{\rho\varphi\left(1+\varphi\left(2+\varphi+\varphi\rho^2\right)\right)}{\left[1-\lambda+\left(2-\lambda\right)\varphi+\left(1-\rho^2\right)\varphi^2\right]^2}$ has the same sign as ρ. Lastly, $\left|\delta\right|$ can be written as

$\left|\delta\right|=\left|\dfrac{\lambda\rho}{2-\lambda+G\left(\varphi\right)}\right|$, where $G\left(\varphi\right)=\dfrac{1}{\varphi}\left(1-\lambda\right)+\left(1-\rho^2\right)\varphi$ is a convex function that attains its minimum at

$\varphi=\sqrt{\dfrac{1-\lambda}{1-\rho^2}}$. □

Proof of Lemma 3.

The manager of firm *i* takes the production level of firm *j*, q_j, as well as the pricing rules as given, and chooses a level of production q_i such as to maximize $E\left[\lambda P_i\left(\tilde{r}_i, \tilde{r}_j\right)+(1-\lambda)\tilde{\pi}_i\left(q_i, q_j\right)\right]$. Using Lemma 1, the objective function of manager *i* can be written as

$\lambda(1-\alpha)\mu_i-\lambda\beta\mu_j+(\alpha\lambda+1-\lambda)q_i\left(a-q_i-q_j-c\right)+\lambda\beta q_j\left(a-q_j-q_i-c\right)$, where

$\mu_A=\hat{q}_A(a-\hat{q}_A-\hat{q}_B-c)$, and $\mu_B=\hat{q}_B(a-\hat{q}_B-\hat{q}_A-c)$, and where $\hat{q}_A$ and $\hat{q}_B$ are conjectured quantities of the two firms. Solving for q_i yields the following first-order condition $q_i=\frac{a-q_j-c}{2}-\frac{\delta q_j}{2}$, where

$\delta=\frac{\lambda\beta}{\lambda\alpha+1-\lambda}$. The second-order condition is $-2+2\lambda(1-\alpha)<0$. □

Proof of Proposition 4.

Lemma 3 establishes that the best production level response of firm *A* is $q_A=\frac{a-\hat{q}_B-c}{2}-\frac{\delta\hat{q}_B}{2}$, and that of firm *B* is $q_B=\frac{a-\hat{q}_A-c}{2}-\frac{\delta\hat{q}_A}{2}$, where $\delta=\frac{\lambda\beta}{\lambda\alpha+1-\lambda}$, and where $\hat{q}_i$ is the conjecture of firm *j* about the quantity chosen by firm *i*, $i=A,B,i\neq j$. Using the fifth equilibrium condition, $\hat{q}_A=q_A$, $\hat{q}_B=q_B$, the solution for the two production response equations is $q_A=q_B=\frac{a-c}{3+\delta}$. These quantities yield expected profits of $E[\tilde{\pi}_A(q_A,q_B)]=E[\tilde{\pi}_B(q_A,q_B)]=(1+\delta)\left(\frac{a-c}{3+\delta}\right)^2$. We have that

$\frac{\partial E[\tilde{\pi}_i(q_A,q_B)]}{\partial\delta}=\frac{(a-c)^2(1-\delta)}{(3+\delta)^3}\geq 0$, $i=A,B$, with equality only at $\delta=1$. □

Proof of Corollary 5.

The proof follows immediately from Lemma 2 and Proposition 4. □

Proof of Proposition 6.

For any conjectured quantities $\hat{q}_A$ and $\hat{q}_B$ of the two firms in equilibrium, the third and fourth conditions of the equilibrium imply that the pricing function is such that

$P_A(r_A,r_B)=E\left[\tilde{\pi}_A(q_A,q_B)\middle|r_A,r_B\right]=E\left[\mu_A+\tilde{\eta}_A\middle|\mu_A+\tilde{\eta}_A+\tilde{\varepsilon}_A=r_A,\mu_B+\tilde{\eta}_B+\tilde{\varepsilon}_B=r_B\right]$ and

$P_B\left(r_A, r_B\right) = E\left[\tilde{\pi}_B\left(q_A, q_B\right) \middle| r_A, r_B\right] = E\left[\mu_B + \tilde{\eta}_B \middle| \mu_A + \tilde{\eta}_A + \tilde{\varepsilon}_A = r_A, \mu_B + \tilde{\eta}_B + \tilde{\varepsilon}_B = r_B\right]$, where $\mu_A = \hat{q}_A(a - \hat{q}_A - \hat{q}_B - c)$, and $\mu_B = \hat{q}_B(a - \hat{q}_B - \hat{q}_A - c)$. Employing our distributional assumptions we get $P_A(r_A, r_B) = (1-\alpha)\mu_A - \beta\mu_B + \alpha\ r_A + \beta\ r_B$ and $P_B(r_A, r_B) = (1-\alpha)\mu_B - \beta\mu_A + \alpha\ r_B + \beta\ r_A$, where

$\alpha = \dfrac{\varphi + (1-\rho^2)\varphi^2}{1 + 2\varphi + (1-\rho^2)\varphi^2}$, $\beta = \dfrac{\rho\varphi}{1 + 2\varphi + (1-\rho^2)\varphi^2}$, and $\varphi = \dfrac{\sigma_\eta^2}{\sigma_\varepsilon^2}$.

The manager of firm *i* takes his/her conjecture about the production level of firm *j*, $\hat{q}_j$, as well as the pricing function as given, and chooses a level of production q_i such as to maximize $E\left[\lambda P_i\left(\tilde{r}_i, \tilde{r}_j\right) + (1-\lambda)\tilde{\pi}_i\left(q_i, \hat{q}_j\right)\right]$. The objective function of manager *i* can be written as $\lambda_i(1-\alpha)\mu_i - \lambda_i\beta\mu_j + (\lambda_i\alpha + 1 - \lambda_i)q_i(a - q_i - q_j - c) + \lambda_i\beta q_j(a - q_j - q_i - c)$, where $\mu_i = \hat{q}_i(a - \hat{q}_i - \hat{q}_j - c)$, and where $\hat{q}_i$ and $\hat{q}_j$ are conjectured quantities of the two firms. Solving for q_i yields the following first-order condition $q_i = \dfrac{a - \hat{q}_j - c}{2} - \dfrac{\delta_i\hat{q}_j}{2}$, where

$\delta_i = \dfrac{\lambda_i\rho\varphi}{1 - \lambda_i + \left(2 - \lambda_i\right)\varphi + \left(1-\rho^2\right)\varphi^2}$. The second-order condition is $-2 + 2\lambda(1-\alpha) < 0$. Using the fifth equilibrium condition, $\hat{q}_A = q_A$, $\hat{q}_B = q_B$, the solution for the two production response equations is

$q_A = \dfrac{a-c}{3 + \delta_A + \left(\delta_A - \delta_B\right)\dfrac{1+\delta_A}{1-\delta_A}}$ and $q_B = \dfrac{a-c}{3 + \delta_B + \left(\delta_B - \delta_A\right)\dfrac{1+\delta_B}{1-\delta_B}}$. These quantities yield expected profits of $E[\tilde{\pi}_A(q_A, q_B)] = \dfrac{(a-c)^2(1-\delta_A)(1-\delta_A\delta_B)}{(4-(1+\delta_A)(1+\delta_B))^2}$ and $E[\tilde{\pi}_B(q_A, q_B)] = \dfrac{(a-c)^2(1-\delta_B)(1-\delta_A\delta_B)}{(4-(1+\delta_A)(1+\delta_B))^2}$. □

Proof of Corollary 7.

Taking the first-order derivative of aggregate quantity with respect to manager A's myopia, we get,

$\dfrac{\partial\left(q_A + q_B\right)}{\partial\lambda_A} = -\dfrac{K_1K_2^2}{K_3^2}$, where $K_1 = \rho\left(a-c\right)\varphi\left(1+\varphi-\rho\varphi\right)\left(1+\varphi+\rho\varphi\right)$;

$K_2 = \left(1-\lambda_B+\varphi-\rho\varphi\right)\left(1+\varphi+\rho\varphi\right) > 0$; and

$$\begin{aligned} K_3 = &-\left(1+\varphi-\rho\varphi\right)\left(1+\varphi+\rho\varphi\right)\left(3\left(1+\varphi-\rho\varphi\right)\left(1+\varphi+\rho\varphi\right) - \left(4\left(1+\varphi\right) - \left(1+\varphi-\rho\varphi\right)\right)\lambda_B\right) \\ &+ \lambda_A\left(\left(1+\varphi-\rho\varphi\right)\left(1+\varphi+\rho\varphi\right)\left(4\left(1+\varphi\right) - \left(1+\varphi-\rho\varphi\right)\right) - \left(4\left(1+\varphi\right)^2 - \left(1+\varphi-\rho\varphi\right)^2\right)\lambda_B\right) \neq 0. \end{aligned}$$

Taking the first-order derivative of aggregate profit with respect to manager A's myopia, we have,

$$\frac{\partial\left(E[\tilde{\pi}_A]+E[\tilde{\pi}_B]\right)}{\partial\lambda_A}=\frac{(a-c)(1-\delta_B)^3(1-\delta_A)}{\left[3-\left(\delta_B+(1+\delta_B)\delta_A\right)\right]^3}\frac{\partial\delta_A}{\partial\lambda_A}$$, where $\frac{(a-c)(1-\delta_B)^3(1-\delta_A)}{(3-\delta_A-\delta_B-\delta_A\delta_B)^3}>0$ and $sign\left(\frac{\partial\delta_A}{\partial\lambda_A}\right)=sign(\rho)$.

Hence, $sign\left(\frac{\partial(q_A+q_B)}{\partial\lambda_A}\right)=-sign(\rho)$ and $sign\left(\frac{\partial\left(E[\tilde{\pi}_A]+E[\tilde{\pi}_B]\right)}{\partial\lambda_A}\right)=sign(\rho)$. By symmetry, it also follows that $sign\left(\frac{\partial(q_A+q_B)}{\partial\lambda_B}\right)=-sign(\rho)$ and $sign\left(\frac{\partial\left(E[\tilde{\pi}_A]+E[\tilde{\pi}_B]\right)}{\partial\lambda_B}\right)=sign(\rho)$.

Taking the first-order derivative of firm A's profit with respect to its own manager's myopia yields

$$\frac{\partial E[\tilde{\pi}_A]}{\partial\lambda_A}=-\frac{\partial\delta_A}{\partial\lambda_A}\frac{(a-c)^2(1-\delta_B)(1+\delta_B+\delta_A-3\delta_A\delta_B)}{(4-1-\delta_A-\delta_B-\delta_A\delta_B)^3}$$, where $sign\left(\frac{\partial\delta_A}{\partial\lambda_A}\right)=sign(\rho)$ and

$sign\left(\frac{(a-c)^2(1-\delta_B)(1+\delta_B+\delta_A-3\delta_A\delta_B)}{(4-1-\delta_A-\delta_B-\delta_A\delta_B)^3}\right)=sign(1+\delta_B+\delta_A-3\delta_A\delta_B)$. Notice that if $\rho>0$ then $1+\delta_B+\delta_A-3\delta_A\delta_B>0$; however, if $\rho<0$ then $1+\delta_B+\delta_A-3\delta_A\delta_B<0$ only if $-1\le\delta_A<0$ and $-1\le\delta_B<-\frac{1+\delta_A}{1-3\delta_A}$. This leads to the possibility of non-monotonicity of $E[\tilde{\pi}_A]$ in λ_A when $\rho<0$.

Taking the first-order derivative of firm A's profit with respect to the rival manager's myopia yields

$$\frac{\partial E[\tilde{\pi}_A]}{\partial\lambda_B}=\frac{\partial\delta_B}{\partial\lambda_B}\frac{(a-c)^2(1-\delta_A)\left(2-\delta_A(1-\delta_A+\delta_B+\delta_A\delta_B)\right)}{(4-1-\delta_A-\delta_B-\delta_A\delta_B)^3}$$, where $sign\left(\frac{\partial\delta_B}{\partial\lambda_B}\right)=sign(\rho)$ and

$\frac{(a-c)^2(1-\delta_A)\left(2-\delta_A(1-\delta_A+\delta_B+\delta_A\delta_B)\right)}{(4-1-\delta_A-\delta_B-\delta_A\delta_B)^3}>0$. □

Proof of Corollary 8.

For ease of exposition, we denote the production quantity and expected profit of each firm in the benchmark case by q^0 and $E[\tilde{\pi}^0]$, respectively. Using this notation, we first provide the proof for the case where $\rho>0$. In this case, $\frac{\partial E[\tilde{\pi}_A(\lambda_A,\lambda_B)]}{\partial\lambda_A}<0$ and $\frac{\partial E[\tilde{\pi}_B(\lambda_A,\lambda_B)]}{\partial\lambda_A}>0$ by Corollary 6. We also have $E[\tilde{\pi}_A(0,\lambda_B)]>E[\tilde{\pi}^0]>E[\tilde{\pi}_B(0,\lambda_B)]$, where the first inequality is because $\lambda_A=0$ implies that $q_B=\frac{a-c}{3+\delta_B+\delta_B\frac{1+\delta_B}{1-\delta_B}}<q^0$, and the second inequality is because $\lambda_A=0$ additionally implies that

$q_A = \frac{a-c}{3-\delta_B} > q^0$. Now, $q_A > q^0 > q_B$ leads to $E[\tilde{\pi}^0] > E[\tilde{\pi}_B(0,\lambda_B)]$ because

$E[\tilde{\pi}^0] = q^0\left(a - 2q^0 - c\right) > q_B\left(a - q_B - q^0 - c\right) > q_B\left(a - q_B - q_A - c\right) = E[\tilde{\pi}_B(0,\lambda_B)]$, where the first inequality is because given that firm A chooses $q_A = q^0$, it is optimal for firm B to choose $q_B = q^0$, and the second inequality is because $q_A > q^0$. Lastly, from Proposition 5 we know that when $\lambda_A = \lambda_B$ $E[\tilde{\pi}_A(\lambda_A,\lambda_B)] = E[\tilde{\pi}_B(\lambda_A,\lambda_B)] > E[\tilde{\pi}^0]$. Combining this with the fact that $E[\tilde{\pi}_A(0,\lambda_B)] > E[\tilde{\pi}^0] > E[\tilde{\pi}_B(0,\lambda_B)]$, it follows from the monotonicity of $E[\tilde{\pi}_A(\lambda_A,\lambda_B)]$ and $E[\tilde{\pi}_B(\lambda_A,\lambda_B)]$ in λ_A that there is a cutoff value for λ_A, denoted by $\lambda_A'(\lambda_B)$, where $\lambda_A'(\lambda_B) \in (0,\lambda_B)$, such that $E[\tilde{\pi}_A(0,\lambda_B)] > E[\tilde{\pi}^0] > E[\tilde{\pi}_B(0,\lambda_B)]$ when $\lambda_A \in \left(0,\lambda_A'(\lambda_B)\right)$, $E[\tilde{\pi}_A(0,\lambda_B)] > E[\tilde{\pi}^0] = E[\tilde{\pi}_B(0,\lambda_B)]$ when $\lambda_A = \lambda_A'(\lambda_B)$, and $E[\tilde{\pi}_A(0,\lambda_B)] > E[\tilde{\pi}_B(0,\lambda_B)] > E[\tilde{\pi}^0]$ when $\lambda_A \in \left(\lambda_A'(\lambda_B),\lambda_B\right)$. When λ_A increases slightly above λ_B it must be that $E[\tilde{\pi}_B(\lambda_A,\lambda_B)] > E[\tilde{\pi}_A(\lambda_A,\lambda_B)] > E[\tilde{\pi}^0]$. While the inequality $E[\tilde{\pi}_B(\lambda_A,\lambda_B)] > E[\tilde{\pi}^0]$ holds when λ_A further increases, depending on the parameter value, there might be a point beyond which an increase in λ_A leads to $E[\tilde{\pi}_A(\lambda_A,\lambda_B)] > E[\tilde{\pi}^0]$.

The proof for the case where $\rho < 0$ and the parameter values are such that $Sign\left(\frac{\partial E[\tilde{\pi}_A]}{\partial \lambda_A}\right) = sign(\rho)$ (i.e., $\delta_A < \frac{1+\delta_B}{-1+3\delta_B}$) for any λ_A is similar to the proof for the case of $\rho > 0$, and thus is omitted. For some parameter values $\frac{\partial E[\tilde{\pi}_A]}{\partial \lambda_A}$ may switches sign for high enough values of λ_A, but this does not alter the proof substantially, because for any λ_A in the range $[0,\lambda_B)$, it is still the case that $E[\tilde{\pi}_A(\lambda_A,\lambda_B)] < E[\tilde{\pi}^0]$ and $E[\tilde{\pi}_A(\lambda_A,\lambda_B)] < E[\tilde{\pi}_B(\lambda_A,\lambda_B)]$. This follows from the fact that $E[\tilde{\pi}_A(\lambda_A,\lambda_B)] + E[\tilde{\pi}_B(\lambda_A,\lambda_B)] < 2E[\tilde{\pi}^0]$ and the fact that $q_A < q_B$ for any $\lambda_A \in [0,\lambda_B)$. □

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FIGURES

FIGURE 1

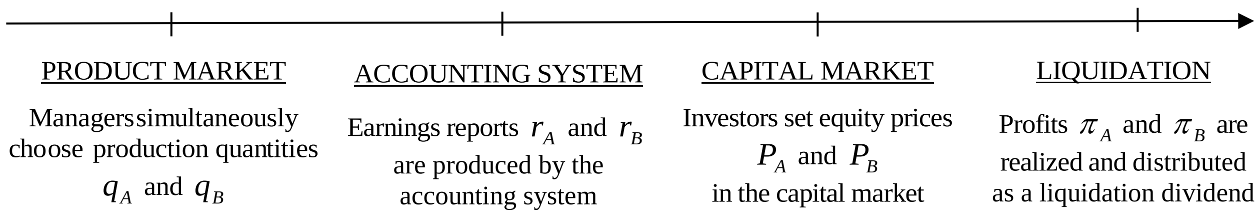

Figure 1 provides a timeline depicting the sequence of events in the model.

FIGURE 2

$\delta > 0$ $\delta < 0$

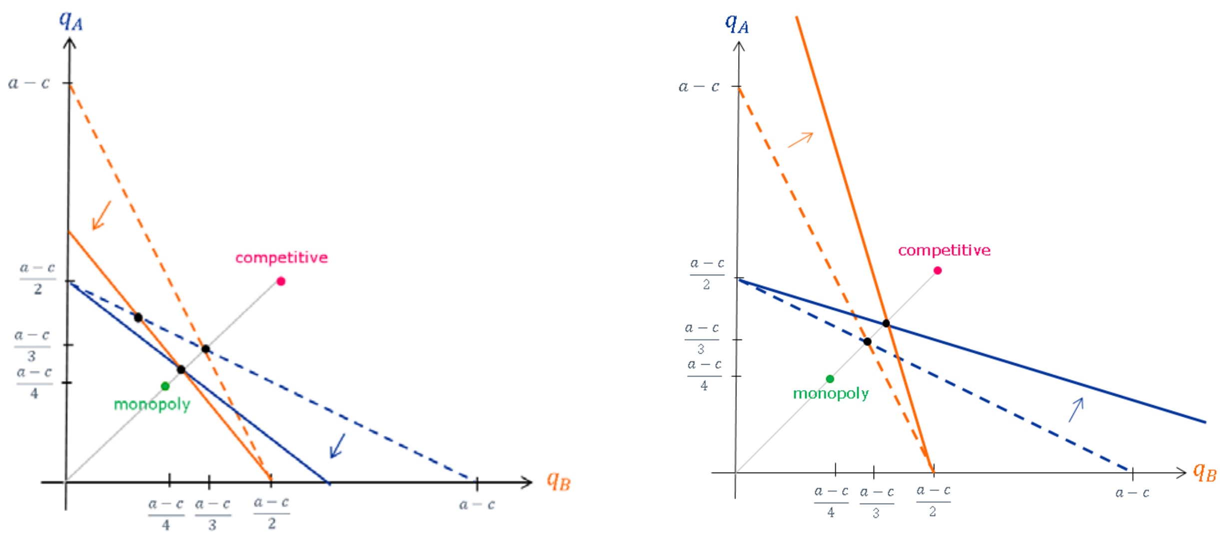

Figure 2 illustrates the response functions of the two managers, where the left plot pertains to the case of $\delta > 0$ and the right plot pertains to the case of $\delta < 0$. In both plots, the production quantity of firm A is illustrated on the vertical axis, while the production quantity of firm B is illustrated on the horizontal axis. The blue solid line in both plots is the production level response of manager A to any given production level of the rival firm B. Similarly, the orange solid line in both plots is the production level response of manager B to any given production level of the rival firm A. The blue and orange dotted lines are the response functions of managers A and B, respectively, in the benchmark of $\delta = 0$. The equilibrium production quantities are captured by the intersection point of the blue and the orange solid lines. The benchmark production quantities are captured by the intersection point of the blue and the orange dotted lines. The green point depicts the monopolist production quantities, while the pink point depicts the competitive production quantities that lead to zero profits.

FIGURE 3

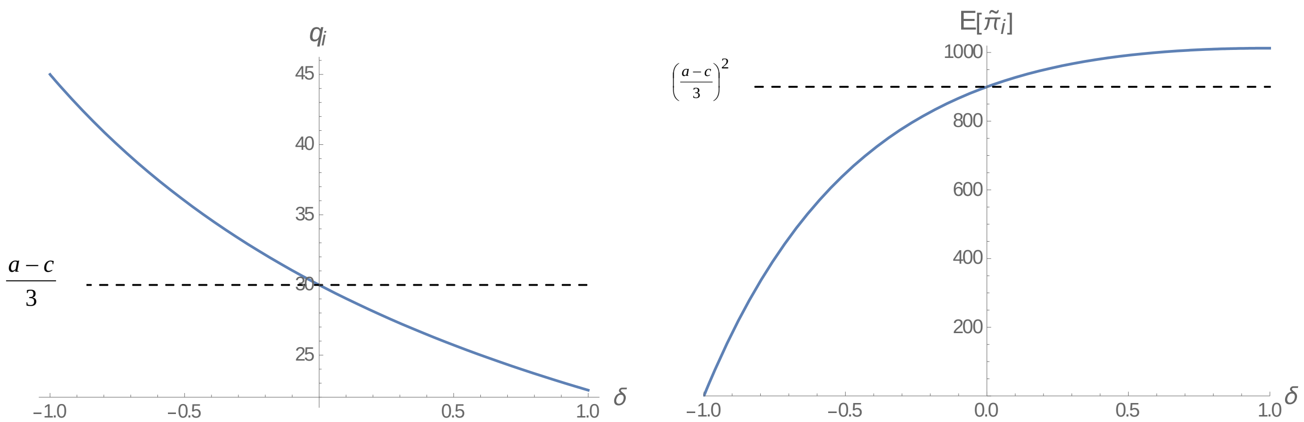

Figure 3 is based on parameter values $a = 100$ and $c = 10$. The left plot illustrates the firms' equilibrium production quantities as a function of the marginal rate of substitution δ. The horizontal axis presents all the possible values of the marginal rate of substitution δ, which may vary from -1 to $+1$. The dotted horizontal line illustrates the benchmark production quantity $\frac{a-c}{3}$ of firm i ($i = A, B$) under $\delta = 0$. The decreasing blue curve describes the equilibrium production quantity q_i of firm i as a function of δ. The right plot illustrates the firms' equilibrium expected profits as a function of the marginal rate of substitution δ. The horizontal axis again presents all the possible values of the marginal rate of substitution δ, which may vary from -1 to $+1$. The dotted horizontal line illustrates the benchmark expected profit $\left(\frac{a-c}{3}\right)^2$ of firm i ($i = A, B$) under $\delta = 0$. The increasing blue curve describes the equilibrium expected profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i as a function of δ.

FIGURE 4

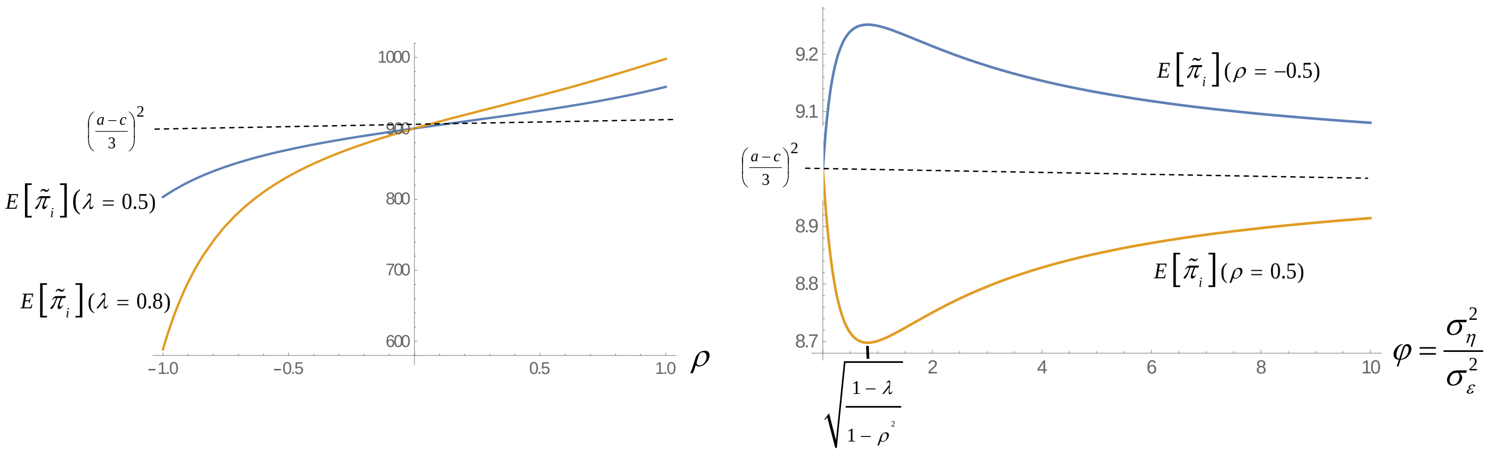

Figure 4 is based on parameter values $a = 100$ and $c = 10$, as in Figure 3. The left plot illustrates the firms' equilibrium expected profits as a function of the parameters ρ and λ, where $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2 = 1$. The horizontal axis describes all the possible values of the parameter ρ, which may vary from -1 to $+1$. The blue curve describes the equilibrium expected profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i ($i = A, B$) as a function of the parameter ρ. As the parameter λ increases from 0.5 to 0.8, the curve of $E[\tilde{\pi}_i(q_A, q_B)]$ moves toward the orange curve. The right plot illustrates the firms' equilibrium expected profit as a function of the parameter $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$, where $\lambda = 0.5$ and $\rho = \pm 0.5$. The horizontal axis describes all the possible values of the parameter $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$, which may vary from zero to infinity. The blue (orange) curve describes the equilibrium expected profit $E[\tilde{\pi}_i(q_A, q_B)]$ of firm i ($i = A, B$) as a function of the parameter $\varphi = \sigma_\eta^2 / \sigma_\varepsilon^2$ for a positive (negative) value of ρ.

FIGURE 5

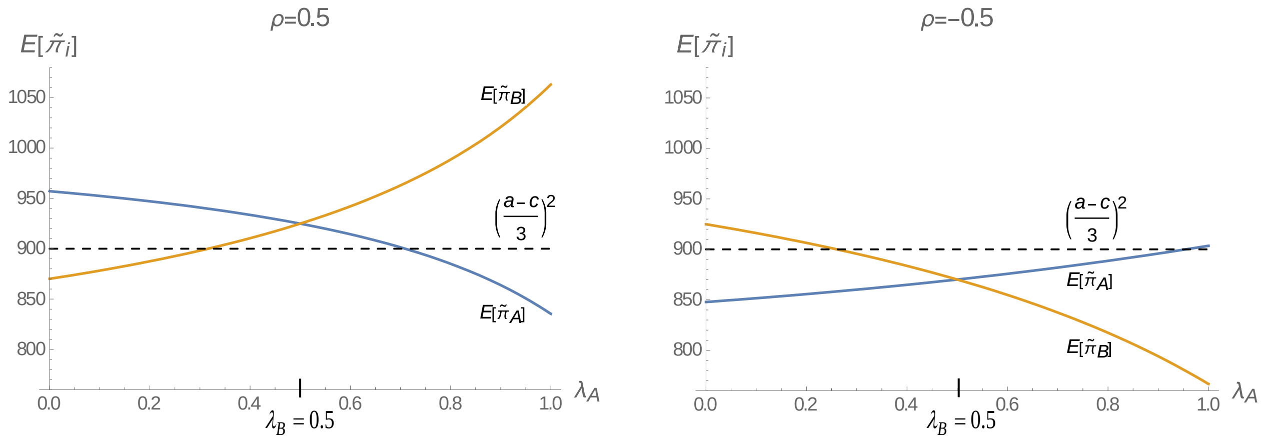

Figure 5 is based on parameter values $a=100, c=10, \varphi=\sigma_\eta^2/\sigma_\varepsilon^2=1, \lambda_B=0.5, \rho=\pm 0.5$. The horizontal axis describes all the possible values of the parameter λ_A, which may vary from zero to $+1$. The blue curve illustrates the expected profit $E[\tilde{\pi}_A(q_A,q_B)]$ of firm A, while the orange curve illustrates the expected profit $E[\tilde{\pi}_B(q_A,q_B)]$ of firm B, as a function of the myopia level λ_A of manager A, holding the myopia level λ_B of manager B fixed (at $\lambda_B=0.5$) for a positive ρ (left plot, $\rho=0.5$) and for a negative ρ (right plot, $\rho=-0.5$). The dotted horizontal line in both plots describes the benchmark expected profit $\left(\frac{a-c}{3}\right)^2$ of each firm.