Compliance with Segment Disclosure Initiatives: 
Implications for the Short and Long Run

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Abstract

Regulatory oversight of capital markets has intensified in recent years, with a particular emphasis on expanding financial transparency. A notable instance is efforts by the Financial Accounting Standards Board (FASB) that push firms to identify and report performance of individual business units (segments). This paper seeks to address short- and long-run consequences of stringent enforcement of and uniform compliance with these segment disclosure standards. To do so, we develop a parsimonious model wherein a regulatory agency promulgates disclosure standards and either permits voluntary compliance or mandates strict compliance from firms. Under voluntary compliance, a firm is able to credibly withhold individual segment information from its competitors by disclosing data only at the aggregate firm level. Consistent with regulatory hopes, we show that mandatory compliance enhances welfare by increasing transparency and leveling the playing field. However, our analysis also demonstrates that in the long-run, if firms are unable to use discretion in reporting to maintain their competitive edge they may seek more destructive alternatives. Accounting for such concerns, in the long-run, voluntary compliance can provide an upside for all parties.

Keywords: Aggregation; Compliance; Investments; Segment disclosure.
1. Introduction

Recent accounting regulatory changes (SFAS 131, IFRS 8) have pushed firms to report not just firmwide financial performance but also details of segment performance. These changes ostensibly seek to create a more transparent marketplace. While transparency can have positive ramifications for capital and product markets alike, support for and compliance with such regulations has not been unanimous. In particular, many industry leaders have objected to such regulations on the grounds that they undercut strategic advantage. Prominent examples are Apple and Dell, two firms who willingly announce firmwide profits but actively seek to keep segment details out of public view. In Apple's case, it has long refused to report margins on iPod and iPhone products separate from its computer products. Its finance chief, Peter Oppenheimer, noted that "...our competitors would just love to know what our specific gross margins are ... and we just don't want to help them" (WSJ, 6/24/06, B4). Dell took a similar stance in its comment to the Exposure Draft of SFAS 131, stating that "[d]isclosing the manner in which management views and operates the various components of an enterprise is, in essence, 'giving away' this proprietary structural and strategic information" (Ettredge et al. 2002, 109).

The consensus view appears to be that objections are merely attempts by industry leaders to protect market power at the expense of competition and economic efficiency. As such, there have been routine calls for strict enforcement of segment disclosure rules to bring uniformity in compliance; these calls, admittedly, have been accompanied by some misgivings.¹ This paper examines the subtleties that underlie the issue of compliance with segment disclosure rules. Formally, we develop a model wherein a firm operates in two segments (markets) and is privy to proprietary information in each market that its rivals do not know. The paper then details outcomes under both voluntary and mandatory disclosure rules.

¹ The byline in Reason (CFO.com, 2001), "Is the SEC's new focus on segment reporting more bark than bite?" succinctly captures the early distrust surrounding the introduction of the new rules.
compliance with segment disclosure standards. Moreover, the consequences are analyzed in the short- and long-run – in the long run, the firms are presumed to be capable of adjusting investments to the regulatory environment in which they operate.

Consider first the short-run results. Under voluntary compliance, firms are willing to comply with firmwide profitability disclosure standards but avoid providing such information at the segment level, keeping rivals partially in the dark. Notice this partial disclosure result is in contrast to the well-known "unraveling" theorem (Grossman and Hart 1980; Grossman 1981; Milgrom 1981; Okuno-Fujiwara et al. 1990). In particular, the unraveling theorem notes that even if a firm wishes to keep its information under wraps ex ante, it cannot resist the ex post temptation to fully reveal what it knows. In this paper, partial disclosure can be sustained as an equilibrium only because the firm operates in multiple segments. In this case, partial disclosure takes the form of aggregation of performance across segments. Under aggregate reporting, if the firm is tempted to reveal favorable information in one market, it also (indirectly) conveys potentially unfavorable information in the other market. In other words, the ex post temptation of the firm to reveal advantageous information in one market can be offset by the concomitant leakage of disadvantageous information in the other market, a point made in Arya et al. (2010).

Given the viability of segment aggregation as an equilibrium outcome, we consider the consequences of mandating compliance with detailed segment reporting rules. In light of the firm's motivation for withholding details, this analysis indicates that mandatory compliance indeed levels the competitive landscape, thereby increasing consumer surplus and economic efficiency.

We then expand the analysis to consider long-run effects by examining firms' investment incentives following shifts in disclosure regulation. In this case, mandatory segment disclosures have the consequence of reducing investment. A firm is less inclined to invest in such an environment because it recognizes that fully informed rivals will compete fiercely and undercut the extent to which it can profit from its investments. In
short, deciphering the long-term societal impact of mandatory disclosure regulations entails a tradeoff between transparency benefits and underinvestment costs.

Broadly speaking, the long-run consequences highlight that disclosure regulation may have unforeseen reverberations. While mandatory compliance eliminates one means for a firm to usurp market power, the consequence may be that the firm seeks other, more pernicious, means of retaining such power. To this end, efforts to mandate compliance may come at a steep cost. Consistent with this view, Caterpillar Inc.'s objection to the Exposure Draft of SFAS 131 emphasized that enforcement of segment reporting may lead companies to change the way they do business to avoid the competitive consequences (Ettredge et al. 2002, 108). Such considerations require a more holistic view of regulation, one that considers both direct (short-term) and indirect (long-term) consequences of mandating compliance by firms already facing strong pressures to maintain profitability in the face of competition.

This paper is closely tied to the literature on discretionary disclosure as well as that addressing consequences of disclosure regulation. The viability of segment aggregation under discretionary disclosure relied upon herein was first noted in Arya et al. (2010). This result is similar in spirit to other papers that demonstrate exceptions to the "unraveling" result. Prominent results include Verrecchia (1983), Dye (1985), and Jung and Kwon (1988). In Verrecchia (1983), proprietary costs of disclosure offset the temptation to disclose to capital markets, thereby supporting an equilibrium in which the firm nontrivially exercises discretion. In Dye (1985) and Jung and Kwon (1988), uncertainty about information endowment means that the withholding disclosure does not necessarily convey the worst-case scenario but perhaps only that the firm did not possess information; this feature supports an equilibrium in which firms may conditionally withhold information.2

The fact that mandatory disclosure rules can serve as salve when voluntary

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2 For a through discussion of the voluminous literature on discretionary disclosure, see review papers by Verrecchia (2001) and Dye (2001), as well as Bolton and Dewatripont (Ch. 5, 2005).
disclosure is limited – a theme in this paper's short-run analysis – has also been utilized in previous works (e.g., Shavell 1994; Fishman and Hagerty 1995). Turning to the long-run analysis, we note that promoting firm investments by permitting discretion in reporting is akin to spurring investments by granting firms' patent protection. In effect, each of these approaches is a means of suitably incentivizing firms recognizing the gains come with the associated cost of stifling competition.

The paper proceeds as follows. Section 2 presents the model. Section 3 demonstrates the viability of segment aggregation under voluntary compliance, and discusses the consequences of mandating compliance with segment disclosure initiatives. Section 4 appends the analysis to consider long run effects of disclosure regulation by endogenizing investment levels. Section 5 summarizes the results and discusses implications.

2. Model

A firm operates in two product markets, denoted markets 1 and 2. In market \( i \), the firm faces a Cournot competitor, denoted rival \( i, i = 1, 2 \). Consumer demand in market \( i \) is represented by a linear, downward-sloping (inverse) demand function

\[ P_i = \alpha_i a_i - q_i^F - q_i^R, \]

where \( P_i \) is product price, and \( q_i^F \) and \( q_i^R \) are the quantities produced by the firm and rival \( i \), respectively, in market \( i \). The demand intercept, \( \alpha_i a_i \), includes one component which is fixed in the short run and one which is stochastic. In particular \( \alpha_i \) is a common knowledge market demand parameter, while \( a_i \in \{\bar{a} - \delta, \bar{a} + \delta\} \) represents the uncertain component of customer demand.\(^3\) The (marginal) probability of each realization of \( a_i \) is 1/2. To incorporate the possibility of correlation in demand across markets, denote the (conditional) probability that \( a_i \) is the same as \( a_j \) by \((1 + \rho) / 2, -1 < \rho < 1\); the limiting

\(^3\) For simplicity, we normalize marginal production cost to zero. Also, throughout the analysis, we assume \( \delta < \bar{a} / 2 \). This condition ensures equilibrium prices and quantities, derived from the relevant first-order conditions, are positive.
values represent the cases of perfect negative and positive correlation, respectively, while \( \rho = 0 \) corresponds to statistically independent markets.

Prior to choosing production levels, the firm (privately) learns the demand coefficients \( a_1 \) and \( a_2 \) and, thus, makes circumstance contingent output decisions. Whether the rivals too can do so depends on the nature of the firm's disclosures. The firm's reports depend on the disclosure standards in place and the compliance (enforcement) that undergirds these standards. We presume the regulatory agency promulgates disclosure at the individual segment level and either permits voluntary compliance or mandates strict compliance from firms. Under voluntary compliance, the firm chooses what to report upon observing \( a_1 \) and \( a_2 \). The firm can choose to reveal neither \( a_i \) value, only one \( a_i \) value, both \( a_i \) values, or an aggregate value, \( a_1 + a_2 \); notationally, \( d \in D = \{ (\emptyset, \emptyset), (a_1, \emptyset), (\emptyset, a_2), (a_1, a_2), a_1 + a_2 \} \). In this case, the firm's strategy, a mapping from \( (a_1, a_2) \) to \( D \), is denoted \( d(a_1, a_2) \). Under mandatory compliance, the firm is required to separately disclose \( a_1 \) and \( a_2 \), i.e., \( d(a_1, a_2) = (a_1, a_2) \). Given this setting, we identify the (subgame perfect) equilibrium outcome under each compliance regime to address what disclosure policies are sustainable under voluntary compliance, and how the competitive landscape is impacted by mandating compliance.\(^5\)

When evaluating consequences of compliance, one should be cognizant of both the short run and long run effects. In this spirit, section 4 appends the model to consider the possibility that the firm can influence market demand, \( \alpha_i \), through investment. In particular, the firm incurs investment of \( c(\alpha_i) \), to achieve a demand (intercept) in market \( i \) of \( \alpha_i a_i \). That is, while consumer demand is subject to some randomness, in the long run it can also be influenced by the firm's actions. For tractability, assume \( c(\cdot) \) is continuously differentiable with \( c(0) = c'(0) = 0 \), and \( c''(\alpha_i) > 0 \) for \( \alpha_i > 0 \). Prior to considering the

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\(^4\) Notice that while the firm has the option to not disclose, disclosures when made are presumed to be truthful. This standard assumption in the accounting disclosure literature is typically justified on the grounds that disclosures are subject to third party audit.

\(^5\) If multiple disclosure policies are sustainable as equilibria, we naturally presume the firm adopts the one which maximizes its expected payoff.
ramifications for investment, we first conduct a short run analysis where investment levels \( \alpha_1 \) and \( \alpha_2 \) are held fixed.

3. **Short Run Analysis**

While long-term investments are unlikely to adjust quickly to disclosure regulation and its enforcement, firm disclosure policies can. If and how a firm's disclosures change with the compliance regime is the focus of this section. In the short run, where \( \alpha_1 \) and \( \alpha_2 \) are held fixed, the sequence of events is as follows. First, the firm privately learns the demand parameters, \( a_1 \) and \( a_2 \). Second, the firm decides what, if any information, to disclose (a choice that is moot under mandatory compliance). Finally, the firm and its rivals choose product quantities in their respective markets. Given this timeline, we next detail the equilibrium outcome under the two compliance regimes.

3.1. **Voluntary Compliance**

Under voluntary compliance, the firm has complete discretion in reporting. With such discretionary disclosure, a natural assertion may be that the firm is unable to resist the ex post temptation to disclose information, thereby rendering the two compliance regimes equivalent. This view emanates from the seminal "unraveling" result (Grossman 1981; Milgrom 1981). The conjecture of unraveling applies in this setting as well, provided the firm operates in only one market. In the single-market case, the firm benefits by disclosing bad news (\( a_i = \bar{a} - \delta \)) about the demand intercept so as to curb its rival's aggressiveness. On the other hand, when \( a_i = \bar{a} + \delta \), the firm prefers to be the only party that is aware of the good news, so it alone can capture the increased consumer demand. Such one-sided desire for silence is precisely what leads to the familiar unraveling, leaving full disclosure as the unique equilibrium in the single market setup.
If the firm competes in only one market, the equilibrium under voluntary compliance necessarily entails full disclosure.

Roughly stated, with concerns confined to one market, silence by the firm speaks volumes (silence implies \( a_i \) must be \( a_i = \bar{a} + \delta \)). The rub in this paper is that the firm's simultaneous focus on two product markets can sustain an equilibrium in which disclosure is not fully revealing. Further, such an equilibrium naturally takes the form of aggregated disclosure. Intuitively, if the firm is tempted to move away from an aggregate disclosure of \( a_1 + a_2 \) to reveal bad news in one market (say by revealing \( a_1 \) is the lower of the two values), it does so at the cost of revealing good news in its other market (by revealing \( a_2 \) is the higher of the two values). This balancing of considerations in the two markets can help sustain aggregate disclosure as an equilibrium (Arya et al. 2010).

Arguments reminiscent of the unraveling result can rule out most possible reporting strategies, leaving only full disclosure or segment aggregation as potentially sustainable ex post. To see the conditions under which aggregation is sustainable, we next determine the competitive outcomes that ensue under each reporting strategy.

The firm can condition its output decision on \((a_1, a_2)\); in contrast, its rivals can condition their output decisions only on the firm's disclosure \(d\). Hence, given disclosure strategy \(d(a_1, a_2)\), let \(q^F_i((a_1, a_2), d(a_1, a_2))\) and \(q^R_i(d, d(a_1, a_2))\) denote the output choices in market \(i\). Also, given the disclosure and disclosure strategy of the firm, denote rival \(i\)'s updated beliefs over \(a_i\) by \(\text{Pr}_i(a_i|d, d(a_1, a_2))\).

For any \((a_1, a_2)\), given its own disclosure and its rivals' production decisions, the firm chooses \(q^F_i((a_1, a_2), d(a_1, a_2))\), \(i = 1, 2\), to maximize its combined profit in the two markets as follows:
the production decisions from (3) in (1) yields production decision in market disclosure; and, substituting into (2), the corresponding profit for rival updated beliefs upon observing the aggregate report as a function of (1) and (2) with these beliefs yields the following equilibrium quantities under full disclosure:

\[
\begin{align*}
\max_{q^F_i((a_1,a_2),d(a_1,a_2))} & \sum_{i=1,2} \left[ a_i a_i - q^F_i((a_1,a_2),d(a_1,a_2)) \right. \\
& \left. - q^R_i(d,d(a_1,a_2)) \right] q^F_i((a_1,a_2),d(a_1,a_2)).
\end{align*}
\] (1)

Similarly, given the disclosure and production decision of the firm, rival \(i\) chooses \(q^R_i(d,d(a_1,a_2))\) in market \(i\) to solve:

\[
\begin{align*}
\max_{q^R_i(d,d(a_1,a_2))} & \sum_{a_i \in [\bar{a} - \delta, \bar{a} + \delta]} \Pr_i(a_1|d,d(a_1,a_2)) \left[ a_i a_i - q^R_i(d,d(a_1,a_2)) \right. \\
& \left. - q^F_i((a_1,a_2),d(a_1,a_2)) \right] q^R_i(d,d(a_1,a_2)).
\end{align*}
\] (2)

Given this formulation, consider the outcome under full disclosure, \(d(a_1,a_2) = (a_1,a_2)\) for all \((a_1,a_2)\). With full disclosure, the updated beliefs are trivial \((\Pr_1(a_1|a_1,a_2),d(\cdot)) = \Pr_2(a_2|a_1,a_2),d(\cdot)) = 1\). Jointly solving the first-order conditions of (1) and (2) with these beliefs yields the following equilibrium quantities under full disclosure as a function of \((a_1,a_2)\) (the "\(\sim\)" reflects full disclosure):

\[
\tilde{q}^F_i(a_1,a_2) = \tilde{q}^R_i(a_1,a_2) = \frac{\alpha_i a_i}{3}, \quad i = 1, 2.
\] (3)

Not surprisingly, the distinct markets receive separate attention in that each party's production decision in market \(i\) depends only on the demand in that market. Substituting the production decisions from (3) in (1) yields \(\tilde{\Pi}^F(\alpha_1,\alpha_2;a_1,a_2)\), firm profit under full disclosure; and, substituting into (2), the corresponding profit for rival \(i\) is \(\tilde{\Pi}^R_i(\alpha_1,\alpha_2;a_1,a_2)\):

\[
\tilde{\Pi}^F(\alpha_1,\alpha_2;a_1,a_2) = \left[ \frac{\alpha_1 a_1}{3} \right]^2 + \left[ \frac{\alpha_2 a_2}{3} \right]^2 \quad \text{and} \quad \tilde{\Pi}^R_i(\alpha_1,\alpha_2;a_1,a_2) = \left[ \frac{\alpha_i a_i}{3} \right]^2.
\] (4)

Next consider the outcome under segment aggregation. In this case, rival \(i\)'s updated beliefs upon observing the aggregate report \(a_1 + a_2\), equal:

\[
\Pr_i(\bar{a} + \delta|2[\bar{a} + \delta],a_1 + a_2) = 1, \quad \Pr_i(\bar{a} + \delta|2[\bar{a} - \delta],a_1 + a_2) = 0, \quad \text{and} \quad \Pr_i(\bar{a} + \delta|2\bar{a},a_1 + a_2) = 1/2.
\]

That is, under aggregate disclosure, a report of \(a_1 + a_2 = 2[\bar{a} + \delta] \) or \(2[\bar{a} - \delta] \) is perfectly revealing in that it conveys either both signals are
favorable or both are unfavorable. On the other hand, if \( a_1 + a_2 = 2\bar{a} \), then the rivals only know one signal is favorable and the other is unfavorable. Jointly solving the first-order conditions of (1) and (2) given these beliefs yields the equilibrium quantities under segment aggregation as a function of \( (a_1, a_2) \) (the "\(-\)" reflects segment aggregation):

\[
\bar{q}_i^F(a_1, a_2) = \frac{\alpha_i(5a_i - a_j)}{12} \quad \text{and} \quad \bar{q}_i^R(a_1, a_2) = \frac{\alpha_i(a_1 + a_2)}{6}, \quad i, j = 1, 2; \ i \neq j. \quad (5)
\]

From (5), when \( a_1 + a_2 = 2[\bar{a} + \delta] \) or \( 2[\bar{a} - \delta] \), the competitive outcome is equivalent to that in (3) since the firm's report, in effect, conveys both \( a_1 \) and \( a_2 \). However, when \( a_1 + a_2 = 2\bar{a} \), the rival's information is less precise. As a consequence, with aggregation the rival produces more in the market with intercept \( \bar{a} - \delta \) (\( \alpha_i\bar{a}/3 \) rather than \( \alpha_i(\bar{a} - \delta)/3 \)), but less in the market with intercept \( \bar{a} + \delta \) (\( \alpha_i\bar{a}/3 \) rather than \( \alpha_i(\bar{a} + \delta)/3 \)). The net result is that in the \( \bar{a} - \delta \) market, the rival's actions elicit a less aggressive response from the firm, with the firm producing \( \alpha_i(\bar{a} - \delta)/3 - \alpha_i\delta/6 \) rather than \( \alpha_i(\bar{a} - \delta)/3 \). Of course, the reverse is true in the \( \bar{a} + \delta \) market. The rival's soft response emboldens the firm, and so the firm produces \( \alpha_j(\bar{a} + \delta)/3 + \alpha_j\delta/6 \) rather than \( \alpha_j(\bar{a} + \delta)/3 \).

The use of aggregate reporting introduces an interdependency in the production decision of the firm reflected in (5) by the fact that the firm's output in market \( i \) depends not just on \( a_i \) but also \( a_j \). Intuitively, under aggregate reporting, for a given \( a_i \), the firm faces an equally well informed rival in market \( i \) when \( a_j = a_i \) but faces an informationally disadvantaged rival when \( a_j \neq a_i \). Accounting for this, the firm's production decision in market \( i \) depends on both \( a_i \) and \( a_j \).

Using the production decisions from (5) yields \( \Pi^F(\alpha_1, \alpha_2; a_1, a_2) \), and \( \Pi^R_i(\alpha_1, \alpha_2; a_1, a_2) \), firm and rival \( i \) profit under aggregate disclosure:

\[
\Pi^F(\alpha_1, \alpha_2; a_1, a_2) = \left[ \frac{\alpha_1(5a_1 - a_2)}{12} \right]^2 + \left[ \frac{\alpha_2(5a_2 - a_1)}{12} \right]^2 \quad \text{and}
\]
Aggregate reporting by the firm can be sustained as an equilibrium if and only if 
\[ \Pi^F(\alpha_1, \alpha_2; a_1, a_2) - \tilde{\Pi}^F(\alpha_1, \alpha_2; a_1, a_2) \geq 0 \] for all \((a_1, a_2)\); else full revelation is the only viable disclosure equilibrium. Also, if the condition for aggregation to be sustained as an equilibrium is satisfied, it is clearly the firm’s preferred disclosure policy (i.e., \(E_{a_1, a_2}[\Pi^F(\alpha_1, \alpha_2; a_1, a_2) - \tilde{\Pi}^F(\alpha_1, \alpha_2; a_1, a_2)] \geq 0\)). The sustainability of aggregation is in question only when the two \(a_i\) signals are in conflict. In this case, using the firm profit expressions from (4) and (6), reveals the conditions under which 
\[ \Pi^F(\alpha_1, \alpha_2; a_1, a_2) - \tilde{\Pi}^F(\alpha_1, \alpha_2; a_1, a_2) \] is nonnegative for \((a_1, a_2) = (\bar{a} + \delta, \bar{a} - \delta)\) and \((a_1, a_2) = (\bar{a} - \delta, \bar{a} + \delta)\). The result of this comparison yields Proposition 1. (All proofs are provided in the appendix.)

**PROPOSITION 1.**

Under voluntary compliance, segment aggregation is sustainable if and only if

\[
\frac{4\bar{a} - 5\delta}{4\bar{a} + 5\delta} \leq \left[ \frac{\alpha_1}{\alpha_2} \right]^2 \leq \frac{4\bar{a} + 5\delta}{4\bar{a} - 5\delta},
\]

in which case it is also the firm’s preferred disclosure policy. Else, the equilibrium necessarily entails full disclosure.

Notice that both bounds in Proposition 1 are positive, with the lower bound being less than 1 and the upper bound being more than 1. Thus, it follows that aggregation can be sustained as an equilibrium as long as the two markets are sufficiently similar. Intuitively, if demand in the first market is significantly greater than in the second market, the firm’s ex post incentives are skewed towards protecting the first market. That is, if the demand news is unfavorable (-\(\delta\)) in the first market but favorable (+\(\delta\)) in the second market, the firm will fully disclose rather than aggregate to depress rival 1’s output in the dominant market. In effect, aggregation can be sustained if and only if both markets are critical, so the firm’s incentives to deviate from aggregation and reveal information in one market are kept in check by the cost associated with the accompanying revelation in the
other market. After all, recall that if there were only one market, full disclosure is the sole viable equilibrium.

While the similarity of markets (in the sense that $\alpha_1$ and $\alpha_2$ are of comparable size) is critical, note the condition in the proposition is free of $\rho$, the demand correlation across the two markets. Of course, the extent to which the firm benefits from aggregating segment data does depend on $\rho$. After all, if $\rho = 1$, aggregation has no effect since the problem then is essentially one of a firm operating in a single market. For all $\rho < 1$, the firm benefits from withholding information from its rival in the event $a_i \neq a_j$. Formally, using (4) and (6), expected firm profits under full disclosure and aggregate disclosure are:

$$E_{a_1,a_2}[\hat{\Pi}^F(\alpha_1,\alpha_2,a_1,a_2)] = [(\alpha_1)^2 + (\alpha_2)^2][\bar{a}^2 + \bar{\delta}^2]/9$$

and

$$E_{a_1,a_2}[\Pi^F(\alpha_1,\alpha_2,a_1,a_2)] = E_{a_1,a_2}[\hat{\Pi}^F(\alpha_1,\alpha_2,a_1,a_2)] + 5\bar{\delta}^2[1-\rho][(\alpha_1)^2 + (\alpha_2)^2]/72. \quad (7)$$

The profit expression in (7) confirm the firm's preference for segment aggregation should it be sustainable. In addition, it captures the effect of correlation among segments on expected profit. In particular, consistent with the firm's risk neutral preferences, expected profit in the case of full disclosure is free of $\rho$. In contrast, under segment aggregation, the firm's expected profit is decreasing in $\rho$, reflecting a demand for diversification despite risk neutral preferences. The demand for diversification arises because the firm can exploit offsetting priorities via aggregation to effectively conceal proprietary information only when the two segments have unequal outlooks. Low correlation implies such eventualities are more likely. This, coupled with the sustainability of aggregation detailed in Proposition 1, yields the following corollary.

**COROLLARY 1.**

When segment aggregation is sustainable as an equilibrium in the voluntary compliance regime, the firm benefits from segment diversification, i.e., the firm's expected profit is
decreasing in $\rho$.

In light of the firm's preference for segment aggregation and its feasibility when markets are sufficiently similar, we next address the welfare consequences of mandating disclosure of segment details.

### 3.2. Mandatory Compliance

From an ex ante perspective, no disclosure of demand is the ideal scenario for the firm: the lack of disclosure keeps the rivals in the dark while allowing the firm to make circumstance contingent production decisions (see, e.g., Raith 1996). While such a policy cannot be sustained ex post, Proposition 1 shows that the firm can sometimes take a step in this direction in the voluntary compliance regime by sustaining aggregate disclosures as an equilibrium. Perhaps not surprisingly, the firm's efforts in this regard come at the expense of its rival and the consumers. Thus, in the short run, the conventional view that mandatory compliance can enhance transparency and be socially beneficial holds.

Consumers benefit from the firm's reporting of segment details due to the heightened competition that ensues. Formally, using (3), consumer surplus under mandatory compliance equals:

$$
\tilde{C}(\alpha_1, \alpha_2; a_1, a_2) = \frac{1}{2} \sum_{i=1,2} \left[ \tilde{q}_i^F(a_1, a_2) + \tilde{q}_i^R(a_1, a_2) \right]^2
= 2 \left( \left[ \frac{\alpha_1 a_1}{3} \right]^2 + \left[ \frac{\alpha_2 a_2}{3} \right]^2 \right).
$$

(8)

In an analogous fashion, using (5), consumer surplus under voluntary compliance, assuming aggregation is supported as an equilibrium, equals:

$$
\overline{C}(\alpha_1, \alpha_2; a_1, a_2) = \frac{1}{2} \sum_{i=1,2} \left[ \tilde{q}_i^F(a_1, a_2) + \tilde{q}_i^R(a_1 + a_2) \right]^2
= \frac{1}{2} \left( \left[ \frac{\alpha_1 (7a_1 + a_2)}{12} \right]^2 + \left[ \frac{\alpha_2 (7a_2 + a_1)}{12} \right]^2 \right).
$$

(9)
Comparing (8) and (9), and taking expectations, confirms that expected consumer surplus is strictly higher under full disclosure than under the aggregate equilibrium.

In terms of overall efficiency, a similar comparison can be made. That is, total welfare with full disclosure (under mandatory compliance) and with segment aggregation (under voluntary compliance), respectively, are:

\[
\tilde{W}(\alpha_1, \alpha_2; a_1, a_2) = \tilde{C}(\alpha_1, \alpha_2; a_1, a_2) + \tilde{\Pi}(\alpha_1, \alpha_2; a_1, a_2) + \sum_{i=1,2} \tilde{\Pi}_i^R(\alpha_1, \alpha_2; a_1, a_2); \text{ and}
\]

\[
\bar{W}(\alpha_1, \alpha_2; a_1, a_2) = \bar{C}(\alpha_1, \alpha_2; a_1, a_2) + \bar{\Pi}(\alpha_1, \alpha_2; a_1, a_2) + \sum_{i=1,2} \bar{\Pi}_i^R(\alpha_1, \alpha_2; a_1, a_2) \tag{10}
\]

Taking expectations of the welfare expressions in (10) yields the result in Proposition 2.

**PROPOSITION 2.**

In the short run, mandatory compliance yields higher expected consumer surplus and higher expected total welfare.

The proposition confirms the view that firms' tendency to withhold segment information is a means of keeping competitive advantage and thereby exercising market power. Such market dominance is detrimental to consumers because they value the close match between production and demand (and the resulting lowering of prices) that transparency can generate. This view broadly supports the conventional wisdom that uniform compliance when it comes to segment disclosure rules is ideal, and efforts to tighten enforcement may serve the public well. This result is subject to the caveat that it is derived in the short run, i.e., under a myopic view of firm investment incentives. In the long run, however, not only can the compliance regime alter the competitive landscape, it can also have reverberations on firms' incentives to innovate in the first place. The next section considers this possibility.
4. Long Run Analysis

In analyzing the long run consequences of disclosure regulation, we recognize that firms can adjust competitive strategy to accommodate regulatory shifts. In particular, we consider the setting in which the dominant firm can undertake upfront investments that affect market demand. In other words, rather than viewing market demand $\alpha_i$ as fixed, we allow the firm to undertake (publicly observed) investment so as to influence demand in each market. In this case, though the firm incurs the initial cost of investment, all producers in the market stand to gain from the ensuing surge in market demand. Such a public good aspect of investment reflects the fact that dominant firms often engage in activities that have positive spillovers for rivals. For example, a firm may extensively invest in advertising a new technology, the benefits of which are also obtained by the followers who employ a related technology. The fact that rivals may free ride can dampen the firm's incentives to engage in such activities. We next identify the long-term outcomes under each compliance regime.

4.1. Voluntary Compliance

Recall from section 3.1 that under voluntary compliance, the firm can sustain aggregation as a viable equilibrium as long as its markets are sufficiently similar. Given the firm's preference for aggregation and the ex ante symmetry of the two markets, such an outcome does arise when investment is viewed as a strategic choice for the firm. In particular, presuming the firm is able to support its preferred disclosure equilibrium (segment aggregation), it picks investment levels to solve:

---

6 The investment spillovers modeled herein can also be viewed more generally as rivals learning from the firm's adoption of innovations, including cost-cutting technology. To incorporate this interpretation, it is convenient to think of the demand intercept as being net of unit production cost (e.g., Singh and Vives 1984). In fairness, we should also note dominant firms may also purposefully engage in activities that impose negative externalities for rivals (via comparative advertising, for example).

7 More broadly, even if the markets have exogenous ex ante differences, the firm's preference for aggregation may entice it to undertake investments so as to make similarity in markets endogenous.
\[
\max_{\alpha_1, \alpha_2} E_{\alpha_1, \alpha_2} \left[ \Pi^F(\alpha_1, \alpha_2; a_1, a_2) \right] - c(\alpha_1) - c(\alpha_2).
\] (11)

Using \( E_{\alpha_1, \alpha_2} \left[ \Pi^F(\alpha_1, \alpha_2; a_1, a_2) \right] \) from (7), the first-order condition of (11) determines the firm's equilibrium investment levels under segment aggregation. Since this condition specifies equal investment in the two markets, it is clear from Proposition 1 that these investment levels coupled with segment aggregation represent the firm's equilibrium policy. The result of this analysis is summarized in Proposition 3.

**Proposition 3.** In the long run under voluntary compliance,

(i) The firm's equilibrium investment is \( \alpha_1 = \alpha_2 = a^V \), where \( a^V \) solves
\[
\frac{c'(a^V)}{\alpha^V} = \frac{2(\alpha^2 + \delta^2)}{9} + \frac{5(1 - \rho)\delta^2}{36}; \quad \text{and}
\]

(ii) The firm's disclosure entails segment aggregation.

While a closed-form expression for \( a^V \) is not generally available, the first-order condition for investment provides some useful insights. Given the initial regularity conditions on \( c(\cdot) \), the left-hand-side of the \( a^V \)-equation is increasing in \( a^V \). Thus, \( a^V \) is increasing in expected market demand (reflected in \( \bar{a} \)) and the extent of uncertainty in the market (reflected in the variance, \( \delta^2 \)), while decreasing in cross-market correlation (\( \rho \)). Each factor reflects the potential payoff from investment in the market, with higher scope for payoff naturally inducing higher firm investment. The correlation effect in particular is notable. In this case, the firm's penchant for diversification arising from segment aggregation carries forward to its market investments. That is, the lower the correlation in markets, the more the firm can exploit aggregation to conceal proprietary information which, in turn, provides increased impetus for investments. Given the spur in market demand afforded by the competitive advantage secured under segment aggregation, we now revisit the welfare consequences of mandating compliance.
4.2. Mandatory Compliance

If the firm is required to comply with segment disclosure regulations, its investment choice solves:

\[
\text{Max } E_{a_1, a_2} \left[ \tilde{\Pi}^F (a_1, a_2; a_1, a_2) \right] - c(a_1) - c(a_2).
\] (12)

Using \( E_{a_1, a_2} \left[ \tilde{\Pi}^F (a_1, a_2; a_1, a_2) \right] \) from (7), the first-order condition of (12) reveals the firm's equilibrium investment decision under mandatory compliance. As alluded to above, the firm responds to stringent disclosure laws that undercut its market power by curtailing investment in each market, as summarized in Proposition 4.

PROPOSITION 4. In the long run under mandatory compliance,

(i) The firm's equilibrium investment is \( a_1 = a_2 = \alpha^M \), where \( \alpha^M \) solves

\[
\frac{c'(\alpha^M)}{\alpha^M} = \frac{2[\bar{a}^2 + \delta^2]}{9}; \text{ and}
\]

(ii) Investment is lower than under voluntary compliance.

Inspection or Propositions 3 and 4 reveals the impetus for investment brought by disclosure discretion, reflected in the additional term \( \frac{5(1 - \rho)\delta^2}{36} \) in Proposition 3(i). Intuitively, securing information advantage via segment aggregation represents a means of protecting the benefits of investment from the competition, inducing the firm to invest more. And, the greater the information advantage to sustain (the greater the variance and/or the lesser the cross-market correlation), the more pronounced this effect is.

The added incentive to invest under voluntary compliance prompts a reexamination of welfare consequences of compliance regimes. Just as patents are justified on the grounds of providing long term investment incentives despite the ex post downside of granting excessive market power to a firm, similar arguments may justify long term benefits of voluntary compliance. Though a firm may exploit segment aggregation to sustain competitive advantage, the prospect of such sustained market power may provide
sufficient incentives for a firm to invest more in technologies which could benefit society more in the long run. In other words, a firm may employ accounting tools to gain competitive advantage if it is given such discretion. However, absent such tools, a firm does not sit complacent but rather seeks other means of being a more lean adversary. In determining the best regulatory course of action, one must weigh the consequences of alternative instruments the firm may employ.

Given this tradeoff, we examine consumer preferences in the long run. From the consumers' perspective, mandatory compliance permits the rival to better match production with demand, leading to increased industry output and lowered product prices. On the other hand, mandatory compliance dampens firm incentives to increase demand by making suitable investments. Using (8) and (9), comparing \[ E_{a_1, a_2} \left[ \bar{C}^F (\alpha^M, \alpha^M; a_1, a_2) \right] \] with \[ E_{a_1, a_2} \left[ \bar{C}^F (\alpha^V, \alpha^V; a_1, a_2) \right] \] verifies that the standard view of mandatory compliance—that it aids consumers as in Proposition 2—can be reversed when incentives to invest are endogenized. In fact, the investment effects can be sufficiently pronounced that all parties prefer voluntary compliance.

PROPOSITION 5. In the long run,

(i) Mandatory compliance yields lower expected consumer surplus if and only if

\[
\left[ \frac{\alpha^V}{\alpha^M} \right]^2 > \frac{\bar{a}^2 + \delta^2}{\bar{a}^2 + (25 + 7\rho)\delta^2 / 32}; \text{ and}
\]

(ii) Mandatory compliance is Pareto dominated if and only if

\[
\left[ \frac{\alpha^V}{\alpha^M} \right]^2 > \frac{\bar{a}^2 + \delta^2}{\bar{a}^2 + (1 + \rho)\delta^2 / 2}.
\]

In Proposition 5(i), a cutoff on the \(\alpha\)-ratio succinctly captures when consumers suffer under mandatory compliance despite it providing greater competition. The cutoff value captures the two underlying tensions, as can be seen by the effect of cross-market correlation. Intuitively, when there is perfect correlation in the markets, aggregation is moot and the left-hand-side and right-hand-side of the condition in Proposition 5(i) are both equal to 1. As \(\rho\) decreases, the ensuing opaqueness associated with segment aggregation
stifles competition. This (lack of) transparency cost to consumers implies the right-hand-side of the condition (the cutoff value) increases. However, recall from Proposition 3(i), as \( \rho \) decreases, the wedge between investment levels under voluntary and mandatory compliance also increases. This investment benefit to consumers implies the left-hand-side of the condition (the \( \alpha \)-ratio) also increases. Thus, in effect, the proposition states that whether or not voluntary compliance aids consumers is equivalent to conducting a simple investment benefit vs. transparency cost tradeoff.

It is natural to conjecture that since segment aggregation is preferred by the firm, it must at least be costly for the rivals. After all, without having precise demand information, the rivals are forced to make production decision which work well "on average" but are not fine-tuned to the circumstance. This intuitive thinking is indeed correct when investment levels under both mandatory and voluntary compliance are equal. However, as confirmed in Proposition 5(ii), the potential for the rival to benefit from aggressive firm investment (through enhanced product demand and/or efficiency-enhancing technology spillovers) means the rivals too may prefer the regime in which the firm reveals only aggregate data. That is, just as was the case with consumers, the rivals reap benefits from the firm's enhanced investment under aggregate reporting (again captured by an \( \alpha \)-ratio) as well as encounter a transparency cost. Moreover, the transparency cost to overcome before the rival gains is greater than what is needed for consumers to gain: the cutoff value on the right-hand-side of the condition in Proposition 5(ii) exceeds that in Proposition 5(i). Thus, when rivals gain, Pareto gains are also sure to arise under voluntary compliance and segment aggregation.

Propositions 5 establishes the succinct \( \alpha \)-ratio cutoffs above which mandatory segment disclosures can harm both consumers and rivals. We next consider the particular form of such cutoffs when closed-form expressions for investment levels are accessible. In particular, for the broad class of polynomial cost functions, \( c(\alpha) = \lambda \alpha^\gamma, \lambda > 0 \), a direct application of Propositions 3 and 4 yields the following closed-form expressions for the
endogenous investment levels:

\[ \alpha^M = \left[ \frac{8a^2 + 8 \delta^2}{36 \lambda \gamma} \right]^{\frac{1}{\gamma-2}} \quad \text{and} \quad \alpha^V = \left[ \frac{8a^2 + 8 \delta^2 + 5(1-\rho)\delta^2}{36 \lambda \gamma} \right]^{\frac{1}{\gamma-2}}. \]  

(13)

As expected, \( \alpha^V > \alpha^M \). Further, the \( \alpha \)-ratio is decreasing in \( \gamma \), approaching 1 for sufficiently large \( \gamma \). Roughly stated, at higher \( \gamma \)-values, the cost associated with marginally increasing demand becomes more prominent, thus leading to the narrowing of the wedge between \( \alpha^V \) and \( \alpha^M \). Since the \( \alpha \)-ratio is monotonic in \( \gamma \), the conditions in Proposition 5 can be recast in terms of \( \gamma \)-cutoffs.

**Proposition 6.** For the polynomial cost function \( c(\alpha) = \lambda \alpha^\gamma \),

(i) Consumers are made worse off by mandatory compliance if and only if \( \gamma < \gamma^* \); and

(ii) All parties are made worse off by mandatory compliance if and only if \( \gamma < \gamma^{**} \), where \( \gamma^{**} < \gamma^* \).

The key features of Proposition 6 are demonstrated pictorially in Figure 1. The figure plots the monotonic relationship between the \( \alpha \)-ratio and \( \gamma \), also demonstrating the relevant cutoff-points from Proposition 5 and the translations of such cutoffs in \( \gamma \)-terms.

---

**Figure 1.**

---

From Proposition 6, for small \( \gamma \), voluntary compliance, and the ensuing aggregate reporting by the firm, is the outcome preferred by all parties. In fact, such unanimous preference for voluntary compliance is guaranteed in the simple case of \( \gamma = 3 \), a setting

---

\(^8\) In the polynomial cost case, the regularity condition \( c'''(\alpha_i) > 0 \) translates into the requirement \( \gamma > 2 \).
wherein the endogenous $\alpha$-values are linear increasing functions of the demand mean ($\bar{\alpha}$) and variance ($\delta^2$), while investment under voluntary compliance is a linear decreasing function of cross-market correlation ($\rho$).

**COROLLARY 2.** For the cubic cost function, $c(\alpha) = \lambda \alpha^3$:

(i) \[ \alpha^M = \frac{2[\bar{\alpha}^2 + \delta^2]}{27\lambda}, \]

(ii) \[ \alpha^V = \alpha^M + \frac{5(1-\rho)\delta^2}{108\lambda}, \text{ and} \]

(iii) All parties are made worse off by mandatory compliance.

The corollary highlights unanimity of preferences for granting firms discretion about how much, if any, segment details to disclose. Though such unanimity is not guaranteed in general, Proposition 5 provides intuitive conditions under which such preferences can arise. Taken together, the results indicate that the more critical firm investments are to an industry, the more important it is to cultivate an environment in which firms feel their proprietary investments can be secured. And, the ability to provide limited segment detail to outside parties can be one means through which such an environment can be nurtured.

Prior to concluding this section, we must add a caveat.\(^9\) This paper’s analysis has focused on one-sided investments – the rivals make no investments in our model. Adding investments by the rivals to the mix necessitates further caution in deriving welfare implications. Formally, let $\beta_i$ be rival $i$’s investment and assume (inverse) demand is now reflected by the formulation $P_i = \alpha_i a_i + \tau \beta_i - q_i^F - q_i^R$, where $\tau \geq 0$ denotes the relative sensitivity of demand in market $i$ to rival $i$’s investment (the base case corresponds to $\tau = 0$). In this additive case, the rivals’ equilibrium investments are independent of the compliance regime, and hence our welfare results are unchanged by two-sided investments. In contrast, suppose $P_i = [\alpha_i + \tau \beta_i]a_i - q_i^F - q_i^R$. In this multiplicative case, the added

\(^9\) We thank a referee for this and many other helpful comments.
force is that while voluntary compliance continues to provide the firm an informational edge spurring its investments, it also results in dampened investments by the informationally disadvantaged rivals. Not surprisingly, the welfare analysis is now parameter specific. However, for small $\tau$-values our baseline results continue to apply.

Our broader point is simple: accounting reporting mandates impact the economic environment on both information and production fronts. This theme also suggests there may be a "patent protection" analog that can serve as a solution here: a defined period of reporting flexibility that permits firms in an industry with positive spillovers to earn a good return on investments.

5. Summary and Implications

This paper presents a model of segment disclosures when a firm faces competition on multiple fronts. The results suggest that while firms may willingly disclose firmwide performance voluntarily, compliance with efforts to expand disclosure to the segment level is unlikely to be uniform. In light of firms' motivation to aggregate segment information, the model also examines the efficacy of strict enforcement of segment disclosure rules. Succinctly stated, the paper's results underscore the importance of a holistic view of disclosure regulation. While it is true that mandating detailed segment disclosures can increase economic efficiency assuming all else is equal, all else may not be equal. In this particular case, when mandatory compliance undercuts a firm's competitive advantage, it also undercuts its incentive to undertake demand enhancing investments since more of the benefits of such investments are sure to be ceded to competitors. Roughly stated, when taking investments into account, the long-term effect of mandating disclosure of segment details can actually be to inhibit competition and, thus, economic efficiency. In fact, such factors may point to all economic participants (the firm, its rival, and consumers) preferring a voluntary compliance regime that affords flexibility in reporting of segment information.

Firm motives to conceal segment information and the consequences of regulation to
mandate such disclosures (e.g., SFAS 14 and 131) has motivated several empirical studies of the attendant effects (e.g., Harris 1998; Street et al. 2000; Ettredge et al. 2002; Botosan and Stanford 2005). The results in this paper provide some guidance in design of these tests. In particular, we show that similarities in market size across segments, the extent of segment risk, and cross-segment correlation are critical factors supporting a firm's desire to undertake segment aggregation for competitive reasons.

In a similar vein, this paper also notes that discerning consequences of disclosure regulation may be subtle. For example, one may seek to examine the effect of mandatory compliance with segment disclosures on the long run profitability of firms who sought flexibility prior to such regulation. Presuming such an analysis demonstrated a gradual lowering of segment profitability, it could naively be interpreted as a sign that increased information transparency has led to greater competition. However, the underlying forces may actually be more complex. It is plausible, for instance, that mandating disclosures leads to a concurrent decrease in firms' R&D expenditures (and thereby a short run boost in profits). In such cases, the subsequent decrease in segment profits may not solely be indicative of increased industry competitiveness (a socially beneficial outcome) but could also be a reflection of inefficiencies introduced by suboptimal R&D investments (a socially detrimental outcome).

In effect, the underlying forces identified herein suggest that an empirical investigation of disclosure regulation necessitates a simultaneous focus on firms' operational decisions and long-term strategic responses. For example, if SFAS 131 prevents firms from obtaining competitive advantage via aggregate reporting, a question to ask is how did firms react in order to keep their competitive edge, and what are the consequences of such behaviors? Empirical answers to such questions may help provide a more comprehensive understanding of the repercussions of disclosure regulation including the impending effects of recent efforts by the IASB (IFRS 8) to promote international convergence in the realm of segment reporting.
APPENDIX

Proof of Proposition 1.

First, we address conditions under which segment aggregation can be sustained as an equilibrium. Using the firm profit expressions from (4) and (6):

\[
\Pi^F(\alpha_1, \alpha_2; \bar{a} + \delta, \bar{a} - \delta) - \widetilde{\Pi}^F(\alpha_1, \alpha_2; \bar{a} + \delta, \bar{a} - \delta) = \\
\frac{\delta}{36} \left[ (\alpha_1)^2 (4\bar{a} + 5\delta) - (\alpha_2)^2 (4\bar{a} - 5\delta) \right].
\]

(A1)

A necessary condition for segment aggregation to be an equilibrium is that the expression in (A1) is nonnegative, in which case aggregation is (ex post) preferred to full disclosure when \((\alpha_1, \alpha_2) = (\bar{a} + \delta, \bar{a} - \delta)\). This yields the lower bound in Proposition 1. Similarly, another necessary condition for segment aggregation to be an equilibrium is that the expression in (A2) is nonnegative:

\[
\Pi^F(\alpha_1, \alpha_2; \bar{a} - \delta, \bar{a} + \delta) - \widetilde{\Pi}^F(\alpha_1, \alpha_2; \bar{a} - \delta, \bar{a} + \delta) = \\
\frac{\delta}{36} \left[ -(\alpha_1)^2 (4\bar{a} - 5\delta) + (\alpha_2)^2 (4\bar{a} + 5\delta) \right].
\]

(A2)

Setting (A2) equal to zero yields the upper bound in Proposition 1. Also, note that \(\Pi^F(\alpha_1, \alpha_2; \bar{a} + \delta, \bar{a} + \delta) - \widetilde{\Pi}^F(\alpha_1, \alpha_2; \bar{a} + \delta, \bar{a} + \delta) = \Pi^F(\alpha_1, \alpha_2; \bar{a} - \delta, \bar{a} - \delta) - \widetilde{\Pi}^F(\alpha_1, \alpha_2; \bar{a} - \delta, \bar{a} - \delta) = 0\). Thus, under the condition in Proposition 1, ex post the firm at least weakly prefers segment aggregation to full disclosure. The choice of off-equilibrium beliefs that \(a_i = \bar{a} + \delta\) when there is no disclosure in market \(i\) ensure that aggregated disclosure is preferred to all other disclosure choices as well and, hence, is an equilibrium. Finally, taking expectations over \(a_1\) and \(a_2\), implies that from an ex ante perspective, segment aggregation is preferred by the firm to full disclosure when (A1) and (A2) are satisfied.

From the above arguments it also follows that if either (A1) or (A2) is violated, i.e., the condition in Proposition 1 is not satisfied, aggregation cannot be sustained as an equilibrium. In this case, the choice of off equilibrium beliefs that \(a_i = \bar{a} + \delta\) when \(a_i\) is not fully revealed ensures that full disclosure is sustained as the equilibrium.

To complete the proof, we next demonstrate that the above cases (aggregation and full disclosure) reflect all possible equilibria. To do so, we need to consider three possible scenarios: (i) the disclosure decision in (at least) one market, say market \(i\), is unaffected by
(a_1, a_2), (ii) the disclosure decision in market \( i \) is affected by \( a_i \) but unaffected by \( a_j \), and (iii) the disclosure decision in each market can be affected by \((a_1, a_2)\).

(i) We first argue that a policy of always withholding in one market is not an equilibrium. Without loss of generality, suppose the firm withholds \( a_1 \). In this case, when \((a_1, a_2) = (\bar{a} - \delta, \bar{a} - \delta)\), the firm is better off revealing both \( a_1 \) and \( a_2 \), regardless of the disclosure policy in market 2. More precisely, if the firm adopts a strategy of always withholding \( a_1 \) but disclosing \( a_2 \), rival 1's updated beliefs in this case are 

\[
\Pr_1(\bar{a} + \delta(\bar{a} - \delta),d(\cdot)) = (1 - \rho)/2.
\]

Under these beliefs, the competitive outcome (derived from the first order conditions of (1) and (2)) yields firm profit of:

\[
\Pi^F(a_1, a_2; \bar{a} - \delta, \bar{a} - \delta) - \frac{\delta(a_1)^2(1 - \rho)[4\bar{a} - (5 - \rho)\delta]}{36},
\]

(A3)

Since the second term is positive (\( \delta < \bar{a}/2 \)), the firm is ex post better off revealing both \( a_1 \) and \( a_2 \). Similar arguments also imply that disclosing both \( a_1 \) and \( a_2 \) is strictly preferred to withholding disclosure in both markets. This covers the policies under (i).

(ii) If the disclosure decision in market \( i \) is unaffected by \( a_j \), a straightforward application of the unraveling result implies that the only such policy which is sustainable in equilibrium entails full revelation. Thus, any such equilibrium can be replicated by the full disclosure equilibrium.

(iii) If the disclosure decision in each market can be affected by \( a_1 \) and \( a_2 \), we next confirm that the only sustainable disclosure strategies are equivalent to those considered previously.

First, note that if the policy entails aggregation for some \((a_1, a_2)\), it is fully revealing and thereby replicates full disclosure unless aggregation occurs for both \((a_1, a_2) = (\bar{a} + \delta, \bar{a} - \delta)\) and \((a_1, a_2) = (\bar{a} - \delta, \bar{a} + \delta)\). Under such aggregation, when \((a_1, a_2) = (\bar{a} - \delta, \bar{a} - \delta)\), the firm cannot resist an ex post temptation to disclose, thereby confirming that any viable equilibrium replicates the aggregation equilibrium.

Turning to the possibility of withholding, if the policy entails disclosure being withheld for only one \((a_1, a_2)\) combination, the outcome is equivalent to full disclosure. If the policy entails disclosure being withheld for two (or more) different \((a_1, a_2)\) realizations, to be sustainable it must entail disclosure when \((a_1, a_2) = (\bar{a} - \delta, \bar{a} - \delta)\). If disclosure is withheld for all realizations except \((a_1, a_2) = (\bar{a} - \delta, \bar{a} - \delta)\), the firm would desire to reveal its information when \(a_1 + a_2 = 2\bar{a}\). The remaining possibility to consider is withholding disclosure only when \(a_1 + a_2 = 2\bar{a}\). Clearly, such an outcome replicates the aggregation equilibrium.  

\[
\boxed{
}\]
Proof of Corollary 1.

If the condition in Proposition 1 is satisfied, segment aggregation is the voluntary compliance equilibrium. Under this equilibrium, expected firm profit is:

\[ E_{a_1, a_2} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) \right] = \]

\[ \frac{(1 + \rho)}{4} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) - \delta - \delta \right] + \frac{(1 - \rho)}{4} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) + \delta - \delta \right] + \]

\[ \frac{(1 - \rho)}{4} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) + \delta - \delta \right] + \frac{(1 + \rho)}{4} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) + \delta + \delta \right]. \]

Substituting for \( \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) \) from (6) yields:

\[ E_{a_1, a_2} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) \right] = \left[ (\alpha_1)^2 + (\alpha_2)^2 \right] \frac{8a^2 + (13 - 5\rho)\delta^2}{72}. \] (A4)

Taking the derivative of (A4) with respect to \( \rho \) proves the corollary:

\[ \frac{dE_{a_1, a_2} \left[ \tilde{\Pi}^F (\alpha_1, \alpha_2; a_1, a_2) \right]}{d\rho} = \frac{-5\delta^2 \left[ (\alpha_1)^2 + (\alpha_2)^2 \right]}{72} < 0. \]

Proof of Proposition 2.

If the condition in Proposition 1 is violated, the voluntary compliance equilibrium entails full revelation. In this case, the outcome is identical to that obtained under mandatory compliance, so the consumer surplus and total welfare under the voluntary and mandatory compliance regimes are the same. If the condition in Proposition 1 is satisfied, the voluntary compliance equilibrium entails segment aggregation, so the outcome is different from that under mandatory compliance. In this case, under voluntary compliance, the expected firm profit is as in (A4) while, using (6) and (9), the expected profit of rival i and expected consumer surplus equal:

\[ E_{a_1, a_2} \left[ \tilde{\Pi}^R_i (\alpha_1, \alpha_2; a_1, a_2) \right] = \frac{\alpha_i^2 \left[ 2a^2 + (1 + \rho)\delta^2 \right]}{18}. \] (A5)

\[ E_{a_1, a_2} \left[ \tilde{C}(\alpha_1, \alpha_2; a_1, a_2) \right] = \frac{\left[ (\alpha_1)^2 + (\alpha_2)^2 \right] \left[ 32a^2 + (25 + 7\rho)\delta^2 \right]}{144}. \] (A6)

Under mandatory compliance, using (4) and (8), the expected firm profit, expected
rival $i$ profit, and consumer surplus equal:

\[
E_{a_1, a_2} \left[ \tilde{\Pi}^F(a_1, a_2; a_1, a_2) \right] = \frac{(\alpha_1)^2 + (\alpha_2)^2}{9} \left[ \tilde{a}^2 + \delta^2 \right]. 
\]  
(A7)

\[
E_{a_1, a_2} \left[ \tilde{\Pi}^R_i(a_1, a_2; a_1, a_2) \right] = \frac{\alpha_i^2}{9} \left[ \tilde{a}^2 + \delta^2 \right]. 
\]  
(A8)

\[
E_{a_1, a_2} \left[ \tilde{C}(a_1, a_2; a_1, a_2) \right] = \frac{2(\alpha_1)^2 + (\alpha_2)^2}{9} \left[ \tilde{a}^2 + \delta^2 \right]. 
\]  
(A9)

Comparing (A6) with (A9) yields:

\[
E_{a_1, a_2} \left[ \tilde{C}(a_1, a_2; a_1, a_2) \right] - E_{a_1, a_2} \left[ \tilde{C}(a_1, a_2; a_1, a_2) \right] = \frac{7\delta^2}{144} \left[ 1 - \rho \frac{(\alpha_1)^2 + (\alpha_2)^2}{c(\alpha_1) - c(\alpha_2)} \right] > 0.
\]

The total welfare is the sum of firm profit, profits of the two rivals, and consumer surplus, as listed in (10). Using (A4)-(A9) yields:

\[
E_{a_1, a_2} \left[ \tilde{W}(a_1, a_2; a_1, a_2) \right] - E_{a_1, a_2} \left[ \tilde{W}(a_1, a_2; a_1, a_2) \right] = \frac{5\delta^2}{144} \left[ 1 - \rho \frac{(\alpha_1)^2 + (\alpha_2)^2}{c(\alpha_1) - c(\alpha_2)} \right] > 0.
\]

**Proof of Proposition 3.**

Assume $\alpha_1 = \alpha_2$ in the long-run under voluntary compliance, a claim subsequently verified. With equal investments, the condition in Proposition 1 is satisfied. Thus, segment aggregation is the voluntary compliance equilibrium, and expected firm profit is as in (A4) less investment costs. The firm's investment problem is then as follows:

\[
\max_{\alpha_1, \alpha_2} \left[ \frac{(\alpha_1)^2 + (\alpha_2)^2}{72} \left[ 8\tilde{a}^2 + (13 - 5\rho)\delta^2 \right] \right] \left[ c(\alpha_1) - c(\alpha_2) \right]. 
\]  
(A10)

Solving the first-order condition of (A10) with respect of $\alpha_1$ and $\alpha_2$, respectively, yields the condition listed in part (i). Since $\alpha_1 = \alpha_2 = \alpha^V$, our initial claim that investment levels are the same in both markets is also verified, proving part (ii).

**Proof of Proposition 4.**

Using (A7), the firm's investment problem in the long-run under mandatory compliance is as follows:
Max \( \frac{(\alpha_1)^2 + (\alpha_2)^2}{9} \left( \frac{\alpha^2 + \delta^2}{\alpha} \right) - c(\alpha_1) - c(\alpha_2). \) \hspace{1cm} (A11)

Solving the first-order condition of (A11) with respect of \( \alpha_1 \) and \( \alpha_2 \), respectively, yields the condition listed in part (i). Further, given the regularity conditions on \( c(\cdot) \), \( c(0) = c'(0) = 0 \), and \( c'''(\alpha_i) > 0 \) for \( \alpha_i > 0 \), the function \( \frac{c'(\alpha)}{\alpha} \) is increasing in \( \alpha \). The ordering \( \alpha^V > \alpha^M \) in Part (ii) then follows directly from the fact that the right-hand-side of the condition in Proposition 3 is greater than the right-hand-side of the condition in Proposition 4.

**Proof of Proposition 5.**

Under voluntary compliance, expected consumer surplus is as in (A6) with \( \alpha_1 = \alpha_2 = \alpha^V \). Under mandatory compliance, expected consumer surplus is as in (A9) with \( \alpha_1 = \alpha_2 = \alpha^M \). Comparing these expected consumer surplus expressions, and solving for \( \alpha^V / \alpha^M \) yields the result in part (i) of the proposition.

The firm does better if given discretion in reporting; after all, the firm can always choose \( \alpha_1 = \alpha_2 = \alpha^M \) and then disclose segment information only in aggregate. The consumers prefer voluntary compliance if the condition in part (i) is satisfied. The only other parties are the rivals in each market. Under voluntary compliance, rival \( i \)'s expected profit is as in (A5) with \( \alpha_1 = \alpha_2 = \alpha^V \); its expected profit under mandatory compliance is as in (A8) with \( \alpha_1 = \alpha_2 = \alpha^M \). Comparing these two expressions implies rival \( i \)'s expected profit is greater under voluntary compliance if and only if 

\[
\frac{\alpha^D}{\alpha^M} \geq \frac{\tilde{a}^2 + \delta^2}{\tilde{a}^2 + (1 + \rho)\delta^2/2}.
\]

Since the right-hand-side of this condition is greater than the right-hand-side of the condition in part (i), it follows that the firm, the rivals, and the consumers all gain under voluntary compliance if and only if the condition in part (ii) is satisfied.

**Proof of Proposition 6.**

Substituting \( c(\alpha) = \lambda \alpha^\gamma \) in the conditions in Proposition 3 and Proposition 4, respectively, yields \( \alpha^V = \left[ \frac{8\tilde{a}^2 + 8\delta^2 + 5(1 - \rho)\delta^2}{36\lambda \gamma} \right]^{\gamma/2} \) and \( \alpha^M = \left[ \frac{8\tilde{a}^2 + 8\delta^2}{36\lambda \gamma} \right]^{\gamma/2} \).

Thus, in the polynomial cost case, the \( \alpha \)-ratio equals:
\[ \left( \frac{\alpha^V}{\alpha^M} \right)^2 = \left[ \frac{\bar{a}^2 + (13 - 5\rho)\delta^2 / 8}{\bar{a}^2 + \delta^2} \right]^{\gamma - 2}. \]  

(A12)

The right-hand-side of (A12) is decreasing in \( \gamma \) for \( \gamma > 2 \). Also, the right-hand-side value of (A12) at \( \gamma = 3 \) \((\gamma \to \infty)\) is more (less) than the right-hand-side value of the condition in Proposition 3. Hence, there exists an interior cutoff \( \gamma \)-value, \( \gamma^* > 3 \), such that consumers prefer voluntary compliance for all \( \gamma < \gamma^* \). This proves part (i).

The same argument as above implies there exists a more stringent cutoff \( \gamma \)-value, \( 3 < \gamma^{**} < \gamma^* \), such that all parties prefer voluntary disclosure for any \( \gamma < \gamma^{**} \). This proves part (ii).

Proof of Corollary 2.

Substituting \( c(\alpha) = \lambda \alpha^3 \) in the conditions in Propositions 3 and 4 yield
\[ \alpha^M = \frac{2[\bar{a}^2 + \delta^2]}{27\lambda} \quad \text{and} \quad \alpha^V = \alpha^M + \frac{5(1 - \rho)\delta^2}{108\lambda}. \]  

Thus, in this case, the \( \alpha \)-ratio equals:
\[ \left( \frac{\alpha^V}{\alpha^M} \right)^2 = \left[ \frac{\bar{a}^2 + (13 - 5\rho)\delta^2 / 8}{\bar{a}^2 + \delta^2} \right]^2. \]  

(A13)

The right-hand-side of (A13) is greater than the right-hand-side value of the condition in part (ii) of Proposition 5. Hence, when \( c(\alpha) = \lambda \alpha^3 \), all parties prefer voluntary compliance.
REFERENCES


Figure 1. The $\alpha$-ratio as a function of $\gamma$. 