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The interaction between corporate tax structure and disclosure policy

Received: (date filled in by *AF*) / Accepted: (date filled in by *AF*)

Abstract When socially desirable behaviors are deemed difficult to legislate, tax code is often called upon to indirectly achieve the desired ends. Adjustments to tax policy have been employed to spark investment, encourage charitable donations, and discourage tobacco consumption, to name a few examples. This paper demonstrates that tax policy may also be an effective means of encouraging welfare enhancing disclosures by firms. Further, by inducing disclosures of the right types of information while discouraging revelation of other types, tax policy proves to be a more versatile instrument than direct regulatory attempts which can mandate (but not prohibit) disclosures. The intuition behind our results is that when firms make decisions to disclose (or withhold) pieces of private information, such a decision is often made with an eye on the potential for a large payoff. In such cases, progressive taxes can dampen the appeal of big payoffs and better align the incentives of firms with those of consumers. In short, while progressive taxes may be criticized for curbing aggressiveness, it is precisely such a decrease in aggressiveness that can prompt efficient sharing of information.

Keywords and phrases Competition · Disclosure · Progressive taxes

JEL Classification Numbers L5 · M4

We thank Mark Bagnoli, Francesco Bova, Ron Dye, John Fellingham, Hans Frimor, Thomas Pfeiffer, Doug Schroeder, Shyam Sunder, Susan Watts, Lixin Ye, Dae-Hee Yoon, Rick Young, and an anonymous referee for helpful comments. Anil Arya gratefully acknowledges assistance from the John J. Gerlach Chair.

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1. Introduction

It has long been recognized that tax policy can have substantial repercussions on incentives. For this reason, many legislative goals have been implemented through judiciously-designed tax laws. An eponymous example is the use of so-called "sin taxes" to limit consumption of socially undesirable goods such as alcohol and tobacco. Accelerated depreciation schedules, charitable contribution deductions, and favorable treatment of mortgage interest are other examples of tax rules that encourage select behaviors. In line with such a view, this paper shows that the progressivity of tax rates can have reverberations on firms' disclosure policies.

Conventional views present progressive taxes as impediments to efficiency. In contrast, we show that progressive taxes can stimulate socially desirable competitive interactions when information is a key commodity. In particular, a well-designed progressive tax schedule can provide appropriate incentives for competition-enhancing information sharing. Further, even if mandatory disclosure can be costlessly implemented, we show that progressive taxes may better achieve the desired ends. This is because when disclosure of some types of information is welfare enhancing but disclosure of others is not, a progressive tax scheme can be implemented that provides incentives for disclosure of only the right types of information.

To elaborate, we consider an oligopoly model of Cournot competition in which one firm is privy to private information, both about a common-value (demand) parameter and a private-value (cost) parameter. In the absence of disclosure regulation and in the face of flat (or no) taxes, the firm's preferred disclosure policy is to reveal only its cost information. Disclosing private-value cost information allows the firm to employ a form of stochastic cooperation with its competitors. When its cost turns out to be below average, the firm takes over the market; when its cost is above average, it cedes market share to its rivals. Disclosure of common-value demand information has the reverse effect: rather than convincing rivals to step aside, disclosing good news only emboldens competitors since they too gain from the good news. Thus, the firm withholds release of demand information.

However, while disclosure of demand information is not in the firm's interest, it is desirable from a welfare perspective (e.g., Raith 1996). A progressive tax can bring such socially desirable disclosure to the fore. The main impediment to disclosing demand information is that the firm is tempted by the possibility of being able to exploit high demand without facing a concomitant spike in competition from rivals. A progressive tax reduces the allure of such a big payoff, as it taxes extreme profits at higher rates. By undercutting the desirability of the payoff under high demand, progressive taxes create an incentive to disclose because doing so at least softens competitive response in the event of low demand. Intuitively, withholding demand information is desirable because the firm wants to take a gamble on a realization of high demand of which competitors will be unaware. Progressive taxes induce risk-aversion on the part of the firm (Fellingham and Wolfson 1985; Scholes and Wolfson 1992) and convince it to take the safe route, achieved via disclosure of demand information.

While this result demonstrates that progressive tax rates can substitute for mandating disclosure, it also raises a question of why that would be necessary given the ability to simply regulate mandatory disclosure. To address this question, the paper's main result is expanded to demonstrate that progressive taxes can not only implement outcomes under mandatory disclosure, but can also convince a firm to withhold some pieces of information should such an approach maximize social welfare.[1]

Recall, in the absence of regulation, the firm opts to disclose cost information because doing so effectively induces cooperation with competitors. If regulators'

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[1] In this light, we stress that while mandating disclosure may be a difficult undertaking, it is conceivable that such behavior can at least be policed. Presumably, a number of institutions (e.g., FASB, SEC, PCAOB, etc.) assist with such concerns. On the other hand, requiring firms to withhold disclosure is more daunting. In fact, in many instances, prohibiting disclosures may not be legally permissible.

priorities are focused on consumers, such inter-firm coordination is clearly not desirable. Fortunately, progressive taxes can also shift this behavior. Disclosure of cost information is tempting to the firm again due to the chance for a big payoff–when competitors recognize the firm's costs are low, they are induced to scale back, leaving the firm as a dominant player in the market. Of course, the firm returns the favor when its costs are high. By taxing high-payoff events at a higher rate, progressive taxes help discourage such cooperative give-and-take among firms.

This paper builds on both the disclosure and taxation literatures and, in doing so, seeks to identify interactions among these two prominent topics. On the disclosure front, the setting builds on work highlighting the subtle incentives to disclose proprietary information in the absence of taxation (Darrough 1993; Gal-Or 1985, 1986; Li 1985; Spulber 1995).[2] Raith (1996) provides a synthesis of these results, identifying determining factors in the decision to disclose. In this paper's Cournot-competition setting, the key determinant of the disclosure decision is whether the information is of private value (cost) or common value (demand). With this as a backdrop, we introduce the role of tax policy in influencing disclosure preferences. Somewhat interestingly, this paper shows that irrespective of whether the information pertains to private or common value, a shift to progressive taxes shifts the firm's disclosure policy for much the same reason (a desire to avoid gambles), and in much the same direction (the change is welfare-enhancing).

While the focus here is on highlighting benefits of progressive taxes in altering disclosure incentives, progressive taxes have proven beneficial in other settings as well. As examples, progressive taxes have been shown to be efficiency enhancing in boosting employment of low-wage workers (Sorensen 1997), alleviating moral hazard issues in

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[2] This stream of literature focuses on pre-established disclosure policies of firms in the presence of competition. A separate stream of the literature highlights the incentive to undertake discretionary disclosures; notable examples are Dye (1985) and Verrecchia (1983). For excellent critical reviews of both streams of literature, see Dye (2001) and Verrecchia (2001).

entrepreneurship (Keuschnigg and Nielsen 2002), and reducing information-induced distortions among trading partners (Arya et al. 2006).

In this paper, the feature of progressive taxes that proves crucial is that they discourage firms from focusing on disclosure policies that provide a chance of a big payoff, instead inducing risk-aversion and providing a preference for smooth income streams. Viewed in this light, the forces in this paper are closest to that in Fellingham and Wolfson (1985). The Fellingham and Wolfson paper highlights the connection between risk aversion and progressive taxes by studying a moral hazard setting with risk neutral participants. Despite risk neutral preferences, a demand for risk sharing (and a tradeoff with incentives) arises when the agent is subject to progressive taxes.

The paper proceeds as follows. Section 2 presents the model. Section 3 derives the equilibrium outcome under a baseline case of flat taxes and then illustrates how progressive taxes can encourage disclosure. Section 4 then shows how progressive taxes can be fine-tuned to fit regulators' particular welfare goals so that they can encourage partial disclosure, i.e., disclosure of only certain pieces of information. Section 5 concludes the paper.

2. Model

A firm (denoted firm 0) is engaged in Cournot competition with n, $n \geq 1$, other firms. Firm i's quantity is denoted q_i, $i = 0,...,n$, and consumer demand for the firms' products is represented by a linear, downward-sloping (inverse) demand function $P = a + \varepsilon_1 - \sum_{i=0}^{n} q_i$, where P is the equilibrium retail price of the product. There is uncertainty about the industry-wide demand intercept. In particular, the component a is known, while $\varepsilon_1 \in \{-e, e\}$, is a mean-zero noise term.

Each of firm 0's rivals incurs a marginal production cost c for each unit produced. Firm 0's cost is uncertain; its cost is $c + \varepsilon_2$, where $\varepsilon_2 \in \{-e, e\}$, is an independent mean-zero noise term. Prior to production, firm 0 privately learns its cost and the uncertain demand parameter. Firm 0 can opt to disclose either, neither, or both privately-observed parameters via its established disclosure policy.[3] The timeline of events is summarized in Figure 1.

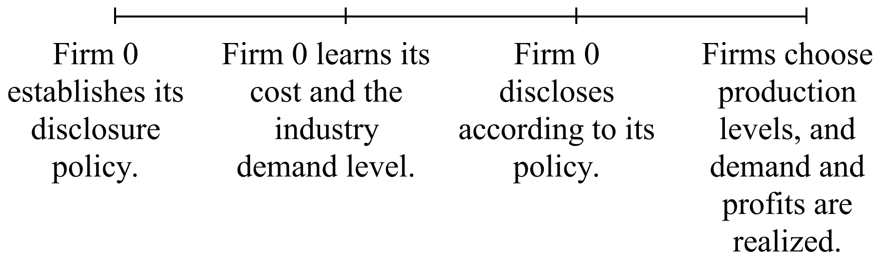

FIGURE 1. Timeline.

Each firm is subject to a tax on profit; denote the marginal tax rate on before-tax profit of π by $t(\pi)$. With this notation, firm 0's expected net (after-tax) profit, Π_0, and firm j's expected net profit, Π_j, $j = 1,\ldots,n$, can be written as:

$$\Pi_0 = E_{\varepsilon_1,\varepsilon_2}\left[\int_0^{(a+\varepsilon_1-\sum_{i=0}^n q_i)q_0-(c+\varepsilon_2)q_0}[1-t(\pi)]d\pi\right] \text{ and } \Pi_j = E_{\varepsilon_1,\varepsilon_2}\left[\int_0^{(a+\varepsilon_1-\sum_{i=0}^n q_i)q_j-cq_j}[1-t(\pi)]d\pi\right]. \quad (1)$$

The expected consumer surplus, denoted CS, is:

$$CS = E_{\varepsilon_1,\varepsilon_2}\left[\int_0^{\sum_{i=0}^n q_i}\left(\sum_{i=0}^n q_i - Q\right)dQ\right] = \frac{1}{2}E_{\varepsilon_1,\varepsilon_2}\left[\left(\sum_{i=0}^n q_i\right)^2\right]. \quad (2)$$

Given a baseline case of flat taxes, $t(\pi) = t_F$ for all π, $0 \leq t_F < 1$, this paper considers the welfare ramifications of revenue-neutral shifts in tax policy. The welfare measure we employ, W, is the standard weighted sum of expected net firm profits and consumer surplus (e.g., Baron 1988; Baron and Myerson 1982):

$$W = \sum_{i=0}^n \Pi_i + \beta CS. \quad (3)$$

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[3] As is standard in the voluntary disclosure literature, we assume if the firm decides to disclose, its pronouncements are truthful.

The weight $\beta \geq 1$ reflects that regulators may be equally concerned with all economy participants or may place more (or all) emphasis on consumers' fates (Baron 1988; Shapiro 1986). In the next section, we consider how tax policy can affect firm 0's disclosure choice. Throughout the analysis, we assume a is sufficiently large to ensure interior solutions.[4]

3. Tax Policy and Disclosure Choice

3.1. Disclosure Choice Under Flat Taxes

We begin by characterizing the equilibrium outcome under each disclosure policy in the baseline case of flat taxes.

Full disclosure

When firm 0 discloses both demand and cost information, each firm can condition its output decision on $(\varepsilon_1, \varepsilon_2)$, so firm *i*'s output is denoted $q_i(\varepsilon_1, \varepsilon_2)$. Given $(\varepsilon_1, \varepsilon_2)$ and its rivals' production decisions, firm 0 chooses $q_0(\varepsilon_1, \varepsilon_2)$ to maximize its net profit in (4):

$$\underset{q_0(\varepsilon_1,\varepsilon_2)}{\text{Max}} \left\{ [a + \varepsilon_1 - \sum_{i=0}^{n} q_i(\varepsilon_1, \varepsilon_2)] q_0(\varepsilon_1, \varepsilon_2) - (c + \varepsilon_2) q_0(\varepsilon_1, \varepsilon_2) \right\} [1 - t_F]. \tag{4}$$

In an analogous fashion, given disclosure of $(\varepsilon_1, \varepsilon_2)$ and its rivals' production decisions, firm j, $j \neq 0$, chooses $q_j(\varepsilon_1, \varepsilon_2)$ to maximize its net profit in (5):

$$\underset{q_j(\varepsilon_1,\varepsilon_2)}{\text{Max}} \left\{ [a + \varepsilon_1 - \sum_{i=0}^{n} q_i(\varepsilon_1, \varepsilon_2)] q_j(\varepsilon_1, \varepsilon_2) - c q_j(\varepsilon_1, \varepsilon_2) \right\} [1 - t_F], \; j = 1, \ldots, n. \tag{5}$$

The firms' optimal production decisions, before-tax profits, and expected after-tax profits in the full disclosure case are presented in Lemma 1. The "*dd*" superscript on the variables denotes that firm 0 *discloses* the demand parameter and the cost parameter, respectively.

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[4] In particular, we assume $a > c + 3e(n+1)/(1 - t_F)$ which is a sufficient condition to ensure interior solutions (for price, quantities, and tax rates) throughout.

Lemma 1. If firm 0 discloses both demand and cost information, the solution is:

$$q_0^{dd}(\varepsilon_1,\varepsilon_2)=\frac{a-c+\varepsilon_1-(n+1)\varepsilon_2}{n+2}\ ;\ q_j^{dd}(\varepsilon_1,\varepsilon_2)=\frac{a-c+\varepsilon_1+\varepsilon_2}{n+2};$$

$$\pi_0^{dd}(\varepsilon_1,\varepsilon_2)=\left[\frac{a-c+\varepsilon_1-(n+1)\varepsilon_2}{n+2}\right]^2;\ \pi_j^{dd}(\varepsilon_1,\varepsilon_2)=\left[\frac{a-c+\varepsilon_1+\varepsilon_2}{n+2}\right]^2;$$

$$\Pi_0^{dd}=\left[\frac{(a-c)^2+e^2(2+2n+n^2)}{(n+2)^2}\right](1-t_F);\text{ and }\Pi_j^{dd}=\left[\frac{(a-c)^2+2e^2}{(n+2)^2}\right](1-t_F).$$

Proof.

Since the rivals of firm 0 are symmetric, the first-order conditions associated with (4) and (5) can be written as $a-c+\varepsilon_1-\varepsilon_2-2q_0(\varepsilon_1,\varepsilon_2)-nq_j(\varepsilon_1,\varepsilon_2)=0$ and $a-c+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-(n+1)q_j(\varepsilon_1,\varepsilon_2)=0$. Solving the two (linear) equations for $q_0(\varepsilon_1,\varepsilon_2)$ and $q_j(\varepsilon_1,\varepsilon_2)$ results in the q-values in Lemma 1. Using these q-values yields the before tax profit (π_i^{dd}) and expected net profit (Π_i^{dd}) expressions in the lemma. ■

Disclosure of only demand information

In this case, firm 0's rivals can condition their output decisions only on the demand information, so we use $q_0(\varepsilon_1,\varepsilon_2)$ and $q_j(\varepsilon_1)$ to denote the firms' production decisions. Given $(\varepsilon_1,\varepsilon_2)$ and its rivals' production decisions, firm 0 chooses $q_0(\varepsilon_1,\varepsilon_2)$ to maximize its net profit in (6):

$$\underset{q_0(\varepsilon_1,\varepsilon_2)}{\text{Max}}\ \left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k(\varepsilon_1)]q_0(\varepsilon_1,\varepsilon_2)-(c+\varepsilon_2)q_0(\varepsilon_1,\varepsilon_2)\right\}[1-t_F].\quad(6)$$

Knowing only ε_1, and given rivals' outputs, firm j chooses output to solve (7):

$$\underset{q_j(\varepsilon_1)}{\text{Max}}\ (1/2)\sum_{\varepsilon_2}\left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k(\varepsilon_1)]q_j(\varepsilon_1)-cq_j(\varepsilon_1)\right\}[1-t_F],\ j=1,\ldots,n.\ (7)$$

The equilibrium outcome in this case is presented in Lemma 2. The "$d\phi$" superscript denotes that firm 0 *discloses* the demand parameter but *does not disclose* the cost parameter.

Lemma 2. If firm 0 discloses only demand information, the solution is:

$$q_0^{d\phi}(\varepsilon_1,\varepsilon_2)=\frac{2(a-c)+2\varepsilon_1-(n+2)\varepsilon_2}{2(n+2)};\; q_j^{d\phi}(\varepsilon_1)=\frac{a-c+\varepsilon_1}{n+2};$$

$$\pi_0^{d\phi}(\varepsilon_1,\varepsilon_2)=\left[\frac{2(a-c)+2\varepsilon_1-(n+2)\varepsilon_2}{2(n+2)}\right]^2;\; \pi_j^{d\phi}(\varepsilon_1,\varepsilon_2)=\frac{(a-c+\varepsilon_1)[2(a-c)+2\varepsilon_1+(n+2)\varepsilon_2]}{2(n+2)^2};$$

$$\Pi_0^{d\phi}=\left[\frac{4(a-c)^2+e^2(8+4n+n^2)}{4(n+2)^2}\right](1-t_F);\text{ and }\Pi_j^{d\phi}=\left[\frac{(a-c)^2+e^2}{(n+2)^2}\right](1-t_F).$$

Proof.

From (6) and (7), the first-order conditions are $a-c+\varepsilon_1-\varepsilon_2-2q_0(\varepsilon_1,\varepsilon_2)-nq_j(\varepsilon_1)=0$ and $a-c+\varepsilon_1-(1/2)[q_0(\varepsilon_1,e)+q_0(\varepsilon_1,-e)]-(n+1)q_j(\varepsilon_1)=0$. Solving these equations for $q_0(\varepsilon_1,\varepsilon_2)$ and $q_j(\varepsilon_1)$ results in the q-values in the lemma. Using these q-values yields the before-tax profit and expected net profit expressions in the lemma. ■

Disclosure of only cost information

In this case, $q_0(\varepsilon_1,\varepsilon_2)$ and $q_j(\varepsilon_2)$ represent the firms' output choices. Given $(\varepsilon_1,\varepsilon_2)$ and its rivals' production decisions, firm 0 chooses $q_0(\varepsilon_1,\varepsilon_2)$ to solve (8):

$$\underset{q_0(\varepsilon_1,\varepsilon_2)}{\text{Max}}\left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k(\varepsilon_2)]q_0(\varepsilon_1,\varepsilon_2)-(c+\varepsilon_2)q_0(\varepsilon_1,\varepsilon_2)\right\}[1-t_F]. \quad (8)$$

Given ε_2 and the rivals' outputs, firm j chooses output to solve (9):

$$\underset{q_j(\varepsilon_2)}{\text{Max}}\;(1/2)\sum_{\varepsilon_1}\left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k(\varepsilon_2)]q_j(\varepsilon_2)-cq_j(\varepsilon_2)\right\}[1-t_F],\; j=1,\ldots,n. (9)$$

The equilibrium outcome in this case is presented in Lemma 3. The "ϕd" superscript denotes that firm 0 *does not disclose* the demand parameter but *discloses* the cost parameter.

Lemma 3. If firm 0 discloses only cost information, the solution is:

$$q_0^{\phi d}(\varepsilon_1,\varepsilon_2)=\frac{2(a-c)+(n+2)\varepsilon_1-2(n+1)\varepsilon_2}{2(n+2)}\ ;\ q_j^{\phi d}(\varepsilon_2)=\frac{a-c+\varepsilon_2}{n+2}\ ;$$

$$\pi_0^{\phi d}(\varepsilon_1,\varepsilon_2)=\left[\frac{2(a-c)+(n+2)\varepsilon_1-2(n+1)\varepsilon_2}{2(n+2)}\right]^2;\ \pi_j^{\phi d}(\varepsilon_1,\varepsilon_2)=\frac{(a-c+\varepsilon_2)[2(a-c)+(n+2)\varepsilon_1+2\varepsilon_2]}{2(n+2)^2};$$

$$\Pi_0^{\phi d}=\left[\frac{4(a-c)^2+e^2(8+12n+5n^2)}{4(n+2)^2}\right](1-t_F);\text{ and }\Pi_j^{\phi d}=\left[\frac{(a-c)^2+e^2}{(n+2)^2}\right](1-t_F).$$

Proof.

From (8) and (9), the first-order conditions are $a-c+\varepsilon_1-\varepsilon_2-2q_0(\varepsilon_1,\varepsilon_2)-nq_j(\varepsilon_2)=0$ and $a-c-(1/2)[q_0(e,\varepsilon_2)+q_0(-e,\varepsilon_2)]-(n+1)q_j(\varepsilon_2)=0$. Solving these equations for $q_0(\varepsilon_1,\varepsilon_2)$ and $q_j(\varepsilon_2)$ results in the q-values in the lemma. Using these q-values yields the before-tax profit and expected net profit expressions in the lemma. ■

No disclosure

In the no disclosure case, $q_0(\varepsilon_1,\varepsilon_2)$ and q_j represent the firms' output choices. Given $(\varepsilon_1,\varepsilon_2)$ and rivals' production decisions, firm 0 chooses output to solve (10):

$$\underset{q_0(\varepsilon_1,\varepsilon_2)}{\text{Max}}\ \left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k]q_0(\varepsilon_1,\varepsilon_2)-(c+\varepsilon_2)q_0(\varepsilon_1,\varepsilon_2)\right\}[1-t_F]. \quad (10)$$

Given the rivals' output choices, and knowing neither demand nor firm 0's cost information, firm j chooses output to solve (11):

$$\underset{q_j}{\text{Max}}\ (1/4)\sum_{\varepsilon_1}\sum_{\varepsilon_2}\left\{[a+\varepsilon_1-q_0(\varepsilon_1,\varepsilon_2)-\sum_{k=1}^{n}q_k]q_j-cq_j\right\}[1-t_F],\ j=1,\ldots,n. \quad (11)$$

The equilibrium outcome in this case is presented in Lemma 4. The "$\phi\phi$" superscript denotes that firm 0 *does not disclose* the demand parameter or the cost parameter.

Lemma 4. If firm 0 does not disclose either demand or cost information, the solution is:

$$q_0^{\phi\phi}(\varepsilon_1,\varepsilon_2) = \frac{2(a-c)+(n+2)(\varepsilon_1-\varepsilon_2)}{2(n+2)}\,;\; q_j^{\phi\phi} = \frac{a-c}{n+2}\,;$$

$$\pi_0^{\phi\phi}(\varepsilon_1,\varepsilon_2) = \left[\frac{2(a-c)+(n+2)(\varepsilon_1-\varepsilon_2)}{2(n+2)}\right]^2;\; \pi_j^{\phi\phi}(\varepsilon_1,\varepsilon_2) = \frac{(a-c)[2(a-c)+(n+2)(\varepsilon_1+\varepsilon_2)]}{2(n+2)^2}\,;$$

$$\Pi_0^{\phi\phi} = \left[\frac{2(a-c)^2+e^2(n+2)^2}{2(n+2)^2}\right](1-t_F)\,;\text{ and } \Pi_j^{\phi\phi} = \left[\frac{a-c}{n+2}\right]^2(1-t_F).$$

Proof.

From (10) and (11), the first-order conditions are $a-c+\varepsilon_1-\varepsilon_2-2q_0(\varepsilon_1,\varepsilon_2)-nq_j=0$ and $a-c-(1/4)[q_0(e,e)+q_0(e,-e)+q_0(-e,e)+q_0(-e,-e)]-(n+1)q_j=0$. Solving these equations for $q_0(\varepsilon_1,\varepsilon_2)$ and q_j results in the *q*-values in the lemma. Using these *q*-values yields the before-tax profit and expected net profit expressions in the lemma. ■

Comparing expressions in the four lemmas, $\Pi_0^{\phi d}-\Pi_0^{dd}>0$, $\Pi_0^{\phi d}-\Pi_0^{d\phi}>0$, and $\Pi_0^{\phi d}-\Pi_0^{\phi\phi}>0$. The following proposition immediately follows.

Proposition 1. *Under flat taxes, the unique (subgame perfect) equilibrium entails firm 0 withholding demand information and disclosing cost information.*

A comparison of pre-tax payoffs for each $(\varepsilon_1,\varepsilon_2)$ realization provides an explanation for the firm's preference to withhold ε_1 but disclose ε_2. First, consider the alternative of withholding both pieces of information. When comparing $\pi_0^{\phi\phi}(\varepsilon_1,\varepsilon_2)$ in Lemma 4 and $\pi_0^{\phi d}(\varepsilon_1,\varepsilon_2)$ in Lemma 3, the difference arises due the impact of the disclosure of the cost information ε_2: ε_2 has a larger impact on firm 0's payoffs when it is disclosed. More precisely, the multiple on ε_2 is $(n+1)/(n+2)$ when ε_2 is known to rivals (Lemma 3) but only 1/2 when it is not (Lemma 4). Given the convexity of payoffs (firm profits are a squared expression), this larger effect makes disclosure of cost information more attractive. Intuitively, when cost information is disclosed, the firms undertake a form of stochastic cooperation wherein competitors cede market share when firm 0's costs are low, and firm 0 cedes market share when its costs are high (this intuition is borne out by the fact that competitors too benefit from the disclosure of cost information, i.e., $\Pi_j^{\phi d} > \Pi_j^{\phi\phi}$).

An analogous effect pushes the firm to withhold demand information. When comparing $\pi_0^{dd}(\varepsilon_1, \varepsilon_2)$ in Lemma 1 and $\pi_0^{\phi d}(\varepsilon_1, \varepsilon_2)$ in Lemma 3, the difference arises due the impact of the withholding of demand information ε_1: ε_1 has a larger impact on firm 0's payoffs when it is withheld. More precisely, the multiple on ε_1 is 1/2 when ε_1 is not known to rivals (Lemma 3) but 1/(*n*+2) when ε_1 is disclosed (Lemma 1). Again, given the convexity of payoffs, this larger effect makes withholding of demand information more attractive for firm 0. Intuitively, when demand information is disclosed, the firms engage in fierce competition because of the firms' abilities to fine-tune their production to (common) consumer demand levels. If demand information is withheld, however, only firm 0 is able to adjust production to the particular state of demand. The allure of being able to take advantage of high demand without competitors' knowledge of such information proves tempting, prompting firm 0 to withhold demand information.

A natural follow up issue is to examine the role of retail competition. Not surprisingly, for any given disclosure strategy, firm 0's expected profit decreases as competition is heightened: each of $\Pi_0^{\phi d}, \Pi_0^{dd}, \Pi_0^{d\phi}$, and $\Pi_0^{\phi\phi}$ is decreasing in *n* (the number of rivals). Further, consider the relative benefit to firm 0 of choosing its preferred disclosure strategy (disclosing only cost information, as noted in Proposition 1) in the presence of intensified retail competition. Using Lemmas 1 - 4, it is easy to verify that each of $\Pi_0^{\phi d} - \Pi_0^{dd}$, $\Pi_0^{\phi d} - \Pi_0^{d\phi}$, and $\Pi_0^{\phi d} - \Pi_0^{\phi\phi}$ is increasing in *n*, leading to Corollary 1.

Corollary 1. Under flat taxes, firm 0's preference to adhere to withholding demand information and disclosing cost information is strengthened by increased competition.

Clearly, in our setting, disclosure is a moot issue for firm 0 if it is a monopolist. When it faces rivals, firm 0's incentives to regulate the information environment are heightened. Building on the intuition presented previously, recall the ε_2-multiple benefit from disclosing cost information is $(n+1)/(n+2)$ - 1/2, while the ε_1-multiple benefit from withholding demand information is 1/2 - $1/(n+2)$. Notice each of these multiple effects is increasing in n, in line with the result in Corollary 1.

Given the equilibrium disclosure policy under flat taxes, the next section considers how tax shifts can be used to encourage welfare-enhancing disclosure.

3.2. Disclosure Choice and Progressive Taxes

Under flat taxes, firm 0's decision to withhold demand information and prevent its competitors from fine-tuning production to the environment has harmful repercussions on consumers and, ultimately, total welfare. In particular, consumer surplus under the flat tax equilibrium is:

$$CS^{\phi d} = (1/4)\sum_{\varepsilon_1}\sum_{\varepsilon_2}\left[\frac{1}{2}\left(q_0^{\phi d}(\varepsilon_1,\varepsilon_2) + \sum_{j=1}^{n} q_j^{\phi d}(\varepsilon_2)\right)^2\right] = \frac{4(a-c)^2(n+1)^2 + e^2(8+4n+n^2)}{8(n+2)^2}. \quad (12)$$

In contrast, under full disclosure, consumers are better off due to better matching of production and demand, as demonstrated in (13).[5]

$$CS^{dd} = (1/4)\sum_{\varepsilon_1}\sum_{\varepsilon_2}\left[\frac{1}{2}\left(\sum_{i=0}^{n} q_i^{dd}(\varepsilon_1,\varepsilon_2)\right)^2\right] = \frac{(a-c)^2(n+1)^2 + e^2(2+2n+n^2)}{2(n+2)^2} > CS^{\phi d}. \quad (13)$$

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[5] This is not to say that full disclosure by firm 0 maximizes consumer surplus. In fact, as shown in Section 4, consumers are made even better off if the firm discloses demand information but withholds cost information. A progressive tax structure which induces full disclosure by firm 0 is constructed in Proposition 2; a progressive tax schedule that induces the firm to disclose only demand information is detailed in Proposition 3.

The welfare enhancing potential of eliciting full disclosure opens the door for a socially desirable shift in tax policy. Recall, the reason firm 0 is reluctant to disclose its demand information is that withholding it intensifies the effect of stochastic shocks on profits. The firm is willing to tolerate the chance that it is the only party who becomes aware of bad news ($\varepsilon_1 = -e$) so as to reap maximum rewards when the firm's rivals are unaware of good news ($\varepsilon_1 = e$). If a progressive tax, wherein marginal tax rates are increasing in profit, is enacted, disclosure incentives change. The higher tax rate for windfall profits reduces the appeal of the upside of withholding disclosure. Put slightly differently, while the firm is risk-neutral in after-tax profits, under progressive taxes it acts as if it is risk-averse in before-tax profits. This curbs the firm's desire to withhold demand disclosures–the large up-and down swing in profits linked to withholding demand information is not desired by a risk-averse party. In fact, a sufficiently progressive tax shift may be able to keep expected tax revenues unchanged while strictly increasing welfare by incentivizing the firm to disclose all pieces of information.

To elaborate on this intuition, consider a simple two-tier progressive tax. The threshold profit above which the upper-tier tax rate applies is $\pi_0^{dd}(e,-e)$ which corresponds to the profit level when firm 0 discloses that the demand parameter is high and its own cost is low. Since this is the maximum profit attainable for the firm under full disclosure, the full disclosure case proceeds as before: in equilibrium, firms always reside in the lower tier. On the other hand, if firm 0 opts to disclose only cost information, $\pi_0^{\phi d}(e,-e) > \pi_0^{dd}(e,-e)$ reflecting the fact that good news about demand has not been revealed to firm 0's rivals. This ordering implies that firm 0 is sometimes subject to the upper bracket tax rate. If this upper tax rate is sufficiently high relative to the lower tax rate, the full disclosure outcome becomes more attractive and can be sustained as an equilibrium. The next proposition formalizes this construction.

Proposition 2. *A revenue-neutral progressive tax can ensure that firm 0 disclosing both cost and demand information is supported as an equilibrium. This equilibrium yields higher welfare than the equilibrium under flat taxes.*

Proof.

Denote the following two-tier marginal tax schedule by $\tilde{T}$:

$$\begin{aligned} t(\pi) &= t_1 && \text{if } \pi \le \pi_0^{dd}(e,-e); \text{ and} \\ &= t_1 + \frac{4e(n+4)(1-t_1)}{4(a-c)+e(5n+8)} && \text{if } \pi > \pi_0^{dd}(e,-e), \text{ where} \end{aligned}$$

$$t_1 = t_F + \frac{e^2 n^2 t_F}{4[(a-c)^2(n+1)+e^2(2+4n+n^2)]}.$$

The proof now proceeds in three steps.

STEP 1. Confirming the equilibrium.

To derive the equilibrium under $\tilde{T}$, assume $\pi_j(\varepsilon_1, \varepsilon_2) < \pi_0^{dd}(e,-e)$, so firm j, j = 1,...,n, is always taxed at the t_1 rate; this claim will be verified shortly. Given this assertion, the expected after-tax profit for firm j is increasing in its expected before-tax profit. Firm 0 faces no uncertainty (it knows ε_1 and ε_2), so it is concerned with its after-tax profit (no expectations are necessary). And, of course, the firm's after-tax profit is increasing in before-tax profit under either flat or the progressive tax schedule. This implies that as far as deriving q's is concerned, under any disclosure policy, the Cournot game under $\tilde{T}$ is the same as the one in the absence of taxes (or, equivalently, under any flat tax). Hence, the q-values under each disclosure regime with $\tilde{T}$ are as derived in Lemmas 1 - 4.

From the lemmas, it is straightforward to verify that firm 0 falls in the low tax bracket in $\tilde{T}$ under full disclosure, disclosure of only demand information, and no disclosure. Hence, in each of these cases, firm 0's expected after-tax profit, denoted $\tilde{\Pi}_0^{dd}$, $\tilde{\Pi}_0^{d\phi}$, and $\tilde{\Pi}_0^{\phi\phi}$, respectively, is as in the corresponding lemma with t_F replaced by t_1.

Now consider the case when firm 0 discloses only cost information. From Lemma 3, only $\pi_0^{\phi d}(e,-e)$ falls in the high tax bracket. Hence, when firm 0 discloses only cost information and the tax structure is $\tilde{T}$, firm 0's expected after-tax profit, $\tilde{\Pi}_0^{\phi d}$, simplifies to:

$$\tilde{\Pi}_0^{\phi d} = \left[\frac{(a-c)^2 + e^2(2+2n+n^2)}{(n+2)^2} \right](1-t_1).$$

Using the expected after-tax profit values under $\tilde{T}$, $\tilde{\Pi}_0^{dd} - \tilde{\Pi}_0^{d\phi} > 0$, $\tilde{\Pi}_0^{dd} - \tilde{\Pi}_0^{\phi d} = 0$, and $\tilde{\Pi}_0^{dd} - \tilde{\Pi}_0^{\phi\phi} > 0$. Finally, note that under all disclosure policies, the solution prescribes $\pi_j(\varepsilon_1, \varepsilon_2) < \pi_0^{dd}(e,-e)$, so the initial claim that firm j, $j = 1,\ldots,n$, always faces the low tax bracket is verified. Thus, firm j's expected net profit under full disclosure, $\tilde{\Pi}_j^{dd}$, is as in Lemma 1 with t_F replaced by t_1.

STEP 2. Confirming revenue neutrality.

From the above equilibrium characterization, the (expected) tax revenue under $\tilde{T}$ is:

$$\frac{1}{4}\left[\sum_{i=0}^{n} \sum_{\varepsilon_1} \sum_{\varepsilon_2} \pi_i^{dd}(\varepsilon_1, \varepsilon_2) \right] t_1 .$$

Substituting t_1 in this expression reveals that tax revenue equals:

$$\frac{1}{4}\left[\sum_{i=0}^{n} \sum_{\varepsilon_1} \sum_{\varepsilon_2} \pi_i^{\phi d}(\varepsilon_1, \varepsilon_2) \right] t_F .$$

As the above term also represents tax revenue under t_F, revenue neutrality is confirmed.

STEP 3. Confirming welfare improvements.

Under the flat tax, firm 0 discloses only cost information, so the q-values are as in Lemma 3. Using these q-values, the consumer surplus is as in (12). Adding the firms' after-tax profits from Lemma 3 to the above consumer surplus yields:

$$W^{\phi d} = \sum_{i=0}^{n} \Pi_i^{\phi d} + \beta CS^{\phi d}$$

$$= \frac{4[a-c]^2[n+1][2(1-t_F)+\beta(n+1)]+e^2 A}{8(n+2)^2}, \text{ where}$$

$$A = 8[\beta + 2(1-t_F)] + 4[\beta + 8(1-t_F)]n + [\beta + 10(1-t_F)]n^2.$$

Under $\tilde{T}$, firm 0 discloses both demand and cost information. Using the *q*-values from Lemma 1, the consumer surplus under this equilibrium is as in (13). Adding the firms' after-tax profits $\tilde{\Pi}_i^{dd}$ to the above consumer surplus, yields:

$$\tilde{W}^{dd} = W^{\phi d} + \frac{e^2 n[(3\beta - 2)n + 4\beta]}{8(n+2)^2}.$$

The second term on the right-hand-side is positive for all $\beta \geq 1$. Hence, $\tilde{W}^{dd} - W^{\phi d} > 0$, completing the proof of the proposition. ■

Note three things from the welfare-enhancing progressive tax employed in the proof. First, the welfare improvements emanating from the progressive tax are robust with respect to the relative weights placed on firm profits and consumer surplus (they apply for all $\beta \geq 1$). Second, the bite of the progressive tax is off the equilibrium path. That is, in equilibrium, no firm is actually taxed at the higher rate; rather, it is the prospect of the higher rate applying that dissuades firm 0 from withholding its demand information. Third, the jump in the tax rate under $\tilde{T}$ is increasing in *n*. Recall, as *n* increases, the firm's inherent preference for withholding demand information is strengthened. To offset the firm's reluctance to disclose demand information, a more progressive tax structure is utilized for higher *n* values.

4. Progressive Taxes and Disclosure Regulation

The results in the previous section raise a follow-up: even if progressive taxes can convince a firm to disclose all of its pertinent private information, why would this be necessary given the ubiquity of mandatory disclosure regulation? This question brings to bear many of the complications that arise in implementation of either form of regulation. After all, the respective histories of both tax law and disclosure law are rife with examples of evasion, loopholes, and bureaucratic red tape that have hampered intended effects.

In this vein, this section considers an additional consideration brought by progressive taxes. While requiring firms to disclose information may be implementable in some form, outlawing disclosure of certain proprietary information by firms appears far less realistic. Progressive taxes, on the other hand, can naturally encourage disclosure of certain types of information while discouraging disclosure of others.

Take the case of cost disclosures. Recall, when cost information is disclosed, it supports a form of stochastic cooperation wherein competitors cede market share when firm 0's costs are low, and firm 0 cedes market share when its costs are high. While such an outcome is beneficial for the firms, consumers suffer. In particular, if cost (but not demand) disclosures are withheld:

$$\begin{aligned} CS^{d\phi} &= (1/4)\sum_{\varepsilon_1}\sum_{\varepsilon_2}\left[\frac{1}{2}\left(q_0^{d\phi}(\varepsilon_1,\varepsilon_2)+\sum_{j=1}^{n}q_j^{d\phi}(\varepsilon_1)\right)^2\right] \\ &= \frac{4(a-c)^2(n+1)^2+e^2(8+12n+5n^2)}{8(n+2)^2} > CS^{dd}. \end{aligned} \tag{14}$$

The consumer surplus benefits that arise when firm 0 withholds cost information means that regulators' preferred disclosure policy may actually be the opposite of that naturally chosen by firm 0: under flat taxes, the firm opts only to disclose cost information, whereas the preferred route is only disclosing demand information. Fortunately, a judiciously-designed progressive tax can again achieve regulatory goals.

As with the temptation to withhold demand information, firm 0's desire to disclose cost information is rooted in the possibility of a large payoff. This payoff arises when firm 0's costs are low and its competitors know it. Again, a two-tier progressive tax can undercut the appeal of this outcome and shift disclosure preferences to the desired policy. In this case, the profit threshold above which the upper tax rate applies is shifted down to $\pi_0^{d\phi}(e,-e)$. Given the lower profit threshold, the higher tax rate does not come into play in the desired disclosure regime (disclosing only demand information), but does kick in for the other disclosure regimes. As long as the higher tax rate is sufficiently large relative to the lower rate, the desired disclosure regime can be sustained as an equilibrium.

As a result, though costless mandatory disclosure can improve welfare, progressive taxes can often do better. The next proposition presents this result.

Proposition 3.

(i) *If $\beta \leq (6n + 16)/(n + 4)$, a revenue-neutral progressive tax can replicate the welfare under mandatory disclosure; and*

(ii) *If $\beta > (6n + 16)/(n + 4)$, a revenue-neutral progressive tax can increase welfare relative to that under mandatory disclosure.*

Proof.

(i) Under mandatory disclosure with any t_F, welfare, denoted W^M, is obtained by summing the firms' profits from Lemma 1 and the consumers surplus from (13). That is,

$$\begin{aligned} W^M &= \sum_{i=0}^{n} \Pi_i^{dd} + \beta CS^{dd} \\ &= W^{\phi d} + \frac{e^2 n[(3\beta - 2(1-t_F))n + 4\beta]}{8(n+2)^2}. \end{aligned}$$

From the proof of Proposition 2, under voluntary disclosure and the two-tiered $\tilde{T}$, firm 0 prefers to disclose both demand and cost information for any choice of t_I. Hence, voluntary disclosure and $\tilde{T}$ with $t_1 = t_F$, yields: (a) the same tax revenue as mandatory disclosure with t_F and (b) welfare of W^M for all β, proving part (i).

(ii) We begin by defining tax schedule $\hat{T}$, and showing that it results in an equilibrium in which firm 0 discloses only demand information. Define $\hat{T}$ as follows:

$$t(\pi) = t_1 \qquad \text{if } \pi \le \pi_0^{d\phi}(e,-e); \text{ and}$$

$$= t_1 + \frac{4e(3n+4)(1-t_1)}{4(a-c)+e(3n+8)} \qquad \text{if } \pi > \pi_0^{d\phi}(e,-e), \text{ where}$$

$$t_1 = t_F + \frac{e^2 n(3n+8)t_F}{4[(a-c)^2(n+1)+e^2(8+8n+n^2)]}.$$

STEP 1. Confirming the equilibrium.

Using the same arguments as in the proof of Proposition 2, the q-values under each disclosure regime with $\hat{T}$ are as in Lemmas 1 - 4. From Lemma 1, under full disclosure, firm 0's highest before-tax profit, $\pi_0^{dd}(e,-e)$, falls in the high tax bracket of $\hat{T}$. Hence, under full disclosure and $\hat{T}$, firm 0's expected after-tax profit, $\hat{\Pi}_0^{dd}$, is at most equal to the expected after-tax profit when the upper tax rate is applied only to $\pi_0^{dd}(e,-e)$, or:

$$\hat{\Pi}_0^{dd} \le \left[\frac{4(a-c)^2 + e^2(8+4n+n^2)}{4(n+2)^2}\right](1-t_1).$$

From Lemma 2, when firm 0 discloses only demand information, it is always in the low tax bracket of $\hat{T}$. Hence, firm 0's expected after-tax profit, $\hat{\Pi}_0^{d\phi}$, is simply $\Pi_0^{d\phi}$ with t_F replaced by t_1.

From Lemma 3, when firm 0 discloses cost but not demand information, only $\pi_0^{\phi d}(e,-e)$ falls in the high tax bracket. Hence, firm 0's expected after-tax profit, $\hat{\Pi}_0^{\phi d}$, is:

$$\hat{\Pi}_0^{\phi d} = \hat{\Pi}_0^{d\phi} - \frac{e^2 n^2[2(a-c)+3e(n+2)]}{(n+2)^2[4(a-c)+e(3n+8)]}(1-t_1).$$

From Lemma 4, when firm 0 does not make any disclosures, only $\pi_0^{\phi\phi}(e,-e)$ falls in the high tax bracket. Hence, firm 0's expected after-tax profit, $\hat{\Pi}_0^{\phi\phi}$, is:

$$\hat{\Pi}_0^{\phi\phi} = \left[\frac{4(a-c)^2 + e^2(8+4n-n^2)}{4(n+2)^2}\right](1-t_1).$$

Using the expected after-tax profit values under $\hat{T}$, $\hat{\Pi}_0^{d\phi} - \hat{\Pi}_0^{dd} \geq 0$, $\hat{\Pi}_0^{d\phi} - \hat{\Pi}_0^{\phi d} > 0$, and $\hat{\Pi}_0^{d\phi} - \hat{\Pi}_0^{\phi\phi} > 0$. Finally, the solution prescribes $\pi_j(\varepsilon_1, \varepsilon_2) < \pi_0^{dd}(e,-e)$, so it is verified that firm j, j = 1,...,n, always faces the low tax bracket. Thus, firm j's expected net profit, $\hat{\Pi}_j^{d\phi}$, is as in Lemma 2 with t_F replaced by t_1.

STEP 2. Confirming revenue neutrality.

From the above equilibrium characterization, the (expected) tax revenue under $\hat{T}$ is:

$$\frac{1}{4}\left[\sum_{i=0}^{n}\sum_{\varepsilon_1}\sum_{\varepsilon_2}\pi_i^{d\phi}(\varepsilon_1, \varepsilon_2)\right]t_1.$$

Substituting t_1 in this expression reveals that tax revenue equals:

$$\frac{1}{4}\left[\sum_{i=0}^{n}\sum_{\varepsilon_1}\sum_{\varepsilon_2}\pi_i^{dd}(\varepsilon_1, \varepsilon_2)\right]t_F.$$

As the above term also represents tax revenue under mandatory disclosure and t_F, revenue neutrality is confirmed.

STEP 3. Confirming welfare improvements.

The welfare value under mandatory disclosure and t_F is W^M in part (i). Under voluntary disclosure and $\hat{T}$, firm 0 discloses only demand information. The consumer surplus under this equilibrium, $CS^{d\phi}$, is in (14). Adding the firms' after-tax profits, $\hat{\Pi}_i^{d\phi}$, and consumer surplus yields W^V, the welfare measure under voluntary disclosure and the chosen progressive tax:

$$\begin{aligned} W^V &= \sum_{i=0}^{n}\hat{\Pi}_i^{d\phi} + \beta CS^{d\phi} \\ &= W^M + \frac{e^2 n[\beta(n+4)-(6n+16)]}{8(n+2)^2}. \end{aligned}$$

The second term on the right-hand-side is positive if and only if $\beta \geq (6n + 16)/(n + 4)$. Thus, for these β-values, $W^V - W^M > 0$, completing the proof of the proposition. ■

Proposition 3 stresses the role of multi-dimensional private information and selective disclosure thereof. The multi-dimensional aspect of the firm's private information also underscores the salience of the forces at work. With either common or private values, under flat taxes, the optimal disclosure policy is one that places a larger multiple on the uncertain parameter. This is because the firm's payoff function in oligopoly models is convex (hence, risk-seeking), and this induces a preference for extreme "spreads" in profits. Not unexpectedly, the consumers tastes are in the reverse. On the other hand, progressive taxes induce a concavity (hence, risk-aversion) since higher profits are taxed at higher marginal rates. This leads the firms to prefer a narrowing of spreads. Thus, a sufficiently progressive tax structure can induce the firm to opt for a disclosure policy which is more in line with what the consumers desire. In fact, from Proposition 3(ii), it follows immediately that if consumer surplus is paramount, a progressive tax structure can help accomplish more than direct attempts to mandate disclosures.

Corollary 2. *The revenue-neutral progressive tax* $\hat{T}$ *increases consumer surplus relative to that under mandatory disclosure.*

5. Conclusion

Research in accounting and finance is frequently concerned with the voluntary disclosure practices of firms, particularly when such information has competitive ramifications. Another ubiquitous theme in the literature concerns the role of taxation on ongoing economic interactions. Somewhat surprisingly, little effort seems to have been focused on the interaction among these two critical components of practice. This paper examines the role of tax rates in influencing disclosure policy and, as such, interaction among the two themes naturally comes to the fore.

Though firms may be reluctant to disclose some information but eager to disclose others for competitive reasons, consumers (and society) may have different priorities. This paper demonstrates that because firms' disclosure practices are often motivated by the allure of the potential for a large payoff, a progressive tax can diminish the attractiveness of such payoffs. The end result is induced risk-aversion by firms with respect to disclosure practices and a natural convergence of firm and consumer preferences. Because progressive taxes can encourage disclosure of particular pieces of information but withholding disclosure of others, they may have beneficial effects above and beyond those achieved via a blanket policy of mandatory full disclosure.

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