Improving Supplier Social Responsibility under Incomplete Visibility

**Problem Definition:** We examine how a manufacturer (she) can improve a supplier’s (he) social responsibility (SR) practices when these practices cannot be perfectly observed by the manufacturer. We focus on the manufacturer’s investment in the supplier’s SR capabilities. To capture the influence of consumer demands, we incorporate the potential for SR information to be disclosed by the manufacturer or revealed by a third party.

**Academic/Practical Relevance:** Most companies have limited visibility into the SR practices of their suppliers. However, there is little research on how a manufacturer should (i) invest to improve a supplier’s SR practices and (ii) disclose SR information to consumers under incomplete visibility. We address this gap.

**Methodology:** We develop a game-theoretic model with asymmetric information to study a supply chain with one supplier and one manufacturer. The manufacturer makes her investment decision given imperfect information about the supplier’s current SR practices. We analyze and compare two settings – the manufacturer does not disclose versus she voluntarily discloses SR information to the consumers.

**Results:** The manufacturer should invest a high (low) amount in the supplier’s capabilities if the information she observes suggests the supplier’s current SR practices are poor (good). She should always be more aggressive with her investment when disclosing (versus not disclosing). This more aggressive strategy ensures a better supplier SR performance under disclosure. When choosing between disclosing and not disclosing, the manufacturer most likely prefers not to disclose when the supplier’s current SR level is neither too high nor too low.

**Managerial Implications:** We show that greater visibility helps a manufacturer to better tailor her investment and become more “truthful” in her disclosure. Any initiative that requires manufacturers to disclose (i) will have a positive impact on suppliers’ SR practices and (ii) is often most effective in driving better SR performance from suppliers who appear to have only average current practices.

**Keywords:** Social responsibility, supply chain visibility, supplier development, information disclosure, game theory, information asymmetry

1. **Introduction**

Establishing socially responsible practices in a supply chain is a difficult task. This is especially true when a company has limited visibility into its suppliers’ practices. In this paper, we examine how a manufacturer (she) can improve a supplier’s (he) social responsibility (SR) practices when these practices cannot be perfectly observed by the manufacturer. We focus on the manufacturer’s investment to improve the supplier’s SR capabilities; for example, a manufacturer developing training programs
at a supplier to educate employees on human rights topics. To capture how consumer demands can influence the manufacturer’s and the supplier’s decisions, we incorporate the potential for SR information to be disclosed by the manufacturer or revealed by a third party (e.g., an NGO). Our results address how the manufacturer should (i) invest to improve the supplier’s SR practices and (ii) disclose SR information to consumers, given her level of visibility into the supply chain. Furthermore, we show how these decisions can positively or negatively impact the SR performance of the supply chain.

A recent study by The Sustainability Consortium found that 81% of the 1,700 companies surveyed lacked full visibility into the SR practices of their suppliers (The Sustainability Consortium 2016). At the same time, improving visibility into a supply chain can be a costly and time-consuming task for a company (Doorey 2011). As a result, complete visibility into a supply chain is rarely achieved. Instead, companies often make decisions on how to improve upstream suppliers’ SR practices and when to disclose SR information to consumers under incomplete visibility.

To motivate a supplier to improve his SR practices, a manufacturer can either offer the supplier incentives (e.g., preferred supplier status or investment in the supplier’s capabilities) or threaten the supplier with penalties (e.g., contract termination). We focus on a manufacturer’s investment in a supplier’s SR capabilities because it has been shown to be highly effective in improving supplier performance (Porteous et al. 2015); however, it remains an underutilized and understudied method (Gillai et al. 2013). Our choice is motivated by recent examples of companies investing in their suppliers’ SR capabilities. For instance, Starbucks has invested more than $100 million in Coffee and Farmer Equity Practices, farmer loans, and other programs aimed at improving farmers’ livelihoods along its supply chain (Starbucks 2017). In working with its suppliers, Hewlett-Packard “invests in programs that empower and protect workers” by training them on topics like anti-discrimination and labor rights (HP 2016). Similarly, Nike organizes training sessions for their contract manufacturers to address topics that impact the ethical treatment of workers such as human resource management and health and safety practices (Porteous and Rammohan 2013).

In this paper, we study a supply chain with one supplier and one manufacturer. The manufacturer sells a product in a market where at least some consumers care whether the product is made in a socially responsible manner. To capture incomplete visibility, we model the supplier’s initial level of SR as his private information. The manufacturer has a prior belief about this level and observes a

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1 We follow the European Commission’s definition of social responsibility as “[companies integrating] social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis,” (Dahlsrud 2008). We specifically focus on social concerns in social responsibility.
signal about it. How likely the signal captures the supplier’s true initial level of SR depends on the manufacturer’s visibility into her supply chain. In practice, an audit report is a good example of a signal since it only provides a snapshot of a supplier’s current practices, and therefore, is subject to noise (EY and UN Global Compact 2016). We focus on the manufacturer’s decisions for a given level of visibility rather than examine how she can improve her visibility (e.g., through more frequent audits).

In our model, the supplier is the only party that can directly improve the SR practices of the supply chain; the manufacturer can only help to reduce the cost of SR by investing in the supplier’s capabilities. The manufacturer is motivated to invest in the supplier in part because the supplier’s level of SR may be revealed to the consumers by an external third party (e.g., an NGO). Similar to Chen and Lee (2016), we treat the level of SR as a “soft” quality attribute, which can only be observed and verified at the supplier’s site (e.g., working conditions). This feature differentiates our work from most of the quality management literature (e.g., Zhu et al. 2007, Babich and Tang 2012) because the final level of SR cannot be inferred via product inspection by either the manufacturer or the consumers.

We analyze and compare two settings: (i) The manufacturer does not disclose SR information to the consumers (No Manufacturer Disclosure), and (ii) the manufacturer voluntarily discloses SR information to the consumers based on her available information (Manufacturer Disclosure). In the latter case, the manufacturer can increase her demand by disclosing, but she may also incur a penalty if she overstates the supplier’s SR performance. We compare the two settings to study when the manufacturer prefers to voluntarily disclose SR information. Our results in the Manufacturer Disclosure setting also help to inform manufacturers’ decisions under regulations that require mandatory disclosure (e.g., the California Transparency in Supply Chains Act). Within the operations management literature there is a growing interest in the topic of supply chain transparency, both with respect to companies’ visibility into their supply chains and the disclosure of SR information to consumers (e.g., Kalkanci and Plambeck 2015, Chen and Lee 2016, Kraft et al. 2017). We contribute to this stream of work by examining how a manufacturer’s incomplete visibility into a supplier’s SR practices impacts her investment to improve the supplier’s capabilities and her decision to disclose SR information to consumers.

We derive a number of key results from our model. First, the manufacturer should invest a high (low) amount of resources to improve the supplier’s capabilities if the information she observes suggests the supplier’s current SR practices are poor (good). With greater visibility into her supply chain, the manufacturer can better tailor her level of investment as she can better identify whether the supplier needs significant support. Second, if the manufacturer plans to disclose SR information to the consumers,
then she should always be more aggressive with her investment in the supplier’s capabilities (as compared to if she plans not to disclose). This more aggressive strategy ensures a better SR performance from the supplier when the manufacturer discloses. Third, when the manufacturer voluntarily discloses SR information to the consumers, she is likely to overstate (understate) the supplier’s SR performance if the observed information suggests very poor (very good) current practices. However, with greater visibility, the manufacturer becomes more “truthful” in her disclosure; i.e., she is less likely to either over- or understate the SR level. Finally, when choosing between disclosing and not disclosing, the manufacturer most likely prefers not to disclose when the supplier appears to have only average SR practices. Furthermore, an increase in visibility or the probability of third-party scrutiny may cause her to prefer not to disclose, thus limiting the SR performance of the supply chain.

**Literature Review:** Our work is closely related to two streams of research: socially responsible supply chains and supplier development. Within the socially responsible supply chain literature, analytical studies that examine suppliers’ SR practices typically address one of two topics: (i) identifying potential SR risks in a supply chain through tools such as audits and inspections (e.g., Huang et al. 2016, Plambeck and Taylor 2016, Wang et al. 2016); and (ii) motivating better SR performance from upstream suppliers. Recent works addressing (i) have begun to examine the effect of a firm’s voluntary disclosure decision on the SR performance of suppliers (e.g., Chen et al. 2015, Kalkanci and Plambeck 2015). The papers examining (ii) consider several different methods including sourcing strategy (e.g., Agrawal and Lee 2016, Guo et al. 2016), supply chain design (e.g., Letizia and Hendrikse 2016, Orsdemir et al. 2016, Zhang et al. 2017), and supplier development (e.g., Mendoza and Clemen 2013).

The works most closely related to ours consider both topics (i) and (ii). Cho et al. (2016) examine a company’s choice of inspection policy and wholesale price to combat a supplier’s use of child labor. They study two separate scenarios: one in which the company’s inspection policy is only known to the company, and the other in which the policy is also known to the supplier and third parties. Chen and Lee (2016) analyze how a company can design incentive schemes in sourcing contracts (e.g., contingency payments) and invest in screening mechanisms (e.g., supplier certifications and process audits) to prevent unethical actions by a supplier. Lewis et al. (2016) investigate a mechanism design problem where a company can invest to develop a supplier’s capabilities to achieve sustainable quality. In their setting, both the company’s demand and the supplier’s production cost are private information.

We contribute to this growing literature in two aspects. First, we model and examine supply chain transparency in a more holistic manner by capturing both a manufacturer’s visibility into a supplier’s practices and the manufacturer’s disclosure of information to consumers. In particular, visibility refers
to the extent to which the manufacturer can observe the SR performance of the supplier. To better represent practice, we consider a continuous level of visibility as opposed to a binary state with either full or no visibility. In addition, we capture incomplete visibility by modeling a game with asymmetric information between the supplier and the manufacturer, where the supplier’s private information about his current SR practices follows a continuous distribution (rather than a two-type distribution). To the best of our knowledge, Lewis et al. (2016) is the only paper in the SR supply chain literature with a similar information asymmetry setup as ours; however, they do not examine a company’s potential voluntary disclosure of information to consumers. Our model allows us to determine how supply chain visibility and the manufacturer’s disclosure decision jointly impact the SR performance of the supplier.

Second, we address topic (ii) by analyzing an understudied approach – a manufacturer’s investment in a supplier’s SR capabilities. This analysis is timely, as companies are increasingly realizing the importance of going beyond monitoring to actually develop better capabilities at their suppliers when addressing SR challenges (Locke et al. 2007, EY and UN Global Compact 2016). Our results offer valuable guidance on how companies should better leverage this underutilized approach to improve suppliers’ SR practices, particularly under the constraint of incomplete visibility.

In the supplier development literature, a number of papers analyze how a buyer can use a contracting approach (e.g., offer a price premium) to improve a supplier’s quality or process (e.g., Corbett and DeCroix 2001, Zhu et al. 2007, Li and Debo 2009, Kim and Netessine 2013). We do not consider supply chain contracts because (i) a supplier’s SR performance is difficult to measure and verify, and thus, often noncontractible (Norman and MacDonald 2004); and (ii) in practice, the use of price premiums is rare and often ineffective for improving a supplier’s SR performance (Porteous et al. 2015). A group of works outside the contracting literature have applied analytical models to examine buyers’ supplier development decisions (e.g., Kim 2000, Babich 2010, Liu et al. 2010, Talluri et al. 2010, Wang et al. 2010, Karaer et al. 2017). Of these papers, the studies that are most closely related to ours examine a company’s investment in supplier reliability, where the investment addresses the uncertainty in the outcome (e.g., production yield) of a known supplier type (Babich 2010, Liu et al. 2010, Wang et al. 2010). We instead consider a setting with information asymmetry, where the manufacturer invests in the supplier’s SR capabilities when the supplier’s type is unknown to the manufacturer.

2. Model Setup

In this section, we review our model formulation and assumptions. We first discuss the setting where the manufacturer does not disclose SR information to the consumers. We then build on this setting to introduce the case where the manufacturer discloses.
2.1. No Manufacturer Disclosure

We consider a supply chain with one manufacturer (she) and one supplier (he). The manufacturer sells a product in a market where at least some consumers care whether the product is made in a socially responsible manner. The supplier’s initial level of SR, \( s_0 \), is his private information. We also refer to \( s_0 \) as the supplier’s type. The manufacturer does not know the supplier’s type but has a prior belief that \( s_0 \) is distributed on \([m, M]\) with cumulative distribution function (CDF) \( \Phi(\cdot) \) and probability density function (PDF) \( \phi(\cdot) \). We assume \( \phi(x) > 0 \) for all \( x \in [m, M] \). Before any decision is made, the manufacturer observes a signal, \( \tilde{s} \), that contains some information about \( s_0 \). The accuracy of the signal (i.e., how likely the signal is equal to \( s_0 \)) depends on the level of supply chain visibility, \( v \in (0, 1) \), that the manufacturer has. Specifically, with probability \( v \), \( \tilde{s} = s_0 \); otherwise, with probability \( 1 - v \), \( \tilde{s} \) is equal to a random value drawn from the manufacturer’s prior belief. Therefore, with higher supply chain visibility (i.e., a higher value of \( v \)), the manufacturer is more certain that the observed signal corresponds to the supplier’s true initial level of SR.

In our setting, the supplier is the only party that can directly impact the final level of SR. Specifically, he can choose to increase from \( s_0 \) to any \( s \geq s_0 \). We assume that the supplier will not reduce his level of SR to \( s < s_0 \); i.e., he does not engage in practices that worsen his current SR level. The manufacturer cannot directly impact SR, but she can indirectly influence the supplier’s choice of \( s \) by investing \( \beta \in [0, 1] \) to improve the supplier’s capabilities and reduce his cost of SR. Note that investing in a supplier’s capabilities differs from direct cost sharing because the former does not require the manufacturer to know \( s_0 \) (and hence the supplier’s cost of improving SR) with certainty. As a result, such an investment can be made with incomplete visibility, whereas cost sharing would be difficult if not impossible.

The market consists of two types of consumers: an \( \alpha \in (0, 1) \) fraction of the consumers are socially conscious (SC); the remaining \( (1 - \alpha) \) fraction are socially neutral (SN). Demand from both types of consumers depends on the retail price \( r \), which is fixed and exogenous. Demand from the SC consumers also depends on the supplier’s final level of SR if this information is revealed. Specifically, the final level of SR may be observed by a third party (e.g., an NGO) with a given, exogenous probability \( q \). If the supplier is found to have a final level of SR below the consumers’ minimum acceptable SR standard, then the third party reveals this information and the demand from SC consumers decreases.

The sequence of events is as follows: (i) After observing the signal \( \tilde{s} \), the manufacturer chooses her investment \( \beta \) to improve the supplier’s SR capabilities. (ii) The supplier selects \( s \geq s_0 \) to be the final level of SR. (iii) With probability \( q \), the third party observes \( s \). If \( s \) is below the SC consumers’
minimum acceptable SR standard, then the third party reveals $s$ to the consumers. (iv) Finally, demand is realized, and the supplier and the manufacturer earn their profits. Next, we discuss each step in more detail.

(i) Manufacturer’s investment in the supplier’s SR capabilities: The manufacturer makes her investment decision to maximize her expected profit, given signal $\tilde{s}$. We can write her expected profit as

$$E_{\tilde{s}}[\Pi_M(\beta, s^*(s_0, \beta)) | \tilde{s}] = \left( D_{SN} + E_{s_0}[D_{SC}(s^*(s_0, \beta)) | \tilde{s}] \right) (r - w) - \delta(\beta).$$

Here $D_{SN}$ is the demand from SN consumers and $D_{SC}$ is the expected demand from SC consumers. The notation $s^*(s_0, \beta)$ represents the supplier’s optimal decision on the final level of SR given his initial level $s_0$ and the manufacturer’s investment $\beta$. Since the manufacturer is a Stackelberg leader, by backward induction, she can fully anticipate $s^*(s_0, \beta)$ when choosing $\beta$. Demand $D_{SN}$ is independent from $s^*(s_0, \beta)$, whereas demand $D_{SC}$ depends on $s^*(s_0, \beta)$. Since $s_0$ is the supplier’s private information, when calculating her expected profit, the manufacturer has to take the expectation over all possible values of $s_0$ based on her posterior belief given $\tilde{s}$. The term $(r - w)$ represents the manufacturer’s profit margin, where $w$ is the wholesale price paid by the manufacturer to the supplier. We model the wholesale price $w$ as exogenous and independent of the supplier’s SR level. This approach is reasonable because in a survey of 334 companies, Porteous et al. (2015) find that price premiums are (i) not commonly used to improve suppliers’ SR practices and (ii) less effective than investing in suppliers’ SR capabilities. Taking $w$ as an exogenous parameter is also common in the socially responsible operations literature (e.g., Guo et al. 2016, Plambeck and Taylor 2016). The function $\delta(\beta)$ captures the manufacturer’s cost to invest in the supplier’s capabilities. We assume $\delta(\beta)$ to be strictly increasing, strictly convex, and twice-continuously differentiable in $\beta$ with $\delta'(0) = 0$.

Note that investing in a supplier’s SR capabilities could potentially help the manufacturer gain better visibility into the supplier’s practices in the long run. However, we focus on a single-period problem in which the manufacturer makes her decisions based on only the current signal that she observes. That is, we do not consider a multi-period setting where the manufacturer’s current investment can influence the future level of visibility, which in turn affects future investment decisions. As a result, we treat visibility $v$ as fixed, exogenous, and independent of the manufacturer’s investment $\beta$.

(ii) Supplier’s SR decision: The supplier selects $s \geq s_0$ to maximize his expected profit

$$\Pi_S(\beta, s) = (D_{SN} + D_{SC}(s)) (w - c) - (1 - \beta) (\rho(s) - \rho(s_0)).$$

The function $\rho(s)$ captures the supplier’s fixed cost for his final level of SR. We assume $\rho(s)$ to be strictly increasing, strictly convex, and twice-continuously differentiable in $s$. We model the supplier’s
cost of improving SR as $\rho(s) - \rho(s_0)$ to capture that the same increase in SR (from $s_0$ to $s$) is more costly at a higher value of $s_0$. In this regard, we assume that his current cost of SR at $s_0$ is a sunk cost.

The parameter $c$ in Equation (2) represents the per-unit cost of production. This cost is exogenous, known to all parties, and independent of $s$ and $s_0$. We make this choice because our motivating examples involve non-production related SR investments at a supplier, such as human resource training. In addition, Rangan et al. (2015) find that 32% (35%) of the 142 managers they surveyed reported decreased (increased) production costs due to SR investments. Given this disparity and our motivating examples, we model the supplier’s unit cost as being independent of the manufacturer’s SR investment. Finally, we capture fixed rather than variable (i.e., per unit sold) costs of SR. The literature on supplier development has examined companies working to decrease suppliers’ unit costs (e.g., Kim 2000, Kim and Netessine 2013) or fixed investment costs (e.g., Babich 2010, Mendoza and Clemen 2013). Our focus on reducing the supplier’s fixed SR costs is in line with the common challenge that SR development typically requires high fixed costs but low variable costs (Borzaga and Becchetti 2010).

(iii) Third-party scrutiny: After the manufacturer and the supplier make their decisions, the third party observes $s$ with probability $q$. To delineate between what consumers feel are good and bad practices, we consider a minimum SR standard, $\hat{s} \in (m, M)$, such that the third party revealing $s = \hat{s}$ would have no impact on the demand from SC consumers. We focus on the third party only revealing bad practices with respect to SC consumers’ minimum standard. That is, the third party reveals $s$ to the consumers only if $s < \hat{s}$. If instead $s \geq \hat{s}$, then no information is revealed.

(iv) Demand and profits are realized: Following a common approach in the literature (e.g., Moorthy 1988, Bagnoli and Watts 2003), we model a continuum of consumers characterized by their private valuations of the product, $\theta$, with $\theta$ being uniformly distributed on $[0, 1]$. Without loss of generality we normalize the total market size to 1. A consumer’s type (SC or SN) is independent of his/her private valuation, and each consumer buys at most one unit of the product. We consider a given retail price $r < 1$ which applies to both types of consumers if they purchase the product.

SC consumers incur an additional utility equal to $\gamma(\min\{s, \hat{s}\})$ if they purchase the product and the third party reveals $s$ (which occurs only if $s < \hat{s}$). The function $\gamma(\cdot)$ is assumed to be strictly increasing, strictly concave, and twice-continuously differentiable. As previously stated, revealing the minimum SR standard $\hat{s}$ has no impact on the demand from SC consumers; i.e., $\gamma(\hat{s}) = 0$. Since the third party only reveals $s < \hat{s}$, we have $\gamma(\min\{s, \hat{s}\}) < 0$ for any third-party revelation.

Given this setup, if no SR information is revealed, then all consumers behave in a similar manner (see, e.g., Dawkins 2004). A consumer with private valuation $\theta$ will buy the product if and only if
\( \theta - r \geq 0 \). Conversely, if the third party reveals \( s \), then SC consumers will buy the product if and only if 
\[ \theta - r + \gamma(\min\{s,\hat{s}\}) \geq 0, \]
while SN consumers continue to buy the product if and only if \( \theta - r \geq 0 \). Recall that an \( \alpha \) fraction of the consumers are SC. Thus, the expected demand from SN and SC consumers can be written as

\[
D_{SN} = (1 - \alpha) \int_{0}^{1} \mathbb{1}_{\theta \geq r} d\theta = (1 - \alpha)(1 - r),
\]

\[
D_{SC}(s) = \alpha (1 - q) \int_{0}^{1} \mathbb{1}_{\theta \geq r} d\theta + \alpha q \int_{0}^{1} \mathbb{1}_{\theta \geq r - \gamma(\min\{s,\hat{s}\})} d\theta
= \alpha (1 - q)(1 - r) + \alpha q \max\left\{0, \min\{1, 1 - r + \gamma(\min\{s,\hat{s}\})\}\right\},
\]

where \( \mathbb{1} \) denotes the indicator function. We make the following assumption regarding demand.

**Assumption 1.** A consumer with (i) the highest valuation \( \theta = 1 \) will always buy the product, i.e., \( \gamma(m) > r - 1 \); (ii) the lowest valuation \( \theta = 0 \) will never buy the product, i.e., \( \gamma(s) < r \) for all \( s \).

Assumption 1 ensures that the manufacturer captures at least some but not all of the market. Under this assumption, the term \( \max\{0, \min\{1, 1 - r + \gamma(\min\{s,\hat{s}\})\}\} \) in Equation (3) simplifies to \( 1 - r + \gamma(\min\{s,\hat{s}\}) \). The resulting total expected demand in the market (including both SN and SC consumers) is therefore equal to \( 1 - r + \alpha q \gamma(\min\{s,\hat{s}\}) \).

### 2.2. Manufacturer Disclosure

The key difference between the Manufacturer Disclosure setting and the No Manufacturer Disclosure setting is the following: After step (ii) (the supplier’s SR decision) and before step (iii) (third-party scrutiny), the manufacturer chooses a (final) level of SR, \( s_D \), to disclose to the consumers. The value \( s_D \) disclosed by the manufacturer does not necessarily match the supplier’s final level of SR; instead, \( s_D \) represents the level of SR that the manufacturer prefers to communicate to the consumers. The manufacturer discloses \( s_D \) before the third party may observe \( s \). If the third party observes \( s \), then it reveals \( s \) to the consumers only if the manufacturer has overstated the supplier’s SR level; i.e., \( s < s_D \). As a result, the manufacturer incurs a penalty proportional to \( (s_D - s) \) and the demand from SC consumers depends on \( s \) instead of \( s_D \). Conversely, if the third party observes \( s \geq s_D \) (i.e., the manufacturer has understated the supplier’s SR level) or if the third party does not observe \( s \), then no information is revealed by the third party, and the demand from SC consumers depends on \( s_D \).

\(^2\)A SC consumer may choose not to purchase the product if the manufacturer does not disclose any SR information. One way to capture this loss of demand is to model the fraction of SC consumers considering buying the product as \( \alpha' \leq \alpha \) (while keeping the fraction of SN consumers as \( 1 - \alpha \)). We can show that all of our results remain qualitatively the same under this alternative setup. The main difference is that when we compare the No Manufacturer Disclosure and Manufacturer Disclosure settings (§5), the manufacturer prefers to disclose for a larger parameter region.
Disclosing SR information to consumers while still lacking full visibility into their supply chains is not an uncommon practice for companies. For example, in 2014 Unilever published a progress report about its Sustainable Palm Oil Policy and disclosed that 58% of the palm oil in their supply chain was traceable to known mills. Despite lacking visibility into the remaining 42%, they still shared information about the progress made in the year and some of the social responsibility initiatives occurring throughout their palm oil supply chain (Unilever 2014).

In this setting, the manufacturer’s expected profit for a given signal $\tilde{s}$ can be written as

$$
E_{s_0} [\Pi_M(\beta, s_D, s^*(s_0, \beta)) | \tilde{s}] = 
\left( D_{SN} + E_{s_0} [D_{SC}(s_D, s^*(s_0, \beta)) | \tilde{s}] \right) (r - w) - \delta(\beta) - pq E_{s_0} [\max(s_D - s^*(s_0, \beta), 0) | \tilde{s}].
$$

The impact of SR information on the expected value of $D_{SC}$ depends on how $\min\{s^*, s_D\}$ compares to $\tilde{s}$ if the third party reveals (does not reveal) bad practices. In addition to the potential impact on demand, the manufacturer may incur a penalty if she overstates the supplier’s SR level in her disclosure. The last term in Equation (4) corresponds to the expected penalty incurred by the manufacturer if $s^* < s_D$. This penalty captures the loss of goodwill the manufacturer suffers (e.g., brand damage) due to the third party revealing that she has overstated the SR level of her supplier (see, e.g., Chen and Lee 2016, Cho et al. 2016, Plambeck and Taylor 2016, for similar goodwill costs). Therefore, when selecting the optimal value of $s_D$ to disclose, the manufacturer must balance the tradeoff between possibly increasing demand and the risk of incurring a penalty from overstating.

The supplier’s expected profit remains the same as in the No Manufacturer Disclosure setting except that the expected value of $D_{SC}$ now depends on both $s$ and $s_D$. We do not include a penalty for the supplier because (i) we are not investigating an audit/compliance setting where the manufacturer imposes a penalty on the supplier for the discovery of poor performance (as in Plambeck and Taylor 2016); and (ii) levying penalties on suppliers in developing countries can be difficult (as discussed in Chen and Lee 2016). Note however that like the manufacturer, the supplier does potentially suffer a loss of demand if the third party reveals $s < \tilde{s}$.

With respect to demand, a SC consumer will buy the product if and only if $\theta - r + \gamma(y) \geq 0$, where $y = s_D$ when the third party does not observe or reveal $s$, and $y = \min\{s, s_D\}$ when the third party observes and reveals $s$ (which occurs only if $s < s_D$). Given Assumption 1 stated earlier, the expected demand from SC consumers can be written as

$$
D_{SC}(s_D, s) = \alpha (1 - q) \int_0^1 1_{\theta \geq r - \gamma(s_D)} d\theta + \alpha q \int_0^1 1_{\theta \geq r - \gamma(\min\{s, s_D\})} d\theta
= \alpha (1 - q) (1 - r + \gamma(s_D)) + \alpha q (1 - r + \gamma(\min\{s, s_D\})).
$$
Table 1 Notation

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<thead>
<tr>
<th>Decision Variables</th>
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<tbody>
<tr>
<td>(\beta) Manufacturer’s investment to improve the supplier’s SR capabilities; (\beta \in [0, 1])</td>
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<tr>
<td>(s) Supplier’s final level of SR; (s \geq s_0)</td>
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<tr>
<td>(s_D) Manufacturer’s disclosed final level of SR (Manufacturer Disclosure setting only)</td>
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<th>SR-related Variables</th>
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<tr>
<td>(s_0) Supplier’s initial level of SR; (s_0 \in [m, M]) and is the supplier’s private information</td>
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<td>(\hat{s}) Signal the manufacturer observes regarding (s_0)</td>
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<td>(\hat{s}) Minimum SR standard of SC consumers; (\hat{s} \in (m, M))</td>
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<tr>
<td>(q) Probability that the third party observes (s); (q \in (0, 1))</td>
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<td>(v) Level of supply chain visibility the manufacturer has; (v \in (0, 1))</td>
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<th>Cost and Demand Parameters</th>
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<tr>
<td>(r) Unit retail price</td>
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<td>(w) Unit wholesale price paid by the manufacturer to the supplier</td>
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<tr>
<td>(c) Supplier’s per-unit cost of production</td>
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<tr>
<td>(p) Penalty factor the manufacturer incurs if the third party discloses (s &lt; s_D) (Manufacturer Disclosure setting only); (p &gt; 0)</td>
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<tr>
<td>(\theta) Consumers’ private valuation for the product; (\theta \sim U[0, 1])</td>
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<td>(\alpha) Fraction of consumers who are socially conscious; (\alpha \in (0, 1))</td>
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<td>(\delta(\beta)) Manufacturer’s cost to invest (\beta) in the supplier’s SR capabilities; (\delta'(\beta) &gt; 0) for (\beta &gt; 0), (\delta'(0) = 0), and (\delta''(\beta) &gt; 0)</td>
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<tr>
<td>(\rho(s)) Supplier’s fixed cost of SR at level (s); (\rho'(s) &gt; 0) and (\rho''(s) &gt; 0)</td>
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<tr>
<td>(\gamma(\cdot)) SC consumer’s additional utility from the disclosure of SR information; (\gamma'(\cdot) &gt; 0) and (\gamma''(\cdot) &lt; 0)</td>
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We next analyze the manufacturer’s and the supplier’s decisions in the No Manufacturer Disclosure (§3) and Manufacturer Disclosure (§4) settings. In addition, we study how these decisions depend on the level of visibility and the probability of third-party scrutiny. In §5 we compare the two settings and show when the manufacturer prefers to disclose SR information versus not disclose, and how the manufacturer’s disclosure choice impacts the supplier’s level of SR. Results presented in Appendix A and the online appendix are referenced as A.X and O.X. Table 1 summarizes our notation.

3. Results: No Manufacturer Disclosure

We first analyze the setting where the manufacturer does not voluntarily disclose any SR information to the consumers. We address the following questions: (i) What is the manufacturer’s optimal investment to improve the supplier’s SR capabilities? (ii) Given this investment, what is the supplier’s optimal choice of SR? (iii) How are these decisions affected by the signal about the supplier’s type, the manufacturer’s visibility, and the probability of third-party scrutiny? Throughout our analysis we define \(R_f(x)\) as the ratio \(\frac{f''(x)}{f'(x)}\) for any function \(f(x)\) and make the following assumptions.

Assumption 2. For any investment \(\beta > 0\), the lowest supplier type (with \(s_0 = m\)) always increases his SR level; i.e., the optimal final level of SR \(s^*(m, \beta) > m\) for any \(\beta > 0\).
Assumption 3. It is never optimal for the manufacturer to choose $\beta$ so high that the highest supplier type (with $s_0 = M$) would increase his SR level.

Assumption 4. $R_\rho(s)$ is non-decreasing in $s$ and $R_\gamma(s)$ is non-increasing in $s$.

Assumption 5. For any $\beta \in (0, 1]$, $R_\delta(\beta)(1 - \beta) \geq 1 + \frac{\phi(s^*_m)}{R_\rho(s^*_m) - R_\gamma(s^*_m)}$, where $s^*_m \equiv s^*(m, \beta)$.

Assumptions 2 and 3 ensure that in the optimal solution the lowest supplier type always improves SR, while the highest supplier type never does. Assumption 4 means that when $s$ is already high, the supplier’s cost of SR, $\rho(s)$, increases sharply as $s$ increases, and when $s$ is already low, SC consumers’ additional utility from SR, $\gamma(s)$, decreases sharply as $s$ decreases. That is, the cost of SR increases rapidly if the supplier attempts to achieve very good SR practices. Conversely, SC consumers’ demand for the product drops significantly when the supplier’s SR practices approach a very poor level. Note that Assumption 4 is satisfied, for example, if $\rho(\cdot)$ and $\gamma(\cdot)$ are exponential functions. Finally, Assumption 5 captures the existence of inefficiencies in the manufacturer’s investment in the supplier’s capabilities. First, $R_\delta(\beta)(1 - \beta) \geq 1$ implies that, for any investment $\beta$, the rate of increase in the marginal cost $\delta'(\beta)$ (captured by $R_\delta(\beta)$) is faster than the rate of reduction in the supplier’s SR cost (captured by $1 - \beta$). For example, as $\beta$ approaches 1, Assumption 5 guarantees that $R_\delta$ goes to $+\infty$.

The second term in the right-hand side captures the additional inefficiency due to the manufacturer not observing the supplier’s type with certainty.

We first analyze the supplier’s optimal choice of SR for a given value of $\beta$. Following §2.1, the supplier’s problem can be specified as

$$\max_{s \geq s_0} \left( 1 - r + \alpha q \gamma(\min\{s, \hat{s}\}) \right) (w - c) - (1 - \beta) \left( \rho(s) - \rho(s_0) \right).$$

(5)

We define the unconstrained supplier’s problem as the maximization problem in Equation (5) without the constraint $s \geq s_0$. Let $s^*_u(\beta)$ denote the unique optimal solution to the unconstrained problem. The following theorem characterizes the supplier’s optimal decision.

Theorem 1. Given $\beta$, the supplier’s optimal SR decision is $s^*(s_0, \beta) = \max\{s_0, s^*_u(\beta)\}$. Furthermore, $\frac{\partial s^*(s_0, \beta)}{\partial \beta} \geq 0$, $\frac{\partial s^*(s_0, \beta)}{\partial q} \geq 0$, and $s^*_u(\beta) \leq \hat{s}$ for all $\beta \in [0, 1]$.

Figure 1 illustrates Theorem 1. For any $s_0$, the supplier’s best response to the manufacturer’s investment is as follows: if $s_0$ is strictly lower than $s^*_u(\beta)$, then the supplier increases his SR level to $s^*_u(\beta)$; otherwise, the supplier does not improve his SR level (i.e., $s^*(s_0, \beta) = s_0$). Furthermore, since the third party never communicates values of $s$ greater than $\hat{s}$ to consumers, the supplier has no incentive to
improve his SR level beyond \( \hat{s} \). Thus, \( s_u^*(\beta) \leq \hat{s} \) for all \( \beta \). This explains why the supplier’s best response is identical for \( \beta = 0.6 \) and \( \beta = 0.8 \) in Figure 1.

Based on the supplier’s best response, we next characterize the manufacturer’s optimal investment to improve the supplier’s SR capabilities. The manufacturer’s optimal investment is determined by the solution to the following problem:

\[
\max_{\beta \in [0,1]} \left( 1 - r + \alpha q \mathbb{E}_{s_0}\left[ \gamma\left( \min\{s^*(s_0, \beta), \hat{s}\}\right) \mid \hat{s} \right] \right) \left( r - w \right) - \delta(\beta),
\]

where \( \mathbb{E}_{s_0}\left[ \gamma\left( \min\{s^*(s_0, \beta), \hat{s}\}\right) \mid \hat{s} \right] \) captures the expected change in demand from SC consumers if the third party observes and reveals the supplier’s final level of SR. We define \( \hat{\beta} \) such that \( s_u^*(\hat{\beta}) = \hat{s} \); i.e., \( \hat{\beta} \) is the minimum investment needed from the manufacturer to ensure that the supplier’s final SR level is at least \( \hat{s} \). Our next result summarizes the manufacturer’s optimal investment decision.

**Theorem 2.** For a given level of visibility \( v \), there exist \( \beta_L(v) \) and \( \beta_H(v) \) such that \( 0 \leq \beta_L(v) \leq \beta_H(v) < 1 \), and the manufacturer’s optimal investment, \( \beta^*(v, \hat{s}) \), is defined as follows:

(a) If \( \beta_L(v) \geq \hat{\beta} \), then \( \beta^*(v, \hat{s}) = \hat{\beta} \) for all \( \hat{s} \).

(b) If \( \beta_L(v) < \hat{\beta} \), then there exists a threshold \( \tau(v) \in (m, \hat{s}) \) such that:

(i) If \( \hat{s} \leq \tau(v) \), then \( \beta^*(v, \hat{s}) = \beta_H(v) = \min\{\beta_H(v), \hat{\beta}\} \);

(ii) If \( \hat{s} > \tau(v) \), then \( \beta^*(v, \hat{s}) = \beta_L(v) \).

Theorem 2 characterizes the structure of the manufacturer’s optimal investment to improve the supplier’s SR capabilities for a given level of visibility, \( v \). In Theorem 2(a), motivating the supplier to increase his SR level to at least \( \hat{s} \) requires a low investment from the manufacturer. Hence, the manufacturer invests \( \hat{\beta} \) for any signal. Theorem 2(b) is illustrated in Figure 2 for two levels of visibility.
In this case, the manufacturer only needs to consider two possible values of $\beta$: a low investment $\beta_L(v)$ or a high investment $\bar{\beta}_H(v)$. If the signal $\bar{s}$ is below the threshold $\tau(v)$, then it is optimal for the manufacturer to make a high investment, $\bar{\beta}_H(v)$. This is because the signal indicates that the supplier may currently have poor SR practices. Conversely, if $\bar{s}$ is above the threshold $\tau(v)$, then it is optimal for the manufacturer to make a low investment, $\beta_L(v)$, because the signal indicates that the supplier may already have good SR practices. The manufacturer makes this low investment only to help improve the supplier’s SR level in case the signal is incorrect (i.e., if $s_0$ is in fact low). If the signal is correct (i.e., $s_0 = \bar{s} > \tau(v)$), then the supplier’s best response to $\beta_L(v)$ is simply to stay at $s_0$. In our subsequent analysis, we focus on case (b) in Theorem 2, when it is too costly for the manufacturer to motivate all supplier types to achieve a final SR level that is at least $\bar{s}$.

3.1. The Effect of Visibility on the Manufacturer’s Optimal Investment Strategy and the Supplier’s Final SR Level

The following proposition demonstrates how improved supply chain visibility helps the manufacturer to better tailor her investment in the supplier’s SR capabilities. To simplify notation, hereafter we will drop the argument $(v)$ and write $\beta_H$, $\bar{\beta}_H$, $\beta_L$, and $\tau$.

**PROPOSITION 1.** (i) $\beta_L$ is strictly decreasing in $v$ and $\beta_H$ is strictly increasing in $v$. (ii) The threshold $\tau$ is increasing in $v$ if and only if

$$\delta(\bar{\beta}_H) - \delta(\beta_L) > \alpha q (r - w) \mathbb{E}_{s_0} \left[ \gamma\left( \min\{s^*(s_0, \bar{\beta}_H), \bar{s}\} \right) - \gamma\left( \min\{s^*(s_0, \beta_L), \bar{s}\} \right) \middle| \bar{s} \neq s_0 \right] .$$  \hspace{1cm} (7)

Proposition 1(i) demonstrates how the two potential investment values in the manufacturer’s optimal strategy change with visibility. As visibility increases, the manufacturer becomes more confident that
the signal she observes captures the supplier’s true initial SR level. As a result, the manufacturer increases her investment (i.e., $\beta_H$ increases) if the supplier likely has poor SR practices as suggested by the signal (i.e., when $\tilde{s} \leq \tau$). Conversely, the manufacturer decreases her investment (i.e., $\beta_L$ decreases) if the signal suggests that the supplier already has good SR practices (i.e., when $\tilde{s} > \tau$). Therefore, better visibility into the supplier’s practices allows the manufacturer to utilize her resources more efficiently and to ensure that she helps those supplier types who need it most. The special cases of $v = 0$ and $v = 1$ further illustrate how visibility impacts the manufacturer’s investment. If the manufacturer had no visibility ($v = 0$ and hence, the signal is uninformative), then she should invest the same amount regardless of $\tilde{s}$ (i.e., $\beta_L(0) = \beta_H(0)$). Conversely, if she had full visibility ($v = 1$ and hence, $\tilde{s} = s_0$ with certainty), then she should not invest at all in high supplier types (i.e., $\beta_L(1) = 0$).

Proposition 1(ii) specifies the condition under which the threshold $\tau$, and hence the range of supplier types for which the manufacturer should make a high investment, increases or decreases with $v$. The left-hand side of Equation (7) captures the manufacturer’s cost difference between a high and a low investment. The right-hand side of Equation (7) captures the manufacturer’s expected revenue gain from making a high versus a low investment if she observes an incorrect signal about the supplier’s initial SR level (i.e., $\tilde{s} \neq s_0$). The intuition behind Proposition 1(ii) is as follows. If the cost difference between a high and a low investment is large relative to the expected revenue gain, then the manufacturer is reluctant to choose a high investment. In this case, greater visibility – i.e., increased confidence that the signal captures the true supplier type – can convince her that investing $\bar{\beta}_H$ is worthwhile for a wider range of $\tilde{s}$ values. Thus, the threshold $\tau$ increases as $v$ increases (Figure 2a). Conversely, if the cost difference is small relative to the expected revenue gain, then the manufacturer is willing to make a high investment in general. With worse visibility, she is less confident that the signal is correct. Hence, she opts for investing $\bar{\beta}_H$ for a wider range of $\tilde{s}$ values to ensure that the supplier’s final level of SR is acceptable. As a result, the threshold $\tau$ increases as $v$ decreases (Figure 2b).

We next discuss how the manufacturer’s level of visibility impacts the supplier’s final level of SR. Note that visibility impacts SR in two ways: (i) it affects the accuracy of the signal $\tilde{s}$, and (ii) it affects the manufacturer’s investment given $\tilde{s}$. Therefore, to understand the combined effect, we analyze how visibility impacts the expected final level of SR for a given supplier type $s_0$, with the expectation taken over all possible signals that the manufacturer may observe. Specifically, the expected final level of SR given $s_0$ is defined as

$$ES(v, s_0) \equiv vs^*\left(s_0, \beta^*(v, s_0)\right) + \left(1 - v\right)\int_{\tilde{s} \in [m, M]} s^*\left(s_0, \beta^*(v, \tilde{s})\right)\phi(\tilde{s})d\tilde{s}.$$
We numerically observe that while greater visibility generally increases the expected final SR level, it can lead to a lower expected final SR level if the supplier’s type takes an intermediate value. In this case, when visibility is not high (hence the signal is often incorrect), the manufacturer makes a high investment to ensure good practices. The (intermediate) supplier responds to this high investment by increasing his SR level. When visibility is instead high, the manufacturer is more likely to observe $s_0$ correctly and realize that the supplier’s current practices are acceptable. As a result, she reduces her investment when observing $\tilde{s} = s_0$, leading to a lower expected final SR level. Proposition A.1 shows that this case always exists for some intermediate $s_0$ values. See Appendix O.1 for further details.

### 3.2. The Effect of Third-Party Scrutiny on the Manufacturer’s Optimal Investment Strategy and the Supplier’s Final SR Level

Regarding the effect of third-party scrutiny on the manufacturer’s investment strategy, we find that $\beta_L$ and $\beta_H$ are not monotone in $q$ (Appendix O.2). Nevertheless, the following result always holds.

**Proposition 2.** The threshold $\tau$ is strictly increasing in $q$.

As the probability of third-party scrutiny increases, the manufacturer prefers the high investment $\bar{\beta}_H$ over the low investment $\beta_L$ for a wider range of signals. To understand the reason behind this result, consider the signal $\tilde{s} = \tau$ for which the manufacturer is indifferent between making a high or a low investment. As $q$ increases, the final SR level $s^*(\tau, \beta)$ is more likely to be revealed to the consumers. Hence, it is in the manufacturer’s best interest to make a high investment to ensure acceptable practices at the supplier. Therefore, she prefers $\bar{\beta}_H$ over $\beta_L$ for a wider range of signals when $q$ increases.

Although an increase in $q$ can lead to a decrease in the manufacturer’s investment, the next proposition shows that it never decreases the supplier’s final level of SR.

**Proposition 3.** $\frac{ds^*(s_0, \beta^*(\tilde{s}, q), q)}{dq} \geq 0$ for all $s_0, \tilde{s} \in [m, M]$.

In our model, third-party scrutiny impacts the supplier’s SR decision in two ways. First, it directly impacts the supplier’s decision by changing the demand from SC consumers. As third-party scrutiny becomes more likely (with a higher $q$), the supplier is more likely to improve SR. Second, third-party scrutiny indirectly impacts the supplier’s SR level through its (nonmonotone) effect on the manufacturer’s investment. Proposition 3 demonstrates that the direct impact of $q$ on demand dominates the indirect impact of $q$ on the manufacturer’s investment. Thus, the supplier is always more motivated to improve his SR practices when there is a higher chance that these practices will be observed by the third party and revealed to the consumers.
4. Results: Manufacturer Disclosure

We next examine the setting where the manufacturer voluntarily discloses SR information to the consumers. In this setting, the manufacturer may increase demand by disclosing, but she may also suffer a penalty if the third party later discovers and reveals that she has overstated the supplier’s final SR level. We address the following questions: (i) What is the manufacturer’s optimal investment to improve the supplier’s SR capabilities? (ii) What is the supplier’s optimal choice of SR? (iii) What level of SR should the manufacturer disclose? (iv) How are these decisions affected by the signal about the supplier’s type, the manufacturer’s visibility, and the probability of third-party scrutiny? We will use subscript $D$ on the relevant variables to indicate the Manufacturer Disclosure setting.

First, we analyze the supplier’s optimal choice of SR given the manufacturer’s investment $\beta_D$ and the final SR level disclosed, $s_D$. The supplier’s problem can be written as

$$\max_{s \geq s_0} \left(1 - r + \alpha (1 - q) \gamma(s_D) + \alpha q \gamma(\min\{s, s_D\})\right) (w - c) - (1 - \beta_D) \left(\rho(s) - \rho(s_0)\right).$$  \hspace{1cm} (8)

Comparing to Equation (5), the only difference in the Manufacturer Disclosure setting is that the expected demand from SC consumers is now affected by the manufacturer’s disclosure, $s_D$. Specifically, if the third party does not observe the supplier’s final level of SR (which happens with probability $1 - q$), then the demand from SC consumers ($\alpha$ fraction of the market) increases by $\gamma(s_D)$. If instead the third party observes the final level of SR (which happens with probability $q$), then it reveals this information only if the manufacturer has overstated the supplier’s level of SR. In this case, the impact to the demand from SC consumers is $\gamma(\min\{s, s_D\})$. Nevertheless, the structure of the supplier’s optimal SR decision, $s^*(s_0, \beta_D)$, remains the same as in Theorem 1, except that now the unconstrained optimal solution satisfies $s^*_{uD}(\beta_D) \leq s_D$ (Theorem A.1). \hspace{1cm} (9)

We next analyze the manufacturer’s investment in the supplier’s SR capabilities and her choice of what final SR level to disclose. The manufacturer solves the following problem:

$$\max_{\beta_D \in [0, 1]} \left\{ \max_{s_D \in [s, M]} \left\{ \left(1 - r + \alpha (1 - q) \gamma(s_D) + \alpha q \mathbb{E}_{s_0}\left[\gamma(\min\{s^*(s_0, \beta_D), s_D\})\right] \bigg| \tilde{s}\right) (r - w) - \delta(\beta_D) - pq \mathbb{E}_{s_0}\left[\max\{s_D - s^*(s_0, \beta_D), 0\} \bigg| \tilde{s}\right] \right\} \right\}. \hspace{1cm} (9)$$

Since the manufacturer does not observe the true supplier type $s_0$ due to incomplete visibility, she cannot condition her disclosure decision on $s_0$ or the corresponding optimal SR decision by the supplier. Thus, from a mathematical standpoint, the supplier’s SR decision and the manufacturer’s disclosure decision can be considered as being made simultaneously.

Technically, $s^*$ also depends on $s_D$. We do not include $s_D$ in the expression of $s^*$ because (i) $s_D$ affects $s^*$ only by imposing an upper bound on $s^*$, and (ii) in equilibrium, this upper bound is already captured by the maximum investment, $\beta_D$, that the manufacturer may invest.
Figure 3  Manufacturer’s Optimal Investment under No Manufacturer Disclosure versus Manufacturer Disclosure

The inner maximization solves for the manufacturer’s optimal disclosure decision given the investment she has made in the supplier. The outer maximization solves for the manufacturer’s optimal investment, taking into account its effect on the supplier’s SR decision and the manufacturer’s own disclosure decision. The manufacturer anticipates the supplier’s optimal SR decision $s^*(s_0, \beta_D)$ for each possible $s_0$ when making her decisions. The last term in Equation (9) captures the expected penalty incurred by the manufacturer if she overstates the supplier’s SR performance and the third party later reveals the supplier’s actual final SR level.

The structure of the manufacturer’s optimal investment $\beta^*_D(v, \tilde{s})$ in this setting remains the same as in the No Manufacturer Disclosure setting (Theorem A.2). As illustrated in Figure 3, the manufacturer makes a high investment $\bar{\beta}_{HD}(v) \equiv \min\{\beta_{HD}(v), \hat{\beta}_D\}$ if the observed signal $\tilde{s}$ is less than or equal to a threshold $\tau_D(v)$. Otherwise, if $\tilde{s} > \tau_D(v)$, then the manufacturer makes a low investment $\beta_{LD}(v)$. The effects of visibility and third-party scrutiny on the manufacturer’s optimal investment decision are also qualitatively the same as in the No Manufacturer Disclosure setting (Propositions A.2–A.3).

Our next result shows that the manufacturer’s optimal investment in the Manufacturer Disclosure setting is strictly higher than that in the No Manufacturer Disclosure setting.

**Proposition 4.** For any level of visibility $v$ and signal $\tilde{s}$, $\beta_{LD} > \beta_L$, $\bar{\beta}_{HD} > \bar{\beta}_H$, $\tau_D > \tau$, and therefore, $\beta^*_D(v, \tilde{s}) > \beta^*(v, \tilde{s})$.

Proposition 4 follows from the fact that in the Manufacturer Disclosure setting, there is always a positive chance that the manufacturer incurs a penalty for overstating the supplier’s final level of SR.

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5 As in Theorem 2(a), if it is inexpensive to motivate the supplier to improve his SR practices, then regardless of the signal, it is optimal for the manufacturer to make a high (and uniform) investment, $\hat{\beta}_D$. We focus here on the more interesting case when this strategy is too costly for the manufacturer.
This result implies that when the manufacturer discloses SR information to the consumers, she invests a strictly larger amount of resources to improve the supplier’s SR capabilities as compared to when she does not disclose SR information (Figure 3).

4.1. What Level of SR Should the Manufacturer Disclose?

When determining the level of SR to disclose, $s_D$, the manufacturer faces a tradeoff between capturing additional demand from disclosing a high $s_D$ versus risking a penalty if $s_D$ turns out to be higher than the supplier’s actual SR performance. The manufacturer’s optimal disclosed level $s_D^*(v, \tilde{s})$ is characterized by the following theorem.

**Theorem 3.** (a) If $\beta_{LD} \geq \hat{\beta}_D$, then $s_D^*(v, \tilde{s}) = s^*(m, \hat{\beta}_D)$ for any $v$ and $\tilde{s}$.

(b) If $\beta_{LD} < \hat{\beta}_D$ and $\alpha (1 - q) (r - w) \gamma' (M) \geq pq$, then $s_D^*(v, \tilde{s}) = M$ for any $v$ and $\tilde{s}$.

(c) If $\beta_{LD} < \hat{\beta}_D$ and $\alpha (1 - q) (r - w) \gamma' (M) < pq$, then for a given level of visibility $v$, there exists thresholds $\tau_L(v)$ and $\tau_H(v)$ satisfying $m < \tau_D \leq \tau_L(v) < \tau_H(v) \leq M$, such that $s_D^*(v, \tilde{s})$ is as follows:

- **Region (i)** If $\tilde{s} < \tau_L(v)$, then $s_D^*(v, \tilde{s}) \in [s^*(\tilde{s}, \beta_D^*(v, \tilde{s})), M]$. In addition, $s_D^*(v, \tilde{s})$ is either constant or piece-wise constant in $\tilde{s}$, with at most one discontinuous drop at $\tilde{s} = \tau_D$.

- **Region (ii)** If $\tau_L(v) \leq \tilde{s} \leq \tau_H(v)$, then $s_D^*(v, \tilde{s}) = s^*(\tilde{s}, \beta_D^*(v, \tilde{s})) = \tilde{s}$.

- **Region (iii)** If $\tilde{s} > \tau_H(v)$, then $s_D^*(v, \tilde{s}) = \tau_H(v) < s^*(\tilde{s}, \beta_D^*(v, \tilde{s})) = \tilde{s}$.

Furthermore, $\tau_H(v) < M$ if and only if $\alpha (1 - q (1 - v)) (r - w) \gamma' (M) < pq (1 - v)$.

Theorem 3(a) captures a scenario when an overstated disclosure is very costly to the manufacturer (e.g., under a high penalty factor $p$ or a high possibility of third-party scrutiny $q$). In this case, the manufacturer is overly cautious. She invests the maximum amount $\hat{\beta}_D$ regardless of the supplier type but discloses the minimum possible final level of SR given her investment; i.e., $s^*(s_0 = m, \hat{\beta}_D)$. In contrast, Theorem 3(b) captures the opposite scenario when the potential penalty associated with an overstated disclosure is very small (e.g., under a low $p$ and $q$). As a result, the manufacturer discloses the maximum possible final level of SR, $M$, regardless of the observed signal $\tilde{s}$.

Figure 4 illustrates Theorem 3(c). First note that in our setup, given $v$ and $\tilde{s}$, the most likely value of $s_0$ from the manufacturer’s perspective is $s_0 = \tilde{s}$. Thus, the value $s^*(\tilde{s}, \beta_D^*(v, \tilde{s}))$ represents the final SR level of the most likely supplier type from the manufacturer’s standpoint. We refer to this value as the manufacturer’s best estimate of the supplier’s final SR level. When the manufacturer observes a low signal (i.e., Region (i) of Theorem 3(c) and Figure 4), she chooses to overstate the final level of SR with respect to her best estimate ($s_D^*(v, \tilde{s}) \geq s^*(\tilde{s}, \beta_D^*(v, \tilde{s}))$). This is in part because if the low signal was incorrect, then the actual supplier type would likely be higher than the signal (i.e., $s_0 > \tilde{s}$ is
likely). Thus, the risk of overstating and incurring a potential penalty is small relative to the benefit of attracting higher demand from SC consumers with a higher $s_D$.

The manufacturer’s decision when she observes a high signal (i.e., Region (iii) of Theorem 3(c) and Figure 4) is exactly the opposite. She now faces a high risk from overstating if the signal turns out to be wrong (and hence the actual supplier type is lower). Therefore, she chooses to be conservative and understates the final level of SR compared to her best estimate ($s^*_D(v, \tilde{s}) < s^*(\tilde{s}, \beta^*_D(v, \tilde{s}))$). Finally, when the manufacturer observes a signal that lies in the intermediate range (i.e., Region (ii) of Theorem 3(c) and Figure 4), she discloses her best estimate, $s^*(\tilde{s}, \beta^*_D(v, \tilde{s}))$, to the consumers. In Region (ii), her best estimate is exactly equal to $\tilde{s}$. This is because for $\tilde{s} > \tau_D$, it is optimal for the manufacturer to make a low investment (i.e., $\beta^*_D(v, \tilde{s}) = \beta_{LD}$; Theorem A.2). As a result, the best response of a supplier with type $s_0 = \tilde{s} > \tau_D$ is to simply stay at $\tilde{s}$ (Proposition A.4). In our subsequent analysis, we focus on case (c) in Theorem 3 when the manufacturer’s optimal disclosure varies by the signal she observes.

**4.2. The Effects of Visibility and Third-Party Scrutiny on the Manufacturer’s Disclosure**

We first show that greater visibility motivates the manufacturer to be more “truthful” in her disclosure.

**Proposition 5.** (a) $\tau_L(v)$ is strictly decreasing in $v$ and $\tau_H(v)$ is non-decreasing in $v$.

(b) The manufacturer’s optimal disclosed level $s^*_D(v, \tilde{s})$ is

(i) non-increasing in $v$ if $\tilde{s} < \tau_L(v)$;

(ii) independent of $v$ if $\tilde{s} \in [\tau_L(v), \tau_H(v)]$; and

(iii) increasing in $v$ if $\tilde{s} > \tau_H(v)$.

Proposition 5(a) implies that the range of $\tilde{s}$ values for which it is optimal for the manufacturer to disclose her best estimate of the supplier’s final SR level widens as visibility increases (see Region
(ii) in Figures 4a to 4c). That is, as the manufacturer becomes more confident that the signal she observes accurately captures the supplier’s initial level of SR, she is more likely to neither overstate nor understate relative to her best estimate.

For the range of $\tilde{s}$ values where the manufacturer finds it optimal to overstate relative to her best estimate (i.e., Region (i) in Figure 4), the optimal disclosed level decreases as visibility increases (Proposition 5(b)-(i)). Since the manufacturer’s best estimate mostly increases with $v$ in Region (i), the decreased disclosed level implies that the extent to which she overstates decreases as visibility increases.\(^6\) This is because as the manufacturer becomes more certain what she observes is the true supplier type, the benefit of overstating decreases and she becomes more cautious about the risk of a potential penalty. Conversely, for the range of $\tilde{s}$ values where the manufacturer finds it optimal to understate relative to her best estimate (i.e., Region (iii) in Figure 4), the optimal disclosed level increases as visibility increases (Proposition 5(b)-(iii)). Hence, the extent to which the manufacturer understates decreases with visibility. Again, the manufacturer’s increased certainty that the signal is correct makes her less concerned about the potential penalty risk. As a result, she finds it beneficial to disclose a level closer to her best estimate. Observe that when visibility is sufficiently high, Region (iii) no longer exists and thus, the manufacturer does not understate the supplier’s SR performance for any $\tilde{s}$ value (see the last condition in Theorem 3 and Figure 4c).

Next, we examine how the probability of third-party scrutiny, $q$, affects the manufacturer’s optimal disclosed SR level. Define $\Omega(v, \tilde{s}) \equiv s^*_D(v, \tilde{s}) - s^*(\tilde{s}, \beta^*_D(v, \tilde{s}))$ as the difference between her optimal disclosed level and her best estimate of the supplier’s final SR level. We show the following result.

**Proposition 6.** For any given $v$ and $\tilde{s}$, $\Omega(v, \tilde{s})$ is non-increasing in $q$. Furthermore, $\tau_H$ is non-increasing in $q$, and strictly decreasing in $q$ if $\tau_H < M$.

As the probability of third-party scrutiny increases, the manufacturer becomes more cautious in her disclosure. For low signals (i.e., $\tilde{s} < \tau_L$; Region (i) in Figure 4), the manufacturer discloses a level that is closer to her best estimate. Conversely, for high signals (i.e., $\tilde{s} > \tau_H$; Region (iii) in Figure 4 if it exists), the manufacturer understates with respect to her best estimate even more as $q$ increases. Finally, $\tau_H$ being non-increasing in $q$ (and strictly decreasing when Region (iii) exists) implies that as $q$ increases, the manufacturer understates the supplier’s SR performance for a wider range of high signals.

\(^6\) One possible exception to this result occurs for $\tilde{s}$ values close to the threshold $\tau_D$, when $\tau_D$ is decreasing in visibility. In this case, the manufacturer’s best estimate decreases with $v$ for some $\tilde{s} < \tau_D$ because her optimal investment decreases from $\beta_{HD}$ to $\beta_{LD}$. Thus, the gap between her optimal disclosed level and her best estimate can increase with visibility.
With respect to the effects of $v$ and $q$ on the supplier’s final level of SR, our findings in the Manufacturer Disclosure setting are qualitatively the same as in the No Manufacturer Disclosure setting, and hence, will not be repeated.

5. When Does the Manufacturer Prefer to Voluntarily Disclose SR Information?

We next investigate under what conditions the manufacturer prefers to disclose versus not to disclose SR information to the consumers. Define $\Pi^*_M(v, \tilde{s})$ and $\Pi^*_MD(v, \tilde{s})$ as the manufacturer’s optimal expected profits in the No Manufacturer Disclosure and the Manufacturer Disclosure settings. For a given level of visibility $v$ and signal $\tilde{s}$, the manufacturer will choose to disclose SR information to the consumers if and only if $\Pi^*_MD(v, \tilde{s}) > \Pi^*_M(v, \tilde{s})$. Theorem 4 summarizes how the difference between these two profits, $\Delta(\Pi(v, \tilde{s}) \equiv \Pi^*_MD(v, \tilde{s}) - \Pi^*_M(v, \tilde{s})$, depends on $\tilde{s}$.

**Theorem 4.** For a given level of visibility $v$, $\Delta(\Pi(v, \tilde{s})$ is continuous and

(i) constant in $\tilde{s}$ for $\tilde{s} \in [m, \tau]$;

(ii) non-increasing in $\tilde{s}$ for $\tilde{s} \in [\tau, \tau_D]$; and

(iii) non-decreasing in $\tilde{s}$ for $\tilde{s} \in [\tau_D, M]$.

Therefore, $\tau_D \in \arg\min_{s} \{\Delta(\Pi(v, \tilde{s})\}$.

Theorem 4 implies the following observation regarding the manufacturer’s choice of whether or not to disclose SR information.

**Corollary 1.** The manufacturer is least likely to disclose SR information when the observed signal is equal to or close to $\tau_D$.

Theorem 4 can be interpreted as follows (also see Figure 3). When the signal is low (i.e., $\tilde{s} \in [m, \tau]$), the manufacturer infers that the supplier’s current practices are poor and thus makes a high investment to improve the supplier’s SR capabilities, regardless of whether she discloses SR information. Note that the supplier’s optimal SR level is independent of $\tilde{s}$ in this case. That is, for $\tilde{s} \in [m, \tau)$, $s^*(\tilde{s}, \tilde{\beta}_H) = s^u(\tilde{\beta}_H)$ in the No Manufacturer Disclosure setting and $s^*(\tilde{s}, \tilde{\beta}_HD) = s^u_D(\tilde{\beta}_HD)$ in the Manufacturer Disclosure setting (Proposition A.4). Thus, neither $\Pi^*_M(v, \tilde{s})$ nor $\Pi^*_MD(v, \tilde{s})$ depends on $\tilde{s}$, and $\Delta(\Pi(v, \tilde{s})$ is constant in $\tilde{s}$ (Theorem 4(ii)). When the observed signal is in the intermediate range (i.e., $\tilde{s} \in [\tau, \tau_D]$), the manufacturer continues to make a high investment ($\tilde{\beta}_HD$) if she plans to disclose SR information.

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7 Theorem 4 and our discussion hereafter consider the case when $\tau_H \geq \tilde{s}$, with $\tau_H$ defined in Theorem 3. If instead $\tau_H < \tilde{s}$, then the manufacturer generally prefers not to disclose, regardless of the $\tilde{s}$ value. See Theorem A.3 and the related discussion in Appendix A for further details.
(and hence, \( \Pi_{MD}^*(v, \tilde{s}) \) remains constant in \( \tilde{s} \)). In doing so she reduces the potential penalty in case of overstatement. If instead the manufacturer plans not to disclose SR information, then she prefers a low investment (\( \beta_L \)). Note that \( s^*(\tilde{s}, \beta_L) = \tilde{s} \) for \( \tilde{s} > \tau \) (Proposition A.4). Thus, \( \Pi_M(v, \tilde{s}) \) is strictly increasing in \( \tilde{s} \) for \( \tilde{s} \in [\tau, \hat{s}] \) and constant thereafter (since the third party does not reveal any SR level above \( \hat{s} \)). Consequently, \( \Delta_{\Pi}(v, \tilde{s}) \) is non-increasing for \( \tilde{s} \in [\tau, \tau_D] \) (Theorem 4(ii)). Finally, when the observed signal is high (i.e., \( \tilde{s} \in [\tau_D, M] \)), in both settings the manufacturer chooses a low investment and her expected profit is first strictly increasing, then constant in \( \tilde{s} \). Since the manufacturer can potentially increase demand by disclosing SR information, \( \Pi_{MD}^*(v, \tilde{s}) \) increases in \( \tilde{s} \) at a faster or equal rate as \( \Pi_M^*(v, \tilde{s}) \). As a result, \( \Delta_{\Pi}(v, \tilde{s}) \) is non-decreasing in \( \tilde{s} \) for \( \tilde{s} \in [\tau_D, M] \) (Theorem 4(iii)).

Theorem 4 leads to five possible disclosure strategies for the manufacturer.

**Corollary 2.** There exist five possible manufacturer disclosure strategies based on the signal \( \tilde{s} \):

(i) Do not disclose for all \( \tilde{s} \in [m, M] \);
(ii) Disclose for all \( \tilde{s} \in [m, M] \);
(iii) Do not disclose if \( \tilde{s} \leq \kappa \) and disclose if \( \tilde{s} > \kappa \), where \( \kappa > \tau_D \);
(iv) Disclose if \( \tilde{s} \leq \kappa' \) and do not disclose if \( \tilde{s} > \kappa' \), where \( \kappa' < \tau_D \);
(v) Do not disclose if \( \tilde{s} \in (\kappa_L, \kappa_H) \), and disclose if \( \tilde{s} \leq \kappa_L \) or \( \tilde{s} \geq \kappa_H \), where \( \kappa_L < \tau_D < \kappa_H \).

In addition, strategies (i) and (ii) are more likely to be optimal under a low level of visibility; strategies (iii)–(v) are more likely to be optimal under a high level of visibility.

Strategies (i)–(iii) are relatively intuitive. For example, if visibility is low and both the possibility of third-party scrutiny (\( q \)) and the penalty factor for overstating the level of SR (\( p \)) are high, then the manufacturer may prefer to be cautious and not disclose any information to the consumers, regardless of the signal (strategy (i)). If instead \( q \) and/or \( p \) are very low, then the manufacturer may prefer to disclose SR information regardless of the signal (strategy (ii)) because the benefit from increased demand outweighs the risk of a potential penalty. Strategy (iii) can be optimal if visibility is high and \( q \) and \( p \) are not too low. In this case, it is preferable for the manufacturer to disclose only when \( \tilde{s} \) indicates that the supplier has good SR practices.

Strategies (iv) and (v) are less intuitive. Figure 5a presents a numerical illustration of when these strategies can be optimal. First observe that strategy (iv) is optimal when visibility is low (i.e., when \( v < 0.6 \)) whereas strategy (v) is optimal when visibility is higher. Recall from Theorems 2 and A.2 that the manufacturer makes a high (low) investment when the observed signal is low (high). The high investment (and the resulting high final SR level) at low signals motivates the manufacturer to
Figure 5 Manufacturer’s Optimal Disclosure Strategy

(a) Optimal disclosure strategy as a function of the signal and visibility \((q = 0.6)\)

(b) Optimal disclosure strategy as a function of the signal and third-party scrutiny \((v = 0.6)\)

Note. Parameters: \(\alpha = 0.4, r = 0.5, w = 0.15, c = 0, p = 17.5\). Functions: \(\rho(s) = e^{1.75s}, \gamma(s) = 0.5 - e^s, \delta(\beta) = \frac{0.5\beta^2}{1 - \beta}\). The supplier’s type \(s_0\) is distributed uniformly between \(m = 0\) and \(M = 1\).

disclose to increase demand (the left half of Figure 5a). In contrast, the manufacturer is more cautious when observing a high signal, especially when visibility is low. In this case, she is not very confident about the signal being correct and hence, faces a considerable risk of penalty from disclosing and overstating her supplier’s SR performance. Hence, she prefers not to disclose (the lower right corner of Figure 5a) and instead saves on her investment cost (her optimal investment is lower if she does not disclose; see Proposition 4). With higher visibility, the manufacturer becomes more certain that a high signal indicates the supplier has good SR practices, and therefore, she chooses to disclose (the upper right corner of Figure 5a). However, for intermediate signals, the manufacturer still prefers not to disclose even under high visibility (the middle top region of Figure 5a). This most likely occurs for \(\tilde{s} \in (\tau, \tau_D)\), where \(\tau\) and \(\tau_D\) are the threshold signals at which the manufacturer decreases her investment under No Manufacturer Disclosure and Manufacturer Disclosure. Within this range, the manufacturer invests a high (low) amount of resources if she plans to disclose (not to disclose). The substantially higher investment cost under disclosure cannot be justified by the moderate increase in demand from disclosing. Thus, the manufacturer prefers not to disclose and instead save on her investment cost in this region.

5.1. The Effects of Visibility and Third-Party Scrutiny on the Manufacturer’s Disclosure Choice

The reasoning behind strategy \((v)\) above also explains why increasing visibility (i.e., going from the bottom to the top of Figure 5a) may cause the manufacturer to switch from disclosing to not disclosing
for intermediate signals (e.g., the region where $\tilde{s}$ is close to 0.6 in Figure 5a). This situation occurs when $\tau$ and $\tau_D$ change with $v$ such that $\tilde{s}$ begins to fall inside $(\tau, \tau_D)$. In particular, for some intermediate signals, as visibility increases, the manufacturer switches from a high to a low investment under No Manufacturer Disclosure because she is more certain that the supplier’s initial SR level is acceptable. However, her investment remains high under Manufacturer Disclosure so that she can better support her claim in case of third-party scrutiny. The substantial investment savings (when not disclosing) cause the manufacturer to switch from disclosing to not disclosing SR information as visibility increases.

Figure 5b shows how an increase in the probability of third-party scrutiny $q$ can affect the manufacturer’s choice between disclosing and not disclosing. We observe that for a large range of $\tilde{s}$ values that are not too high (e.g., when $\tilde{s} \leq 0.75$ in Figure 5b), increased scrutiny motivates the manufacturer to switch from not disclosing to disclosing. This change is driven by the fact that increased scrutiny (i.e., a higher value of $q$) incentivizes the supplier to improve his SR performance (see Proposition 3). As a result, the manufacturer finds it beneficial to disclose and increase demand. However, for higher values of $\tilde{s}$ (e.g., $\tilde{s} > 0.8$ in Figure 5b), we observe that as $q$ increases, the manufacturer may switch from disclosing to not disclosing, and then back to disclosing. The first switch is because a higher $q$ implies a larger potential penalty for disclosing and overstating the supplier’s SR level. Hence, the manufacturer becomes more cautious and chooses not to disclose. As $q$ further increases, the direct effect that $q$ has on increasing the supplier’s SR decision outweighs the potential penalty. As a result, the manufacturer again finds it beneficial to disclose SR information.

5.2. The Effect of the Manufacturer’s Disclosure Choice on the Final SR Level

The manufacturer’s decision of whether or not to disclose can have a significant impact on the supplier’s final SR level. Specifically, we show that the manufacturer’s disclosure of SR information always leads to an equal or better final SR level from the supplier, as compared to when she does not disclose.

**Proposition 7.** For any supplier type $s_0$, the final level of SR in the Manufacturer Disclosure setting is greater than or equal to that in the No Manufacturer Disclosure setting. Furthermore, there exists $\tau_{SR} < \tau_D$ such that it is strictly greater for $s_0 \in [m, \tau_{SR}]$.

This result follows directly from the fact that the manufacturer’s optimal investment is strictly higher under Manufacturer Disclosure than under No Manufacturer Disclosure (Proposition 4). It holds true when evaluating the final level of SR given a fixed signal and in expectation over all possible signals.

As discussed in §5.1, an increase in visibility or the probability of third-party scrutiny may lead the manufacturer to switch from disclosing to not disclosing SR information (see Figure 5). Therefore, an increase in either $v$ or $q$ can result in a lower final level of SR from the supplier.
Corollary 3. An increase in supply chain visibility, \( v \), or the probability of third-party scrutiny, \( q \), can result in a lower final level of SR from the supplier if such an increase motivates the manufacturer to prefer not disclosing SR information over disclosing.

This result is noteworthy given our findings that for each individual setting (i.e., No Manufacturer Disclosure and Manufacturer Disclosure), an increase in third-party scrutiny never decreases the supplier’s final level of SR (Propositions 3 and A.5). In other words, when disclosure is not mandatory but instead an option for the manufacturer, intensifying third-party scrutiny can result in undesirable consequences and actually hurt the level of SR in the supply chain.

6. Conclusions and Managerial Insights
Companies are increasingly facing pressure from consumers and external stakeholders to guarantee good SR practices in their supply chains. However, most companies do not have good visibility into their suppliers’ practices. Our research provides guidance to manufacturers on how to improve a supplier’s SR performance under incomplete supply chain visibility. Specifically, we examine two decisions for a manufacturer – her investment to improve a supplier’s SR capabilities and her disclosure (or not) of SR information to consumers. We show how these decisions are impacted by the manufacturer’s available information about her supplier’s current practices, the level of supply chain visibility she has, and the probability of third-party scrutiny. To capture the social impact of the manufacturer’s actions, we investigate the effect of her decisions on the resulting SR performance of the supplier.

We conclude the paper by discussing three specific insights on (i) a manufacturer’s strategy for investing in a supplier’s SR capabilities, (ii) how the manufacturer’s investment strategy should change when she discloses SR information to consumers, and (iii) the impact of the manufacturer’s investment and disclosure decisions on the supplier’s SR performance.

**Insight 1** A manufacturer should invest a high (low) amount of resources to improve a supplier’s SR capabilities if the information she observes suggests poor (good) practices. Greater visibility into her supply chain helps the manufacturer to be more efficient with her investment.

Our analysis demonstrates when a manufacturer should provide a supplier with significant support to improve his SR practices. Specifically, if the supplier appears to currently have poor practices, then the manufacturer should invest a large amount of resources to improve the supplier’s capabilities. If instead the supplier appears to already have good practices, then the manufacturer does not need to make a significant investment. The higher the level of visibility the manufacturer has into her supplier’s practices, the more she can trust her available information, and thus, better recognize whether the
supplier truly needs support. This can then help the manufacturer to tailor the extent of her investment and increase (decrease) it as she becomes more certain that the supplier’s practices are poor (good).

Our insight aligns with investment strategies observed in practice. For example, Starbucks, who has extensive visibility into its supply chain, focuses most of its efforts toward improving the practices of disadvantaged coffee bean farmers in developing countries (Starbucks Corporation 2015). More generally, a recent study by the Organization for Economic Cooperation and Development (OECD) and the World Trade Organization (WTO) found that over 65% of the 219 companies surveyed engaged in development activities with suppliers in developing countries. Of these activities, more than 40% were driven by the companies’ SR agendas, with 31% of the companies citing better working conditions as one of the main results achieved (OECD/WTO 2013, pp. 111–113).

**Insight 2** *If a manufacturer plans to disclose SR information to consumers, then her investment in a supplier’s SR capabilities should be more aggressive as compared to when she plans not to disclose. A more aggressive strategy when the manufacturer discloses leads to better SR practices by the supplier.*

If the manufacturer plans to disclose, then she should follow the same approach outlined in Insight 1 but with a more aggressive investment (as compared to if she does not disclose). This includes (i) always increasing the amount of resources she offers a supplier, and (ii) investing significant resources in a supplier whose current practices appear to be “good enough,” and hence, she would not invest a lot in if she were not to disclose. With a more aggressive strategy, the manufacturer can reduce the possibility and the potential impact of a third party uncovering her overstating a supplier’s SR performance. The higher level of investment also ensures that the resulting SR performance of the supplier is always greater when the manufacturer discloses SR information to consumers.

Insight 2 suggests that any initiative which requires manufacturers to disclose SR information to consumers (e.g., government regulation such as the California Transparency in Supply Chains Act) will have a positive impact on suppliers’ SR practices. However, manufacturers typically have the freedom to choose whether or not to disclose SR information to consumers. Our last insight highlights when a manufacturer having this choice may negatively impact the SR practices of a supplier.

**Insight 3** *Voluntary disclosure by a manufacturer is least effective in improving the SR practices of a supplier when the supplier appears to currently have only average practices.*

We find that a manufacturer most likely prefers not to disclose SR information when a supplier appears to have only average SR practices (hereafter referred to as an average supplier). This is in large part due to Insight 2 and the fact that if a manufacturer discloses, then she would need to offer an
average supplier significant support. Conversely, if the manufacturer does not disclose, then she would not need to offer this same supplier as much support. Due to this difference in investment strategy, the manufacturer may find it more economical to invest fewer resources and not disclose SR information. Note that this is also why increased supply chain visibility may cause a manufacturer to prefer not to disclose when working with an average supplier. The improved visibility helps the manufacturer to confirm that there may be an opportunity to save costs by not disclosing SR information to the consumers and only making a low investment in the supplier’s SR capabilities. As previously discussed, the resulting SR performance of the supplier is always higher when the manufacturer discloses. Therefore, anything that causes the manufacturer to prefer not to disclose may result in a lower level of SR performance in the supply chain as compared to when the manufacturer discloses.

We indeed observe examples of companies not focusing on their average suppliers’ SR practices. For example, Inditex (the parent company of Zara) is considered a leader in terms of supply chain transparency (Fashion Revolution 2016). However, a 2016 report from the European workers’ rights campaign Labour Behind the Label found that footwear workers at Zara’s suppliers in Albania “were earning as little as 49p [pound pennies] an hour including overtime” (The Guardian 2016). Interestingly, Inditex’s 2015 annual report primarily discusses its work with suppliers operating in developing countries such as Bangladesh, Cambodia, and India, and does not discuss much about Inditex’s Eastern European suppliers (Inditex 2015). This lack of disclosure suggests that Inditex may not have invested enough in its average suppliers (i.e., those located in Eastern Europe) to improve their SR practices.

Supply chain transparency is an emerging topic both in practice and the academic literature. With limited visibility into the SR practices of their suppliers, many companies are now facing the challenge of (i) how to invest resources to improve suppliers’ SR performance and (ii) whether and what SR information to disclose to consumers. We hope that our work will motivate other researchers to further study social responsibility issues under the context of incomplete supply chain visibility.

Appendix A: Additional Analytical Results

**Proposition A.1.** There exists a range of supplier types \( s_0 \in (m, M) \) such that, for high enough \( v \), the expected final level of SR, \( ES(v, s_0) \), is strictly decreasing in \( v \).

**Theorem A.1.** Given \( \beta_D \) and \( s_D \), the supplier’s optimal SR decision is \( s^*(s_0, \beta_D) = \max \{ s_0, s^*_{uD}(\beta_D) \} \). Furthermore, \( \frac{\partial s^*(s_0, \beta_D)}{\partial s_D} \geq 0 \), \( \frac{\partial s^*(s_0, \beta_D)}{\partial \beta_D} \geq 0 \), and \( s^*_{uD}(\beta_D) \leq s_D \) for all \( \beta_D \in [0, 1] \).

**Theorem A.2.** For a given level of visibility \( v \), there exist \( \beta_{LD}(v) \) and \( \beta_{HD}(v) \) such that \( 0 \leq \beta_{LD}(v) \leq \beta_{HD}(v) < 1 \), and the manufacturer’s optimal investment, \( \beta^*_D(v, \tilde{s}) \), is defined as follows:
(a) If $\beta_{LD}(v) \geq \hat{\beta}_{D}$, then $\beta^{*}(v, \tilde{s}) = \hat{\beta}_{D}$ for all $\tilde{s}$.

(b) If $\beta_{LD}(v) < \hat{\beta}_{D}$, then there exists a threshold $\tau_{D}(v) \in (m, \hat{s}_{D})$ such that:

(i) If $\tilde{s} \leq \tau_{D}(v)$, then $\beta_{D}^{*}(v, \tilde{s}) = \hat{\beta}_{HD}(v) = \min \{ \beta_{HD}(v), \hat{\beta}_{D} \}$;

(ii) If $\tilde{s} > \tau_{D}(v)$, then $\beta_{D}^{*}(v, \tilde{s}) = \beta_{LD}(v)$,

where $\hat{s}_{D} \equiv s_{*D}(\hat{\beta}_{D})$.

**Proposition A.2.** (i) $\beta_{LD}$ is strictly decreasing in $v$ and $\beta_{HD}$ is strictly increasing in $v$. (ii) The threshold $\tau_{D}$ is increasing in $v$ if and only if

$$\delta(\beta_{HD}) - \delta(\beta_{LD}) > \mathbb{E}_{v_0}[\Theta(\beta_{HD}, s_{D_H}) - \Theta(\beta_{LD}, s_{D_L}) | \tilde{s} \neq s_0],$$

(A.1)

where $\Theta(\beta_{D}, s_{D}) \equiv \left( D_{SN} + \mathbb{E}_{v_0}[D_{SC}(s_{D}, s^{*}(s_0, \beta)) | \tilde{s}] \right)(r - w) - pq \mathbb{E}_{v_0}[\max\{s_{D} - s^{*}(s_0, \beta), 0\} | \tilde{s}]$, and $s_{D_H}$ (or $s_{D_L}$) is equal to the optimal value of $s_{D}$ given a signal immediately to the left (right) of $\tilde{s} = \tau_{D}(v)$.

**Proposition A.3.** The threshold $\tau_{D}$ is strictly increasing in $q$.

**Proposition A.4.** For any level of visibility $v$, the manufacturer’s best estimate of the supplier’s final level of SR can be characterized as follows. Under No Manufacturer Disclosure: (i) If $\tilde{s} \leq \tau(v)$, then $s^{*}(\tilde{s}, \beta^{*}(v, \tilde{s})) = s^{*}(\tilde{s}, \hat{\beta}_{H}) = \hat{s}$. Under Manufacturer Disclosure: (ii) If $\tilde{s} > \tau(v)$, then $s^{*}(\tilde{s}, \beta^{*}(v, \tilde{s})) = s^{*}(\tilde{s}, \hat{\beta}_{H}) = \hat{s}$. Under Manufacturer Disclosure: (iii) If $\tilde{s} \leq \tau_{D}(v)$, then $s^{*}(\tilde{s}, \beta_{D}^{*}(v, \tilde{s})) = s^{*}(\tilde{s}, \hat{\beta}_{HD}) = s_{*D}(\hat{\beta}_{HD})$; (iv) If $\tilde{s} > \tau_{D}(v)$, then $s^{*}(\tilde{s}, \beta_{D}^{*}(v, \tilde{s})) = s^{*}(\tilde{s}, \hat{\beta}_{LD}) = \tilde{s}$.

Furthermore, $\lim_{\tau(v) \uparrow} s^{*}(\tilde{s}, \beta^{*}) > \lim_{\tau(v) \downarrow} s^{*}(\tilde{s}, \beta^{*})$ and $\lim_{\tau_{D}(v) \uparrow} s^{*}(\tilde{s}, \beta_{D}^{*}) = \lim_{\tau_{D}(v) \downarrow} s^{*}(\tilde{s}, \beta_{D}^{*})$; i.e., the best estimates are discontinuous at $\tau(v) [\tau_{D}(v)]$ under No Manufacturer Disclosure [Manufacturer Disclosure].

**Theorem A.3.** If $\tau_{H} < \tilde{s}$, then given any $v$, $\Delta_{H}(v, \tilde{s})$ is continuous and (i) constant in $\tilde{s}$ for $\tilde{s} \in [m, \tau)$; (ii) decreasing in $\tilde{s}$ for $\tilde{s} \in [\tau, \tau_{D})$; (iii) increasing in $\tilde{s}$ for $\tilde{s} \in [\tau_{D}, \tau_{H})$; (iv) decreasing in $\tilde{s}$ for $\tilde{s} \in [\tau_{H}, \tilde{s})$; and (v) constant in $\tilde{s}$ for $\tilde{s} \in [\tilde{s}, M]$. Furthermore, there exists $\tilde{\tau} \in [m, \tau_{D})$ such that $\Delta_{H}(v, \tilde{s}) < 0$ for all $\tilde{s} \geq \tilde{\tau}$.

Theorem A.3 implies that if $\tau_{H} < \tilde{s}$, then there exists some signal $\tilde{\tau} \geq m$ such that the manufacturer prefers not to disclose SR information to the consumers for any $\tilde{s} \geq \tilde{\tau}$. In general, the manufacturer prefers not to disclose for any signal; i.e., $\tilde{\tau} = m$ is likely. This is because the conditions for $\tilde{\tau} > m$ are typically hard to satisfy. In particular, (a) the manufacturer must prefer disclosing a higher value of SR for the lowest possible signals (i.e., close to $m$) than for the highest possible signals (i.e., close to $M$); and (b) the manufacturer’s optimal disclosure decision must be strictly smaller than $\tilde{s}$ even when $\tilde{s} = M$.

**Proposition A.5.** $\frac{d s^{*}(s_0, \beta_{D}(\tilde{s}, v), q)}{d q} \geq 0$ for all $s_0, \tilde{s} \in [m, M]$.

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