Supplier Centrality and Auditing Priority in Socially-Responsible Supply Chains

Motivation and research questions. Most supply networks are characterized by firms that source from multiple suppliers and suppliers that serve multiple firms, thus resulting in suppliers who differ in their degree centrality, i.e., the number of firms they supply to. In such networks, any negative publicity from suppliers' noncompliance of socially-responsible practices – e.g., employment of child labor, unsafe working conditions, and excessive pollution – can significantly damage the reputation of the buying firms. To mitigate this impact, firms preemptively audit suppliers, although resource and time considerations typically restrict the number of suppliers a firm can audit. For example, even a cash-rich company like Apple audited only about 50% of its suppliers in 2013. Therefore, a key question is whether firms should prioritize the auditing of suppliers with low or high centrality, ceteris paribus.

From a supplier's perspective, the risk of causing social harm depends on the extent of her responsibility effort. It may, however, not always be possible for a supplier to adjust this effort in anticipation of an audit. For instance, as is common in developing economies, suppliers may be unaware of social-responsibility standards due to, say, lack of education, communication, or ethical perception.

For a given decentralized, socially-responsible network consisting of multiple buyers and multiple suppliers, the suppliers with higher (degree) centrality are especially significant for the simple reason that their social-responsibility decisions affect more buyers. This – together with our earlier observation that buyers typically audit only a subset of their suppliers – raises important questions: (1) When buyers audit some, but not all, of their respective suppliers, how do the centralities of the suppliers affect the

auditing priority of the buyers? (2) How can the buyers cooperate in making auditing decisions to improve their profits? (3) Are buyers’ auditing decisions always in sync with a social-planner’s objective of minimizing harm to society via the identification of socially-irresponsible practices?

**Model and analysis.** We develop a stylized, game-theoretic model of an assembly supply network consisting of two buyers; each buyer sources two inputs – one each from two distinct suppliers – to assemble his final product. To focus on the role of supplier centrality in the network, the two suppliers of a buyer are symmetric from the buyer’s perspective except that one of the two suppliers is common to both the buyers. Thus, each buyer has one *independent supplier* who uniquely supplies to that buyer, and one *common supplier* who supplies to both the buyers. To incorporate the practice of buyers auditing only a subset of their suppliers due to resource constraints, we assume that each buyer chooses to audit at most one supplier. The buyers unilaterally and simultaneously decide which suppliers to audit as well as the extent of their respective auditing efforts. Then, the uncertainty pertaining to potential social harm from the suppliers’ actions is resolved – this may be detected either by a buyer’s audit or by public scrutiny. If a supplier’s harmful practices are discovered through a buyer’s audit, then the supplier incurs additional cost to implement corrective actions and the buyer completes his procurement from the supplier. Otherwise, if they are discovered in public, then the buyer suffers a damage to the maximum willingness-to-pay (MWTP) of his customers and has to source the corresponding input at a higher wholesale price. We consider two settings – a benchmark case in which the two buyers do not engage in quantity competition in the downstream market and another in which they do.

When the buyers do not compete, among the equilibria in which at least one supplier is audited, there are two types: (i) Each buyer audits his independent supplier. (ii) One buyer audits his independent supplier and the other buyer audits the common supplier. The latter equilibrium is Pareto-dominant: When the buyers do not compete, a buyer is indifferent between auditing his independent supplier and the common
supplier, given that the other buyer audits his own independent supplier. However, auditing the common supplier exerts a positive externality on the other buyer, and thereby yields a Pareto-dominant outcome.

When the buyers compete, however, they never audit the common supplier in equilibrium. Regardless of the other buyer’s auditing decision, a buyer’s audit of the common supplier intensifies downstream competition and negatively impacts his profit. Thus, while auditing the common supplier is better for the aggregate profit of the buyers, competition drives them away from auditing that supplier.

To mitigate this inefficiency, we investigate the possibility of the buyers *jointly auditing* the suppliers. We show that the buyers can form a *stable coalition* to jointly audit the suppliers and share the auditing cost in a fair manner based on the notion of Shapley value. We also find that in *any* equilibrium where at least one supplier is audited, the common supplier is always audited. Thus, the stable joint-auditing coalition corrects the inefficiency resulting from competition and enables the buyers to earn higher profits relative to when they act unilaterally.

The practice of joint-auditing, however, may not necessarily be good for a social goal. For instance, consider the objective of minimizing the probability of damage from social-irresponsibility, defined as the probability that at least one of the suppliers is unsafe but is not discovered in the auditing process of the buyer(s). This probability may be higher under joint-auditing than under unilateral auditing because, while joint-auditing is more cost-effective for the buyers, it is possible that the number of suppliers audited is lower under joint-auditing. The social planner can avoid such a possibility by appropriately subsidizing auditing costs under joint-auditing.

We also demonstrate the robustness of our insights on an alternate setting in which each buyer, when auditing unilaterally, divides his limited auditing resource among his two suppliers. When auditing jointly, the buyers pool their auditing resources and divide them among their three suppliers.