

Trust and Information Sharing in Supply Chains

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Abstract

Drawing on empirical and experimental research into the composition and development of trust, we construct a multi-period model to examine the role of trust in a supply chain. We specifically focus on trust building in the context of a wholesale salesperson who acts as a representative of a manufacturer and shares demand forecast information with a retailer. The actions of the salesperson affect both her immediate economic gain and her future credibility as determined by retailer trust. We consider three types of salespersons: (i) a “benevolent” salesperson, whose objective is to maximize retailer’s profit, (ii) a “self-serving” salesperson, whose objective is to maximize her own quantity-based incentive pay and (iii) an “honest” salesperson who always reports her true forecast. As we would expect, we find that a benevolent salesperson attains higher levels of retailer trust than a self-serving salesperson. However, neither the benevolent nor the self-serving salesperson is completely honest. A benevolent salesperson tells occasional “white lies” (e.g., moderating an extreme forecast) to preserve trust while a self-serving salesperson tells “manipulative lies” (e.g., inflating a forecast to drive up order quantities). We show that increasing the length of the salesperson-retailer relationship tends to induce honest behavior because of the need for the salesperson to retain enough trust to be effective. Consequently, even a self-serving salesperson can enable the retailer, as well as the manufacturer, to increase profits.

Keywords: Supply Chain, Trust, Lies, Relationship Building, Forecast Sharing;

1 Introduction

Since the 1990s, supply chain management has been the subject of considerable research attention. A major concern in this research is how to coordinate the decisions of the suppliers, manufacturers and retailers in a supply chain. Various forms of contracts and incentives have been proposed for improving supply chain coordination and information sharing (Tsay et al. 1999 and Cachon 2003). Recent experimental work has found that subjects tend to deviate from the optimal decisions suggested by the contract theoretical literature (Ben-Zion et al. 2005, Bolton and Katok 2005, Keser and Paleologo 2004, Schweitzer and Cachon 2000). This suggests that there is something more to supply chain relationships than mere economic coordination. In this paper, we suggest that one factor that makes up a supply chain (or indeed any business) relationship is trust.

Trust is important because contracts protect participating parties by specifying rights and responsibilities but they cannot address all the contingencies that may come about in today's business relationships (Bernheim and Whinston, 1998). Furthermore, there is overwhelming evidence on the importance and impact of successful relationships in business decisions (Anderson and Coughlan 2002, Uzzi 1996, Zaheer and Venkatraman 1995). For example, Uzzi (1996) showed in a longitudinal empirical study of supplier-manufacturer relations in the apparel industry that economic exchange over time becomes rooted in complex relationships that involve economic investment, friendship and altruistic attachments.

In collaboration with a major automotive manufacturer, we performed a field survey of the salespersons who represent the manufacturer to dealerships in order to understand their role in supply chain performance (see Hopp et al. 2006 for details). Almost all of the salespersons we interviewed indicated that the key to successful selling is a trusting and mutually beneficial relationship with the client dealers. A key function of these salespersons is assisting the dealers in forecasting future demand. In this paper, we specifically examine the role trust plays in this forecasting function.

Drawing on empirical and experimental research into the composition and development of trust, we construct a multi-period model with which to examine the evolution of trust and its impact on the sharing of demand forecast information between a salesperson and a retailer (dealer). In each period, the retailer and the wholesale salesperson make demand forecasts. Depending on the circumstances, the salesperson's forecast may be more or less accurate than the retailer's. However, the retailer does not know the actual capability of the salesperson and must decide to what extent he should trust the salesperson. The key decision the retailer must make is the amount of inventory to purchase from the manufacturer. Using his own forecast, the retailer can compute an order quantity by solving a newsvendor problem. But the salesperson also makes a recommendation of an order quantity. Depending on how much the retailer trusts the salesperson, he can adjust his order quantity in response to the salesperson input. After each period, the retailer observes actual demand (and hence the optimal order quantity) and updates his trust based on the salesperson's relative accuracy.

We consider three types of salespersons: (i) a "benevolent" salesperson, who seeks to maximize the retailer profit, (ii) a "self-serving" salesperson, who seeks to maximize the retailer order quantity because she receives a quantity-based commission from the manufacturer, and (iii) an "honest salesperson", who always tells the truth.

As one would expect, we find that a self-serving salesperson tends to inflate her forecast to manipulate the retailer's orders. However, because trust affects her influence, she sometimes deflates

her forecast and sacrifices current revenue to gain trust. We also find that a long salesperson-retailer relationship improves the extent to which trust reflects the salesperson’s forecast accuracy for both the benevolent and self-serving salesperson.

Interestingly, we find that while the benevolent salesperson is more trusted by the retailer than the other types of salespersons, she nevertheless tells occasional “white lies”. As expected, a self-serving salesperson generates the greatest manufacturer profit (but the least retail profit) and a benevolent salesperson generates the greatest retailer profit (but the least manufacturer profit). However, total supply chain profit under the benevolent and the honest salespersons are very similar and tend to be greater than that under the self-serving salesperson. Finally, we find that the difference between the manufacturer’s profits resulting from the three types of salespersons decreases with the length of the relationship. This suggests that in long term supply chain relationships where trust is vital for reasons beyond forecasting and ordering, rewarding the salespersons for forecast accuracy (to make them honest) or for retailer satisfaction (to make them benevolent) may actually be a more effective strategy for the manufacturer than using a quantity-based commission plan.

2 Literature Review

The major context in which trust plays a role in supply chains is with regard to information sharing. Hence, we first review work on the effects of information in supply chain coordination. Then, we review general definitions of trust and its role in various business relationships. Lastly, we discuss empirical and analytical results specifically on trust in supply chains.

Information sharing between supply chain members has been shown to be beneficial to both individual members and overall system performance. Cachon and Fisher (2000) showed that combining manufacturer and retailer forecasts improves the flow of goods in supply chain. Aviv (2001) compared a “local forecasting” supply chain, in which the manufacturer and the retailer maintain separate forecasts, with a “collaborative forecasting” supply chain, in which the manufacturer and the retailer join their forecasting efforts. He showed that “collaborative forecasting” tends to be superior to “local forecasting” because of benefits from diversification of forecasting capabilities. Cachon and Lariviere (2001) proposed contracts that can induce the buyer to tell the truth about his forecast, which results in improved supply chain performance. For a detailed literature review of information sharing in supply chains see Chen (2003) and Aviv (2004).

The concept of trust has been explored by researchers across different disciplines, including economics, psychology and sociology. One of the earliest studies of trust in interpersonal relationships was by Mellinger (1956). Mellinger defined trust as an individual’s confidence in another person’s

intentions, motives and sincerity of speech. In the past few decades, researchers have proposed various definitions of trust, consisting of one or a more of the following three attributes: *(i)* benevolence – care for the well-being of the other party, *(ii)* integrity – honesty in words and actions, and *(iii)* competence – ability and creditability (Larzelere and Huston 1980). For additional discussions on defining trust see Rousseau et al. (1998).

Many experimental and field research studies have examined the effect of trust in business relationships. In the context of negotiation, trust between the negotiating parties has been shown to facilitate information sharing (Thompson 1991), reduce uncertainty (Kollock 1994) and increase cooperation (Mayer et al. 1995). Carnevale and Isen (1986) suggested that trust leads to more efficient negotiated agreements because it induces reciprocity. Within an organization, trust has been shown to be effective in increasing employee cooperation (Smith et al. 1995) and solving agency problems (Jones 1995). In buyer-seller relationships, studies have suggested that trust increases opportunities for future sales (Crosby et al., 1990) and is fundamental for conflict resolution and sustainable buyer-seller relationships (Ganesan 1994). Trust has also been shown to act as a substitute for legally binding contracts (Zaheer and Venkatraman 1995, Malhotra and Murnighan 2002, Narayanan and Raman 2004).

Recently, economists have used trust games to examine the role of trust in investment decisions. Berg et al. (1995) studied a single round trust game in which player A decides how much of the show-up fee to send to an anonymous counterpart player B. The amount of money triples when it is passed. Player B then decides if and how much money to return to player A. The authors found that, in contradiction of the non-cooperation prediction of game theory, player A tends to send money to player B. The authors attribute this trusting behavior to the participants' belief that it is human nature to reciprocate. Moreover, the authors found that the likelihood of player B to reciprocate player A's trusting behavior increases when information on social history (e.g., results on how other individuals behaved in past experiments) is provided.

A number of investment trust games have been derived from the work of Berg et al. (1995). Glaeser et al. (2000) combined trust game experiments with surveys and found that individuals who are closer socially exhibit more trust and trustworthiness behavior. Engle-Warnick and Slonim (2004) extended that study to a multi-stage game where the time horizon can be definite or indefinite. They found that, with inexperienced subjects, the level of trust was the same in the definite and indefinite settings. However, trust in the definite time horizon setting decreases as subjects gain experience in the game. Lastly, Bohnet and Zeckhauser (2004) compared a trust game with a probabilistic decision process. They found that, because of aversity to betrayal, individuals were

more willing to take investment risks when the outcome is due to pure chance than when it depends on another player's trustworthiness.

Only recently has research in operations management begun to study the effect of trust. Most of this work has been empirical. For example, surveys of supply chain parties has suggested that building trust improves supply chain responsiveness to market changes (Handfield and Bechtel 2002) and induces cooperation among supply chain members (Terwiesch et al. 2005).

While analytical work on trust is uncommon, some has been done. For example, Ren et al. (2004) considered a supply chain whose buyer shares his demand forecast with a supplier to facilitate the supplier's decisions in building manufacturing capacity. While the buyer has incentive to inflate the demand forecast in an attempt to ensure future supply, the supplier may respond by under-investing in capacity. The authors showed that, if the relationship is long term, it is optimal for the buyer to report the true forecast to the supplier in order to gain the supplier's trust. Taylor and Plambeck (2003) considered a similar model in which the buyer and supplier have an informal agreement on required capacity. They concluded that the buyer will honor such an agreement because of the future value of cooperation. In both of these models, trust is defined as perceived credibility and is considered to be binary. The trustor either trusts and cooperates, or distrusts and refuses to cooperate.

Our definition of trust differs from previous supply chain models in that: *(i)* we consider trust on a continuum, with extremes representing complete trust and complete distrust (as proposed in the work of Tardy 1988, Lewicki and Bunker 1995), and *(ii)* trustworthiness is not only a measure of creditability, but also a reflection of competence. Our model also differs from previous work by considering a supply chain with sufficient capacity in which retailer (buyer) and salesperson (seller) make demand forecasts which may be combined to make ordering decisions.

The remainder of the paper is organized as follows. In Section 3, we formulate our models of trust building through forecast sharing and illustrate the evolution of trust. In Section 4, we study the optimal forecast reporting strategy of a benevolent salesperson and examine the relationship between trust, truthfulness and supply chain performance. In Section 5, we provide an analogous examination of a supply chain with a self-serving salesperson. In Section 6, we compare the differences in trust and system performance between an honest salesperson and a dishonest salespersons (either self-serving or benevolent). We summarize our insights into the role of trust in supply chains and suggest future research directions in Section 7.

3 Trust Building in Forecast Sharing

To provide a rigorous framework for examining the role of trust in a supply chain where a salesperson, representing a manufacturer, shares forecast information with a retailer, we make use of a discrete time model. In each period (a month in the automotive case that motivated this work), the retailer and the salesperson make forecasts of demand and calculate appropriate order quantities for the retailer to purchase from the manufacturer. We model the retailer’s problem as one of profit maximization, which can be represented by a discrete time Markov decision process in which the decision variables are (i) the weight to give to the information provided by the salesperson and (ii) the order quantity. The salesperson’s only decision variable is the order quantity to recommend, which she will choose to maximize her local objective (i.e., either commission pay or, in the case of a benevolent salesperson, the profit of the retailer). We translate these dynamics into a model below.

3.1 Model Basics

We consider a supply chain with a manufacturer, a retailer and a wholesale salesperson, who is hired by the manufacturer to facilitate the ordering process. We model the actual market demand in period k as a discrete random variable $D_k \in \{\underline{d}, \underline{d} + 1, \dots, \bar{d}\}$ where \underline{d} and \bar{d} are integers that denote the lower and upper bounds on market demand, respectively. Moreover, we denote the cumulative probability distribution of market demand by F_D and the probability mass function for this distribution by f_D .

Since our focus is on the role of trust, we will assume that demand is independent across periods. This eliminates the need for time series forecasting methods. Note that having a time series element in the forecasting process could be allowed within our framework. But in order for interesting issues of trust to arise, the salesperson and retailer must have access to at least some different information. Hence, for simplicity, we focus only on the outcomes of the forecasting processes of the salesperson and the retailer, rather than the processes themselves. Since it does not affect the results, we make the further simplification that D_k is uniformly distributed on $\{\underline{d}, \underline{d} + 1, \dots, \bar{d}\}$.

We assume that the salesperson and the retailer make their forecasts in each period independently. We also assume that the salesperson knows the retailer’s forecast accuracy but the retailer does not know the salesperson’s forecast accuracy. We base this assumption on our observation of the interaction between wholesale salespersons and dealers (retailers) in the automotive supply chain. Because of the nature of the salesperson’s job, she tracks behavior of the dealer much more closely than the dealer tracks the salesperson’s behavior. Moreover, while the dealer has no incen-

tive to hide his true forecast, the salesperson may have incentive to exaggerate her forecast in an attempt to increase the dealer's order quantity. Hence, it is difficult for the dealer to evaluate the salesperson's true forecast accuracy.

Mathematically, we represent the forecast of the retailer as a discrete random variable $D_k^r \in \{\underline{d}, \dots, \bar{d}\}$. To model the accuracy of the retailer's forecast, we assume that given the actual market demand in period k is $D_k = d_k$, the cumulative conditional probability distribution of the retailer's forecast is denoted by $F_D^r(D_k^r|d_k)$ and is given by a discrete beta distribution with mean $\mu_D^r = d_k$ and standard deviation of σ_D^r . (We use the beta distribution because it has a very flexible shape distribution and is also amenable to Bayesian updating.) These assumptions imply unbiased forecasts with constant variance independent of d_k . We denote the probability mass function for the conditional distribution that represents retailer's forecasts by $f_D^r(D_k^r|d_k)$.

Hence, when the retailer's forecast in period k is $D_k^r = d_k^r$, the retailer can use Bayes rule to compute the corresponding market demand distribution as follows:

$$\begin{aligned} \mathbf{P}(D_k = d_k | D_k^r = d_k^r) &= \frac{\mathbf{P}(D_k^r = d_k^r | D_k = d_k) \mathbf{P}(D_k = d_k)}{\sum_{d_k=\underline{d}}^{\bar{d}} \mathbf{P}(D_k^r = d_k^r | D_k = d_k) \mathbf{P}(D_k = d_k)} \\ &= \frac{f_D^r(d_k^r|d_k) f_D(d_k)}{\sum_{d_k=\underline{d}}^{\bar{d}} f_D^r(d_k^r|d_k) f_D(d_k)} \end{aligned} \quad (1)$$

We assume the wholesale and retail prices (p_w , p_r) are pre-determined and fixed. We also assume that the manufacturer has sufficient production capacity to meet the retailer's order so that manufacturer shortages are not an issue. We assume that any leftover inventory at the retailer level is sold for a unit salvage value (represented by a negative holding cost h_r) at the end of the period; and the retailer is penalized for any unfulfilled demand at a unit shortage cost of s_r . Hence, the retailer profit is

$$\Pi^r(Q_k) = p_r \min\{d_k, Q_k\} - p_w Q_k - h_r [Q_k - d_k]^+ - s_r [d_k - Q_k]^+.$$

In each period, the retailer shares his optimal order quantity Q_k^{r*} with the salesperson, which is determined by the order quantity that maximizes retailer's expected profit:

$$\begin{aligned} Q_k^{r*}(d_k^r) &= \max_{Q_k} \mathbb{E} \left[\Pi^r(Q_k(d_k^r)) \right] \\ &= \max_{Q_k} \sum_{d_k=\underline{d}}^{\bar{d}} \Pi^r(Q_k(d_k)) \mathbf{P}(D_k = d_k | D_k^r = d_k^r), \end{aligned} \quad (2)$$

where $\mathbf{P}(D_k = d | D_k^r = d_k^r)$ is given in Equation (1).

Similarly, we model the forecast of the salesperson as a discrete random variable $D_k^s \in \{\underline{d}, \dots, \bar{d}\}$. Given the actual demand in period k is $D_k = d_k$, then the cumulative conditional distribution of

the salesperson's forecast is denoted by $F_D^s(D_k^s|d_k)$ and is given by a discrete beta distribution with mean $\mu_D^s = d_k$ and standard deviation σ_D^s . The probability mass function of this conditional distribution is given by $f_D^s(D_k^s|d_k)$.

Hence, when the salesperson's forecast in period k is $D_k^s = d_k^s$, the salesperson can compute the corresponding market demand distribution as follows:

$$\mathbf{P}(D_k = d_k | D_k^s = d_k^s) = \frac{f_D^s(d_k^s|d_k) f_D(d_k)}{\sum_{d_k=\underline{d}}^{\bar{d}} f_D^s(d_k^s|d_k) f_D(d_k)} \quad (3)$$

The corresponding optimal order quantity that maximizes retailer's expected profit for period k is

$$\begin{aligned} Q_k^{s*}(d_k^s) &= \max_{Q_k} \mathbb{E} \left[\Pi^r(Q_k(d_k^s)) \right] \\ &= \max_{Q_k} \sum_{d_k=\underline{d}}^{\bar{d}} \Pi^r(Q_k(d_k)) \mathbf{P}(D_k = d_k | D_k^s = d_k^s) \end{aligned} \quad (4)$$

where $\mathbf{P}(D_k = d_k | D_k^s = d_k^s)$ is given in Equation (3). For simplicity reason, we omit (d_k^s) from $Q_k^{s*}(d_k^s)$ and (d_k^r) from $Q_k^{r*}(d_k^r)$ in the remainder of the paper unless necessary.

While $Q_k^{s*}(d_k^s)$ represents the salesperson's best estimate of the optimal order quantity, she may have incentive to recommend another value to the retailer. For example, the salesperson may be motivated to increase order quantity in order to maximize her commission-based compensation or to increase the profit of her employer (i.e., the manufacturer). Hence, after computing her own order quantity and learning that of the retailer's, the salesperson must decide on how much to adjust her *reported* order quantity in period k , which we denote by

$$\tilde{Q}_k^{s*}(Q_k^{s*}, \beta_k) = Q_k^{s*} + \beta_k.$$

where β_k is the *bias* (or lie) the salesperson adds to her optimal order quantity in period k .

Since the market demand is bounded below by \underline{d} and above by \bar{d} , we assume that the retailer is rational and would not believe an order quantity outside that range. Hence, the salesperson's recommended order quantity $\tilde{Q}_k^{s*} \in \{\underline{d}, \dots, \bar{d}\}$ and her bias $\beta_k \in \{Q_k^{s*} - \underline{d}, \dots, \bar{d} - Q_k^{s*}\}$.

The retailer is then faced with two order quantities, his own, Q_k^{r*} , and that of the salesperson, \tilde{Q}_k^{s*} . As suggested by Stone (1961), and Clemen and Winkler (1999), we assume that the retailer combines the two order quantities using a simple weighted average approach:

$$Q_k^*(w_k, Q_k^{r*}, Q_k^{s*}, \beta_k) = (1 - w_k)Q_k^{r*} + w_k\tilde{Q}_k^{s*}(Q_k^{s*}, \beta_k)$$

where w_k is the weight allocated to the salesperson's recommended order quantity in period k such that $0 \leq w_k \leq 1$.

Research has shown that information provided by a trusted party is used more and considered to have greater value to the trustor (Moorman et al. 1992, Glaeser et al. 2000). Hence, the more the retailer trusts the salesperson, the more weight he puts on her recommendation. Because placing a greater weight on the salesperson's recommended order quantity has significant economic consequences, it is an act of trust. Hence, we can view the weight on the salesperson's forecast as a measure of the retailer's trust in the salesperson.

After the retailer purchases order quantity Q_k^* , the actual market demand d_k is realized. The retailer compares the relative accuracy of his forecast to that of the salesperson and updates his weight on salesperson's recommendation in the next period w_{k+1} .

Research has shown that individuals update trust in one another based on experience. Mayer et al. (1995) proposed that in organizational relationships, "outcomes of trusting behaviors will lead to updating of prior perceptions of the ability, benevolence and integrity of the trustee." Kramer (1999) suggested that decision makers assess interaction histories to provide a basis for drawing inferences regarding their trustworthiness and for making predictions about the future behavior of others. Hence, whenever the salesperson's forecast is more accurate than the retailer's, we would expect the retailer's perception of the salesperson's ability and integrity to increase. However, whenever the salesperson's forecast is less accurate than that of the retailer, the retailer may begin to doubt the honesty and/or competence of the salesperson. In our model, this implies that the retailer adjusts his weight on the salesperson's recommendation based on her past forecasting accuracy.

We model the updating process using a simple model in which the weight in period $k + 1$, i.e., w_{k+1} , is a linear combination of the weight in period k , i.e., w_k , and the relative accuracy of the salesperson's forecast:

$$w_{k+1}(w_k, Q_k^{r*}, Q_k^{s*}, \beta_k, d_k) = w_k + \delta \left(|d_k - Q_k^{r*}| - |d_k - \tilde{Q}_k^{s*}(Q_k^{s*}, \beta_k)| \right)$$

where δ is a sensitivity parameter that reflects the speed with which the retailer gains or loses trust in the salesperson. Since the literature on trust suggests that the rates of gain or loss of trust may not be symmetric (Wrightsmann 1991; McKnight and Chervany 1996), we model δ via two separate parameters, one for gains δ_g , and one for losses δ_l , such that:

$$\delta = \begin{cases} \delta_g & \text{if } |d_k - Q_k^{r*}| \geq |d_k - \tilde{Q}_k^{s*}| \\ \delta_l & \text{if } |d_k - Q_k^{r*}| < |d_k - \tilde{Q}_k^{s*}| \end{cases}$$

and $\delta_g, \delta_l \geq 0$. When $\delta_g > \delta_l$, it is easier to gain the retailer's trust than to lose it. We define a retailer with this behavior as "trusting". When $\delta_g < \delta_l$, it is harder to gain the retailer's trust than

to lose it. We define a retailers with this behavior to be “skeptical”. For modeling purposes, we will assume that both parties know δ_g and δ_l . In practice, the salesperson would have to estimate the rates of trust gain and loss by analyzing the actual order quantities over time.

In addition to the rates of change over time, the initial trust level (i.e., initial weight w_1), reflects the ability of the salesperson to influence retailer decisions at the beginning of the relationship. This initial weight can be affected by a variety of factors, including the salesperson’s reputation (Ganesan 1994, John and Weitz 1989), first impression from initial interactions (Ajzen and Fischbein 1980, Mcknight et al. 1998), and the retailer’s emotional state and background (Gächter et al. 2004, Jones and George 1998). Again, we will assume that the initial weight is known to both parties. In practice, the salesperson can easily deduce this weight by observing the order quantity placed by the retailer in the first period.

3.2 Model Formulation

To compute the *salesperson’s* optimal policy (i.e., what order quantities to recommend each period), we make use of dynamic programming. Since we assume that excess inventory is sold at a reduced price (a reasonable approximation of what happens at an auto dealership), inventory from previous periods does not carry over. We consider a finite horizon with N periods, where N represents the length of the relationship between the salesperson and the retailer. Later in this paper we study the effects of the length of the relationship on salesperson’s behavior and on supply chain performance. The state space when the number of remaining periods is j includes the current trust level (w_j), the salesperson’s optimal order quantity (Q_j^{s*}) and the retailer’s optimal order quantity (Q_j^{r*}). We can specify the dynamic program as follows:

- *State Space* S includes states (w, Q^{s*}, Q^{r*}) , where $Q^{s*} = \underline{d}, \underline{d}+1, \dots, \bar{d}$ and $Q^{r*} = \underline{d}, \underline{d}+1, \dots, \bar{d}$, and $w \in [0, 1]$.
- *Decision epochs* are the beginning of every period after the retailer has offered his recommended order quantity.
- *Action space* A includes all values of possible bias that can be chosen by the salesperson. Since market demand is discrete and uniformly distributed on $\{\underline{d}, \underline{d}+1, \dots, \bar{d}\}$, we know that the bias level β has to take values in increments of $\frac{1}{n-1}(\bar{d} - \underline{d})$ (where n is the number of discrete demand). Moreover, as discussed in Section 3.1, since the market demand is bounded above and below, we know that β is also bounded such that $\beta \in \{Q^{s*}(d^s) - \underline{d}, \dots, \bar{d} - Q^{s*}(d^s)\}$.

We denote the value function where the number of remaining periods is j for state $(w_j, Q_j^{s*}, Q_j^{r*})$ by $V_j[w_j, Q_j^{s*}, Q_j^{r*}]$, which represents the objective of the salesperson from period $k = N - j$ until the end of the time horizon (period $k = N$). Moreover, we define $G(w_j, Q_j^{s*}, Q_j^{r*}, \beta_j)$ to be the

component of the salesperson's objective function that corresponds to the j^{th} (remaining) period. We write the optimality equation of the salesperson for period $k = N - j$ as:

$$\begin{aligned} V_j[w_j, Q_j^{s*}, Q_j^{r*}] &= \max_{\beta_j} \left\{ G(w_j, Q_j^{s*}, Q_j^{r*}, \beta_j) \right. \\ &\quad \left. + \sum_{d_j=\underline{d}}^{\bar{d}} \sum_{Q_{j-1}^{s*}=\underline{d}}^{\bar{d}} \sum_{Q_{j-1}^{r*}=\underline{d}}^{\bar{d}} V_{j-1}[w_{j-1}(w_j, Q_j^{r*}, Q_j^{s*}, \beta_j, d_j), Q_{j-1}^{s*}, Q_{j-1}^{r*}] \right. \\ &\quad \left. \mathbf{P}(d_j|d_j^s)\mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}) \right\} \end{aligned} \quad (5)$$

where $j = 1, 2, \dots, N$. We know from equation (3) that

$$\mathbf{P}(d_j|d_j^s) = \frac{\mathbf{P}(d_j^s|d_j)\mathbf{P}(d_j)}{\sum_{d_j=\underline{d}}^{\bar{d}} \mathbf{P}(d_j^s|d_j)\mathbf{P}(d_j)}.$$

Moreover, since Q_{j-1}^{s*} is a function of d_{j-1}^s and Q_{j-1}^{r*} is a function of d_{j-1}^r (equations 2 and 4) and the salesperson knows the retailer's forecast accuracy (i.e., $\mathbf{P}(d_{j-1}^r|d_{j-1})$), we find that

$$\begin{aligned} \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}) &= \sum_{d_{j-1}^s=\underline{d}}^{\bar{d}} \sum_{d_{j-1}^r=\underline{d}}^{\bar{d}} \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}|d_{j-1}^s, d_{j-1}^r)\mathbf{P}(d_{j-1}^s, d_{j-1}^r) \\ &= \sum_{d_{j-1}=\underline{d}}^{\bar{d}} \sum_{d_{j-1}^s=\underline{d}}^{\bar{d}} \sum_{d_{j-1}^r=\underline{d}}^{\bar{d}} \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}|d_{j-1}^s, d_{j-1}^r)\mathbf{P}(d_{j-1}^s, d_{j-1}^r|d_{j-1})\mathbf{P}(d_{j-1}) \end{aligned}$$

On the other hand, since the retailer's and salesperson's forecasting processes are independent of each other, we have

$$\begin{aligned} \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}|d_{j-1}^s, d_{j-1}^r) &= \mathbf{P}(Q_{j-1}^{s*}|d_{j-1}^s)\mathbf{P}(Q_{j-1}^{r*}|d_{j-1}^r) \\ \mathbf{P}(d_{j-1}^s, d_{j-1}^r|d_{j-1}) &= \mathbf{P}(d_{j-1}^s|d_{j-1})\mathbf{P}(d_{j-1}^r|d_{j-1}) \end{aligned}$$

Thus, we will have

$$\mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}) = \sum_{d_{j-1}=\underline{d}}^{\bar{d}} \sum_{d_{j-1}^s=\underline{d}}^{\bar{d}} \sum_{d_{j-1}^r=\underline{d}}^{\bar{d}} \mathbf{P}(Q_{j-1}^{s*}|d_{j-1}^s)\mathbf{P}(Q_{j-1}^{r*}|d_{j-1}^r)\mathbf{P}(d_{j-1}^s|d_{j-1})\mathbf{P}(d_{j-1}^r|d_{j-1})\mathbf{P}(d_{j-1})$$

Note that probability $\mathbf{P}(Q_{j-1}^{s*}|d_{j-1}^s)$ (probability $\mathbf{P}(Q_{j-1}^{r*}|d_{j-1}^r)$) is one, if in period $j-1$ the retailer's order size calculated by the salesperson (calculated by the retailer) based on her forecast d_{j-1}^s (his forecast d_{j-1}^r) is Q_{j-1}^{s*} (is Q_{j-1}^{r*}); otherwise, this probability is zero.

We write the optimality equation of the salesperson in the last period (where $j = 0$) as:

$$V_0[w_0, Q_0^{s*}, Q_0^{r*}] = \max_{\beta_0} \left\{ G(w_0, Q_0^{s*}, Q_0^{r*}, \beta_0) \right\}$$

where $0 \leq w_0 \leq 1$, $Q_0^{s*} = \{\underline{d}, \underline{d} + 1, \dots, \bar{d}\}$ and $Q_0^{r*} = \{\underline{d}, \underline{d} + 1, \dots, \bar{d}\}$.

4 Benevolent Salesperson

In this section, we consider a salesperson that has the retailer's best interests as her objective function. This might be the case if the manufacturer uses a non-commission pay scheme that motivates the salesperson to try to foster long term profitability of the retailer. We are interested in: (i) will such a benevolent salesperson lie? (ii) if so, assuming the salesperson is rational, what direction (i.e., overstating or understating) will she lie about the forecast? and (iii) how does this behavior affect the supply chain performance?

We model the objective of the benevolent salesperson, which is to find the optimal bias in period k (i.e., β_k^*) such that the expected profit of the retailer is maximized, as follows:

$$\beta_k^* = \max_{\beta_k} \sum_{l=k}^N \mathbb{E} \left[\Pi_l^r(Q_l^*(\beta_l)) \right]$$

We recall that $\Pi^r = p_r \min\{d_k, Q_k^*\} - p_w Q_k^* - h_r [Q_k^* - d_k]^+ - s_r [d_k - Q_k^*]^+$ where $Q_k = Q_k^*(w_k, d_k^r, d_k^s, \beta_k)$ and N is the total number of periods. Hence, the salesperson chooses the optimal amount of bias β^* so as to maximize the sum of the retailer's current profit and his expected profits from the future periods. Therefore, function $G(\cdot)$ in (5) is $\Pi^r(w_j^s, Q_j^{s*}, Q_j^{r*}, \beta_j)$, and (5) can be written as

$$\begin{aligned} V_j[w_j, Q_j^{s*}, Q_j^{r*}] &= \max_{\beta_j} \left\{ \mathbb{E}_{d_j} \left[\Pi^r(w_j^s, Q_j^{s*}, Q_j^{r*}, \beta_j) \right] \right. \\ &\quad \left. + \sum_{d_j=\bar{d}} \sum_{d_{j-1}^s=\bar{d}} \sum_{d_{j-1}^r=\bar{d}} V_{j-1}[w_{j-1}(w_j, Q_j^{r*}, Q_j^{s*}, \beta_j, d_j), Q_{j-1}^{s*}, Q_{j-1}^{r*}] \right. \\ &\quad \left. \mathbf{P}(d_j | d_j^s) \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}) \right\} \end{aligned}$$

and

$$V_0[w_0, Q_0^{s*}, Q_0^{r*}] = \max_{\beta_0} \left\{ \Pi^{r*}(w_0, Q_0^{s*}, Q_0^{r*}, \beta_0) \right\}.$$

We determine the optimal policy for the benevolent salesperson using backward recursion.

4.1 Truthfulness and Trust of a Benevolent Salesperson

To gain insight into trust and its effect on the salesperson's recommendations, we examined the system behavior of 3240 cases using the above DP to compute the optimal policy and simulation to generate demand outcomes for the following parameter ranges:

- *Salesperson's forecast accuracy* $\frac{1}{\sigma^s}$: The salesperson's forecast accuracy is characterized by the standard deviation σ^s of her forecast distribution F_D^s . We considered values of the normalized standard deviation to be 0.05, 0.1, and 0.2.

- *Retailer's forecast accuracy $\frac{1}{\sigma^r}$* : The retailers's forecast accuracy is characterized by the standard deviation σ^r of his forecast distribution F_D^r . We considered values of the normalized standard deviation to be 0.05, 0.1, and 0.2.
- *Retailer's level of skepticism ϕ* : Define $\phi = \delta_l/\delta_g$. This ratio represents the relative ease with which the salesperson loses the retailer's trust as opposed to gaining it. A small ratio represents a trusting retailer while a large ratio represents a skeptical retailer. We considered values 0.5, 1, and 2.
- *The critical order ratio z^** : Define $z^* = F^{-1}\left(\frac{p_r - p_w + s_r}{p_r + s_r + h_r}\right)$ where F is the cumulative distribution of a standard normal distribution. This measure is the well-known critical ratio for a newsvendor problem where demand is normally distributed. It characterizes the relative cost of having too little inventory versus having too much. A negative ratio represents a case where a high overage cost makes it optimal to order less than the average demand forecast. A positive ratio represents a case where a high underage cost makes it optimal to order more than the average demand forecast. We considered values -0.5 , 0 and 0.5 .
- *Initial trust level w_1* : This measure represents the initial level of trust the retailer puts in the salesperson's recommended order quantity. We considered values 0 , 0.25 , 0.5 , 0.75 and 1 .
- *Length of the relationship N* : This is the total number of periods the salesperson will work with the retailer. We considered values of 3 , 6 , 12 , 24 , 60 , 120 , 240 , and 480 . If periods represent months, then this covers a range from three months to 40 years.

Note that the retailer revises his trust level w_k after he observes the actual demand. Since demand is stochastic, to attain a minimum confidence interval of 95% on the trust levels w_k for $k = 1, 2, \dots, N$, we conducted 2500 simulation replications for each case. In the remainder of this section, we present our findings and discuss their implications for (i) the factors that promote a benevolent salesperson to lie, (ii) the resulting level of trust, and (iii) the effect of lying on trust, manufacturer's profit and the retailer's profit compared to those of a supply chain without a salesperson.

We define $\bar{\mathbf{B}}$ to be the *overall bias*, which is the average bias in the salesperson's reported forecast over the duration of the salesperson-retailer relationship, given by

$$\bar{\mathbf{B}} = \frac{1}{N} \sum_{k=1}^N \frac{\beta_k}{Q_k^{s*}}.$$

We also define $\overline{\mathbf{W}}$ to be the *overall trust*, which is the average trust level over the duration of the salesperson-retailer relationship, given by

$$\overline{\mathbf{W}} = \frac{1}{N} \sum_{k=1}^N w_k.$$

Among the 3240 simulation cases we considered, we found that the salesperson lies at least once during the relationship in 96% of them. Moreover, 44% of the cases have a positive overall bias, while 52% of the cases have a negative overall bias. We regard the benevolent salesperson’s overstatement and understatement of order quantities as “white lies” because her intention is not to harm the retailer but rather to help him.

Table 1. Average overall bias $\overline{\mathbf{B}}$ for a benevolent salesperson.

Critical Order Ratio (z^*)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
-0.50	1.3%	1.2%	1.1%	1.0%	1.1%	0.9%	0.8%	0.7%	1.0%
0.00	-1.7%	-1.3%	-1.2%	-1.0%	-0.5%	0.2%	-0.2%	0.0%	-0.7%
0.50	-2.2%	-2.1%	-1.5%	-1.3%	-0.9%	-0.6%	-0.4%	-0.4%	-1.2%

In Table 1, we summarize the average overall bias ($\overline{\mathbf{B}}$) of a benevolent salesperson for different critical order ratios (z^*) and length of relationships (N). We find that bias moves inversely to the critical order ratio. A benevolent salesperson is more likely to overstate her recommendation when the cost of excess inventory is high ($z^* < 0$) and a benevolent salesperson is more likely to understate her recommendation when the cost of having a shortage is high ($z^* > 0$). This is because the retailer tends to shy away from ordering more stock when the cost of overage is high, but he may over-order when the cost of shortage is high. The salesperson overstates or understates her recommendation accordingly to overcome these tendencies. Note that this occurs regardless of whether the salesperson is more or less accurate than the retailer. We also observe that a benevolent salesperson is more likely to lie when the duration of the relationship is short. This is because, with a limited time, she is willing to take the risk of losing the retailer’s trust in the future in order to enhance the retailer’s short-term profit. Hence, we conclude the following:

Observation 1 *It is not optimal for a salesperson to be entirely truthful even when she has the retailer’s best interest at heart, but the extent of lying diminishes with the length of the retailer-salesperson relationship.*

In Table 2, we illustrate the overall trust level ($\overline{\mathbf{W}}$) of a benevolent salesperson for various relative forecast accuracy (σ_s/σ_r) and relationship length (N).

We see that in cases where the salesperson has superior forecasting ability ($\sigma_s/\sigma_r < 1$), average trust $\overline{\mathbf{W}}$ increases as the relationship length N increases. In cases where the salesperson has inferior

forecasting ability ($\sigma_s/\sigma_r > 1$), average trust decreases as the relationship length increases. Hence, the retailer’s trust in the salesperson is more reflective of the salesperson’s competence (i.e., forecast accuracy) in a long term relationship than in a short-term relationship.

Table 2. Average overall trust \bar{W} for a benevolent salesperson

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.25	0.53	0.57	0.69	0.81	0.92	0.96	0.98	0.99	0.81
0.5	0.51	0.54	0.60	0.68	0.81	0.87	0.91	0.92	0.73
1	0.42	0.44	0.45	0.46	0.46	0.45	0.45	0.44	0.45
2	0.41	0.42	0.39	0.34	0.22	0.16	0.14	0.13	0.28
4	0.41	0.40	0.36	0.30	0.20	0.14	0.08	0.06	0.24
Average	0.46	0.47	0.50	0.52	0.52	0.52	0.51	0.51	0.50

4.2 Value of a Benevolent Salesperson to Supply Chain Profits

In this section, we examine whether having a benevolent salesperson is beneficial for the manufacturer and the retailer in a supply chain. Specifically, we are interested in: (i) when the salesperson has retailer’s best interest as her objective, does she always improve the retailer profit? and (ii) does she ever increase manufacturer profit?

We use the superscripts “ r ” and “ w ” to represent the retailer and the manufacturer (wholesaler), respectively. We denote the average profits over the duration of the salesperson-retailer relationship by

$$\bar{\Pi}^r = \frac{1}{N} \sum_{k=1}^N \Pi_k^r, \quad \bar{\Pi}^w = \frac{1}{N} \sum_{k=1}^N \Pi_k^w$$

Note that, since we did not make any assumption about the salesperson’s compensation, the manufacturer profit is the revenue it receives without taking into account of the salesperson’s compensation cost. We also use the subscripts “ ns ” and “ b ” to represent the supply chains without a salesperson and one with a benevolent salesperson, respectively.

Table 3. Average percentage increase in retailer’s profit if a benevolent salesperson is hired.

Initial Trust (w_1)	Length of the Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.00	0.2%	0.6%	1.2%	2.0%	3.0%	3.5%	3.7%	3.8%	2.3%
0.25	1.9%	2.0%	2.3%	2.8%	3.4%	3.7%	3.8%	3.9%	3.0%
0.50	2.6%	2.7%	2.9%	3.2%	3.6%	3.8%	3.8%	3.9%	3.3%
0.75	1.6%	1.8%	2.3%	2.8%	3.3%	3.6%	3.8%	3.9%	2.9%
1.00	1.1%	1.2%	1.5%	2.1%	2.9%	3.4%	3.7%	3.9%	2.5%
Average	1.5%	1.6%	2.0%	2.6%	3.3%	3.6%	3.8%	3.9%	2.8%

To model a supply chain without a salesperson, we use the same modeling approach described in Section 3.1 except with only one forecast from the retailer. For our tests, we considered parameter ranges given in Section 4.1 and ran 2500 replications of each case.

As expected, retailer profit tends to be greater in (79% of the 3240 cases) in a supply chain with a benevolent salesperson than without one. However, retailer profit in a supply chain with a benevolent salesperson can be *less* (in 14% of the cases) than in one without a salesperson. Tables 3 and 4 show that this happens when (i) the salesperson’s forecasting skill is substantially worse than the retailer’s ($\sigma_s/\sigma_r = 2$), (ii) the initial trust level is 100%, and (iii) the salesperson-retailer relationship is very short ($N \leq 6$). An initial trust level of 100% in a salesperson who is poor in forecasting represents a case of misplaced trust. Moreover, when the time horizon is short, there is limited opportunity for the retailer to appropriately lower his trust level in the salesperson based on actual performance. While such an outcome is possible, we do not consider it very likely because an incompetent salesperson would probably not project a sufficiently strong first impression to achieve a 100% initial trust level. Hence, in most circumstances, a benevolent salesperson will improve retailer profitability.

Table 4. Average percentage increase in retailer’s profit if a benevolent salesperson is hired.

Relative Forecast Accuracy (σ_s/σ_r)	Retailer Skepticism (ϕ)			
	0.5	1	2	Average
0.25	15.3%	15.3%	16.0%	15.5%
0.5	5.4%	6.0%	6.2%	5.9%
1	0.2%	0.4%	0.0%	0.2%
2	-1.2%	-1.5%	-1.6%	-1.4%
4	-1.5%	-1.9%	-2.0%	-1.8%
Average	2.6%	2.6%	2.6%	2.6%

More interestingly, we find that while manufacturer profit tends to decrease (in 64% of the cases) when he hires a benevolent salesperson, such a salesperson can sometimes increase manufacturer profit (in 31% of the cases). Table 5 summarizes the percentage change in manufacturer profit from a supply chain without a salesperson to one with a benevolent salesperson under different system parameters.

Table 5. Average percent increase in manufacturer’s profit if a benevolent salesperson is hired

$z^* = -0.5$				$z^* = 0$				$z^* = 0.5$			
σ_s	σ_r			σ_s	σ_r			σ_s	σ_r		
	0.05	0.1	0.2		0.05	0.1	0.2		0.05	0.1	0.2
0.05	0.1%	-6.3%	-17.1%	0.05	0.2%	-6.2%	-18.8%	0.05	0.3%	-6.6%	-20.4%
0.1	-0.2%	-0.3%	-9.9%	0.1	-0.2%	-3.1%	-4.2%	0.1	-2.4%	5.1%	3.9%
0.2	-1.1%	-4.1%	-16.5%	0.2	-0.9%	-1.8%	1.2%	0.2	-4.1%	8.5%	24.1%

Table 5 shows that a benevolent salesperson improves manufacturer profit most when (i) the salesperson is less accurate than the retailer (i.e., $\sigma_s \geq \sigma_r$), (ii) the retailer has a substantial amount of forecasting error ($\sigma_r \geq 0.1$), and (iii) the critical order ratio is high ($z^* = 0.5$). When the benevolent salesperson’s forecasting skill is poor and the cost of shortage is high, the salesperson is likely to overstate her recommendation which encourages the retailer to order more than necessary.

Moreover, since the retailer's forecast is poor, it is difficult for the retailer to appropriately adjust his trust in the salesperson, which enables the salesperson to maintain her influence on the retailer. Hence, the retailer's poor forecast is coupled with the salesperson's poor forecast, resulting in a greater tendency for the retailer to over-order with a salesperson than without one. This promotes manufacturer profit at the expense of the retailer.

5 Self-Serving Salesperson

Since it is very common for salespeople to be compensated in proportion to the volume of their sales (e.g., in commission based compensation plans), we consider a self-serving salesperson whose objective is to maximize the order quantity. Clearly, such an objective gives the salesperson incentive to inflate her recommended order quantity. But while inflating her recommendation may boost the retailer order quantity, it will also undermine the retailer's trust in future periods. Hence, the salesperson needs to balance immediate and future gains when selecting an order quantity to recommend to the retailer.

We model the objective of the self-serving salesperson as finding the optimal bias at each period (i.e., β_k^*) such that her expected total compensation is maximized. Since the salesperson's compensation is a linear function of the order size, the equivalent maximization problem is:

$$\beta_k^* = \max_{\beta_k} \sum_{l=k}^N \mathbb{E} [Q_l^*(\beta_l)],$$

where N is the total number of periods in the salesperson-retailer relationship.

Hence, we can rewrite the dynamic programming model (5) for the self-serving salesperson as:

$$\begin{aligned} V_j[w_j^s, Q_j^{s*}, Q_j^{r*}] &= \max_{\beta_j} \left\{ Q_j^*(w_j, Q_j^{s*}, Q_j^{r*}, \beta_j) \right. \\ &+ \sum_{d_j=\underline{d}}^{\bar{d}} \sum_{Q_{j-1}^{s*}=\underline{d}}^{\bar{d}} \sum_{Q_{j-1}^{r*}=\underline{d}}^{\bar{d}} V_{j-1}[w_{j-1}(w_j, Q_j^{r*}, Q_j^{s*}, \beta_j, d_j) Q_{j-1}^{s*}, Q_{j-1}^{r*}] \\ &\left. \mathbf{P}(d_j|d_j^s) \mathbf{P}(Q_{j-1}^{s*}, Q_{j-1}^{r*}) \right\} \end{aligned}$$

and

$$V_0[w_0, Q_0^{s*}, Q_0^{r*}] = \max_{\beta_0} \left\{ Q^*(w_0, Q_0^{s*}, Q_0^{r*}, \beta_0) \right\}$$

Considering the same parameter ranges given in Section 4.1, we examine a supply chain with a self-serving salesperson and discuss the implications of our results for (i) the factors that promote a self-serving salesperson to lie, (ii) the process of trust building, and (iii) the effect of lying on trust and profits compared to those of supply chains without a salesperson and with a benevolent salesperson.

5.1 Truthfulness of a Self-Serving Salesperson

In this section, we first investigate the factors that promote lying and the whether it is ever advantageous for the salesperson to understate her optimal order quantity. In Tables 6 and 7, we present the average overall bias for various system inputs, including relationship length, initial trust level, relative forecast accuracy and retailer skepticism level.

Table 6. Average overall bias \bar{B} for various relationship lengths and initial trust levels

Initial Trust (w_1)	Length of the Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.00	0.5%	2.6%	4.5%	5.3%	6.7%	8.2%	7.9%	8.1%	5.5%
0.25	16.6%	14.2%	11.7%	9.1%	8.1%	9.0%	8.3%	8.3%	10.6%
0.50	34.6%	26.8%	18.3%	12.8%	9.5%	9.7%	8.7%	8.5%	16.1%
0.75	40.9%	35.6%	23.6%	16.5%	11.0%	10.4%	9.1%	8.7%	19.5%
1.00	46.7%	42.3%	31.6%	21.1%	12.6%	9.0%	9.5%	8.8%	22.7%
Average	27.9%	24.3%	17.9%	13.0%	9.6%	9.3%	8.7%	8.5%	14.9%

From Table 6, we observe that the salesperson lies more on average when the length of the salesperson-retailer relationship is short (i.e., N is small) and when initial trust is high (i.e., w_1 is large). This is because the salesperson can exploit the initial trust of the retailer to induce higher order quantities, but only for a limited time. Eventually, exaggerations by the salesperson result in a loss of trust and hence an inability to influence retailer ordering. Hence, as the length of the relationship increases, the benefits from lying diminish. Note that a high level of initial trust has a larger impact on lying in short relationships than in long ones. This suggests that high turnover rates among salesperson could induce more lying and less trust than in systems with stable salesperson assignments.

Table 7. Average overall bias \bar{B} for a self-serving salesperson

Relative Forecast Accuracy σ_s/σ_r	Retailer's Skepticism Level (ϕ)			
	0.5	1	2	Average
0.25	43.9%	32.5%	27.8%	34.7%
0.5	28.6%	22.1%	17.3%	22.7%
1	15.4%	13.6%	10.5%	13.1%
2	7.8%	7.9%	5.0%	6.9%
4	3.4%	3.7%	1.1%	2.7%
Average	19.8%	16.0%	12.3%	16.0%

Furthermore, comparing Table 1 with Table 6, it is clear that a self-serving salesperson lies more than a benevolent salesperson. This is because, unlike a benevolent salesperson who only lies to help, a self-serving salesperson lies to manipulate. Hence, a benevolent salesperson only adjusts her recommendation just enough to refine the retailer order quantity; while a self-serving salesperson lies as much as she can get away with.

From Table 7, we observe that the salesperson lies more on average when the salesperson's forecasting ability is better than the retailer's (i.e., σ_s/σ_r is small). This is because when the

salesperson has better forecasting ability, she is more confident about her knowledge of the actual demand and can better manipulate her recommended order quantity to maximize the retailer order quantity. Armed with the power of knowledge, the self-serving salesperson can lie more without causing the retailer to lose trust too quickly. The results in Table 7 also indicate that a salesperson takes even more advantage of the power of accuracy when the retailer is a trusting in nature (i.e., ϕ is small).

Observation 2 *On average, a self-serving salesperson lies more when (i) the salesperson has better forecasting skills than the retailer, (ii) the overall length of the relationship is short, (iii) initial trust is high, and (iv) retailer skepticism is low.*

When a salesperson inflates her recommendation, it tends to boost the retailer’s actual order quantity and hence increases the self-serving salesperson’s compensation. From Tables 4 and 5, it is clear that a self-serving salesperson often inflates her optimal order quantity. Indeed, the average overall bias was positive in 81.0% of the 3240 cases we examined. While this suggests a strong structural tendency to exaggerate, there are cases where the salesperson deflates her optimal order quantity (average $\bar{\mathbf{B}} < 0$). This occurs when she is less confident about her ability to keep or gain the retailer’s trust. For instance, as shown in Figure 1.*Left* and Figure 1.*Right*, the salesperson is more likely to deflate her forecast ($\beta < 0$) when her forecasting skill is worse than the retailer’s. However, note that even in this case, the salesperson inflates her recommended order quantities toward the end of the relationship because she no longer has to worry about the effect of trust on her future influence.

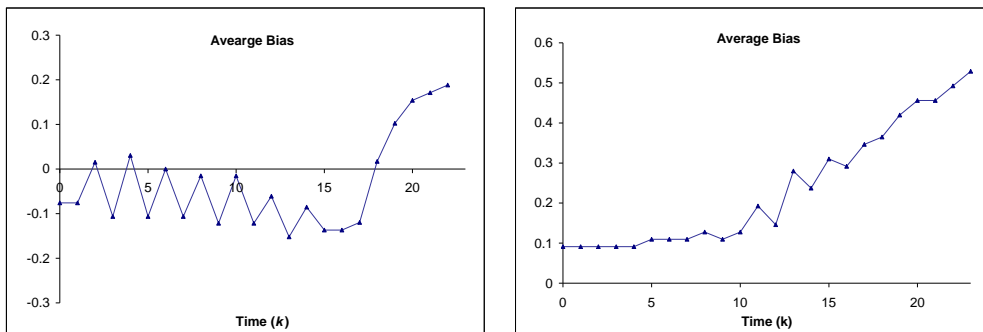


Figure 1: The change in bias over time (averaged across 2500 simulation replications) where $z^* = 0.5$, $\phi = 1$, $w_0 = 0.25$ and $N = 24$; *Left*: Case where salesperson has less accurate forecasts than the retailer ($\sigma_s = 0.2$, $\sigma_r = 0.1$), *Right*: Case where salesperson has more accurate forecasts than the retailer ($\sigma_s = 0.05$, $\sigma_r = 0.1$).

When the salesperson’s forecasting skill is worse than the retailer’s, she is more concerned about maintaining the retailer’s trust when initial trust level is low (as illustrated in Figure 2.*Left* and

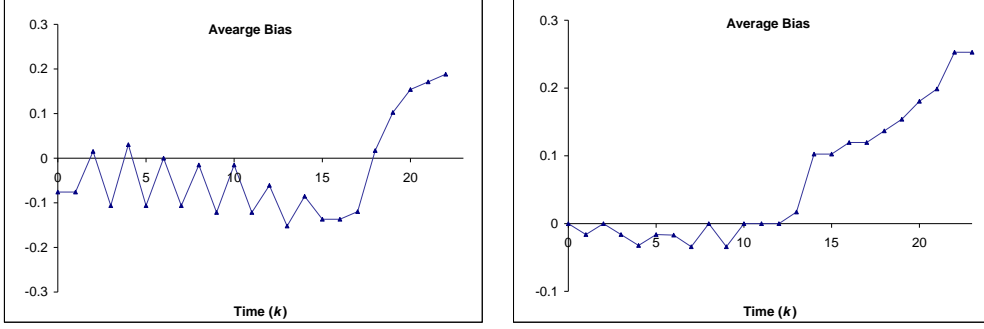


Figure 2: The change in bias over time (averaged across 2500 simulation replications) where $\sigma_s = 0.2$, $\sigma_r = 0.1$, $z^* = 0.5$, $\phi = 1$, and $N = 24$; *Left*: Case where the initial trust is low ($w_1 = 0.25$), *Right*: Case where the initial trust is high ($w_1 = 0.75$).

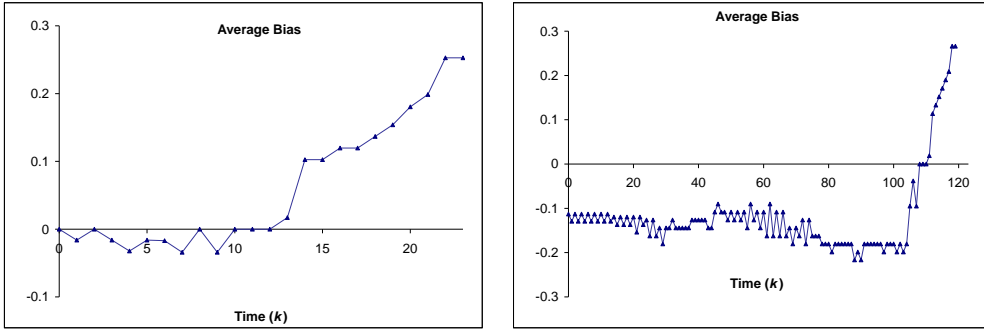


Figure 3: The change in bias over time (averaged across 2500 simulation replications) where $\sigma_s = 2$, $\sigma_r = 1$, $z^* = 0.5$, $\phi = 1$, and $w_1 = 0.75$; *Left*: Case where the salesperson-retailer relationship is short ($N = 24$), *Right*: Case where the salesperson-retailer relationship is long ($N = 120$).

Figure 2.*Right*), and when the relationship is fairly long (as illustrated in Figure 3.*Left* and Figure 3.*Right*). Hence, we conclude the following:

Observation 3 *A self-serving salesperson tends to inflate her optimal order quantities to boost retailer purchases. However, she sometimes deflates her order quantity recommendation when it is difficult to retain trust, which occurs when (i) she is less accurate than the retailer, (ii) initial trust is low, and (iii) the relationship is fairly long.*

5.2 Evolution of Trust

In this section, we examine the evolution of trust and bias over the duration of the relationship. Figure 4 illustrates a typical case for various initial trust levels. Figure 4.*Left* illustrates a scenario where the relationship is fairly long and Figure 4.*Right* illustrates a scenario where the relationship is fairly short.

We find that in most cases, regardless of initial trust level, trust converges fairly smoothly over time to a steady level \bar{w} (see Figure 4.*Left*). After an initial “warm up” period, trust holds steady at

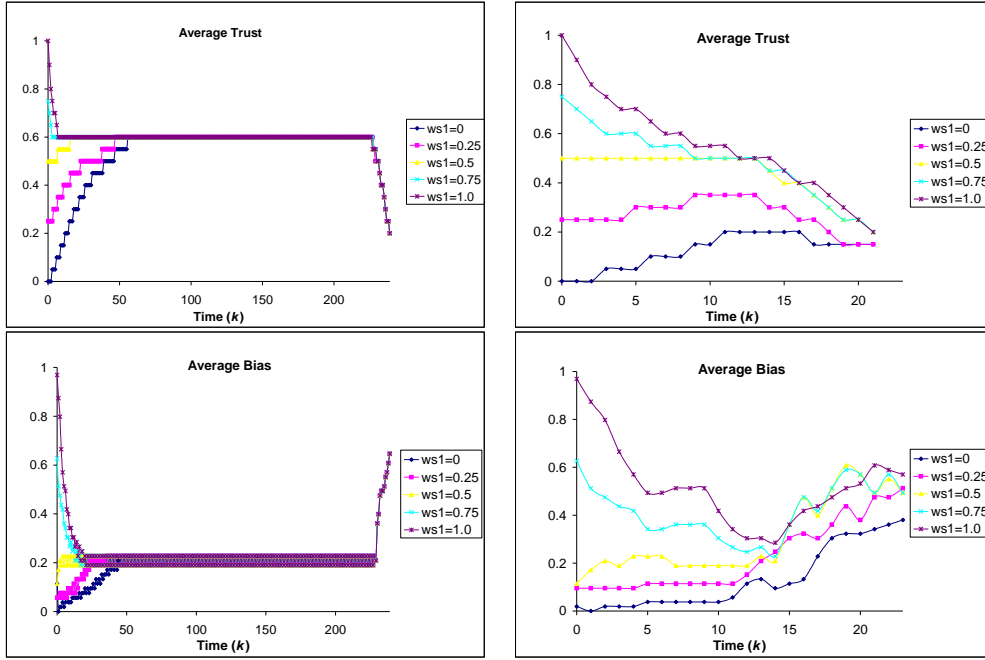


Figure 4: The change of bias and trust over time (averaged across 2500 simulation replications) where $\sigma_s = 1$, $\sigma_r = 2$, $z^* = 0.5$, $\phi = 1$; *Left*: Case where the salesperson-retailer relationship is long ($N = 240$), *Right*: Case where the salesperson-retailer relationship is short ($N = 24$).

\ddot{w} until near the end of the relationship when the salesperson takes advantage of the limited future to ignore trust considerations. Note that the steady trust level \ddot{w} in the intermediate periods is an indication of how much would retailer trust the salesperson if the relationship were to continue forever. This steady state trust level depends heavily on the salesperson’s relative accuracy and the retailer’s skepticism. The evolution of the salesperson’s bias follows a similar pattern. After a “warm up” period, the amount of bias stabilizes and fluctuates around a steady level. Toward the end of the relationship, bias increases significantly as the salesperson tries to boost order quantities.

Table 8. Average overall trust \overline{W} for a self-serving salesperson

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.25	0.52	0.51	0.58	0.67	0.74	0.77	0.78	0.78	0.67
0.5	0.50	0.45	0.46	0.50	0.62	0.69	0.73	0.69	0.58
1	0.48	0.40	0.36	0.35	0.37	0.36	0.36	0.35	0.38
2	0.45	0.36	0.29	0.26	0.16	0.12	0.10	0.10	0.23
4	0.44	0.34	0.26	0.19	0.15	0.10	0.06	0.04	0.18
Average	0.48	0.41	0.39	0.39	0.41	0.41	0.41	0.39	0.41

When the salesperson-retailer relationship is fairly short, the trust level never stabilizes before the “end of horizon” effect begins. Hence, initial trust in the early periods and manipulative behavior by the salesperson in the late periods dominate the course of the relationship. Figure 4. *Right* illustrates an example of such behavior.

In Table 8, we further illustrate the effect of relationship length on the average trust of a

self-serving salesperson. Similar to the case for a benevolent salesperson, the retailer’s trust in a self-serving salesperson is more reflective of the salesperson’s competence (i.e., forecast accuracy) in a long term relationship than in a short-term relationship. However, from contrasting Table 8 with Table 2, it is clear that a self-serving salesperson is less trusted than a benevolent salesperson. We summarize our findings on how trust evolves and how it is affected by the length of the relationship in the following observations:

Observation 4 *Trust declines rapidly toward the end of a relationship because a self-serving salesperson exaggerates her bias.*

Observation 5 *Increasing the length of the relationship improves the extent to which retailer trust in the salesperson reflects the salesperson’s competence (i.e., forecast accuracy).*

5.3 Value of a Self-Serving Salesperson to Supply Chain Profits

In this section, we examine the value to the manufacturer of a self-serving salesperson. We use our findings for a supply chain without a salesperson from Section 4.2 and compare them to those for the supply chain with a self-serving salesperson. We use the subscript “s” to represent a supply chain with a self-serving salesperson.

Table 9. Average percent increase in manufacturer’s profit if a self-serving salesperson is hired

Initial Trust (w_1)	Length of the Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.00	0.0%	0.9%	2.2%	3.9%	6.0%	7.2%	7.8%	8.1%	4.5%
0.25	15.1%	11.0%	8.5%	7.6%	7.8%	8.0%	8.2%	8.3%	9.3%
0.50	34.3%	26.0%	18.2%	13.4%	10.4%	9.4%	8.8%	9.0%	16.2%
0.75	54.0%	43.1%	30.7%	21.0%	13.8%	11.1%	9.7%	9.4%	24.1%
1.00	70.9%	59.8%	43.2%	28.3%	16.9%	12.7%	10.5%	9.8%	31.5%
Average	34.8%	28.2%	20.6%	14.9%	11.0%	9.7%	9.0%	8.9%	17.1%

Relative Forecast Accuracy (σ_s/σ_r)	Retailer’s Skepticism (ϕ)			
	0.5	1	2	Average
0.25	29.7%	21.5%	16.1%	22.4%
0.5	26.6%	19.0%	12.5%	19.4%
1	21.0%	17.1%	12.1%	16.7%
2	15.8%	15.3%	11.2%	14.1%
4	16.0%	16.0%	11.4%	14.5%
Average	21.5%	17.5%	12.4%	17.1%

Among the 3240 cases, we find that manufacturer profit in a supply chain with a self-serving salesperson is always at least as large as that for a supply chain without a salesperson. Table 9 illustrates the percentage increase in manufacturer profit that results from a self-serving salesperson.

As we would expect, the effects of various parameters on the change in manufacturer profit are similar to their effects on the amount of bias (see Section 5.1). Specifically, we find that the gain

in manufacturer profit is most significant when (i) the relationship is short, (ii) the initial trust is high, (iii) the relative accuracy of salesperson’s forecast is high and, and (iv) retailer’s skepticism is low.

Table 10. Average percent increase in retailer’s profit if a self-serving salesperson is hired

Initial Trust (w_1)	Length of the Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.00	-2.5%	-2.9%	-3.3%	-3.8%	-4.7%	-5.1%	-5.3%	-5.4%	-4.1%
0.25	-8.6%	-6.6%	-5.4%	-5.1%	-5.3%	-5.4%	-5.5%	-5.5%	-5.9%
0.50	-19.0%	-14.4%	-10.2%	-7.8%	-6.4%	-5.9%	-5.7%	-5.6%	-9.4%
0.75	-30.6%	-24.4%	-17.3%	-11.9%	-8.1%	-6.8%	-6.1%	-5.8%	-13.9%
1.00	-41.0%	-34.5%	-24.7%	-16.2%	-9.8%	-7.7%	-6.6%	-6.0%	-18.3%
Average	-20.3%	-16.5%	-12.2%	-9.0%	-6.9%	-6.2%	-5.8%	-5.7%	-10.3%

Relative Forecast Accuracy (σ_s/σ_r)	Retailer Skepticism (ϕ)			
	0.5	1	2	Average
0.25	-20.9%	-13.5%	-8.9%	-14.4%
0.5	-17.7%	-12.0%	-8.3%	-12.7%
1	-12.4%	-9.8%	-7.3%	-9.8%
2	-9.1%	-8.9%	-6.8%	-8.3%
4	-7.9%	-7.9%	-5.6%	-7.1%
Average	-13.3%	-10.3%	-7.4%	-10.3%

In contrast, retailer profit in a supply chain with a self-serving salesperson is always less than one without a salesperson, with an average decrease of 10.3%. Table 10 illustrates that, the effects of various parameter on the change of retailer profit are opposite to those on the manufacturer profit.

6 Honest Salesperson

In this section, we examine a truth-telling salesperson and compare the difference in performance of systems with an honest salesperson, a self-serving or a benevolent salesperson. We are interested in (i) will an honest salesperson be more trusted than a benevolent (but dishonest) salesperson? (ii) how much will it cost the manufacturer for the salesperson to be honest instead of self-serving? (iii) what is the effect on overall supply chain performance under the different salesperson types?

To model an honest salesperson, we use the same modeling approach described in Section 3.1 except that the salesperson’s bias is always zero. For our tests, we considered parameter ranges given in Section 4.1 and ran 2500 replications of each case.

6.1 Trust of an Honest Salesperson

We first examine the difference in trust level of an honest salesperson and a self-serving and a benevolent salesperson. Table 11 summarizes the percentage difference in trust of an honest sales-

person and that of a self-serving salesperson among the 3240 cases. Table 12 shows the percentage difference in trust of an honest salesperson and that of a benevolent salesperson.

Table 11. Average differences in trust levels of an honest salesperson and a self-serving salesperson.

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship N								Average
	3	6	12	24	60	120	240	480	
0.25	-13.3%	-21.8%	-24.5%	-23.8%	-22.3%	-21.9%	-21.7%	-21.6%	-21.4%
0.5	-15.3%	-25.8%	-31.8%	-33.1%	-33.4%	-32.3%	-31.4%	-30.9%	-29.2%
1	-13.0%	-25.0%	-32.0%	-32.0%	-24.9%	-22.0%	-19.7%	-20.7%	-23.7%
2	-11.2%	-21.7%	-21.4%	-6.4%	8.8%	13.8%	17.1%	27.5%	0.8%
4	-3.4%	-12.1%	-5.6%	3.2%	11.5%	20.2%	21.3%	24.3%	7.4%
Average	-11.2%	-21.3%	-23.1%	-18.4%	-12.1%	-8.4%	-6.9%	-4.3%	-13.2%

Table 11 shows that an honest salesperson tends to be more trusted than a self-serving salesperson. However, trust of a self-serving salesperson is higher when (i) the retailer has better forecasting skills than the salesperson, and (ii) the relationship is long. This is because when a self-serving salesperson is less competent than the retailer, she would lie to gain trust in order to maintain her influence on the retailer.

Table 12. Average differences in trust levels of an honest salesperson and a benevolent salesperson.

Initial Trust (w_1)	Length of Relationship N								Average
	3	6	12	24	60	120	240	480	
0.00	-11.8%	-15.8%	-15.3%	-13.1%	-3.1%	2.8%	7.0%	9.4%	-5.0%
0.25	-1.6%	-3.2%	-4.1%	-3.7%	-1.0%	1.9%	4.3%	7.0%	-0.1%
0.50	0.1%	1.3%	5.0%	4.8%	6.3%	6.5%	7.3%	9.6%	5.1%
0.75	0.9%	2.6%	7.7%	7.8%	17.9%	18.4%	19.2%	23.2%	12.2%
1.00	1.0%	2.7%	7.0%	8.7%	21.3%	20.7%	22.6%	30.5%	14.3%
Average	-2.3%	-2.5%	0.1%	0.9%	8.3%	10.1%	12.1%	15.9%	5.3%

Relative Forecast Accuracy (σ_s/σ_r)	Retailer's Level of Skepticism			
	0.5	1	2	Average
0.25	-6.5%	-8.9%	-7.0%	-7.4%
0.5	-3.9%	-4.6%	-3.5%	-4.0%
1	3.0%	-3.0%	-4.1%	-1.4%
2	10.5%	13.5%	8.4%	10.8%
4	44.0%	26.1%	16.2%	28.8%
Average	9.4%	4.6%	2.0%	5.3%

On the other hand, Table 12 illustrates that a benevolent salesperson is usually more trusted than an honest salesperson. However, a benevolent salesperson is less trusted when maintaining high trust is not critical to promote retailer profit in the overall time horizon. This happens when (i) the salesperson is significantly more accurate than the retailer, (ii) the relationship is short, (iii) initial trust is high, and (iv) the retailer's level of skepticism is low. Recall from Section 5.2 that a benevolent salesperson is always more trusted than a self-serving salesperson. Therefore, we can conclude the following:

Observation 6 *On average, a benevolent salesperson is most trusted, a self-serving salesperson is the least trusted, and an honest salesperson is in between.*

6.2 Differences in System Profits

In this section, we address the question of which type of salesperson, self-serving, benevolent or honest, induces better supply chain performance. We first compare the system performance based on manufacturer and retailer profits in Tables 13. Figure 5 illustrates the percentage difference in retailer and manufacturer profits for a supply chain with an honest salesperson and one with a self-serving/benevolent salesperson.

Table 13. Average Retailer's and Manufacturer's profit with a benevolent salesperson, an honest salesperson and a self-serving salesperson

Length of Relationship (N)	Retailer's Profit			Manufacturer's Profit		
	Benevolent	Honest	Self-Serving	Benevolent	Honest	Self-Serving
3	656.0	590.6	549.3	278.7	320.9	379.0
6	658.0	623.6	576.9	278.2	312.0	361.3
12	662.1	655.2	622.6	277.4	306.0	337.4
24	667.5	672.1	645.4	276.3	290.3	318.8
60	318.8	682.5	664.7	274.5	283.0	305.8
120	682.8	680.7	665.2	273.2	277.2	295.2
240	684.3	685.4	672.9	272.4	274.1	279.8
480	698.5	695.4	685.3	272.0	272.2	275.4
Average	697.6	660.7	627.8	275.3	295.8	319.1

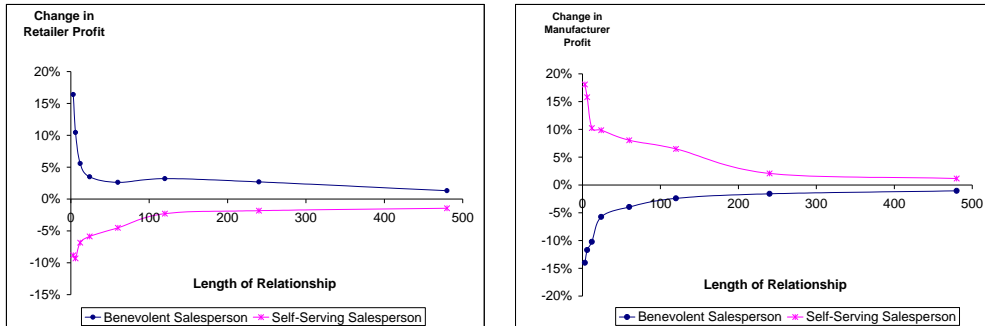


Figure 5: *Left:* Percent increase in retailer's profit (Π^r) if an honest salesperson is replaced by a benevolent salesperson or a self-serving salesperson; *Right:* Percent increase in manufacturer's profit (Π^w) if an honest salesperson is replaced by a benevolent salesperson or a self-serving salesperson.

As we would expect, a benevolent salesperson always generates the greatest retailer profit and the least manufacturer profit among the three kinds of salespersons. Moreover, a self-serving salesperson always generates the greatest manufacturer profit and the least retailer profit. However, the differences in system performance (for both the retailer and the manufacturer) diminish as the relationship becomes longer. This is because when the relationship is long, the self-serving salesperson cannot maintain trust unless her recommendation consistently outperforms that of the retailer. Hence, it becomes more difficult for a self-serving salesperson to be manipulative in a long term relationship. On the other hand, to make the best ordering decision in the long run, it is beneficial for the retailer to know the actual accuracy of the salesperson and be able to account

for it accordingly. Hence, a benevolent salesperson tends to tell the truth and reveals her forecast ability in a long-term relationship and behaves similar to an honest salesperson. We conclude the following:

Observation 7 *In long term relationships, the benefits to the manufacturer of a self-serving salesperson, compared to a benevolent and an honest salespersons, are small.*

Observation 8 *In long term relationships, the benefits to the retailer of a benevolent salesperson, compared to a self-serving and an honest salespersons, are small.*

The insight here is that, given a sufficiently long time horizon, the need to gain retailer’s trust forces a certain degree of truthfulness on the salesperson, which makes her almost benevolent. Since trust is often necessary to promote other business functions beyond simple ordering transactions (Covey 2006), it may actually be preferable for the manufacturer to incent salespersons to focus on the interests of the retailer or simply, encourage the salespersons to be honest.

Lastly, we consider the total supply chain profit. Since the manufacturer can always share profits with the retailer (e.g., via transfer payment, see Lee and Whang 1999 and Cachon 2003), the salesperson that generates a higher total supply chain profit is likely to be the most beneficial to both the manufacturer and the retailer. We define total supply chain profit Π^t as the sum of the manufacturer and retailer profits:

$$\Pi^t = \Pi^w + \Pi^r.$$

We find that total supply chain profit with an honest salesperson is very close to that with a benevolent salesperson. The average difference in total supply chain profit is 0.9% while the maximum and minimum differences are 4.2% and -3.7% , respectively.

Since total supply chain performance between an honest salesperson and a benevolent salesperson is very similar, we focus on comparing the performance between an honest salesperson and a self-serving salesperson in the remainder of this section. We find that the total supply chain profit is greater under an honest salesperson than under a self-serving salesperson in 73% of the cases; and is lower under an honest salesperson than under a self-serving salesperson in the remaining 29% of the cases. Tables 14, 15, and 16 summarize the average percentage difference in total profit for a supply chain with an honest salesperson and a supply chain with a self-serving salesperson. Specifically, Table 14 illustrates cases where the retailer holding cost is negative ($h_r = -2.23$), which implies that the retailer can sell every unit of leftover inventory at the price of 2.23. Tables 15 and 16 illustrate the results for cases where leftover inventory at the retailer carries a low holding

cost ($h_r = 5$) and a high holding cost ($h_r = 8.45$), respectively.

Table 14. Percent increase in total supply chain profit when a benevolent salesperson is replaced by a self-serving salesperson when salvage value is positive $h_r = -2.23$

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.25	5.3%	5.4%	5.6%	5.5%	5.6%	5.5%	5.7%	5.7%	5.5%
0.5	4.5%	4.2%	3.7%	3.6%	3.4%	3.5%	3.5%	3.3%	3.7%
1	4.2%	3.5%	2.8%	2.4%	1.6%	1.5%	1.3%	1.3%	2.3%
2	3.6%	2.7%	1.7%	0.9%	0.4%	0.2%	0.1%	0.1%	1.2%
4	3.7%	2.8%	1.5%	0.9%	0.2%	-0.1%	-0.2%	-0.3%	1.1%
Average	4.3%	3.7%	3.1%	2.7%	2.2%	2.1%	2.1%	2.0%	2.8%

Table 15. Percent increase in total supply chain profit when a benevolent salesperson is replaced by a self-serving salesperson when retail holding cost is low $h_r = 1.00$

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.25	-3.1%	-2.9%	-2.8%	-2.8%	-2.9%	-2.9%	-2.9%	-2.7%	-2.9%
0.5	-2.1%	-1.9%	-1.7%	-1.6%	-1.6%	-1.5%	-1.5%	-1.5%	-1.7%
1	-1.4%	-1.1%	-0.7%	-0.5%	-0.4%	-0.4%	-0.4%	-0.4%	-0.7%
2	-0.3%	-0.3%	-0.1%	-0.3%	-0.2%	-0.4%	-0.5%	-0.5%	-0.3%
4	0.6%	0.5%	0.4%	0.3%	0.1%	0.1%	0.1%	0.1%	0.3%
Average	-1.3%	-1.1%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.1%

Table 16. Percent increase in total supply chain profit when a benevolent salesperson is replaced by a self-serving salesperson when retail holding cost is high $h_r = 8.45$

Relative Forecast Accuracy (σ_s/σ_r)	Length of Relationship (N)								Average
	3	6	12	24	60	120	240	480	
0.25	-20.1%	-18.9%	-17.9%	-18.1%	-18.2%	-18.3%	-18.3%	-18.3%	-18.5%
0.5	-18.6%	-16.7%	-14.7%	-13.6%	-13.2%	-13.1%	-13.0%	-13.0%	-14.5%
1	-16.6%	-14.0%	-10.9%	-8.6%	-6.9%	-6.4%	-6.2%	-5.8%	-9.4%
2	-14.7%	-11.4%	-7.7%	-4.8%	-3.2%	-2.8%	-2.6%	-2.5%	-6.2%
4	-12.2%	-8.8%	-5.2%	-2.7%	-1.2%	-0.7%	-0.4%	-0.3%	-3.9%
Average	-16.4%	-14.0%	-11.3%	-9.5%	-8.5%	-8.2%	-8.1%	-8.0%	-10.5%

Comparing Tables 14, 15, 16, it is clear that a self-serving salesperson is more beneficial to total supply chain profit when the retailer holding cost is low. The reason for this is as follows. Given the wholesale price in this model is fixed at $p_w = 5$, a low holding cost results in a high wholesale price to holding cost ratio. Similarly, a high holding cost results in a low wholesale price to holding cost ratio. In cases where the ratio of wholesale price and holding cost is high, as the order quantity increases, the rate of increase in manufacturer profit is greater than the rate of decrease in retailer profit. Since a self-serving salesperson tends to promote a greater order quantity than a benevolent salesperson, when the wholesale price to holding cost ratio is high, the increase in manufacturer profit is likely to compensate for the decrease in retailer profit, which improves total supply chain profit.

Finally, it is clear from Table 13 that the increase in total supply chain profit from replacing an honest salesperson cases with a self-serving salesperson is large when : (i) the relationship is short, and (ii) the salesperson's forecasting skill is superior to the retailer's. This is because a shorter

relationship and superior forecasting skill gives the self-serving salesperson more power to inflate her recommendation. Hence, the total supply chain profit is increased to a greater extent when the wholesale price to retailer holding cost ratio is high. We conclude the following:

Observation 9 *A benevolent salesperson and an honest salesperson generate similar level of total supply chain profits.*

Observation 10 *On average, an honest salesperson tends to generate greater total supply chain profit than a self-serving salesperson. However, a self-serving salesperson can generate greater total supply chain profit when (i) the ratio of wholesale price to retailer holding cost is high, (ii) the overall length of the relationship is short, and (iii) the salesperson has better forecasting skills than the retailer.*

7 Summary

While it is widely acknowledged in industry that relational factors play an important role in supply chain performance and coordination, operations management research has generally relegated such issues to the category of “intangibles”. At best, the development of trust has been modeled a something that evolves in a “black box” and is therefore not directly addressed. In this study, we have made a preliminary step toward modeling trust as a dynamic and quantifiable component in supply chain decisions. This has allowed us to examine the evolution of trust and its impact on the supply chain members’ behavior.

We find that a benevolent salesperson who focuses on retailer profit does not necessarily tell the truth. In fact, she occasionally tells white lies to increase retailer profit. In contrast, a self-serving salesperson manipulates the retailer to order more stock by lying, particularly when her forecasting skill is superior to that of the retailer and when the initial trust on the part of the retailer is high. A self-serving salesperson also exploits the trust she builds in the early part of a relationship to lie excessively toward the end of the relationship.

In terms of supply chain performance, a benevolent salesperson always generates less manufacturer profit, but more retailer profit, than a manipulative self-serving salesperson and a truth-telling salesperson. Furthermore, while a benevolent salesperson and an honest salesperson generate very similar total supply chain profit, an honest salesperson is more likely to generate greater total supply chain profit than a self-serving salesperson. However, if the wholesale price is significantly greater than the retail holding cost, a self-serving salesperson can improve the total supply chain profit. Under these circumstances, a manufacturer can always share profit with the retailer, so it

is possible for a self-serving salesperson to benefit the retailer.

In general, regardless of how manipulative a self-serving salesperson is, time (i.e., duration of the relationship) has the power to reveal her competence (i.e., actual forecast ability). In a long term relationship, a self-serving salesperson is more cautious about the tradeoff of immediate gain (current order quantity) and value of future cooperation (which affects future orders). As a result, differences in order quantity, manufacturer profit and retailer profit under a self-serving salesperson and a benevolent salesperson become fairly small as the time horizon grows long. Benevolent actions induce greater trust in the salesperson-retailer relationship, which may yield benefits in other aspects of the business relationship and offset the small decrease in commissions. This suggests that in long term supply chain relationships where trust is vital, job assignments and salesforce incentives that promote a focus on long term relationships can benefit both the manufacturer and retailer in a supply chain.

In this paper, we have focused on trust only in the context of forecast sharing. To develop a more comprehensive understanding of the impact of trust on other aspects of supply chain coordination, further modeling work is needed. For instance, it would be useful to consider a salesperson who performs multiple tasks, possibility including demand promotion and inventory allocation, in addition to forecast sharing, and examine the impact of trust building on the salesperson's effectiveness in the other tasks. It would also be interesting to extend the analysis of trust to a supply chain with various types of supply chain contracts. The goal would be to discover how trust affects the optimal contract structure, and how to strike an appropriate balance between formal contracts and informal trust as promoted by salesperson incentives.

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