Scheduling sales force training: Theory and evidence

Anand Krishnamoorthy [a,*], Sanjog Misra [b], Ashutosh Prasad [c]

[a] BA2-308S, Department of Marketing, College of Business Admistration, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816-1400, USA
[b] Simon Graduate School of Business Administration, University of Rochester, Rochester, NY 14627, USA
[c] School of Management, The University of Texas at Dallas, Richardson, TX 75083-0688, USA

Abstract

To have a productive sales force, firms must provide their salespeople with sales training. But from a profit-maximizing perspective, there are also reasons to limit training: training is expensive, it has diminishing returns, and trained salespeople need to be compensated at a higher level since their value in the outside labor market has increased. Due to these reasons, the following inter-related questions are not straightforward to answer: (1) How much training should be provided and how should training be scheduled over time? (2) How should compensation vary with training? (3) Should salespeople be asked to pay for some or all of their training? An analytical model is developed and analyzed using optimal control theory to provide answers to these questions. Thereafter, an empirical investigation is undertaken that broadly corroborates the analytical findings.
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"Firms must decide how long it will take to properly train individuals. At Procter and Gamble, the training period lasts 12 to 18 months; at State Farm, training is a two-year stint; Dow Chemical requires 30 weeks; and Merck puts marketing reps through an initial training period of 12 months with frequent refresher courses. The duration of training depends on several factors such as the complexity of the selling task and the company's product line, and the individual trainee's background and experience." (Semenik & Bamossy, 1995, p. 420).

1. Introduction

The quantitative literature on sales force management has examined several methods by which sales force productivity can be increased. These include, but are not limited to, sales force compensation (e.g., Basu, Lal, Srinivasan, & Staelin, 1986; Basu & Kalyanaram, 1990), sales force sizing (e.g., Lodish, Curtis, Ness, & Simpson, 1988), call allocation (e.g., Lodish, 1971), territory design and alignment (e.g., Rangaswamy, Sinha, & Zoltners, 1990; Skiera & Albers, 1998), and sales force benchmarking (e.g., Horsky & Nelson, 1996). Seemingly overlooked, however, has been the use of training as a means to increase the productivity of the sales force.[1]

* Corresponding author. Tel.: +1 407 823 1330; fax: +1 407 823 3891.
E-mail address: akrishnamoorthy@bus.ucf.edu
(A. Krishnamoorthy).

[1] Notably, Darmon (2004) examines training schedules to ensure the continued availability of trained replacements given expected turnover rates. The effect of training on productivity, however, is not examined.

This omission is surprising given that studies have consistently stressed that training is a prerequisite for successful selling (Churchill, Hartley, & Walker, 1986). Training increases sales force productivity by giving salespeople the skills needed to perform their tasks effectively. For example, data from a Bell South video sales training program showed that training increased sales effectiveness by 50% (Martin & Collins, 1991). Training also increases profits by lowering the firm's selling and supervision costs. A study of Nabisco's sales training program by Klein (1997) found a $122 increase in sales and a twenty-fold increase in profit for every dollar invested in training. Adept salespeople are particularly important for a firm to maintain its competitive edge in the face of keen competition (Ingram & LaForge, 1992). Today's customers expect salespeople to have deep product knowledge, to add ideas to improve the customer's operations, and to be efficient and reliable. Firms, therefore, must train their salespeople in firm and product specific knowledge, selling and negotiation skills, customer behavior, industry trends, and market conditions.

However, the benefits from sales force training come at a steep price. Training expenses have risen steadily over the years. These expenses include instructional materials, living and transportation expenses, instructional staff, outside courses and seminars, management time spent with the salesperson, and the opportunity cost of lost sales. According to one study, firms spend on average between $22,500 and $28,455 to train a salesperson (O'Connell, 1988), while in the technology sector, this training cost can be as high as $100,000 (Dubinsky, 1996). According to Futrell and Parasuraman (1984), the estimated cost of recruiting, training, and managing a sales trainee, combined with the opportunity costs of lost sales from an unmanned territory, can be as high as $75,000. Given the magnitude of training costs, firms are trying to make the most out of every dollar invested.

An additional, implicit cost of training is that trained salespeople must be compensated at a higher level to match their increased worth in the outside labor market. In this regard, it is useful to classify training as specific training, which is specific to the firm's products and does not increase the salesperson's value in the outside labor market, and general training, which is portable because it imparts general knowledge and selling skills. Since general training almost necessarily constitutes some fraction of total training, it will normally be the case that to facilitate retention, compensation must increase with training. However, all or part of this increase may be covered by higher commissions since a trained salesperson is more productive and consequently earns a higher commission. Thus, whereas it is clear that the training decision is not independent of the compensation plan decision, and vice versa, it is unclear whether or how much the salary or commission rate needs to be adjusted. Relevant also is the job tenure of the salesperson, i.e., the expected length of time that a salesperson will stay with the firm. Training will translate into profits only if the salespeople stay with the firm (Darmon, 1990). If, instead, they quit after receiving the training, the firm stands to lose on its investment in human capital.

Since both the compensation and the market value of a salesperson increase with training, it is natural to ask whether salespeople should be required to pay for their own training (Barron, Berger, & Black, 1999). For example, many firms sponsor their salespeople to do MBA programs. In some cases, the cost of this education is fully funded, whereas in other cases, the employee is asked to subsidize a part of the expenses, such as that for books and other reading materials. We will examine whether and when firms should ask salespeople to pay for all or part of their training.

Despite the importance of sales force training, there is no research on optimal training policies or an integrated approach to training and compensation. As a step in that direction, this paper seeks to answer the following three questions already alluded to:

1. *How should training be scheduled and what should be the training duration?*
2. *How should sales force compensation vary with training?*
3. *Is it optimal to ask salespeople to pay for some or all of their own training?*

Answers to these questions contribute to the substantive literature on training and compensation. The rest of the paper is organized as follows: First, we develop the model together with some preliminary analysis. Second, we discuss the main results and their implications. Third, an empirical test of the analytical results is reported. Fourth, we deal with the case where salespeople buy their own training. Finally, we conclude by summarizing the findings and providing limitations of the research as well as directions for future research.

2. Model development

This section develops a model of sales force training that takes into account compensation and turnover. The

Table 1
Hypothetical training schedules

Training schedule	Potential rationale
(A) All training up front	The salesperson has greater productivity as early as possible.
(B) Constant training over time	This is the baseline case. The firm balances the arguments for an increasing or decreasing schedule.
(C) Increasing training over time	Less compensation is paid out in the beginning, so this structure rewards employees who stay with the firm longer.
(D) Decreasing training over time	Due to decreasing marginal returns, training becomes less effective over time and is reduced.

model is analyzed using optimal control techniques to determine the training schedule and compensation plan that maximizes the profit for the firm[2]. To understand the need for optimal control, consider a firm trying to decide between the four training schedules shown in Table 1.

Each schedule has some merit, making it difficult to choose between them. Thus, in schedule A, the firm spends its entire training budget at the beginning and quickly increases the productivity of the salesperson, but the risk here is that the salesperson might quit before the firm obtains a return on its investment. The converse is true for Schedule C. It should be noted, in addition, that this is clearly not an exhaustive set of training policies, since one can also countenance, among other things, cyclical schedules. Moreover, knowing how training should vary over time does not determine the amount of training or the duration of training. This discussion illustrates the need to precisely trade-off several relevant factors, for which a mathematical model is appropriate. Since both training and sales are time-varying, we require the dynamic optimization technique of optimal control to model the situation.

2.1. Model

We begin by listing the notation in Table 2, and the modeling assumptions (A1)–(A6).

(A1). We assume a standard principle-agent setting where a risk-neutral, profit-maximizing firm employs risk-averse, utility-maximizing salespeople to sell its products to the market (Basu et al., 1986). Assuming no externalities between salespeople, and no information asymmetry between the firm and a salesperson except with respect to unobservability of the salesperson's effort, we may focus on the interaction of an individual salesperson and the firm. The salesperson

is posited to have an exponential utility function, given by

$$U(t) = 1 - e^{-\gamma(S(\tilde{x}(t)) - C(t))}, \tag{1}$$

where $S(\tilde{x}(t))$ is the compensation based on sales $\tilde{x}(t)$ at time t, $C(t)$ is the salesperson's disutility, γ is the risk aversion parameter and r is the discount rate.

(A2). Compensation is of the form $S(x(t)) = \alpha(t) + \beta(t)x(t)$, where $\alpha(t)$ is the salary and $\beta(t)$ the commission rate (Basu & Kalyanaram, 1990; Bhardwaj, 2001; Joseph, 2001; Lal & Srinivasan, 1993).

(A3). Sales is a random variable given by

$$\tilde{x}(t) = \rho(t)a(t) + \varepsilon(t), \tag{2}$$

where $a(t)$ is the salesperson's effort choice, $\rho(t)$ is the productivity of the salesperson's effort, and $\varepsilon(t)$ is a stochastic noise component distributed $N(0, \sigma^2)$. The expected sales is $x(t) = \rho(t)a(t)$.

(A4). The training expense at time t is referred to simply as training and denoted $m(t)$, where $m(t) \in$

Table 2
Notation

$a(t)$	Effort exerted by the salesperson at time t.
$x(t)$	Expected sales at time t.
$\alpha(t)$	Salary paid to the salesperson at time t.
$\beta(t)$	Commission rate paid to the salesperson at time t.
$S(t)$	Compensation to the salesperson at time t. $S(t) = \alpha(t) + \beta(t)x(t)$.
$m(t)$	Training given to the salesperson at time t. $0 \leq m(t) \leq \bar{m}$
$C(t)$	Salesperson's disutility from selling and training at time t.
$\rho(t)$	Salesperson's productivity at time t; Initial productivity $\rho_0 \equiv \rho(0) \geq 0$.
$g(\rho)$	The salesperson's value in the outside labor market.
$\psi \in [0,1]$	Proportion of productivity increase caused by general training.
$\delta > 0$	Obsolescence rate leading to decrease in productivity.
$r > 0$	Discount rate.
$p > 0$	Gross margin of the firm.
$\mu > 0$	Turnover rate of salespeople in the firm.
$\theta > 0$	Parameter for the effectiveness of training in increasing productivity.
$\gamma > 0$	Coefficient of risk aversion.
$\sigma^2 > 0$	Variance (uncertainty) in sales outcome.

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[2] Details of the optimal control techniques used in this paper can be found in several textbooks, including Sethi and Thompson (2000).

$[0,\bar{m}]$. We conceptualize training as increasing the salesperson's stock of selling abilities, i.e., the productivity of the salesperson, which in turn influences sales. We assume that productivity increases with the cumulative amount of training received, but with decreasing returns. Furthermore, there is obsolescence caused by the presence of new knowledge and skills in the selling environment, together with forgetting. We specify the relationship between productivity and training that has all these properties as

$$\frac{d\rho(t)}{dt} = \theta m(t) - \delta\rho(t), \quad \rho(0) = \rho_0, \quad (3)$$

where θ is a training effectiveness parameter, δ represents an obsolescence rate, and ρ_0 is the initial productivity of the salesperson[3]. Since obsolescence increases faster in a dynamic environment, the parameter δ also captures the effect of the rapidity of change in the selling environment. Observe that if the salesperson does not receive any training, his or her selling ability declines over time. When training at level $m(t)$ and effectiveness θ is provided, the stock of abilities will go up or down depending on whether $\theta m(t)$ is larger or smaller than the attrition $\delta\rho(t)$.

(A5). The salesperson's disutility function is convex and specified as

$$C(t) = \frac{(m(t) + a(t))^2}{2}. \quad (4)$$

This specification highlights the fact that training and selling both require a time and effort commitment and are costly substitutes.

(A6). The salesperson's best outside option provides a certainty equivalent (utility) of $g(\rho(t),\psi)$, where g represents the valuation of productivity in the labor market, $g>0$ and $g'(\equiv dg/d\rho)>0$. And ψ is the fraction of the productivity level that is portable, i.e., comes from general training. If there is no general training component, then $\psi=0$ and the value of the outside option remains at $g(\rho_0)$. We further assume that the firm must provide a utility that is at least equal to the outside utility at each point in time to retain the salesperson.

To summarize, we have overlaid a training component to the standard LEN (linear incentives, exponential utility, normal errors) model of Holmstrom and Milgrom (1987) and Lal and Srinivasan (1993). When $\theta = \delta = 0$, the model will reduce to a pure compensation model that does not include training, i.e., exactly to that of Lal and Srinivasan. Thus, the proposed model generalizes their results to include training. The model is in continuous time, which may be conceptualized as an approximation of a multi-period model, where in each period, the salesperson concurrently exerts selling effort and obtains training, and compensation is awarded at the end of the period.

2.2. Preliminary analysis

The salesperson chooses an effort level to maximize utility which, following Lal and Srinivasan (1993), is the same as maximizing the certainty equivalent

$$\text{Max} \int_0^\infty e^{-rt}\left(\alpha(t) + \beta(t)\rho(t)a(t) - \frac{(m(t) + a(t))^2}{2}\right.$$
$$\left. - \frac{\gamma\sigma^2\beta(t)^2}{2}\right)dt. \quad (5)$$

Equating the derivative of (5) with respect to $a(t)$ to zero yields $a(t) = \beta(t)\rho(t) - m(t)$, the optimal effort choice of the salesperson. From this, it follows that more training reduces the effort applied by the salesperson, *ceteris paribus*. In practice, the substitution of selling effort by training is one reason that prevents managers from providing more training to salespeople. Given the effort choice of the salesperson, expected sales is

$$x(t) = \rho(t)a(t) = \rho(t)(\beta(t)\rho(t) - m(t)). \quad (6)$$

To try to ensure that the salesperson is retained, but not overcompensated, the firm matches the salesperson's best outside option at each time t. This gives

$$\alpha(t) + \beta(t)x(t) - \frac{\beta(t)^2\rho(t)^2}{2} - \frac{\gamma\sigma^2\beta(t)^2}{2} = g(\rho). \quad (7)$$

Now consider sales force turnover. Although the firm has matched the salesperson's best outside offer, with some probability that varies for different firms and industries, salespeople will switch jobs (Hoverstad, Moncrief, & Lucas, 1990; Lucas, Parasuraman, Davis, & Enis, 1987). In the customer retention literature, a hazard formulation is used to model turnover (Helsen &

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[3] The formulation of the dynamics is analogous to the Nerlove and Arrow (1962) conceptualization of advertising affecting sales through the intermediate stock of goodwill. The analysis where the dynamic is analogous to that of Vidale and Wolfe (1957) generates similar results and is available from the authors. The model is also robust to changes in the specification of sales in Eq. (2) to $\tilde{x}(t) = h(\rho(t))a(t) + \varepsilon(t)$ where $h>0$, $h'>0$, $h''<0$, and the cost in Eq. (4) to $C(t) = c_1(a(t) + c_2 m(t))^2$ where c_1 and c_2 are positive constants.
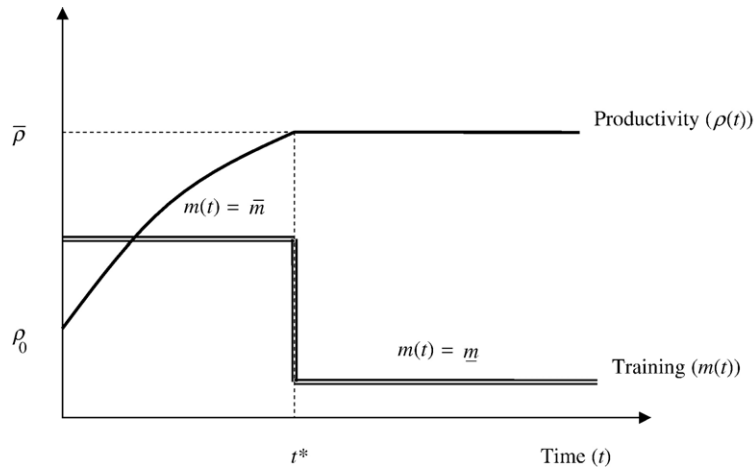
Fig. 1. Optimal training schedule and productivity over time ($\rho_0 \leq \bar{\rho}$).

Schmittlein, 1993). The probability that the salesperson will remain with the firm until time t is given by $e^{-\mu t}$, where μ is the turnover rate. Following Darmon (2004), the turnover rate is assumed to be constant and independent of training, which is also justified by empirical studies that have found weak or no effects of training on turnover (Dearden, Machin, Reed, & Wilkinson, 1997; Green, Felstead, Mayhew, & Pack, 2000).

At the beginning of employment the firm describes the training and compensation schedules. The firm's objective is

$$\max_{\alpha(t),\beta(t),m(t)} J = \int_0^\infty e^{-rt}e^{-\mu t}\left(\underbrace{px(t)}_{\text{Sales}} - \underbrace{\{\alpha(t)+\beta(t)x(t)\}}_{\text{Compensation}} - \underbrace{m(t)}_{\text{Training}}\right)dt,$$
(8)

to be maximized subject to (3), (6), and (7). In what follows, without loss of generality, we scale the firm's margin, p, to 1. Inserting (6) and (7) into (8), the firm's discounted profit maximization problem can be rewritten as

$$\max_{\beta(t)\geq 0,m(t)} J = \int_0^\infty e^{-(r+\mu)t}(\rho(t)(\beta(t)\rho(t)-m(t))$$
$$-\left\{\frac{\beta(t)^2\rho(t)^2}{2}+\frac{\gamma\sigma^2\beta(t)^2}{2}+g(\rho)\right\}$$
$$-m(t))dt,$$
(9)

$$\text{s.t.} \quad \frac{d\rho(t)}{dt} = \theta m(t) - \delta\rho(t), \quad \rho(0) = \rho_0,$$
(10)

$$0 \leq m(t) \leq \bar{m}.$$
(11)

For any value of $\rho(t)$, the optimal commission rate is

$$\beta(\rho(t)) = \frac{\rho(t)^2}{\rho(t)^2+\gamma\sigma^2},$$
(12)

obtained by differentiating the objective function with respect to $\beta(t)$. This can be inserted into (9) to yield an optimal control problem with state variable $\rho(t)$ and a single control, $m(t)$.

The objective function (Eq. (9)) and state equation (Eq. (10)) are both linear in $m(t)$. It is a characteristic of such problems that there exists an optimal level of productivity, and the optimal solution is to take the most rapid approach path (MRAP) to attain it (Sethi, 1977). In the ideal case, the firm would hire salespeople that have optimal productivity. But, in practice, new hires will not meet this requirement. Let us first consider the case shown in Fig. 1, where the salesperson's initial productivity lies below the optimal, denoted $\bar{\rho}$.

The optimal control $m^*(t)$ is

$$m^*(t) = \begin{cases} \bar{m}, & 0 \leq t \leq t^*, \\ \underline{m}, & t > t^*. \end{cases}$$
(13)

The time t^* is the *training duration*. At the maximum training rate, it takes this long to bring the salesperson to optimal productivity. After this time, maintenance training, denoted $\underline{m}$, is given to keep productivity at the optimal level. Since, in our case, the optimal productivity path turns out to be constant, the maintenance training level can be found as the training level such that $d\rho/dt = 0|_{\rho=\bar{\rho}}$. Using Eq. (10), this yields $\bar{m}=\delta\bar{\rho}/\theta$.

Inserting Eq. (13) in Eq. (10) and solving the resulting differential equation shows how the salesper-
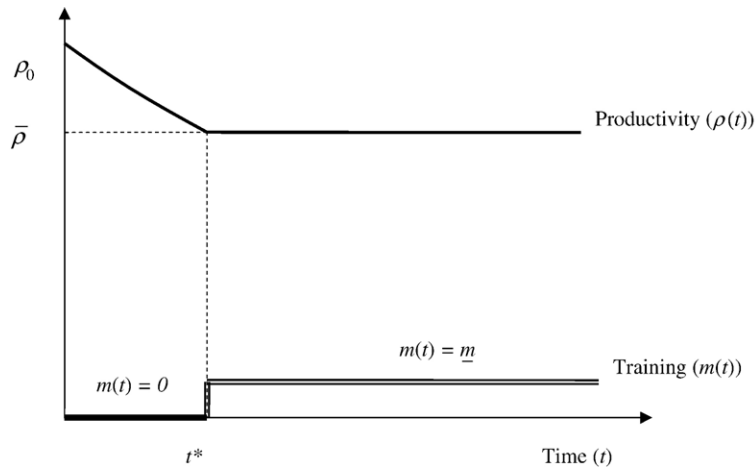
Fig. 2. Optimal training schedule and productivity over time ($\rho_0 > \bar{\rho}$).

son's productivity changes as a result of the training schedule.

$$\rho(t) = \begin{cases} \dfrac{\theta\bar{m}}{\delta} - \left(\dfrac{\theta\bar{m}}{\delta} - \rho_0\right)e^{-\delta t}, & 0 \leq t \leq t^*, \\ \bar{\rho} \equiv \rho(t^*), & t > t^*. \end{cases} \quad (14)$$

In the unlikely event that the salesperson is more productive than optimal, Fig. 2 shows that the solution is to offer no training and allow productivity to decay until such time as maintenance training at the rate $\underline{m} = \delta\bar{\rho}/\theta$ is required as before. The decay is exponential, and by setting training to zero in (10), we find $\rho(t) = \rho_0 e^{-\delta t}$. Using this, we get $t^* = \frac{1}{\delta}\ln\left(\frac{\rho_0}{\bar{\rho}}\right)$ to be the initial duration of no training.

3. Results and discussion

This section summarizes the analysis in the preceding section in the form of two propositions and explains what they imply for managerial practice and, in particular, for the questions raised in the introduction.

3.1. Scheduling sales force training

The first question dealt with scheduling sales force training: Should the training be provided upfront or should it be provided later in the salesperson's tenure? The solution is given by Proposition 1.

Proposition 1. *The optimal productivity level $\bar{\rho}$ solves the implicit equation*

$$\frac{r + \mu + \delta}{\theta} + \frac{\bar{\rho}(r + \mu + 2\delta)}{\theta} + g'(\bar{\rho})$$

$$- \frac{\bar{\rho}^3(\bar{\rho}^2 + 2\gamma\sigma^2)}{(\bar{\rho}^2 + \gamma\sigma^2)^2} = 0. \quad (15)$$

(a) For $\rho_0 \leq \bar{\rho}$, training should be provided at the maximum rate $\bar{m}$ from time $t = 0$ till $t = t^*$, where the training duration $t^* = \frac{1}{\delta}\ln\left(\frac{\theta\bar{m} - \delta\rho_0}{\theta\bar{m} - \delta\bar{\rho}}\right)$. Beyond t^*, training should be at the maintenance level $\underline{m} = \delta\bar{\rho}/\theta$.

(b) For $\rho_0 > \bar{\rho}$, there should be no training till time $t^* = \frac{1}{\delta}\ln\left(\frac{\rho_0}{\bar{\rho}}\right)$. Beyond t^*, training should be at the maintenance level $\underline{m} = \delta\bar{\rho}/\theta$. (All proofs and technical conditions are in the Technical Appendix.[4])

Training is provided to bring the salesperson as quickly as possible to optimal productivity and maintain that level. Due to the costs associated with training, optimal productivity is not the same as maximum productivity. Continued maintenance training is required to counter obsolescence by providing product-market information or new selling skills in a dynamic environment.

Regarding Proposition 1(b), our empirical data shows that no firm had a zero initial training duration, suggesting that this case is unlikely to occur in practice. Consequently, we focus hereafter on part (a).

From Proposition 1(a), the training duration t^* depends on several parameters, such as the initial productivity ρ_0, the maximum training rate $\bar{m}$, and the obsolescence rate δ. Proposition 1 gives a transcendental equation in ρ that has no simple solution. However, one can use implicit differentiation to obtain hypotheses about the influence of the model parameters on the training duration, *ceteris paribus*. These results are stated in Corollary 1.

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[4] The Technical Appendix is available from the authors upon request.

Corollary 1. *From Proposition 1(a), the following comparative statics emerge: $\frac{\partial t^*}{\partial \bar{m}}<0, \frac{\partial t^*}{\partial \rho_0}<0, \frac{\partial t^*}{\partial r}<0, \frac{\partial t^*}{\partial \mu}<0, \frac{\partial t^*}{\partial g'}<0, \frac{\partial t^*}{\partial \psi}<0, \frac{\partial t^*}{\partial \gamma}<0, \frac{\partial t^*}{\partial \sigma^2}<0$. The directions of $\frac{\partial t^*}{\partial \delta}$ and $\frac{\partial t^*}{\partial \theta}$ are ambiguous.*

The decrease in the ∂training duration t^* with the maximum training level $\bar{m}$ is to be expected since the salesperson will achieve optimal training faster under a more intense training regimen. As an aside, an increase in $\bar{m}$ can only increase the profitability of the firm since its strategy space is enlarged. The ceiling on the rate of training occurs because of the lack of time and resources or because of the inability of the salesperson to learn beyond a threshold level. Hence, the relaxation of any of these constraints would reduce training time.

The decrease of t^* due to an increase in the initial productivity ρ_0 occurs because less additional training is required to bring the salesperson up to optimal productivity. A salesperson with low initial ability or experience, corresponding to a low initial productivity, should be trained for a longer period of time.

Training decreases with the discount rate r. Since high discount rates would be seen in risky ventures like small start-ups or firms competing in fast-paced industries, such firms should train their salespeople for a shorter period of time. The intuition for the effect of the turnover rate μ is similar to the one for r. Since the returns from training are lower, the firm should decrease investment in training.

The training duration decreases with g', the slope of the outside option. Thus, if the labor market values incremental productivity steeply, as may be the case in complex, competitive and cutting-edge industries, then it becomes less profitable for the firm to provide training, because it must also increase compensation steeply with training to match the rest of the industry.

The effects of the coefficient of risk aversion γ and the uncertainty in sales σ^2 are in the same direction so they can be considered together. The sensitivity results state that risk-averse salespeople in uncertain environments should be given less training. This may be tied to the fact that the risk premium in such cases is higher, decreasing the returns on investment in training.

Finally, the comparative statics of the training effectiveness parameter θ and the obsolescence rate δ are ambiguous, for similar reasons. An increase in θ (respectively, δ) causes two effects to occur. First, training is more (less) effective, suggesting that the duration of training is be less (more) to achieve the same level of productivity but, second, the optimal productivity level

itself increases (decreases). Hence, the combined effect on the training duration is unclear.

3.2. Compensation and training

The second issue in the introduction dealt with the interaction of compensation and training. A more trained salesperson would have to be compensated to a greater extent, but the exact form of the salesperson's compensation is given in the following proposition.

Proposition 2. *The salesperson's total expected compensation $\alpha^*(t) + \beta^*(t)x^*(t)$ is given by*

$$\begin{cases} g(\rho(t)) + \dfrac{\rho(t)^4}{2\left(\rho(t)^2 + \gamma\sigma^2\right)}, & 0 \leq t \leq t^*, \\ g(\bar{\rho}) + \dfrac{\bar{\rho}^4}{2\left(\bar{\rho}^2 + \gamma\sigma^2\right)}, & t > t^*, \end{cases} \quad (16)$$

where

$$\rho(t) = \frac{\theta\bar{m}}{\delta} - \left(\frac{\theta\bar{m}}{\delta} - \rho_0\right)e^{-\delta t} \text{and } \bar{\rho} \equiv \rho\left(t^*\right).$$

Total compensation increases with productivity, and hence with cumulative training. Consistent with this result, Brown (1989) finds a strong contemporaneous positive link between training and wage growth, with the average cumulative training effect on wage growth being 11%–20%.

The Technical Appendix provides explicit expressions for the salary and the commission rate. The salary increases to match the outside value of the salesperson, and this increase is greater for better-trained salespeople who have more valuable outside options. However, for salespeople with less valuable outside job offers, the salary can actually decrease with training. The commission always increases with the training duration.

The next section provides an empirical test of the hypotheses from the analysis of the model and a discussion of the performance of the model using data from various industries.

4. Empirical validation

We used 1996–1998 survey data from Dartnell Corporation's annual survey of sales force managers. The dataset contains descriptive information on sales force size, turnover, salesperson demographics, compensation, training, and sales volume from over 600 individual firms (Heide, 1999). Since there is one survey per firm, even though a firm may have multiple sales forces, the responses are to be interpreted as averages

for the firm. After accounting for missing information and other data inconsistencies, data from 406 firms was retained. The respondents are from a broad range of industries including Agriculture, Banking, Business Services, Communications, Construction, Electronics, Food Products, Insurance, Manufacturing, Paper, Pharmaceuticals, Retail, and Wholesale. The 'average' firm had about 167 salespeople with each salesperson contributing around $570,000 in sales revenue.

The analytical model was derived at the individual-level and, therefore, is suitable for understanding within-firm heterogeneity. However, to be consistent with the available data, which is at the firm-level, we will consider the analytical results as applying to a representative salesperson in each firm. This allows the analytical and empirical models to be comparable at the firm-level.

4.1. Variables and operationalization

Where applicable, the operationalization of variables is similar to that of Coughlan and Narasimhan (1992), who used Dartnell's 1986 survey to study sales force compensation plans. Table 3 gives the operationalization and descriptive statistics of the key variables used in the analysis.

4.2. Dependent variable

- *Training Duration, t**: The dependent variable is the duration of training (in months) provided to new sales-

people. The *Training Duration* corresponds directly to our theoretical construct.

Empirically, the reported training is for new sales-people. A surprising discovery is that no firm had zero training length. Given the abundance of small firms in the data, one might have expected otherwise. The fact that all the firms in the dataset offered at least some training underscores the importance of training in the sales force setting.

Compensation was not used as a dependent variable since the hypotheses relating to it are similar to those in Basu et al. (1986) and Lal and Srinivasan (1993), and have previously been empirically tested (Coughlan & Narasimhan, 1992). Hence, we focus only on the unique hypotheses related to training, given in Corollary 1.

4.3. Independent variables

- *Maximum Training Level, $\bar{m}$*: If the qualitative result holds that initial training should be provided at the maximum rate, then the operationalization of $\bar{m}$ is the *Training Expenditure per Day* (in dollars) variable reported in the survey. Else, it is still the best available proxy for this variable.
- *Change in Outside Option due to Productivity, g'*: Since there is no survey question that explicitly measures this variable, we constructed a measure for it from available variables. For every industry, we computed the average difference in total pay between new and experienced salespeople and divided it by the average productivity differential

Table 3
Variables, operationalization, and summary statistics

Variable	Operationalization	Mean	Std. Dev.
Training duration, $t*$	Duration of training (months) provided to new salespeople	4.65	4.56
Maximum training level, $\bar{m}$	Average training expenditure ($/day)	141.61	203.55
Market price of productivity, g'	Average difference in compensation between exp and new salespeople divided by productivity difference ($'000)	1.64	2.37
Productivity from general training, ψ	Proportion of total training that is general selling training	0.566	0.258
Turnover rate, μ	1-(ratio of the average number of years after which salespeople leave to the average experience)	0.241	0.609
Uncertainty in sales, σ^2	Average number of calls required to close a sale	5.761	10.18
Obsolescence rate, δ	Classification based on rate of change in the industry	0.547	0.493
Control variables			
Span of control	Ratio of the number of managers to the number of salespeople	0.186	0.162
Factor 1	Marketing support expenditures incurred	− 0.032	0.979
Factor 2	Marketing support expenditures incurred	0.146	0.992
Demographic variables			
Service	Average number of years of experience with the sales force	7.81	5.30
Age	Average age of salespeople in the sales force	36.50	6.20
Education	Whether or not a graduate/technical degree is required (yes=1, no=0)	0.344	0.553

(reported in the survey) between the two. This new variable then is the dollar value per unit of performance and is a clear proxy for the incremental change in the outside option due to productivity. We term our measure the *Market Price of Productivity*.

- *Productivity from General Training, ψ*: The data contains information about the nature of the training provided by the responding firms. We use the proportion of *Selling to Total Training* as a measure of ψ, the proportion of productivity from general training. Since selling training constitutes the bulk of general transferable skills training, we expect this to be a good proxy.

- *Turnover Rate, μ*: The Dartnell survey asked firms whether their turnover was higher or lower than in the previous year but did not ask for the turnover rate itself. The survey does, however, contain information about the average duration of employment before salespeople leave the firm. The shorter this duration, the higher the turnover. To make this comparable across industries, we took the ratio of the average number of years after which salespeople leave to the average experience, and subtracted it from one. This parameterization allows us to this computed *Turnover Rate* as a direct proxy for the turnover rate μ.

- *Uncertainty in Sales, σ^2*: Following Coughlan and Narasimhan (1992), the average number of *Calls to Close* a sale is taken as a proxy for the uncertainty (variance) in sales. The longer it takes to close a sale, the more important sales effort is relative to other marketing mix variables, and the less outside uncontrollable variation is due to other marketing factors.

- *Obsolescence Rate, δ*: In order to ascertain the impact of obsolescence on training duration, we classified industries based on rate of change in the industry. To ensure the objectivity of our measure, we compared our classification to that independently judged by four graduate Business students with industry experience and found no differences. This variable, termed *Dynamic Industry*, takes on the value of 1 if the industry is a rapidly changing industry (e.g., Electronics, Computers, Health Care, Pharmaceuticals, etc.), and 0 otherwise (Construction, Agriculture, and Forestry, Paper, etc.).

4.4. Control variables

As in Coughlan and Narasimhan (1992), a factor analysis of other marketing expenditures reveals two factors, *Factor1* and *Factor2*, reflecting marketing support expenditures. These factors are relevant as control variables to account for the fact that they might be substitutes or complements to training. For example, a firm that deals with technologically complicated products may have longer training lengths but may also reimburse salespeople for the use or purchase of laptops. On the other hand, it is also possible that the same firm spends a lot on providing technical information (via brochures, documents, or demos), and, consequently, reduces the training element. By including the two factors in our analysis, we control for these effects. In addition, we also used other "demography" variables as controls such as

- ○ *Service*: Average number of years of experience with the firm's sales force.
- ○ *Age*: The average age of salespeople in the sales force.
- ○ *Education*: Whether or not the sales force required a graduate/technical degree, represented by a dummy variable with value 0 for no requirement, and 1 for graduate or technical degree requirement.

Since the theory assumes that moral hazard exists, it is useful to control for its impact on training duration. Following Eisenhardt (1988), the *Span of Control* is used as a measure of monitoring, and is operationalized as the ratio of the number of managers to the number of salespeople in the firm. The greater the number of managers in a firm, the better the firm's ability to monitor the performance of its salespeople. The *Size* or scale of the firm, given by the volume of sales per sales call for an average salesperson, might be a proxy for other factors that might impact training length. The survey asked the firms to place themselves into 10 bins ranging from less than $5 million in revenue to over $5 billion, and this measure is used in the regression. To account for any industry-level effects, three-digit SIC codes are used as *SIC Dummies*. Since discount rates are industry-specific, they are accounted for in the industry dummies.

4.5. Estimation

The approach is to run a multiple regression of the form

$$t^* = \kappa_0 + \sum_{j=1}^{J} \kappa_j X_j + \varepsilon, \tag{17}$$

where t^* is the observed duration of the training provided, and the X_j are the set of j factors that influence

this duration. The Weibull distribution, which is a typical choice for duration models, is used for the error term ε.[5] A second problem encountered in duration data is that of censoring. Since the training duration for each firm is known and is non-zero, this was not an issue.

In deriving the log-likelihood, since the training duration is assumed to be distributed Weibull, a log-transform is used to recast the problem as an Extreme Value likelihood.

Defining $w_i = \ln t_i^*$ and $v_i = \kappa_0 + \sum_{j=1}^{J} \kappa_j X_j$ for firm $i \in \{1, \ldots, n\}$, the likelihood becomes

$$L = \prod_{i=1}^{n} \frac{1}{\xi} \exp\left(\frac{w_i - v_i}{\xi}\right) \exp\left(-\exp\left(\frac{w_i - v_i}{\xi}\right)\right),$$

(18)

hence the complete log-likelihood can be written as

$$\ln(L) = \sum_{i=1}^{n} \left(\frac{\ln t_i^* - \kappa_0 - \sum_{j=1}^{J} \kappa_j X_j}{\xi} - \ln \xi \right. $$
$$\left. - \exp\left(\frac{\ln t_i^* - \kappa_0 - \sum_{j=1}^{J} \kappa_j X_j}{\xi} \right) \right).$$

(19)

Maximizing the log-likelihood function in Eq. (19) provides the relevant parameter estimates (i.e., ξ, κ_0, and κ_j).

4.6. Accounting for heterogeneity

Even though the estimation allows for fixed effects by using industry-level dummies, there is still the possibility of heterogeneity across firms. To account for this heterogeneity, we specify and estimate a random coefficients version of the Weibull model presented above. We can write the log-likelihood for firm i as

$$\ln L_i = \left(\frac{\ln t_i^* - \kappa_{i0} - \sum_{j=1}^{J} \kappa_{ij} X_{1j} - \sum_{k=1}^{K} \omega_k X_{2k}}{\xi} - \ln \xi \right.$$

[5] Alternative specifications such as the Log–Normal and Log–Logistic were also run. There were no qualitative differences in the results. The Weibull is particularly favored in the study of duration models because it allows the hazard function to be fairly flexible.

$$\left. - \exp\left(\frac{\ln t_i^* - \kappa_{i0} - \sum_{j=1}^{J} \kappa_{ij} X_{1j} - \sum_{k=1}^{K} \omega_k X_{2k}}{\xi} \right) \right).$$

(20)

In the above specification, we have partitioned the matrix of explanatory variables X into X_1 and X_2, where all the key (non-control) variables that have random effects that vary across firms and the intercept are in X_1, with corresponding random coefficients κ, while the matrix X_2 contains the control variables and has a fixed coefficient vector ω. We assume that the density of the parameter vector κ follows a multivariate normal density with mean φ and variance covariance matrix Ω. The sample likelihood function can then be written as

$$\ln(\mathbf{L}) = \ln \int_{\kappa} L_i(\kappa, \omega, \xi | X) f(\kappa | \varphi, \Omega) d\kappa. \qquad (21)$$

We approximate Eq. (21) using a Quasi Monte-Carlo approach as follows. The simulated analog of Eq. (21) can be depicted as

$$\ln(\mathbf{L}) \approx \ln \frac{1}{S} \sum_{s=1}^{S} L_i\left(\kappa^{(s)}, \omega, \xi | X\right). \qquad (22)$$

In (22), the $\kappa^{(s)}$ are draws from the multivariate normal density $f(\kappa | \varphi, \Omega)$. We simulated the vector $\kappa^{(s)}$ as follows: Start with $S = 100$ randomized scrambled Halton draws (Bhat, 2003), transform them to normal deviates using the inverse CDF method and then multiply them by Λ, which is derived from the Cholesky factorization of Ω (i.e., $\Omega = \Lambda' \Lambda$). Maximizing (22) gives us consistent estimates of the parameters of interest.

4.7. Discussion of results

Table 4 presents the results of our estimation procedure. Of the six key variables tested in our analysis, we found strong support for four. As hypothesized in Corollary 1, higher levels of *Training Expenditure per Day* negatively and significantly impacted training duration. In other words, firms that spend more on training on a daily basis tend to have shorter training durations. We also found the effect of the *Market Price of Productivity* and *Turnover Rate* variables to be significant and negatively related to training duration. Both these effects are consistent with our theory and intuition. If either the market price of productivity

Table 4
Parameter estimates from the random coefficients Weibull model

	Variable	Estimate	Std. Err.	t-ratio	*P*-value	Support
Random effects	Intercept	1.6897	0.0039	43.163	0.0000	
	Calls to close	− 0.0006	0.0011	− 0.586	0.5580	n.s.
	Selling to total training	0.1805	0.0400	4.512	0.0000	×
	Training expenditure per day	− 0.0015	0.0001	− 26.492	0.0000	√
	Market price of productivity	− 0.0278	0.0039	− 7.194	0.0000	√
	Dynamic industry	− 0.1485	0.0209	− 7.122	0.0000	√
	Turnover rate	− 0.1554	0.0163	− 9.554	0.0000	√
Control variables	Size	− 0.0436	0.0046	− 9.440	0.0000	
(Fixed)	Span of control	− 0.3578	0.0633	− 5.650	0.0000	
	Factor 1	0.1088	0.0097	11.249	0.0000	
	Factor 2	0.0644	0.0105	6.132	0.0000	
	Service	0.0197	0.0021	9.387	0.0000	

or the turnover rate is high, firms will be wary of investing in training because of the threat of poaching by competition.

While the theoretical comparative statics pertaining to the obsolescence rate were ambiguous, the *Dynamic Industry* variable is significant and negative. In other words, industries that are rapidly changing tend to have shorter training lengths. This result has face validity in that the relevance of training in these industries does not last very long and hence creates disincentives for firms to invest in training.

There were two effects that did not provide support for the theoretical predictions. The first of these was the *Calls to Close* variable, which we used as a proxy for uncertainty. While the sign of this effect was consistent with theory, it turned out to be insignificant. The coefficient of the ratio of *Selling to Total Training* was the only effect that ran contrary to our expectation. Since this estimate was significant, it can be interpreted as a rejection of our theoretical hypothesis relating to the effectiveness of general training. While it is unclear why this result might have been obtained, our conjecture is that the type of selling training provided by these firms may not be completely "general," and hence may be non-transferable.

Table 5 depicts the estimated variance–covariance matrix. We found very strong evidence of heterogeneity since all diagonal terms in the matrix were significant. This is not surprising since the data consists of firms of varying sizes and from different industries. Clearly, not accounting for such heterogeneity would result in inconsistent estimates of the effects.

To summarize, the empirical analysis finds strong support for four of the key variables (*Turnover Rate, Market Price of Productivity*, *Dynamic Industry*, and *Training Expenditure per Day*). Other hypotheses about the effects of the effectiveness of training in increasing productivity, the initial productivity, and the coefficient of risk aversion on the duration of training could not be tested due to lack of data on those variables. While we would have liked to conduct a more comprehensive test, the availability of suitable data precluded this. We leave this endeavor to future empirical research.

5. Sales force buys training

We now consider the possibility that the firm may allow, or require, salespeople to buy their own training in addition to that provided by the firm. This could involve extra training sessions at the firm or in an outside facility.

Table 5
Estimated variance–covariance matrix* (Ω)

	Intercept	Calls to close	Selling to total training	Training expenditure per day	Market price of productivity	Dynamic industry	Turnover rate
Intercept	0.409350	0.012546	0.048663	0.000254	0.001622	0.177410	0.060027
Calls to close	0.012546	0.000446	0.001368	0.000002	− 0.000021	0.009108	0.002537
Selling to total training	0.048663	0.001368	0.365245	0.000020	− 0.011465	0.249391	0.054975
Training expenditure per day	0.000254	0.000002	0.000020	0.000011	0.000017	− 0.000263	− 0.000010
Market price of productivity	0.001622	− 0.000021	− 0.011465	0.000017	0.005301	− 0.022002	− 0.003650
Dynamic industry	0.177410	0.009108	0.249391	− 0.000263	− 0.022002	0.551145	0.116390
Turnover rate	0.060027	0.002537	0.054975	− 0.000010	− 0.003650	0.116390	0.070746

* All diagonal elements are significant at the $\alpha = 0.05$ level.

The salesperson's willingness to buy training is relevant to the firm's decision of how much training to provide. Note that the "salesperson paying for training" case appears to be equivalent to accepting a lower compensation from the firm and letting the firm pay for the training (Barron et al., 1999). The equivalence is not exact, however, since if the firm provides more compensation, it is not certain that the salesperson will want to use the additional compensation to buy more training. Alternatively, if the firm allows salespeople to buy training, they may over-buy. We show in this section that the latter outcome is in fact the greater problem for the firm.

Let the salesperson buy training $m_1(t)$ after the firm has announced the training it will provide, denoted by $m_2(t)$. The certainty equivalent of the compensation and training exactly matches the outside option available to the employee, as before, hence,

$$\alpha(t) + \beta(t)x(t) - \frac{(m_1(t) + m_2(t) + a(t))^2}{2} - \frac{\gamma\sigma^2\beta^2(t)}{2}$$
$$= g(\rho(t)). \tag{23}$$

Therefore, the salesperson's maximization problem is

$$\max_{m_1(t) \in [0, \bar{m} - m_2(t)]} \int_0^\infty e^{-rt} g(\rho(t)) dt, \tag{24}$$

$$\text{s.t.} \quad \frac{d\rho(t)}{dt} = \theta(m_1(t) + m_2(t)) - \delta\rho(t). \tag{25}$$

Proposition 3 provides the result.

Proposition 3. *It is always optimal for the salesperson to buy the maximum training, i.e., $m_1(t) = \bar{m} - m_2(t), \forall t$. Since $\bar{\rho}$ is optimal for the firm, the firm is indifferent between letting salespeople buy training or providing training itself till $\bar{\rho}$, but does not prefer training beyond that other than maintenance training.*

Salespeople want $m_1(t)$ to be as large as possible to maximize their outside options which are the key determinant to the surplus provided by the firm. Since this is the case, the main issue for the firm is that the salesperson should not be allowed to overbuy training because above $\bar{\rho}$ it becomes suboptimal for the firm to match the outside value of the salesperson and, in the extreme case, it may have to let the salesperson go.

Below $\bar{\rho}$, the reason for the indifference is that the firm can substitute training and compensation. The indifference holds only if the cost of training is identical for the employee and the firm. If the firm can obtain the training at a lower price due to quantity discounts or bargaining power, as is likely to be the case, then the firm would always prefer to provide the training rather than pay the salesperson to acquire it. Likewise, the firm may prefer to maintain quality control and have uniform training for all employees. These reasons may explain the preponderance of firm-provided training in the marketplace despite our result that the two types of training can be economically identical.

6. Conclusions

In this paper, we derive the optimal sales training schedule for a firm using an integrated model of training, compensation, and turnover. This should assist sales managers in understanding how training programs can be scheduled to maximize the firm's long-run profit. Normative guidelines based on the model suggest that a firm should train its salespeople at the highest intensity starting from the beginning of the salesperson's tenure and continuing till a well-defined time. Thereafter, continuous retraining should be provided to maintain the sales force at its optimal productivity.

The training duration depends on various factors. The hypotheses are that training duration decreases if there is an increase in the maximum level of training, the initial productivity of the salespeople, changes in the outside option due to productivity, the proportion of general training, discount rate, turnover rate, risk aversion, or the uncertainty in sales. Empirical analysis of data from various industries supported the analytical results with only one hypothesis, dealing with the effects of the proportion of general training, rejected while another relating to the uncertainty in sales was inconclusive.

In addition to these results we explored the possibility that salespeople might choose to buy training in addition to that provided by the firm. The analysis reveals that the firm is indifferent between providing the training and having salespeople pay for it up to the point where the salesperson becomes over-trained. We discuss reasons why the firm, despite being shown to be indifferent in the analysis, may, in fact, prefer to provide all the training. These reasons include being able to ensure the uniformity and quality of training to its employees.

The paper provides a framework for understanding the scheduling of sales force training and the differences in training practices across corporations. There is need for further research in this area. Parameters such as the proportion of portable training can be time-varying. A stochastic relationship can exist between training and productivity. These features could be included in a stochastic differential game using a closed-loop solution, and would be an important contribution

to the theory. Learning of salespeople over time (e.g., Dearden & Lilien, 1990) and information asymmetry issues (Mishra, Heide, & Cort, 1998) may also be considered.

In our model, we have looked at two categories of training, general and specific training. However, investigation into finer categories of training is necessary. There are many ways to build the content of a training program, some more profitable than others. More or less emphasis can be given to skill development, basic product knowledge, market and customer knowledge, and/or company procedures (for instance). It is important to find not only how much training to give salespersons, but how much of each type of training should be given.

Assumption (A6) states that the firm meets the outside utility of the salesperson at each point in time. While it makes the analysis tractable, deferred compensation schemes could not be investigated. Firms sometimes provide loans to employees to pay for training, and these loans must be repaid if the employee leaves the firm. These types of golden handcuff or deferred compensation schemes warrant further theoretical and empirical investigation. Finally, there is scope for additional empirical work since, due to the limitations of the dataset, several hypotheses could not be tested. Particularly, analysis of data on the initial productivity, the discount rate, and the coefficient of risk aversion would be of value.

Acknowledgements

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