On optimal salesforce compensation in the presence of production learning effects

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This paper presents a theory of multi-period salesforce compensation in which a firm experiences a production learning effect. Firm management uses the salesforce compensation plan to promote current period sales (and production) in order to lower future period production costs. The firm management (principal)–salesperson (agent) relationship is modeled as an agency relationship. The model is a two-period extension of the Basu, Lal, Srinivasan and Staelin (1985) one-period agency model of salesforce compensation. We demonstrate that (relative to the results for the one-period model) firm management should, in the first period, decrease the salary portion of the compensation plan and increase the commission rate (as a percentage of sales). Such changes in the compensation plan motivate the salesperson to increase first period sales effort. The firm is able to increase discounted two-period expected profit by considering production dynamics in this compensation plan. We discuss managerial implications of our model.

1. Introduction

Dynamic pricing and advertising strategies can increase a firm's long-term profitability relative to a static, myopic strategy (see Dolan and Jeuland, 1981; Horsky and Simon, 1983; Kalish, 1983, 1985). Here we consider how a dynamic salesforce compensation plan can be used to achieve the same goal. A firm that produces a product whose costs decline with cumulative production may wish to implement a compensation plan that motivates the salesforce to promote greater current period sales in order to decrease future production costs. This paper develops a theory of salesforce compensation for a firm that experiences a production learning effect and whose goal is to maximize long-term profit.

In many industries manufacturing costs decline with cumulative volume or with production experience (Boston Consulting Group, 1970). This phenomenon is referred to as the *learning curve* or experience curve effect. The relationship between costs and cumulative volume is often expressed in log-linear form, although other functional forms are popular (Yelle, 1979; Hax and Majluf, 1982). The learning curve has been used in decision problems as diverse as management control, cost reduction programs, purchasing decisions, non-manufacturing applications, and management strategy (Yelle, 1979). The possibility to lower future period production costs by increased current period sales and output provides a firm with an incentive to increase current period sales and output.

Dolan and Jeuland (1981) and Kalish (1983) suggest that, in the presence of a production learning effect, a rational firm may lower price in a current period in order to increase current period sales and production and thus to lower future period production costs. Price is a variable that a firm can use to control its demand and, thus, its learning rate. Alternatively, the firm can use its salesforce to achieve the same objective. In this

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paper, we assume that the firm under consideration is a price taker. This assumption is not critical to our results, and its purpose is to isolate the effect of the salesforce compensation function from that of the pricing function on the learning rate.

The paper proceeds in the following manner. In Section 2 we discuss the salesforce motivation problem presented in Basu, Lal, Srinivasan and Staelin (1985a) (hereafter, BLSS). Our models extends the BLSS analysis. Section 3 presents the assumptions and methodology of our model. Section 4 discusses the shape of the optimal compensation plan and then presents comparative statics on how production learning affects the compensation plan. Section 5 discusses managerial implications and conclusions.

2. The BLSS salesforce motivation problem

BLSS analyse a salesforce motivation problem in which sales are conditionally distributed on effort, and the expected value of the sales response is increasing in effort. Their analysis determines optimal compensation schemes, and demonstrates that these schemes specify a combination of salary and commission. One result of the BLSS analysis is that as sales uncertainty increases, the salary portion of the compensation increases, and the commission rate (as a percentage of sales) decreases. With increased uncertainty in the sales environment, there is a greater need for the firm to protect the salesperson from factors other than effort that cause low sales. A major innovation of the BLSS model is that it examines the design of an optimal compensation scheme, and not just the level of commission rates, under the realistic assumption of uncertainty in the relationship between effort and sales. (Berger (1972, 1975) considered sales uncertainty earlier, but he restricted his attention to commission plans only.)

However, the BLSS analysis is restrictive in that the firm has a one-period planning horizon. In their one-period model, the firm will not offer increased commissions (or bonuses) to currently promote a product for its future benefits.

Economists have also examined firm management–salesforce relationships in the context of the principal-agent problem. Holmstrom (1979) and Grossman and Hart (1983) developed the methodology used in BLSS. Moreover, the economics literature also examines multi-period agency problems. The concern of the economics literature on repeated relationships is whether long-term contracts and relationships improve the economic efficiency of an agency relationship (see Hart and Holmstrom (1987) for a review). However, that literature has not addressed the issue of the design of an optimal compensation plan that accounts for the intertemporal cost relationships described here.

In the following sections we develop a theory of salesforce compensation that extends the BLSS analysis. We consider a firm with (i) a multi-period planning horizon, (ii) a production learning effect, and (iii), as in BLSS, uncertainty in the effort–sales relationship.

3. Assumptions and analysis

3.1. Model assumptions

Our analysis uses the agency-theoretic approach, in which the firm (principal) contracts with the salesperson (agent) to sell the firm's product. The firm's problem is to choose a salesforce compensation plan to maximize firm profit, subject to the constraint of motivating a salesperson who has his own objective. The firm cannot pay the salesperson as a function of his effort because of the difficulties and costs of monitoring effort. Thus, the firm chooses a compensation plan, such as salary and some form of commission, that is not based directly on effort.

This agency-theoretic approach borrows from Holmstrom (1979), Grossman and Hart (1983) and BLSS. Our assumptions are as follows.

(1) We consider a two-period model. In each period, there are three stages. In the first stage, the firm presents the salesperson with a contract that states the salary and the commission rate (as a percentage of sales). In the second stage, the salesperson decides the effort (time) to devote to selling the product. In the third stage, the firm produces enough of the product to meet the realized sales, and compensates the salesperson.

(2) The firm's objective is to choose a compensation scheme in each period that maximizes its discounted profit stream (over current and future periods). The firm is farsighted in the sense that it is concerned with the effect of its first period actions on its second period profit. The firm's first period objective function is a two-period extension of the one-period objective function in BLSS. The salesperson's objective in each period, on the other hand, is to maximize his own discounted utility. (This last assumption is discussed later.)

(3) The salesperson's utility function for compensation, s_i, and time devoted to selling, t_i, in each period i (where $i=1,2$) is additively separable as $U(s_i) - V(t_i)$, where U is the utility for compensation and V is the disutility for sales effort. We consider, as do BLSS, the utility function $U(s_i)=2s_i^{1/2}$, and the disutility function $V(t_i)=dt_i^{\gamma}$, where $d>0$ and $\gamma>1.5$. The salesperson's utility from his outside option (next best alternative) is m_i. We assume the salesperson's utility function and m_i are known by both the salesperson and the firm. In addition, the market for salespeople is assumed perfectly competitive.

(4) The marginal cost of production and distribution in period i, c_i, is constant in current period output. Second period unit cost, c_2, is decreasing in first period sales and output x_1. The cost relationship (the learning curve) may be expressed by $c_2(x_1)$, where $c_2>0$, $c_2'<0$, and $c_2''\leqslant 0$. The firm is a price taker in each period, and the market price is normalized to 1.

(5) The dollar sales rate is probabilistically influenced by effort. As BLSS, we examine two distribution functions of sales—the gamma and the binomial distribution. Here, we examine the gamma distribution only. The results for the binomial distribution have the same qualitative features as those for the gamma distribution. For the gamma distribution, the conditional probability density function (pdf) for sales in period i is written as

$$f(x_i\mid t_i)=\frac{1}{\Gamma(\cdot)}\frac{q}{g(t_i)}\times\left(\frac{qx_i}{g(t_i)}\right)^{(q-1)}\mathrm{e}^{-(qx_i)/g(t_i)},$$

where $\Gamma(\cdot)$ is the gamma function. For this distribution, the conditional mean is

$$E(x_i\mid t_i)=g(t_i)$$

and the variance is

$$\operatorname{var}(x_i\mid t_i)=g^2(t_i)/q.$$

We assume the conditional distribution of sales given an effort rate is known by both the salesperson and all firms in the market.

(6) In the first period we assume the firm cannot pre-commit to a second period compensation scheme (Fexias, Guesnerie and Tirole, 1985; Laffont and Tirole, 1987). Consistent with this assumption, we employ the sub-game perfect equilibrium solution concept (Selten, 1975), which requires that whenever an agent is called on to choose an action, he chooses one to maximize his expected payoff from that moment on.

An important implication of this assumption is the following. With an increased learning rate and the resultant increased second period profit margin and optimal sales, the salesperson would earn a share of the gains from the production learning if firm management were to commit at the onset of the first period not to change the compensation package between periods. Thus, with this commitment, the firm may not have to increase first period commission rates and lower first period salary in order to motivate increased first period sales. However, examples abound of firms that do not commit to future compensation schemes and ratchet down salesforces' compensation package and economic rent after sales successes. Thus, we impose sub-game perfection.

Several of these assumptions, although common in agency theory, deserve comment. First we assume that the firm (as well as its competitors) know the sales response function for each salesperson. This assumption implies that a salesperson's sales rate does not necessarily indicate his ability; rather, each firm in a market knows a salesperson's ability independently. A salesperson then cannot modify his market value by his specific actions: a salesperson is motivated only by his own firm's compensation scheme.

Holmstrom (1982a) considers problems in which sales do indicate ability. Thus, a salesperson may increase current period effort in order to increase future period market value. An interesting problem that has been considered in the economics of search literature (see Lippman and McCall, 1976) is one in which a salesperson's employer has better information about the salesperson's ability than other firms in the market. In this case, the probability that a salesperson leaves a firm is decreasing in his ability. The firm can optimally choose to increase compensation for (and retain) better salespeople, and to let poor performers go.

Depending on the degree of market information about salespeople, either our model or one in which the salesperson's performance signals his ability to the firms in the market is more appropriate. However, our results will be consistent with those modeling incomplete information about salesperson ability: if sales indicate ability, an increased production learning rate will cause the firm to change the compensation scheme in order to promote increased current period sales effort.

Second, under the assumption of a perfectly competitive salesperson labor market and no commitment in compensation contracts (under the sub-game perfect equilibrium solution concept), the firm compensates the salesperson in each period such that his expected utility from working for the firm is equal to m_i in that period. There are three implications of this assumption.

(a) The salesperson's second period expected utility is not increasing in his first period sales. (With a larger profit margin in the second period, the firm offers a larger second period commission rate and a lower second period salary: while holding second period expected utility for the salesperson constant at m_i. This result is established in BLSS. Thus, the second period compensation plan, and not the salesperson's expected utility, depends on the first period sales rate.) The salesperson does not derive any of the benefits of the decreased costs from the production learning effect. This is related to a general problem in repeated agency relationships—the ratchet effect (see Dearden, Ickes and Samuelson, 1990).

(b) If a salesperson improves his performance over time, his m_i increases, the firm keeps the same salesperson over time, and it does so at no additional cost relative to hiring a new salesperson.

(c) Because the salesperson's expected utility is independent of first period sales, his first period sales effort if he is farsighted will be the same as if he were myopic. This is a result of the structure of the compensation scheme, so our results apply to a salesperson who is either myopic or farsighted.

Third, agency problems generally assume a perfectly competitive labor market and that the agent (or salesperson) has no "bargaining power". The salesperson earns no more than his market value from any firm, so the firm offers the salesperson a "take-it-or-leave-it" contract, in which the firm knows the market value of the salesperson (or the minimum amount that the salesperson will take). Future research should empirically examine the "bargaining power" salespeople have in negotiating compensation contracts.

Fourth, because we examine a two-period model, the firm is myopic in the second period. Thus, in the second period, we essentially have a BLSS model. A more realistic, operational model should consider a far longer time horizon. However, our research really focuses on the effect the future (the second period) has on what the compensation scheme should look like now (the first period). For this purpose, two periods are sufficient; with a production learning effect between the first and second periods, our model can examine how the firm should change first period compensation. The direction and type of change will be the same whether the effect lasts for one period in the future or for many periods.

Finally, our model assumes that each salesperson receives a customized compensation package and that each salesperson's actions have no effect on other salespeople. Hence, we do not examine how a firm compensates salespeople when there are "team" sales. Lal and Staelin (1986) and Holmstrom (1982b) address this problem. Another way to view our results is that the firm employs many independent salespeople, each of whose effects add to learning. The result would be a different level of learning (since the selling effort of the sales people combine), but the effect would be directionally equivalent to our results here. This assumption limits the operational character of our results but not their basic nature.

3.2. The formal model

Following BLSS, the firm's second period optimization problem, given realized first period sales $\bar{x}_1$ (where the overbar indicates a realized value), is

$$\begin{aligned}\max_{s(x_2),t_2} \int & \{[1-c_2(\bar{x}_1)]x_2 - s(x_2)\} \\ & \times f(x_2 \mid t_2)\,\mathrm{d}x_2 \\ & + \theta_2\left\{\int U(s(x_2))f(x_2 \mid t_2)\,\mathrm{d}x_2 \right.\\ & \left. \qquad - V(t_2) - m_2\right\} \\ & + \mu_2\left\{\int U(s(x_2))f_{t_2}(x_2 \mid t_2)\,\mathrm{d}x_2 \right.\\ & \left. \qquad - V'(t_2)\right\}, \end{aligned} \qquad (1)$$

where

$f_{t_i}(x_i \mid t_i) = \mathrm{d}f(x_i \mid t_i)/\mathrm{d}t_i$

and

$V'(t_i) = \mathrm{d}V(t_i)/\mathrm{d}t_i$.

The compensation function $s^*(x_2)$ and the sales effort function t_2^* solve this problem. The first constraint, the term multiplied by θ_2, states that the firm compensates the salesperson so that his expected utility from staying with the firm, given $s(x_2)$ and t_2, is equal to his expected utility from joining a new firm. The second constraint, the term multiplied by μ_2, states that the salesperson chooses t_2 to maximize his or her utility.

In the first period, following the sub-game perfect equilibrium requirement, the firm solves the problem

$$\begin{aligned}\max_{s(x_1),t_1} & \int \{[1-c_1]x_1 - s(x_1)\}f(x_1 \mid t_1)\,\mathrm{d}x_1 \\ & + D\int\int\{[1-c_2(x_1)]x_2 - s^*(x_2)\} \\ & \qquad \times f(x_1 \mid t_1)f(x_2 \mid t_2^*)\,\mathrm{d}x_1\,\mathrm{d}x_2 \\ & + \theta_1\left\{\int U(s(x_1))f(x_1 \mid t_1)\,\mathrm{d}x_1 \right.\\ & \left. \qquad - V(t_1) - m_1\right\} \\ & + \mu_1\left\{\int U(s(x_1))f_{t_1}(x_1 \mid t_1)\,\mathrm{d}x_1 - V'(t_1)\right\}. \end{aligned} \qquad (2)$$

The first-order conditions for the second period optimization problem are identical to those presented in BLSS, and the first-order conditions for the first period problem are presented in Dearden and Lilien (1990).

From BLSS, the optimal period i compensation function for the gamma distribution is given as

$$s(x_i) = \left[\theta_1 + \frac{\mu_i g'(t_i) g}{g^2(t_i)} [x_1 - g(t_i)]\right]^2. \tag{3}$$

The compensation functions may be written as

$$s(x_i) = [A_i + B_i x_i]^2, \tag{4}$$

where A_i is the salary component, and B_i is the commission component of the compensation package.

4. Shape of the optimal compensation plan: Results and numerical example

4.1. Results

There are many variables that determine a firm's optimal salesforce compensation plan in our analysis. As in BLSS, the optimal plan is affected by (1) the uncertainty in the sales environment, (2) the profit margin, (3) the salesperson's market value, (4) the effectiveness of sales effort, and (5) the base level of sales. Our analysis differs from BLSS in that we examine the effect of the production learning curve on two components of the first period compensation scheme—the salary component (denoted by A_1) and the commission rate for each sales rate (denoted by B_1). Next we present a proposition that summarizes the effect of the production learning curve.

Proposition 4.1. *The greater the increase in second period discounted expected profit from an increase in first period sales* (x_1), *the less the first period salary component of compensation* (A_1) *and the greater the first period commission rate* (B_1).

Sketch of proof. Dearden and Lilien (1990) provide details of the proof; we sketch it here. In the proof, the present authors consider the gamma distribution only. The proof proceeds in three steps. First, we demonstrate that the second period expected profit (Π_2^*) is decreasing in c_2 (where the asterisk indicates the optimized function). Thus, Π_2^* is increasing in $\bar{x}_1$, because c_2 is decreasing in $\bar{x}_1$. Second, we borrow from BLSS, who show that A_1 is decreasing in t_1 and B_1 is increasing in t_1. Third, we prove that the greater the increase in Π_2^* from an increase in $\bar{x}_1$, the greater t_1. These three steps prove the claim of the proposition. □

Figure 1 summarizes the result of Proposition 4.1.

One important result of Proposition 4.1 is that the farsighted firm can increase expected

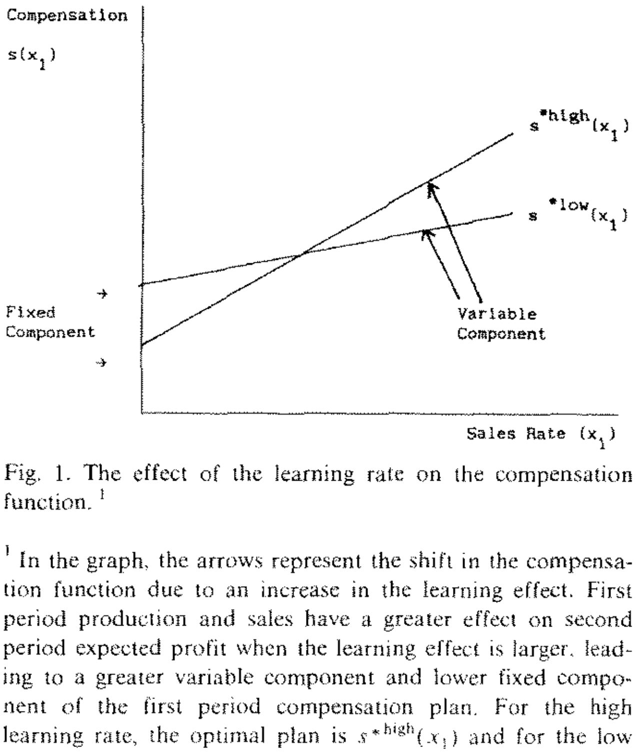

Fig. 1. The effect of the learning rate on the compensation function.[1]

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[1] In the graph, the arrows represent the shift in the compensation function due to an increase in the learning effect. First period production and sales have a greater effect on second period expected profit when the learning effect is larger, leading to a greater variable component and lower fixed component of the first period compensation plan. For the high learning rate, the optimal plan is $s^{*\text{high}}(x_1)$ and for the low learning rate the optimal plan is $s^{*\text{low}}(x_1)$.

profit by employing a compensation scheme that optimally accounts for the production learning effect. The discounted profit rate, $\Pi_1 + D\Pi_2$, from the optimal choices, t_1^*, t_2^*, $s^*(x_1)$, and $s^*(x_2)$, which solve equations (1) and (2), is strictly greater than the discounted profit rate from the choices for the myopic firm, $\hat{t}_1$, $\hat{t}_2$, $\hat{s}(x_1)$, and $\hat{s}(x_2)$, which solve the BLSS model, if $D > 0$ and $c_2'(\bar{x}_1) < 0$.

4.2. Numerical analysis

We now demonstrate the results of the model in terms of a numerical analysis. Consider a learning curve where $c_2(x_2) = 0.9 - b\bar{x}_1$. We thus examine a linear learning curve to approximate the more common log-linear form; the difference between these forms in the regions we will study are minimal. The parameter b is the marginal effect of first period sales ($\bar{x}_1$) on second period unit cost of production (c_2). We use the gamma distribution for the sales response function and set $E(x_i \mid t_i) = 1 + 10t_i$, $D = 0.9$, $a = 0.9$, $\gamma = 2$, $q = 100$, $c_1 = 0.9$, and $m_i = 1$. We vary the slope of the learning curve, b, and examine the resultant changes in the first period optimal compensation schemes, the time devoted to sales in each period, and the profit rate for the farsighted and for the myopic firm. In our model, a value of $b = 0.02$ corresponds to approximately a 25% decrease in unit cost for the farsighted firm, when $E(x_1 \mid t_1)$ is at its optimal rate. Table 1 provides these results.

There are two important results from the numerical analysis. First, the myopic firm's first period compensation plan, selling time t_1, and profit rate Π_1 are invariant with respect to the size of the learning curve, since the myopic firm ignores the learning effect.

Table 1
The effect of the learning rate on the optimal compensation plan and profitability [a]

				The myopic firm					
Learning rate b	Period 1 effort t_1^*	Period 2 effort t_2^*	Period 1 salary A_1	Period 1 commission B_1	Relative cost c_2/c_1	Period 1 profit Π_1^*	Period 2 profit Π_2^*	Discounted total profit $\Pi_1^* + D\Pi_2^*$	
0.0000	0.6759	0.6759	0.3520	0.0678	1.000	0.2425	0.2487	0.4662	
0.0002	0.6759	0.6765	0.3520	0.0678	0.998	0.2425	0.2546	0.4716	
0.001	0.6759	0.6787	0.3520	0.0678	0.991	0.2425	0.3010	0.5152	
0.002	0.6759	0.6815	0.3520	0.0678	0.983	0.2425	0.3639	0.5699	
0.005	0.6759	0.6896	0.3520	0.0678	0.958	0.2425	0.5486	0.7363	
0.010	0.6759	0.7031	0.3520	0.0678	0.914	0.2425	0.8648	1.0208	
0.020	0.6759	0.7290	0.3520	0.0678	0.828	0.2425	1.3644	1.4705	
				The farsighted firm					
b	t_1^*	t_2^*	A_1	B_1	c_2/c_1	Π_1^*	Π_2^*	$\Pi_1^* + D\Pi_2^*$	Percent improvement of farsighted vs. myopic firm (%)
0.0000	0.6759	0.6759	0.3520	0.0678	1.000	0.2425	0.2487	0.4662	–
0.0002	0.6816	0.6765	0.3498	0.0682	0.997	0.2424	0.2547	0.4718	0.03
0.001	0.7040	0.6788	0.3409	0.0704	0.990	0.2415	0.3052	0.5161	0.17
0.002	0.7310	0.6819	0.3299	0.0731	0.981	0.2387	0.3725	0.5739	0.70
0.005	0.8066	0.6923	0.2970	0.0807	0.952	0.2201	0.6014	0.7613	3.40
0.010	0.9189	0.7125	0.2430	0.0919	0.887	0.1597	1.0687	1.1216	9.87
0.020	10.1119	0.7608	0.1353	0.1112	0.731	.0787	2.3198	2.1665	47.33

[a] For the numerical exercise, the parameter values are $E(x_i \mid t_i) = 1 + 10t_i$, $D = 0.9$, $a = 0.9$, $q = 100$, $m_i = 1$, $c_1 = 0.9$, and $c_2(\bar{x}_1) = 0.9 - b\bar{x}_1$. Note that a value of $b = 0.02$ corresponds to roughly a drop in unit cost (at maximal expected sales) of 25%; other values of b have similar interpretations.

For the farsighted firm, the first period salary parameter A_1 is decreasing and the commission rate B_1 is increasing in b. Also, for the farsighted firm, first period selling effort is increasing in b. Therefore, the farsighted firm promotes greater first period selling effort by increasing the first period commission rate and decreasing the first period salary. The result is an increase in the discounted expected profit stream for the farsighted firm over that of the myopic firm. Also, notice that, comparing first period expected profit of the farsighted and myopic firms, the farsighted firm accepts a decrease in first period profit in order to invest in the production cost decline and ultimately to increase the discounted profit stream.

Second, when there is no learning curve ($b = 0$), the results are identical to those of BLSS. As the learning rate increases, the percentage improvement in expected profit from the farsighted compensation plan over the myopic compensation plan increases. For $b = 0.02$, there is a 47% increase in profits from the farsighted plan over the myopic plan. Also, as the learning rate increases, the relative cost (c_2/c_1) decreases at a faster rate for the myopic firm than for the farsighted firm. Thus, firms with larger learning rates (and larger discount factors) gain more by employing a compensation scheme that optimally accounts for a production learning effect. And, as the learning effect increases, the first period optimal compensation scheme for the farsighted firm moves further from the compensation scheme for the myopic firm (as derived in BLSS).

5. Managerial implications and conclusions

Our results apply to the wide range of sales environments described in BLSS for the gamma (and binomial) distributions. However, our analysis is limited in that we have examined one specific utility function and our results require a number of other technical assumptions described above. These conditions are quite reasonable, however, and the key result—that the firm can increase long-term profitability by coordinating salesforce compensation with production economies—should hold in most real environments.

Our results are analogous to those of Dolan and Jeuland (1981) and Kalish (1983, 1985) in the sense that a firm may either lower price (if it is not a price taker), or provide the salesforce with incentives to promote current period sales. Our results may be contrasted with BLSS in that here a firm bases its current period compensation plan on future period variables as well as current period variables.

An extension of this work could consider the design of an optimal compensation plan in which the firm produces multiple products (Srinivasan, 1981, examines a one-period model of this type). We suspect that the firm, in this case, will also increase the first period commission rates and decrease salary for the product with the learning effect. However, the magnitude of the changes may well be different. It may also prove valuable to model the firm directly as an employer of multiple salespeople. Modeling group sales effort may present some challenging issues for further research (Holmstrom, 1982b; Lal and Staelin, 1986; Fudenberg, Holmstrom and Milgrom, 1987). In addition, further work might consider risk-averse salespeople who deflate response functions in optimizing their behavior, a different and, perhaps, more realistic model of how the salesperson responds to the compensation and sales-response environment.

From the standpoint of application, we have three comments. First, both practitioners and academics recognise both the possible importance of instilling a long-term orientation in salespeople and the different types of long-term orientation. John and

Weitz (1989), in synthesizing the salesforce management literature, state that:

> Plans emphasizing salary are recommended when firms want their salespeople to adopt a long-term orientation and invest time servicing accounts to realize future sales. Deemphasis of incentives based on present sales encourages salespeople to forgo sales that will not be in their customers' long-term best interest. In contrast, plans emphasizing incentives are advocated when firms are entering a new market and seeking to build up short-term sales. (p. 3)

This statement sheds light on the complexity of salesforce compensation for a firm with intertemporal sales effects. Our model and results apply to a firm whose goal is to build short-term sales—in order to lower future period production costs. As John and Weitz (1989) recognise, there are other intertemporal issues. The firm's goal may be to deemphasize current sales in order to build new accounts. If building a future account requires several periods before fruition, it may not be possible for the firm to use current period commissions on that account to promote its future period sales.

In our model, the larger the production learning rate, the greater should be the decrease in salary and the larger the increase in the commission portion of the compensation package during the introductory periods of the product. Moreover, the larger the production learning rate, the greater the gain in profitability from adopting our recommendations. However, the precise values for the salary and commission components of the compensation package depend on firm specific characteristics, such as equity across salespeople, the salesforce's response to financial incentives, regions and product lines, understandability and the like. Our example in the last section illustrates this phenomenon; empirical testing and gaming experiments will be required to move these results toward implementation. (Darmon, 1987, for example, empirically examined salespersons' behavioral patterns in responding to financial incentives.)

Our results are easily understood and easy to implement. Firm managers should employ an analysis similar to ours, with assumptions appropriate to the firm, in order to determine an optimal compensation scheme. Currently, many firms offer bonuses for selling new products because they are difficult to sell and the products offer large carryover effects on the demand side. (In our analysis, if we model demand carryover effects, the results are analogous to those we derive for the production learning effect. With an increased carryover effect, the firm should lower salary and increase commission in order to promote first period sales. The proof of this proposition, although not included in this exposition, is similar to a proof in Dearden and Lilien, 1990.)

Second, the coordination between production management and sales management to implement the farsighted compensation plan we suggest is minimal. Sales management needs to be aware of the expected learning effect.

Third, a critical problem in implementing such a compensation program is whether the salesforce will accept such a change. Note that under both the myopic compensation plan and the farsighted plan, the salesperson earns an expected utility of m_1 in the first period and m_2 in the second period (this result is derived from the optimization problem). Thus, the salesperson should be indifferent to the change from the myopic to the more farsighted compensation package. The salesforce could be motivated to accept this change by an overall increase in compensation, perhaps by having the firm institute a share of its increased expected profit to overcome whatever disutility the salesperson may perceive as a result of the more complex compensation scheme.

Our comments and results on intertemporal sales issues are not surprising and support the conventional wisdom that in designing a current period compensation scheme a firm may sacrifice current period profit in order to promote future period sales and profitability. As for our specific model, there is a plethora of examples of firms that offer bonuses or increased commission on new products. With new products a firm often faces a both a production learning effect and intertemporal demand effects, and we believe that firms consider both demand and production sides when promoting new products.

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