Gone Today, Here Tomorrow: Behavioral Causes of Product Returns in the Agribusiness Industry

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Abstract

Hybrid seed suppliers experience excessive and costly rates of seed returns from dealers, who order in advance of grower demand realization and may return unsold seeds at the end of the season. Here we develop a formal dynamic model of the interaction of sales effort allocation and dealer hoarding behavior to understand the dynamics of corn seed returns through a model-based field study. Sales representatives know they should carefully gather information on grower demand for seed types and quantities to improve their demand forecast (positioning effort). However, they abandon time-consuming seed positioning late in the sales cycle to push out dealers' inflated orders and quickly meet revenue quotas. Such push effort leads to excessive returns in the next period, generating more inflated orders by dealers and increasing the total sales that agents must achieve to meet their quota, requiring them to push still more seed. Depending on the availability of sales resources, this biased sales effort allocation can generate a self-perpetuating stream of returns. Our analysis highlights the importance of adequately managing sales resources to ensure desired system performance while maintaining system robustness.

Keywords: Salesforce management; sales resource allocation; behavioral modeling; system dynamics.

1. Introduction

The hybrid seed industry experiences excessive and costly rates of seed returns (10% – 30%) from dealers. The demand for hybrid seeds such as corn is highly uncertain, heterogeneous, and deeply influenced by weather and current crop productivity. Year-to-year uncertainty in total corn planted area is high due to changes in prices and supplies (Westcott et al. 2003); planted area uncertainty by region and farm size is even higher. Supply is characterized by long product development and production delays. Suppliers offer hundreds of products, with several new seed hybrids each year. Short and unpredictable product lifecycles lead to rapid turnover of seed hybrids in the catalog. Corn-seed production decisions occur months in advance of grower demand, leading to common short supply of specific hybrids. Due to uncertain demand and limited supply, dealers place their orders before grower demand is available and inflate them above demand expectations to hedge against shortages of possibly high performing hybrids. Aware of dealer hedging behavior, sales representatives gather information on grower demand for seed types and quantities (also known as positioning seeds) to improve their demand forecast. Such positioning effort improves sales forecasts and matches the supply of limited seed hybrids with uncertain demand, reducing returns this period. However, as pressure to meet revenue targets builds up late in the sales period, salespeople abandon time-consuming seed positioning to push out dealers' inflated orders and quickly increase revenues. The effort to push originally inflated orders leads to excessive returns this period. Clearly, the balance between the amounts of seeds positioned and pushed influences the total percentage of seeds returned this period. However, because salespeople receive bonuses for seeds shipped this period but compensate for seeds returned in the following period, seeds returned this period influence pressure on salespeople to meet sales targets next period. Hence, periods are not independent. Sales returns in one period influences sales pressure and returns in future periods. This paper seeks to understand what factors contribute to the level of returns that seed suppliers may experience and how do returns evolve over time.

Here we describe a field study and develop a formal model of the interaction of sales effort allocation and dealer hoarding behavior to understand the dynamics of corn seed returns in the agribusiness industry. To develop the physical features (e.g., shipments, returns) of our model, we draw on our field work and interviews with managers at the supplier and dealers. On the behavioral side, we rely on research on cognitive psychology and human decision making (Hogarth 1987, Kahneman et al 1982, Plous 1993, Gersick 1988, Sterman 1989). To capture the interdependency and feedback processes between the physical and behavioral components, we rely on research on system dynamics (Forrester 1961, Morecroft 1985, Sterman 2000, Repenning 2001). Our research suggests that a key factor contributing to excessive seed returns is the unplanned allocation of sales resources to meet revenue quotas late in the sales cycle. In particular, we find that: (1) managerial pressure and sales representatives' efforts to meet quotas coupled with dealer hoarding of scarce products can lead to high return rates, and (2) this mechanism is self-reinforcing. In addition, sales resource utilization plays a major role determining whether the system can present this self-reinforcing mechanism leading to a high-return equilibrium.

Because salespeople must allocate effort between working hard (pushing seeds, i.e., improving performance by requesting dealers to take early delivery of seeds) and working smart (positioning seeds, i.e., generating a better forecast through information gathering on grower demand), a choice to allocate *more* effort to working hard is also a choice to allocate *less* effort to working smart. Task interdependence is particularly important when demand is highly uncertain and salespeople play a crucial role in generating better demand forecasts. Since demand is highly uncertain in the agribusiness industry, pushing seeds contributes to excessive returns because it *prevents* salespeople from generating better forecasts through positioning. Unfortunately, task interdependency is also the case in many different sales environments. The publishing industry, where return rates average 35%, is of particular interest, because demand uncertainty is extremely high and market research is limited (Boss 2007). At the same time, Rogers and Tibben-Lembke (1999) suggest that publishing industry sales have been decreasing, placing greater stress on salespeople to meet their revenue targets. With inadequate demand forecasting tools and increased pressure to meet revenue targets, salespeople in the publishing industry focus on working hard.

This research provides one example of an adaptation study (as defined by Gino and Pisano 2006) in behavioral operations management (Boudreau et al. 2003, Bendoly et al. 2006). In particular, we offer a better understanding of how salespeople are likely to behave in multi-task sales environments, and describe how such behavior and cognitive biases affect resource allocation, leading to excessive returns. While a traditional prescription to the problem described here would be to implement adequate incentives for salespeople and dealers, our analysis shows that due to the strong influence of sales resource utilization incentives help but can be ineffective at solving the problem. Moreover, there are strong behavioral and cognitive reasons why allocating effort to pushing seeds takes precedence over positioning them. Resource allocation is commonly biased toward tasks with higher short-term benefit (such as cutting corners or working harder), especially under stressful conditions (Oliva and Sterman2001, Repenning and Sterman 2002). Hence, initial errors resulting from this biased resource allocation are self-reinforcing, driving the system to a low level of performance. While there can be several causes of returns, this work describes how biased sales effort allocation can generate a self-perpetuating stream of returns.

The paper proceeds as follows. The next section presents the field site. Section 3 develops a stylized model that captures the essential dynamics of returns in the seed supply chain. Section 4 shows the behavior of the model, and proves that the system is characterized by multiple equilibria separated by a tipping point. We conclude with a discussion of our results and its implications.

2. Field site

Seed suppliers often endorse some level of returns, encouraging dealers to overstock seeds to stimulate opportunistic sales or to limit competitors' shelf space. While the benefits associated with additional sales exist, the costs associated with excessive returns may far outweigh them. Our model rests on data gathered from a three-month in-depth study of excessive rates of seed returns at a major U.S. supplier of hybrid corn and soybean seeds (Figure 1a). In 2001, the direct costs (e.g., transportation, discards, testing, reconditioning, repackaging) associated with corn returns at the field site peaked at 15% of net income. The indirect costs due to excess capacity were also large since total production was 70% higher than net sales.

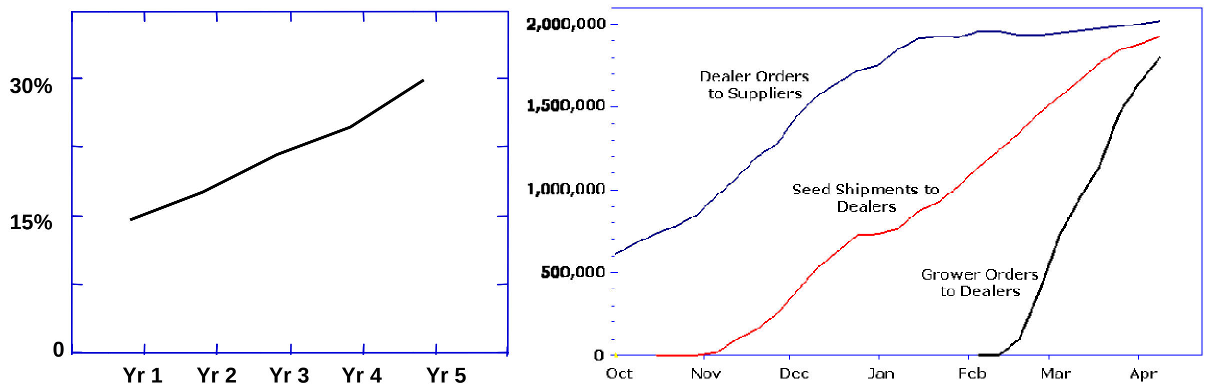

Figure 1. (a) Percent of corn-seed returns and (b) timing and volume of orders and shipments.

In the seed supply chain, the supplier sells seeds to dealers, who resell them to growers. To secure access to limited supply, dealers place orders with the supplier early in the sales season, much before grower demand materializes (Figure 1b). Shipments from suppliers to dealers also take place months in advance of demand. Growers base their orders on seed hybrids that perform well in the current harvesting season (November to December) and start placing orders with dealers late in the sales season, after harvesting. Since seed hybrid performance is highly uncertain and dependent on weather conditions, dealer orders placed early may differ widely from grower orders, often leading to a high volume of returns.

During our field work, we conducted approximately thirty semi-structured interviews with company and dealer managers. Most of the interviewees (80%) were managers at the seed supplier in charge of operations, logistics, quarterly initiatives, production planning, demand forecasting, sales, order processing, and supply chain management. The remaining interviewees (20%) were managers working at dealers. The quantitative and qualitative data support the development of a system dynamics model of the problem, providing crucial information on managers' and salespeople's decision heuristics for performing daily activities, causal relationships among different areas of the business, and specific data on monthly returns and net sales, weekly requests and shipment rates, quarterly sales quotas, and fraction of such quotas met by salespeople. To develop our general theory of sales resource allocation, we follow standard methods for the development of grounded theory case study research through ethnographic fieldwork (Glaser and Strauss 1967, Eisenhardt 1989).

3. Model Overview

The seed supplier sales operations start at the beginning of the fourth quarter (Q4) and finish at the end of the first quarter (Q1) of every year. No dynamics contributing to sales or returns take place during Q2 and Q3; hence, these quarters are not modeled explicitly. Dealers place a large fraction of their orders at the beginning of the sales season (October) and returns occur at the end of the sales season (April). For computational convenience and simplicity, we account for orders as occurring at the beginning and returns at the end of each quarter. The quarterly orders and returns representation allows each quarter to be mathematically equivalent and can be interpreted as the fraction of orders and returns that have occurred in that quarter. Figure 2 provides an overview of the stylized seed sales process.

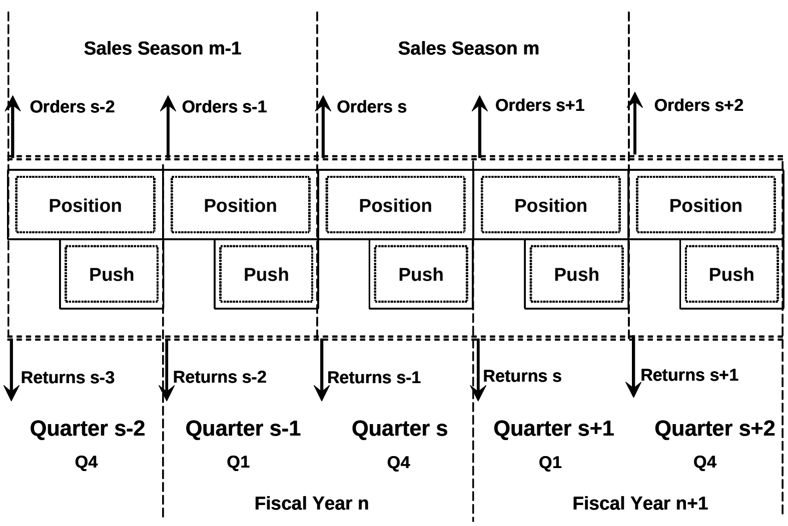

Figure 2. Overview of seed sales process.

During the sales season, salespeople must perform two (very different) types of tasks: *position* seeds with, or *push* seeds to dealers. Positioning means salespeople gather information on grower demand, before it is realized. Through field trips and interviews with growers and dealers, salespeople seek to understand which hybrids used in the previous season were high performing (similar hybrids will likely be in high demand this season); explore growers' intentions to maintain planted areas or to rotate between crops; review the previous season's hot selling hybrids; and survey dealers' intentions to gain market share. Positioning seeds is a time intensive task. However, salespeople's positioning effort leads to an improved sales forecast, more effectively matching the supply with the highly heterogeneous demand. In contrast, pushing seeds to dealers does not improve the order forecast. Pushing seeds is comparatively quick and involves making phone calls to request dealers to take delivery of early inflated orders placed. By pushing seeds, salespeople increase their revenue contribution, rapidly closing the gap to their quarterly revenue targets.

The marketing literature offers similar concepts to the positioning and pushing tasks found in the agribusiness industry. Sujan (1986) and Weitz, Sujan and Sujan (1986) define *working smart* as the development of knowledge about sales situations and effective use of such knowledge and *working hard* as the overall amount of sales effort. We equate sales positioning effort to working smart, because it develops knowledge about potential seed sales via improved demand forecasts; and sales pushing effort to working hard. Analogously, Hauser, Simester, and Wernerfelt (1994) argue that "all employees (managers, product designers, service providers, production workers, etc.) allocate their effort between actions that influence current period sales and actions that influence sales in future periods." Efforts that help current period sales are called *ephemeral*; those that help future sales are *enduring*. The distinction suggests that while the former activities have a short-term beneficial impact, the latter have a beneficial long-term impact. As it will be shown later, pushing and positioning efforts can also be associated with short-term and long-term gains.

While both activities consume the same resource (*salespeople's hours*, H), averaging about 50 hours/week, the time required to position (T_A) a certain quantity of seeds is substantially higher than the time necessary to push (T_B) the same amount. The time to position (T_A) a load (L) of 40 bags of corn at dealers is on average 5 hours, whereas the time to push (T_B) the same amount is on average 1 hour.[2] Assuming a constant number of salespeople in the *workforce* (W), we obtain the positioning rate (A) and pushing rate (B), in number of bags of corn/week, from the ratio of the total number of salespeople's hours to the time to place (position or push) them at dealers.

$$A = \frac{W \cdot H \cdot L}{T_A} \text{ and } B = \frac{W \cdot H \cdot L}{T_B} \quad (1)$$

An important aspect of both activities is the impact they have on the probability of future returns. Since salespeople's positioning effort results in a better forecast of grower demand, it allows them to better align supply availability with specific dealers' needs, thereby reducing the probability of future returns. In contrast, since salespeople's pushing effort results in shipping inflated orders to dealers, it does not align supply to demand leading to a high probability of future returns. We assume a fixed low probability of returns, P_L, when salespeople position seeds and a high probability of returns, P_L+P_H, when salespeople push them. P_L is the probability of returns that cannot be avoided by gathering demand information through positioning; and, P_H is the probability of returns that can.

We disaggregate the inventory of seeds at dealers in two types: "right" and "wrong" seeds. Inventory of "right" seeds have the corresponding grower demand and can generate final sales. In contrast, "wrong" seeds inventory cannot generate final sales and must be returned to the supplier at the end of the selling season.[3] We do not know *a priori* whether seeds are the "right" or the "wrong" ones, however, they are determined by the probability of returns, which depends on whether salespeople are positioning or pushing seeds and their associated return probabilities. As the pressure to meet quarterly goals (p) reaches a threshold (p_T), positioning gives way to pushing, and the *Probability of Shipping Wrong Seeds* (P_W) increases from the minimum, unavoidable level P_L towards P_L+P_H:

[2] Average (and standard deviation) times to position and push corn seeds were estimated using one year of seed shipment data and responses from interviews with sales managers to identify periods where seeds were positioned or pushed.
[3] We assume that once the corn-seeds reach a specific dealer location they are not shipped to another one. In the real system, the supplier has no visibility of dealers' inventory and there are no cross-shipments among dealers.

$$P_W = \alpha P_L + (1-\alpha)(P_L + P_H) \quad \text{and} \quad \alpha = \begin{cases} 1, \ if \ \ p < p_T \\ 0, \ if \ \ p \geq p_T \end{cases} \tag{2}$$

where α is the fraction of resources allocated to positioning seeds and p_T is an arbitrary pressure threshold determining when salespeople shift from positioning to pushing.

The pressure to meet the quarterly revenue goals determines whether salespeople position or push seeds. When pressure is low salespeople position all seeds. However, as the pressure rises above the threshold, salespeople shift to pushing mode.[4] We model the pressure to meet quarterly revenue goals as the revenue needed to meet the quota relative to the time remaining to do so. Specifically, the pressure is the ratio of the revenue gap fraction (RG_F) to the time remaining fraction (TR_F). The proposed pressure formulation leads to a pattern of behavior that is consistent with the explanations obtained from the value function of Prospect Theory (Kahneman and Tversky 1979) for empirical results in the goal literature on effort (Heath, Larrick and Wu 1999).

$$p(s,t) = \frac{RG_F(s,t)}{TR_F(s,t)} \tag{3}$$

where quarters are discrete and indexed by s, time within a quarter is continuous and indexed by t, and $p(s,t)$ is the pressure in quarter s at time t.

The fractional revenue gap measures the fraction of the original distance remaining to the revenue goal. Hanssens and Levien (1983) and Carroll et al. (1985) have used a similar construct to measure recruiter pressure in navy enlistment programs. More recently, Kivetz, Urminsky, and Zheng (2006) named it the goal-distance model and used it to describe the rate at which customers allocate effort as a function of the fractional distance remaining to the goal. Here, the fractional revenue gap (RG_F) is modeled as the difference between the target revenue (R^*) plus lost revenues from previous quarter returns ($R_L(s\text{-}1)$) and current accumulated gross revenues (R_G), normalized by the target revenue (R^*) and

[4] As a test of model robustness, we formulated a linear sales effort allocation on both positioning and pushing tasks as pressure increases. The linear allocation yields similar results to the discrete shift; however, it is analytically messier. We use the threshold formulation for tractability.

last quarter lost revenues ($R_L(s\text{-}1)$). That is, to meet the quota this period the salesperson must achieve revenues of R^* plus enough revenues to cover the cost of returns from last period.

$$RG_F(s,t) = \frac{\left(R^*(s) + R_L(s-1)\right) - R_G(s,t)}{\left(R^*(s) + R_L(s-1)\right)} \tag{4}$$

While the time remaining to make a decision is not traditionally incorporated in many marketing models, research applying regret theory to model the impact of coupon expiration date on consumer behavior suggests that high redemption rates take place just prior to the expiration date (Inman and McAlister 1994). In addition, time remaining is a major component of hyperbolic discounting theory, a theory that helps to describe choice behavior over time (Ainsle and Haslam 1992). The fractional time remaining in the quarter (TR_F) is given by the ratio of the time remaining (T_R) to the total time available in the quarter, T (13 weeks), where the time remaining is given by the total time in the quarter (T) minus the time elapsed (t).[5]

$$TR_F(s,t) = \frac{T-t}{T} \tag{5}$$

3.1. Model Structure

Figure 3 provides a more detailed view of the central structure in a system dynamics model of the corn-seed supply chain. Stocks, represented by rectangles, correspond to accumulations of seeds. Stocks are mathematically equivalent to integrals. Flows, represented by arrows with valve symbols, correspond to actions, such as shipments. Flows are mathematically equivalent to derivatives. Solid arrows capture the influence of other variables on the flows.

[5] As time to meet revenue quotas elapses, the fractional time remaining approaches zero and salespeople pressure rocket toward infinitum. It is possible to improve on the formulation above by adding a constant, τ, characterizing the minimum fractional time required to complete the simplest task. This more robust formulation is consistent with Mazur (1987), but unnecessary here. In our hybrid discrete-quarters continuous-time model, model parameters are reinitialized at the beginning/end of each quarter and the maximum sales pressure is inversely proportional to the time step of integration.

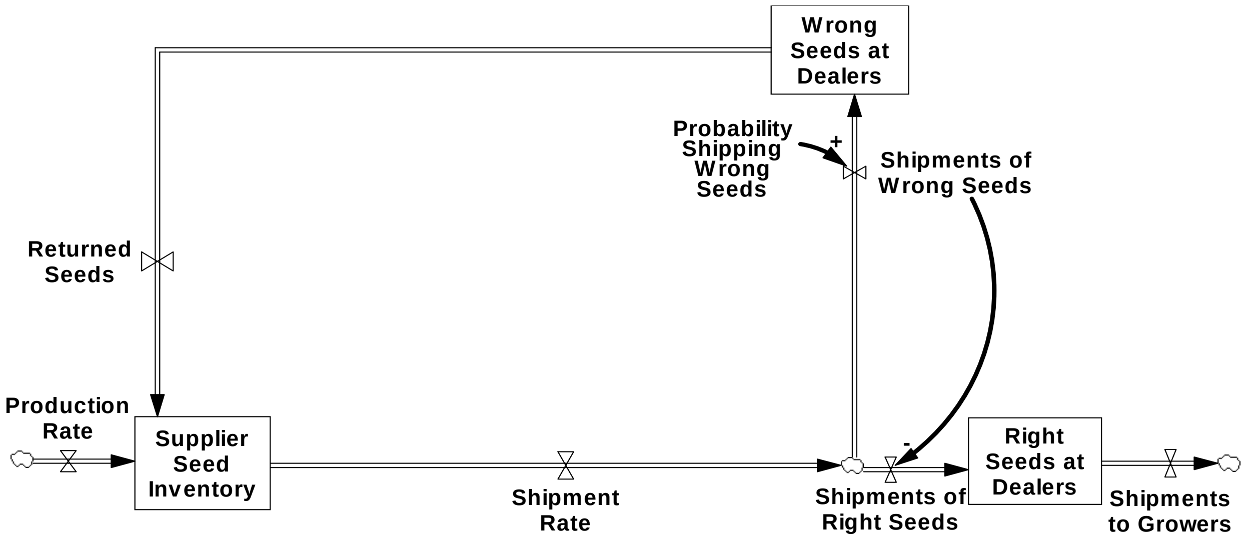

Figure 3. Stock-and-flow diagram for seed supplier shipments.

At the beginning of each quarter, the *Production Rate* replenishes the stock of *Seed Supplier Inventory*. Sales effort to position or push seeds determines the *Shipment Rate*, according to the positioning and pushing rates given by equation (1). Shipments decrease the supplier inventory. The probability of the "right" (or "wrong") seeds, i.e., seeds with (or without) corresponding grower demand, reaching dealers follows equation (2) and depends on sales effort allocation to positioning or pushing seeds. The quantity of *Wrong Seeds at Dealers* accumulates over the quarter at a rate given by the product of the *Shipment Rate* and the *Probability of Shipping Wrong Seeds* (P_W). Wrong seeds accumulated at dealers return to the supplier inventory at the end of the quarter and are accounted as *Lost Revenues from Returns*. The quantity of *Right Seeds at Dealers* accumulates over the quarter at a rate given by the *Shipment Rate* minus *Shipments of Wrong Seeds*. Right seeds accumulated at dealers are shipped to growers.

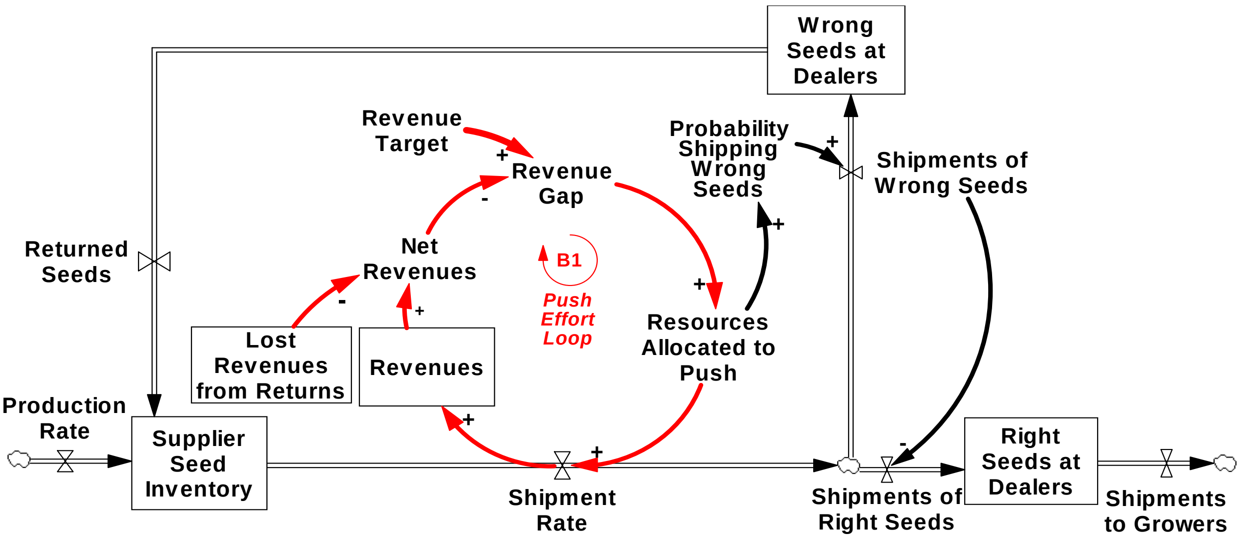

Figure 4. Push effort balancing feedback loop.

Figure 4 incorporates an important feedback loop capturing salespeople's heuristic for pushing seeds. The push effort loop (B1) is a balancing (or negative) feedback mechanism that regulates the revenue gap by adjusting the amount of effort allocated to pushing seeds. A large discrepancy (*Revenue Gap*) between the *Revenue Target* and *Net Revenues* leads to high pressure to meet quarterly revenue goals. While sales pressure is below the threshold, salespeople allocate resources to positioning seeds, shipping seeds to dealers with the positioning rate, A, and a probability of shipping wrong seeds, P_L. However, once sales pressure rises above the threshold, salespeople allocate resources to pushing seeds, shipping seeds to dealers with the faster pushing rate, B, and a higher probability of shipping wrong seeds, P_L+P_H. As resources are allocated to pushing seeds, salespeople accumulate *Revenues* more rapidly in the quarter, closing the revenue gap and easing the pressure to meet quarterly revenue quotas.

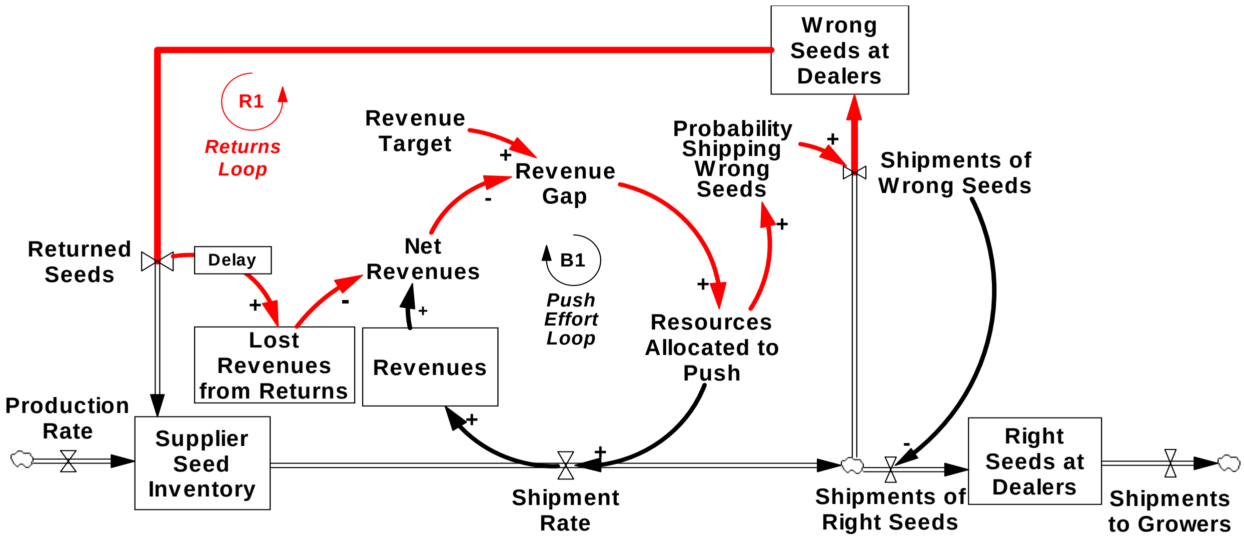

Figure 5. Returns reinforcing feedback loop.

Figure 5 incorporates a reinforcing (or positive) feedback mechanism, the returns loop (R1), capturing the impact of seed returns in the system. The reinforcing loop can operate in a vicious or virtuous way. If sales resources are sufficient to position a large quantity of seeds, pressure to meet revenue goals remains below the pressure threshold for most of the quarter, resulting in a small amount of seeds pushed and consequently a small amount of returns. The following quarter, dealers do not need to inflate orders as much and sales resource requirements are even lower, requiring salespeople to push an even smaller amount of seeds, leading to even lower returns. As described here, the reinforcing loop behaves in a virtuous way. In contrast, if sales resources are insufficient to position a sufficiently large quantity of seeds, pressure to meet revenues goals will mount. After pressure increases above the threshold, salespeople will push more seeds, leading to a higher probability of shipping seeds to dealers with inadequate grower demand and resulting into a large fraction of returns. Higher returns result in lost revenues; increase the following quarter's revenue gap and the pressure on salespeople; and raises resource requirements for the following quarter, compelling salespeople to push even more seeds. The loop works in a vicious way, leading to high returns and poor salesforce performance.

Perfectly rational salespeople (or firm managers) would not allow such a vicious cycle to occur. But properly assessing the costs and benefits of pushing and seeing how pushing today hurts revenue tomorrow, is difficult. The benefits of pushing seeds are recognized immediately – salespeople get rewarded (they receive a cash bonus) for meeting the quarterly revenue target, but the costs associated with returns occur only much later. Also, while the benefits of pushing seeds are financial, the costs of returns to salespeople are not. When returns occur at the end of the quarter, the associated lost revenues are accounted for in the following quarter, increasing the revenue gap, raising pressure to meet the quarterly goals and compelling salespeople to push even more seeds.

3.2. Model Assumptions

Three main assumptions are central to the dynamics of the model. The first key assumption is that salespeople's positioning effort results in a better alignment of supply and grower demand, thereby reducing the probability of seed returns. This assumption is captured in equation (2). The second key assumption captures dealers' hoarding behavior. Dealers place large orders early to hedge against the possibility of shortages. As one seed dealer expressed:

> "We base our orders on last year's sales and typically increase by 10-20% … [placing] 50% of total orders early in the season… We would order more than that, if we knew that supplies were short… If my sales rep would tell me that a certain variety is on short supply, I would order as much as I could, or as much as my rep would allow."

Dealers' initial orders are largely determined by the fraction of seeds returned the previous year. Dealers expect a large fraction of returns in one year if returns on the previous one have also been large. To compensate for the expected returns, dealers inflate their orders by the amount necessary to adjust for them. For instance, suppose grower demand is G and a dealer orders exactly G units to meet demand. Because of unpredictable weather conditions, imperfect knowledge of grower preferences and hybrid performance, the dealer sells only a fraction of their order, fG, returning the rest, rG, where r, is the return fraction ($r = 1-f$). The following quarter, to be able to sell G units to growers, dealers order G/f such that the fraction of seeds sold, *f*(*G*/*f*),will allow them to meet all grower demand. Since $r = 1\text{-}f$, the amount that dealers order (*O*) is simply *G*/(*1-r*). For simplicity we assume dealers have a good estimate of the underlying grower demand, *G*. [6]

$$O(s) = \frac{G}{(1 - r(s-1))} \tag{6}$$

where *r*(*s-1*) is the amount of returns in the previous quarter, i.e., quarter (*s-1*).

The third assumption specifies how salespeople allocate their effort between positioning seeds with and pushing seeds to dealers. For simplicity we assume that salespeople do not shirk, so the total of positioning and pushing effort is constant.[7] The total effort exerted by a salesperson is assumed constant at 50 hours/week. Furthermore, we assume that salespeople respond promptly and strongly to the sales pressure (*p*) once it is above a threshold value (p_T), by pushing seeds to dealers instead of positioning them. We aggregate salespeople, capturing their mean response over the distribution of possible response strengths. While the intensity of individual responses follow a distribution, our interviews show that they respond similarly to the same stimuli. All salespeople interviewed characterized that they faced a "crunch time" during which they pushed seeds, expediting dealer orders. According to a sales representative:

> "We start out really trying to load toward true grower demand. Everybody makes an honest effort of positioning seeds. But when it gets down to crunch time … you are just shipping what you can get, where you can get it, and when you can get it."

We implement the effort allocation shift from positioning to pushing as taking place when pressure to meet revenues (*p*) is greater than a pressure threshold (p_T). This formulation is supported by our field work which suggests, as illustrated by the quote above, that the switch from positioning to pushing takes place quickly. This sharp switch happens as salespeople realize that there are only few

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[6] Accounting for uncertainty in estimates of grower demand, *G*, would further amplify the overordering dealers require to ensure adequate stocks of seed and would strengthen the results reported here.

7 According to the goal-gradient hypothesis originally proposed by Hull (1934) and recently revisited by Kivetz, Urminsky, and Zheng (2006), proximity to the goal leads to a stronger tendency to approach the goal. That is, the goal-gradient hypothesis suggests that salespeople work harder (increase effort) as they approach the deadline. Relaxing the fixed effort assumption as pressure increases (a proxy for an approaching deadline) would intensify the effectiveness of push efforts and strengthen the results presented here.

weeks left in the quarter to meet the revenue quota. This sharp reversal between activities is consistent with a number of theories of motivation (Steel and König 2006). Research on work teams (Gersick 1988, Gersick and Hackman 1990) suggests that the behavior of groups on tasks tends to shift to greater focus on completing the task about halfway through the time allotted.

4. Model Behavior and Analysis

Table 1 presents the base case parameters for the model. Since the important activity with respect to seed sales occur in the first and fourth quarters, our model, without loss of generality, captures two quarters in each simulated year (Q4 and Q1). Base case results are shown in Figure 6. To explore the internal dynamics of the modeled system, we study its operation without external random shocks; instead exploring how a single perturbation may trigger an endogenous increase in returns. We discard the first five years of each simulation to avoid initial transient behavior.

TABLE 1 – BASE CASE PARAMETERS

Parameter	Definition	Value	Units
G	Grower demand	1,800,000	Seed bags
T_A	Time to position seeds	5	hours/40 seed bags
T_B	Time to push seeds	1	hours/40 seed bags
W	Number of salespeople in workforce	420	salespeople
H	Number of work hours per week	50	hours/week
T	Number of weeks in quarter	13	weeks
P_L	Probability of shipping to wrong dealers when positioning seeds	0.1	-
P_L+P_H	Probability of shipping to wrong dealers when pushing seeds	0.6	-

Note: Base case parameters are motivated by values obtained through interviews with the seed supplier. Parameter values for P_L and P_H are difficult to assess for the real supplier. Here, their choice is arbitrary. The behavior of the system would be similar for a large range of values (e.g., higher P_L and lower P_H).

4.1. Base case

Early in the quarter salespeople have plenty of time to sell, pressure to meet the revenue target is low (Figure 6a) and salespeople allocate all resources to positioning seeds (Figure 6b). Shipments to dealers take place at the positioning rate, A. Since the probability of shipping "wrong" seeds is small, P_L, the amount of "right" seeds at dealers, increases rapidly (Figure 7a). If sales resources are insufficient to position all seeds and meet the revenue targets, pressure increases as the end of the quarter approaches (Figure 6a).

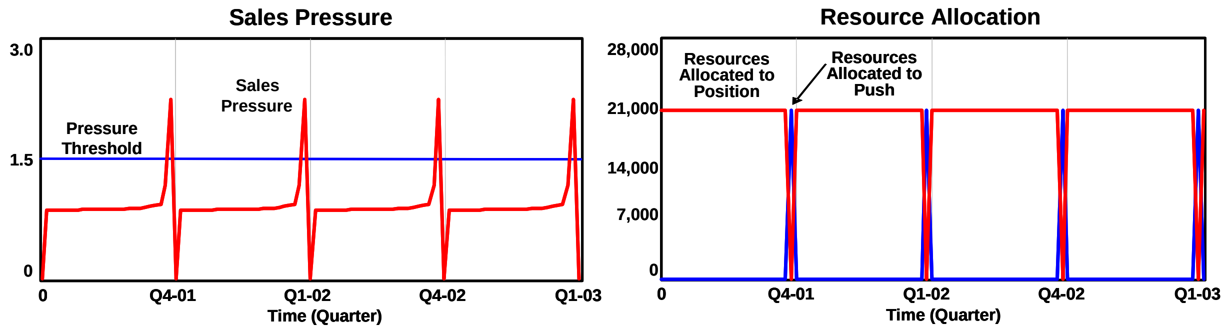

Figure 6. (a) Sales pressure and (b) resource allocation.

When the pressure reaches a threshold, salespeople shift resource allocation from positioning to pushing seeds (Figure 6b). During these high-pressure "crunch" periods, seed shipments take place at the much faster pushing rate, *B*, and the higher probability of shipping "wrong" seeds to dealers, P_L+P_H (Figure 7a). The increased shipment of wrong seeds accumulates over time, leading to higher returns to the seed supplier at the end of the quarter (Figure 7b).

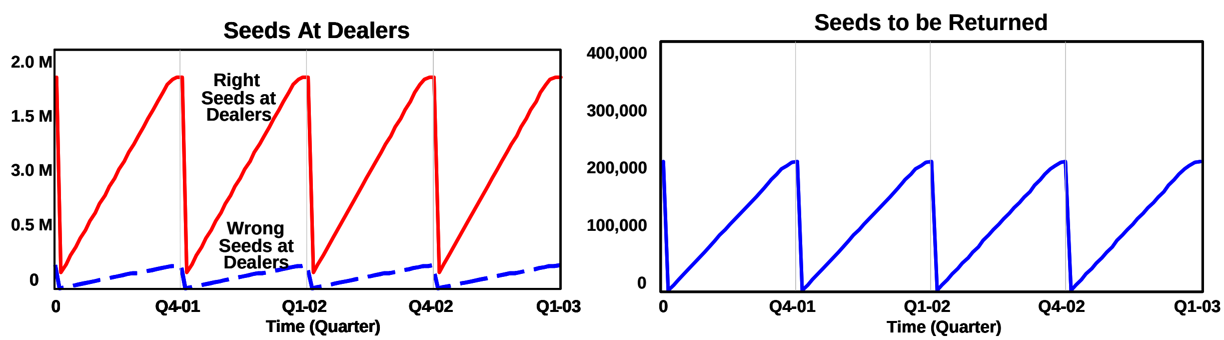

Figure 7. (a) Seed stocks at different dealers and (b) shipments to wrong dealers.

In the base case, the simulated supplier allocates most resources to positioning seeds, and pushes only a modest amount of wrong seeds to dealers, so total returns are relatively small. While dealers' orders in the following quarter compensate for the fraction of seeds returned in the previous one, the small amount of returns allows the seed supplier to allocate most of the time to positioning seeds thereby limiting future returns.

4.2. Demand shocks

Given this desired mode of operation, it is important to explore whether the modeled system can generate the excessive returns observed in the seed supplier and what factors may contribute to it. Two simulation experiments provide insight into these questions. In these simulations, we temporarily increase grower demand (and sales quotas) in the first quarter, by 5 percent and 10 percent respectively, returning them to base case levels during the remaining quarters. This transient increase in demand might arise due to a rise in the price growers can get for their corn or an increase in government subsidies.

With fixed sales resources and increased dealer orders, salespeople are unable to position all seeds and must increase their dependence on pushing seeds to dealers. In both simulations, following the increase in grower demand, the fraction of time salespeople allocate to positioning falls (Figure 8a). As more seeds are pushed, the probability of sending the wrong seeds increases, leading to more returns (Figure 8b). In the case of the 5% increase, the fraction of time allocated to positioning begins to recover and the fraction of seeds returned falls after a while. Though the demand shock increases the fraction of returns temporarily, the system is able to recover and goes back to the desired operation mode where salespeople position their seeds most of the time.

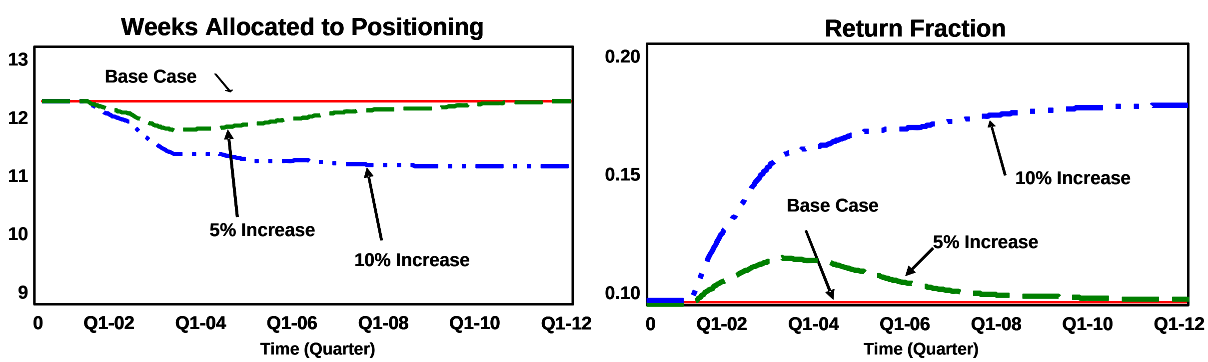

Figure 8. (a) Weeks allocated to positioning and (b) return fraction.

The behavior resulting from a 10% increase in demand, however, is quite different. Here, the fraction of time allocated to positioning does not recover after grower demand returns to normal levels. As more seeds are pushed to dealers, a larger fraction is returned, requiring even more pushing the following quarter. Following the transient increase in demand, the system settles in a new operation mode, in which a large fraction of salespeople's effort is allocated to pushing seeds and the fraction of seeds returned is permanently high. In this case, the demand shock is sufficient to bring the system to a high-return operation mode.

4.3. Phase plot analysis

To understand why different size shocks generate such divergent behavior, we follow an analysis procedure developed by Repenning (2001). First, we reduce the high order nonlinear structure of the system to a one-dimensional map, by studying the system dynamics *between* quarters. Since dealer orders in a quarter depend on seeds returned in the previous quarter, and since the system is integrable, we can capture the dynamics of returns as a discrete time map in which returns this quarter, $r(s)$, are a function of returns last quarter, $r(s\text{-}1)$, that is, $r(s) = f(r(s\text{-}1))$; see, e.g., Ott (1993). Second, we use the map to characterize the conditions required for the different operating modes of the system to emerge. Resource availability and the positioning and pushing rates in the sales organization play an important role in determining the operating mode of the system. To derive the map, begin with the determination of returns as a function of salesforce effort (see appendix 1 for details on this derivation):

$$r(s) = P_L + P_H Max\left(0, \frac{B(T_F - t_C)}{At_C + B(T_F - t_C)}\right) \tag{7}$$

where A is the positioning rate, B is the pushing rate, t_C is the critical time when salespeople shift from positioning to pushing (associated with the pressure threshold, p_T), and T_F is the time that shipments end (which may occur before the end of the quarter, T.) If T_F=T, the supplier may or may not be able to ship all dealer orders. Note that pushing seeds has the positive effect of allowing the supplier to ship a greater fraction of dealer orders. The additional amount of seeds that can be shipped while pushing is given by $(B - A)(T_F - t_C)$. However, pushing has the negative impact of leading to a higher probability of returns. In particular, pushing leads to returns of $[B(P_L + P_H) - AP_L](T_F - t_C)$. For the parameter values established in table 1 (T_A=*5*, T_B=*1*, P_L=*0.1*, P_H=*0.5*), the positive effect of shipping more seeds is higher (by almost 50%) than the negative impact of returns. Therefore, we make an *a priori* assumption that the net impact of pushing is *advantageous* to the company.

The equation for the return fraction (7) has an intuitive interpretation. The minimum return fraction, P_L, takes place when the critical time to switch from positioning to pushing is sufficiently high ($T_F \leq t_C \leq T$). When $r(s) = P_L$, salespeople only position seeds and never push. The maximum return fraction, $P_L + P_H$, occurs when t_C equals zero ($t_C = 0$). If the critical time to switch to pushing is zero, salespeople will push seeds from the beginning of the quarter and returns will be given by the maximum probability of shipping wrong seeds ($P_L + P_H$). Between these extreme conditions, the degree of excess returns, P_H, is given by:

$$\left(\frac{B(T_F - t_C)}{At_C + B(T_F - t_C)} \right) \tag{8}$$

Since the numerator in equation (8) provides the total amount of seeds pushed to dealers and the denominator gives the total amounts of seeds shipped, the ratio suggests that the degree of excess returns is proportional to the *fraction of seeds pushed* to dealers. Moreover, it is possible to characterize the critical time (t_C) from the definition of pressure in equation (3) and after we introduce t_C in the equation above, the return fraction can be expressed as (see appendix 2 for details on this derivation):

$$r(s) = P_L + P_H \cdot Max\left(0, 1 - \frac{A}{G/(1-r(s-1))} \cdot Min\left(\frac{p_T - 1}{p_T - AT \Big/ \frac{G(1+r(s-1))}{(1-r(s-1))}} T, T \right) \right) \tag{9}$$

This equation captures the dynamics of product returns in a multi-activity sales environment system by relating the fraction of seeds returned in a quarter, $r(s)$, to the amount of seeds that can be positioned in a quarter (AT), the quarterly grower demand (G), the pressure threshold for pushing (p_T) and the return fraction in the previous quarter $r(s\text{-}1)$. A phase plot relating the current return fraction, $r(s)$, to the previous quarter return fraction, $r(s\text{-}1)$, provides a graphical representation of the return map in equation (9).[8]

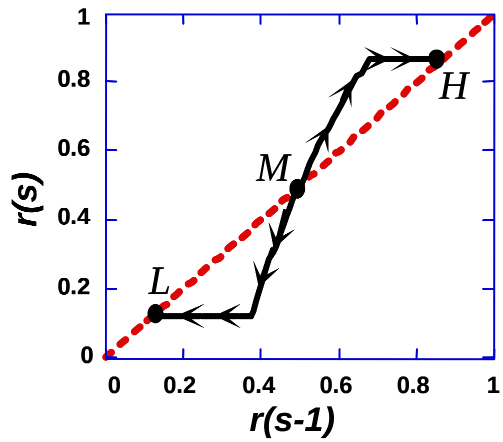

Figure 9. Phase plot for return fraction.

Note: Solid circles (fixed points) represent equilibria. The return fraction in the low (*L*) and high (*H*) equilibria are stable – once reached the system will remain there. The middle (*M*) equilibrium is unstable. A system starting close to (*M*) will follow the arrows toward one of the two stable equilibria.

To interpret the dynamics represented by the phase plot, shown in figure 9, start with a point in the x-axis, referring to the return fraction in the previous quarter, $r(s\text{-}1)$, and through the phase function find the associated value on the y-axis, the current return fraction, $r(s)$. To find the return fraction in the next quarter, $r(s+1)$, start with the value obtained for $r(s)$ on the x-axis. Repeating the process allows us to obtain a summary of the evolution of the return fraction in the system. Note that any time the phase plot crosses the forty five degree line, the return fraction in the previous quarter will equal the current return fraction ($r(s) = r(s\text{-}1)$). Since the system is a one-dimensional map, these are the fixed points where the system is in equilibrium. Fixed points where the phase plot has a slope less than 1 are stable (e.g., the low (*L*) and high (*H*) equilibria.) Balancing feedbacks dominate the dynamics of the system such that departures from equilibrium are counteracted. Once these fixed points are reached, the system will remain there. In contrast, fixed points where the phase plot has a slope greater than 1 are unstable (e.g., the middle (*M*) equilibrium). Positive feedbacks dominate the dynamics around unstable equilibria; departures from these fixed points are reinforced, following the trajectory indicated by the arrows on the

[8] Repenning (2001) provides an interesting application of an analogous phase plot to understand the emergence and persistence of fire-fighting in multi-product development systems.

phase plot. Hence, if the system starts with a return fraction ($r(s\text{-}1)$) *below* the unstable equilibrium, the positive loop will operate in a *virtuous* way moving the system toward the equilibrium with a low return fraction (L). If instead, the system starts with a return fraction ($r(s\text{-}1)$) *above* the unstable equilibrium, the positive loop will operate in a *vicious* way moving the system toward the equilibrium with a high return fraction (H). The unstable equilibrium, or *tipping point*, determines the position where the positive returns loop *changes* direction, or *tips*, from a *virtuous* operation mode to a *vicious* one, and vice-versa.

There are important implications of these insights. First, the existence of an unstable equilibrium that allows for a tipping point suggests that even when the system starts in the desired operation mode, there is no guarantee that it will remain there. This insight explains the difference in the dynamic behavior observed in the two simulation experiments above. In the base case, the system operates in a desired operation mode with a low return fraction. While the five percent increase in grower demand leads to a higher return fraction in the current year, it is insufficient to push the system beyond the tipping point, so the system returns to the original equilibrium. However, the ten percent increase in grower demand is large enough to push the system beyond the unstable equilibrium, taking the system to the equilibrium with high return fraction. Finally, the existence of the stable equilibrium with high returns ($r(s) = P_L + P_H$) suggests that the problem of high returns can be a steady-state phenomenon to seed suppliers.

4.4. Characterizing possible system phase plots

The analysis above provides an explanation of how a sufficiently large shock can push the system beyond the tipping point, leading to an undesired mode of operation with a high return fraction. Here, we characterize the conditions under which the unstable equilibrium arises in the system. The conditions that contribute to the existence of a tipping point are obtained through analysis of equation (9). When the maximum constraint binds at zero, the equilibrium return fraction is simply $r(s) = P_L$, indicating that a single equilibrium with low returns exists. To analyze which conditions allow the maximum constraint to bind at zero, we must first look at the minimum constrain. The minimum constraint will bind at the value of T, only if the number of seeds that can be positioned in the quarter (AT) is larger than the total seeds that the supplier must ship out $\left(G\left(1+r\left(s-1\right)\right)/\left(1-r\left(s-1\right)\right)\right)$, consisting of the sum total dealer orders $\left(G/\left(1-r\left(s-1\right)\right)\right)$ and the amount of prior-quarter returns $\left(Gr\left(s-1\right)/\left(1-r\left(s-1\right)\right)\right)$. When the condition above holds, salespeople's choice of the pressure threshold (p_T) does not matter and the maximum constraint binds if the number of seeds that can be positioned in the quarter (AT) is larger than total dealer orders $\left(G/\left(1-r\left(s-1\right)\right)\right)$. Since the latter follows from the requirements for the minimum constraint to bind, we find that salespeople must have sufficient resources to position all desired shipments to dealers, regardless of the previous quarter returns $\left(r\left(s-1\right)\right)$. In the worst case scenario, the fraction of previous quarter returns would equal (P_L+P_H). Figure 10 shows the phase plot for the single equilibrium at $r(s)$ = P_L when $AT > G\left(1+\left(P_L+P_H\right)\right)/\left(1-\left(P_L+P_H\right)\right)$. Intuitively, if sales resources are sufficient to enable all seeds to be positioned at all times no matter how high returns are, the system will always recover to a high performance equilibrium with the low return rate. Such a situation is highly unlikely, as the salesforce needed and the resulting costs would be prohibitive. A firm finding itself with so much sales capacity would almost surely downsize the sales organization to eliminate the excess capacity.

In contrast, when the positioning capacity (AT) is close to zero, which can happen if the time to position seeds (T_A) is extremely high, or the salesforce is so small that salespeople never position seeds, then the equilibrium return fraction is simply $r(s) \cong P_L+P_H$. (The phase plot associated with this equilibrium is not shown.) Because salespeople have insufficient resources to position any seeds, they must push all of them to dealers. This high equilibrium return fraction $r(s) = P_L+P_H$ is equivalent to the one obtained if the pressure threshold for pushing (p_T) is one (equivalent to a critical time, t_C, equal to zero). Intuitively, when there are so few resources relative to the workload requiring salespeople to push all the time, the system will always evolve to the high-return equilibrium even if demand temporarily falls. Firms would normally not reduce their salesforce capacity so much relative to the workload, forcing the sales system to always be in push mode. We therefore expect that this extreme condition is also likely to be rare (if for no other reason than that such a firm will have an uncompetitive rate of returns and either add sales resources or go out of business).

Three other general cases for the phase plots remain. Since in equilibrium $r(s) = r(s\text{-}1)$, we solve for the fixed points by substituting $r(s)$ for $r(s\text{-}1)$ in equation (9), yielding a quadratic equation in $r(s)$. The equilibrium values of $r(s)$ are given by the roots of:

$$ar^2(s) + br(s) + c = 0 \qquad (10)$$

where:

$$a = p_T G + AT(1 - P_H(p_T - 1))$$

$$b = p_T G(1 + (P_L + P_H)) - AT(1 - (P_L + P_H))$$

$$c = p_T G(P_L + P_H) - AT((P_L + P_H) + P_H(p_T - 1))$$

The roots are: $r_{1,2}(s) = \left(-b \pm \sqrt{b^2 - 4ac}\right)/2a = (-b \pm \Delta)/2a$

Depending on the seed positioning capacity (AT), grower demand (G), the pressure threshold for pushing (p_T), and the probabilities (P_L, P_H), equation (10) may have zero roots (if $\Delta < 0$), one root (if $\Delta = 0$), or two real roots (if $\Delta > 0$), equivalently generating the same number of equilibria. Figure 10 shows these three general cases (and the previously mentioned case of a single low return equilibrium) as a function of the company's available resources for positioning seeds (AT). As the diagram suggests, as the company increases positioning capacity (AT) the shape of the phase plot changes from a system with a single low performance equilibrium (at P_L+P_H), to one with three equilibria – two stable (one low-return at P_L and one high-return) and one unstable – and then to one with a single high performance equilibrium (at P_L). (Note that the phase plot case with $\Delta = 0$ is not shown.)

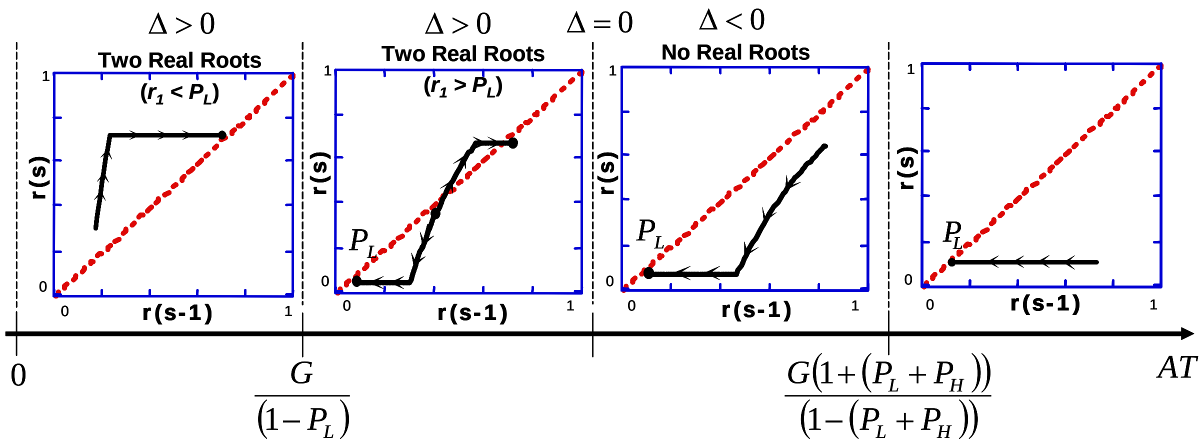

Figure 10. The system's phase plots.

The first case occurs when the supplier has *insufficient* resources to position the lowest possible amount of seeds demanded by dealers $(AT < G/(1-P_L))$. Here, the quadratic equation has two real roots (Δ>0) but one of them lies below the minimum return fraction ($r_1 < P_L$). This situation can arise for different values of the pressure threshold for pushing (p_T). Here, the system has a single stable low-performance equilibrium with a high probability of returns and the positive loop of returns always works as a vicious cycle.[9] The second case arises when the supplier has *sufficient* resources to position the lowest possible amount of seeds demanded by dealers, $(AT > G/(1-P_L))$, *insufficient* resources to position the maximum amount of seeds required by dealers, $AT < G(1+(P_L+P_H))/(1-(P_L+P_H))$, and the quadratic equation has *no real roots* (Δ<0). This situation arises when the pressure threshold (p_T) is high, allowing salespeople to use the available resources to position seeds. Here, the system has a single stable equilibrium at the low probability of returns (P_L)[10] and the positive loop of returns always works as a virtuous cycle. The final case arises when the supplier has *sufficient* resources to position the lowest possible amount of seeds demanded by dealers, $(AT > G/(1-P_L))$, *insufficient* resources to position the maximum amount of seeds required by dealers, $AT < G(1+(P_L+P_H))/(1-(P_L+P_H))$, and the quadratic

[9] Returns will be high but lower than P_L+P_H, because that can only be achieved if no seeds are positioned in the quarter.
[10] The equilibrium at $r(s) = P_L$ is given by the max function in eq. (9) and not by the roots of the quadractic equation.

equation has *two real roots* ($\Delta>0$). Here, the system has two stable equilibria – one at the low probability of returns (P_L) and one at the high probability of returns – separated by one unstable equilibrium.

The unstable equilibrium is obtained by the smaller of the two roots and determines the location where the positive returns loop changes direction. Here, the positive loop can work either as a virtuous or a vicious cycle. Since companies may have sufficient resources to *position* some seeds $G/(1-P_L) < AT < G(1+(P_L+P_H))/(1-(P_L+P_H))$ and salespeople are unlike to adopt very high pressure thresholds (p_T), we should expect to observe this case frequently in the agribusiness industry. As figure 10 suggests, the amount of positioning resources (AT) influences the location of the unstable equilibrium. The fewer resources available, the closer the unstable equilibrium will be to the low-returns equilibrium ($r(s)=P_L$), indicating that smaller shocks are capable of tipping the system into the undesirable operating mode. Therefore, it is important to recognize that resources not only affect the ability of the system to attain the desired operation mode (with low returns) but also determine the vulnerability of the system to shocks that can cause it to degenerate into the undesirable operation mode.

4.5. Incentives and sales resources

Another important consequence of the availability of sales resources is the impact it has on the ability of incentives to salespeople and dealers to curb the high return problem. The lack of adequate incentives to dealers contributes to the volume of returns because dealers face significant penalties for under-stocking corn-seeds, including sales and reputation losses, but no penalties for over-ordering seeds. An incentive scheme that penalizes dealers for high returns would likely reduce the amount of inflated orders and should be a part of the prescription to solve the problem. However, our analysis shows that the effectiveness of incentives depends on the availability of sales resources. Sufficiently low sales resources can make incentives ineffective in solving the high return problem. We illustrate the case through the implementation of a dealer incentive scheme that charges dealers a penalty cost for returns. When there is no penalty for returns, dealers over-order by a factor of $1/(1-r(s-1))$. We define a maximum penalty charge as the amount that causes dealers to order exactly the grower demand. Fractional penalty charges (compared to the maximum) decrease the amount of dealer over-ordering in proportion to the maximum over-ordering. We investigate fractional charges because implementing such incentive scheme faced significant barriers. Managers at the seed supplier were unwilling to penalize dealers and would not implement the most severe penalty policy. They held a strong belief that penalty for returns would lead to loss of sales and market share, especially because competitors did not have similar policies in place.

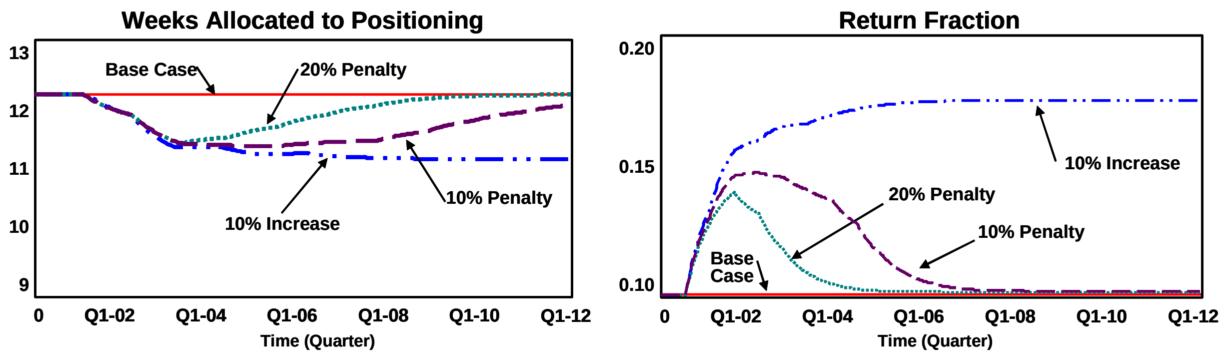

Figure 11. Dealer disincentive: (a) weeks allocated to positioning and (b) return fraction.

Figure 11 shows the results of the dealer incentive for two different levels of penalties imposed: 10% and 20% of the threshold penalty. Higher fractions of the threshold penalty can bring the system back to the desired operation mode of low returns more quickly, but also face more resistance from management. For the initial level of sales resource parameters (420 salespeople working 50 hours a week), the two penalty levels allow the seed supplier to recover from the 10% increase in demand. By reducing the amount of dealer overordering, the policy prevents the system from being pushed beyond the unstable equilibrium by the 10% shock. However, when we reduce available sales resources by 10% (380 salespeople working 50 hours a week) neither the 10% nor the 20% penalty is capable of solving the problem anymore (Figure 12). With fewer available sales resources (380 salespeople), the transient 10% shock requires a larger fraction of salespeople's time to be allocated to pushing seeds, resulting in a higher fraction of seeds returned. Due to the susceptibility of system performance to the availability of sales resources, isolated consideration of incentives is likely to be ineffective.

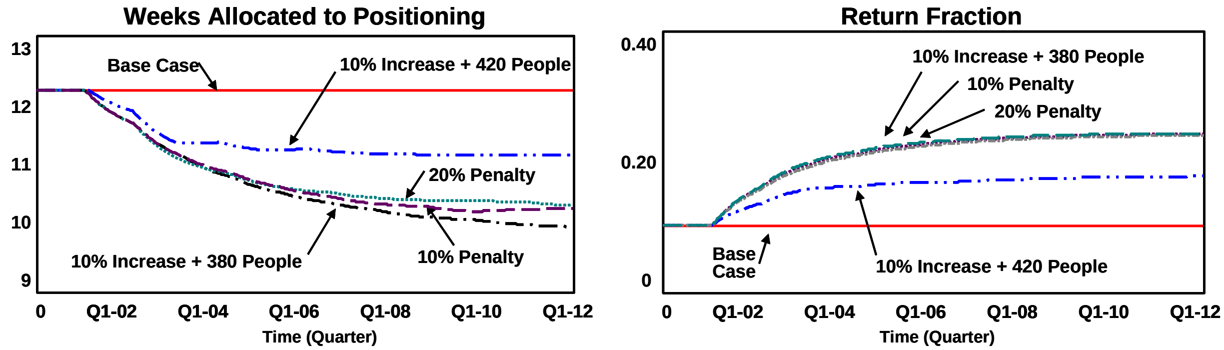

Figure 12. Dealer disincentive with 10% fewer sales resources.

5. Discussion

Through a formal dynamic model of sales resource allocation in the agribusiness industry, we have shown that: (1) the interaction of sales effort allocation and dealer hoarding behavior can lead to high corn-seed return rates, and (2) this mechanism is self-reinforcing. In addition, the analysis highlights the importance of adequately managing sales resources to ensure desired system performance while maintaining system robustness. While returns can have several causes, this work describes how biased sales effort allocation can tip the system into a self-reinforcing high-return equilibrium. Specifically, sales representatives abandon time-consuming seed positioning late in the sales cycle to push out dealers' inflated orders and quickly meet revenue quotas. While the seed supplier emphasizes the importance of positioning seeds, quarterly pressure to meet revenues goals shifts salespeople's attention to pushing seeds. More resources allocated to pushing seeds lead to short-term financial benefits but also result in higher seed returns the following period, generating more inflated orders by dealers and increasing the sales that agents must attain to reach their quota, leading to even more pressure and more pushing the following period. Our research suggests that this biased allocation of resources toward pushing seeds is a key factor contributing to excessive dealer returns.

5.1. Resilience of Returns

While a traditional prescription to the problem described here would be to implement adequate incentives for salespeople and dealers, our analysis shows that due to the strong influence of sales resource utilization incentives help but can be ineffective at solving the problem. Moreover, there are strong behavioral and cognitive reasons why allocating effort to pushing seeds takes precedence over positioning them. First, pushing seeds is more salient and tangible than the process of positioning seeds. Research shows that people consistently over-weight salient and tangible features of the environment (Kahneman et al. 1982, Taylor and Fiske 1975). To push seeds, salespeople request early delivery of dealer orders that already exist; with specified volumes and hybrid types. Salespeople's financial rewards depend strongly on meeting revenue targets and falling has tangible negative impact: salespeople receive lower bonuses. In contrast, salespeople must gather information, learn about dealers' purchasing intentions, and generate a demand forecast when positioning seeds. The benefits of the extra time required by positioning are unclear, uncertain, and delayed, while the benefits of the additional time spent pushing are salient, unambiguous, and immediate.

Second, the time required to position and push seeds is highly uneven. Positioning seeds is a time intensive task, requiring significant amount of effort. Salespeople spend a great deal of time – from half-day to a whole-day per dealer – exploring potential grower demand. In contrast, pushing seeds is relatively quick and requires much less effort. It involves making phone calls to dealerships in the sales representative's region and requesting early delivery of orders already in the system. The uneven amount of effort to push and position seeds leads pressured salespeople to choose the former instead of the latter.

Third, pushing seeds have a more certain outcome than positioning them. Salespeople's financial rewards depend strongly on meeting revenue targets. Falling short of the quota has a clear negative impact and there is no ambiguity in the benefit associated with meeting the revenue targets. In contrast, the costs associated with returns are not as clear. Salespeople had difficulty specifying the policy used to charge them for obsolescence costs and could not quantify the dollar amount being charged. Research has shown people to be ambiguity averse (Einhorn and Hogarth 1985, Plous 1993). Hence, faced with pressure to meet revenues, most salespeople will prefer the more certain gain of pushing seeds to the ambiguous positioning effort.

Fourth, the rewards accrued for pushing seeds occur closer in time to salespeople's actions, whereas the sales associated with positioning seeds are often not close in time. Lost revenues associated with returns do not result in a deduction from salespeople bonuses. Instead, salespeople are expected to make up for the losses from returns by meeting a higher revenue target the following quarter. People have been shown to exhibit time inconsistent preferences, favoring rewards that are closer in time (Loewenstein 1996, Angeletos et al. 2001) Faced with the choice of receiving rewards now for pushing or delayed compensation for positioning, salespeople choose the former.

Together these four considerations suggest that salespeople are not rationally optimizing their time allocation based on a cost-benefit analysis, but that the salience of information and overweighting of immediate consequences strongly condition which information cues are used in their effort allocation decision, a strong behavioral effect. Pushing seeds requires less effort and leads to certain, short-term, financial rewards. In contrast, positioning seeds requires more effort and has ambiguous and delayed costs associated with returns. Since salespeople have very salient information about their effort levels and the resulting outcome, they learn quickly that they can achieve their quotas and financial rewards by pushing seeds. This research offers a better understanding of how salespeople are likely to behave in multi-task sales environments, and describe how such behavior and cognitive biases affect resource allocation, leading to excessive returns in the seed supply chain.

5.2. Implications

The implications of this research are of general interest because the seed industry is similar to other high-technology, high-velocity industries characterized by short and unpredictable product lifecycles, rapid turnover of SKUs in the catalog, long product development and production delays, and volatile and unpredictable customer demand. In addition, due to fierce competition and the constant need to drive down costs, more and more companies in diverse industries face eroding sales capacity and increasing pressure to meet aggressive sales goals. Because salespeople must allocate effort between different tasks (such as working hard and working smart) in many sales environments, interdependency between tasks is the norm. Sales task interdependence is particularly important when demand is highly uncertain and salespeople play an important role in generating better demand forecasts.

Book and drug returns in the publishing and healthcare industries, respectively, present prompt opportunities to apply the findings reported here. Demand uncertainty in the publishing industry is extremely high (Boss 2007). Return rates, averaging 35%, have been growing in large part due to the spread of superstores and their increased ability to order large quantities of new books and then return them at no cost (Rogers and Tibben-Lembke 1999). At the same time, publishing industry sales have been decreasing, placing greater stress on salespeople to meet their revenue targets. Since market research is limited, salespeople have inadequate demand forecasting tools and face increased pressure to meet revenue targets in a fiercer environment. As our study suggests limited resources and aggressive targets are the basic conditions required for the existence of tipping points in sales environments. Furthermore, as these conditions deteriorate, the system becomes more vulnerable to exogenous shocks, requiring smaller shocks to trap it into the undesirable operating mode.

The system dynamics show that salespeople making resource allocation decisions in multi-task sales environments face a "better-before-worse" trade-off (Repenning and Sterman 2001). The positive, but transient, consequence of pushing seeds is rapid, easy to assess and benefits mainly the individual sales representative. In contrast, the negative, but lasting, consequences occur with a delay and affect the whole system as seed returns accumulate the following season and degrade firm performance. Unfortunately, the biased allocation of resources toward tasks with higher short-term benefit is common in different settings (such as new product development, banking services, process improvement efforts, fisheries, etc.) especially under stressful conditions (Repenning 2001, Oliva and Sterman 2001, Repenning and Sterman 2002, Moxnes 1999). Initial errors resulting from this biased resource allocation are self-reinforcing, driving the system to a low performance, high-return equilibrium. A manager that does not understand the dynamics discussed above and interprets the ability to meet more aggressive goals with a smaller salesforce as a productivity improvement (Oliva and Sterman 2001) is likely to find her organization trapped in the low performance equilibrium. To prevent this, managers must focus on the system and its ability to robustly handle the required tasks.

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Appendix 1

This appendix provides a detailed derivation for the return fraction in a quarter $r(s)$, which we define as the ratio of the amount of seeds returned (RR) by the total seeds shipped (TS):

$$r(s) = \frac{RR}{TS} = \frac{\int_0^T S \cdot P_W dt}{\int_0^T S dt} \tag{A1}$$

The instantaneous shipment rate (S) is determined by available sales resources and whether salespeople position seeds, shipping with the positioning rate (A), or push seeds at the pushing rate (B).

$$S = \alpha A + (1-\alpha)B \quad \text{where } \alpha \text{ is given by:} \quad \alpha = \begin{cases} 1, \ if \ \ p < p_T \\ 0, \ if \ \ p \geq p_T \end{cases} \tag{A2}$$

and the pressure threshold (p_T) determines when salespeople shift from positioning to pushing seeds.

Since a *Critical Time* (t_C) is associated with the pressure threshold (p_T), we can eliminate α and rewrite the interval of integration using t_C, such that the total amount of shipments (TS) in the quarter is:

$$TS(s) = \int_0^{t_C} A dt + \int_{t_C}^T B dt \tag{A3}$$

Recognizing that the *Probability of Shipping Wrong Seeds* (P_W) when salespeople position seeds is P_L and it is $P_L + P_H$ when salespeople push them and using the critical time in the interval of integration allows us to define the amount of seeds returned (RR) at the end of the quarter:

$$RR(s) = \int_0^{t_C} A P_L dt + \int_{t_C}^T B(P_L + P_H) dt \tag{A4}$$

Substituting the equations for total seeds returned (*RR*) and total shipments (*TS*) into equation (A1), yields:

$$r(s)=\frac{\int_0^{t_C} AP_L\,dt+\int_{t_C}^{T} B(P_L+P_H)dt}{\int_0^{t_C} A\,dt+\int_{t_C}^{T} B\,dt} \tag{A5}$$

If salespeople push early in the quarter (i.e., pressure threshold is low) or pushing is very effective (i.e., a significant amount of seeds are shipped to dealers), available resources might be sufficient to ship all dealer demand before the end of the quarter (T). Therefore, we allow for the possibility that shipments end at time T_F, where $T_F < T$. If $T_F=T$, the supplier may or may not be able to ship all dealer orders placed. Substituting the results above in the returns fraction, $r(s)$, equation yields:

$$r(s)=\frac{AP_L t_C+B(P_L+P_H)(T_F-t_C)}{At_C+B(T_F-t_C)} \tag{A6}$$

Simplifying and incorporating the maximum plausible value for the critical time t_C, yields:

$$r(s)=P_L+P_H Max\left(0,\frac{B(T_F-t_C)}{At_C+B(T_F-t_C)}\right) \tag{A7}$$

Appendix 2

To reduce the high order nonlinear model dynamics to a one-dimensional map, we simplify equation (A7) recognizing that the final time T_F is the time required to meet dealer demand $\left(\frac{G}{(1-r(s-1))}\right)$ while positioning and pushing seeds with the available sales resources $\left(At_C+B(T_F-t_C)\right)$:

$$r(s)=P_L+P_H Max\left(0,1-\frac{At_C}{G/(1-r(s-1))}\right) \tag{A8}$$

It is possible to characterize the critical time (t_C) from the definition of pressure in equation (3) and its components, equations (4) and (5). The threshold pressure is given by the ratio of the fractional gap in revenues (RG_F) at the critical time and the fractional time remaining (TR_F):

$$p_T = \frac{\dfrac{\left(R^* + R_L(s-1)\right) - R_G(t_C)}{\left(R^* + R_L(s-1)\right)}}{\dfrac{T - t_C}{T}} \tag{A9}$$

One simplifying assumption is required to obtain the lost revenues from previous quarter returns ($R_L(s\text{-}1)$). We assume that the volume of seeds shipped in the previous quarter ($G/(1-r(s-2))$) is the same as the volume sent out this quarter ($G/(1-r(s-1))$). This simplification allows the return fraction in a quarter to depend only on the return fraction in the previous quarter (instead of the last two quarters) and it slightly underestimates (overestimates) the critical pressure when returns are increasing (decreasing) from quarter to quarter.

$$p_T = \left(1 - \frac{A \cdot t_C}{G(1+r(s-1))/(1-r(s-1))}\right) \Big/ \left(1 - \frac{t_C}{T}\right) \tag{A10}$$

Isolating the critical time (t_C) and conveniently arranging terms, we obtain: $t_C = Min\left(\frac{p_T - 1}{p_T - F_P} T, T\right)$ where the fraction of seeds that can be positioned in the quarter (F_P) is: $F_P = \frac{AT}{\frac{G(1+r(s-1))}{(1-r(s-1))}}$; and the nonlinearity prevents critical switching times that are larger than the duration of the quarter (T). In the equation for F_P the denominator ($\frac{GT(1+r(s-1))}{(1-r(s-1))}$) captures the amount of seeds that *must* be shipped in the quarter and the numerator (AT) determines the amount of seeds that *can* be positioned in the quarter. If two many resources (salespeople's hours) are available, it is possible to have $F_P>1$, that is, the supplier can position more seeds than the amount required to ship. This would lead to critical times higher than T, indicating that the salespeople would only position seeds. Within a quarter it is convenient to capture only critical times that are lower than or equal to its duration.

While the pressure threshold (p_T) influences critical time (t_C), t_C changes with the fraction of units positioned (F_P) as it depends on the return fraction from previous quarter ($r(s\text{-}1)$). Since returns often change from quarter to quarter, the critical time changes accordingly for a given pressure threshold according to the figure below (Figure A1).

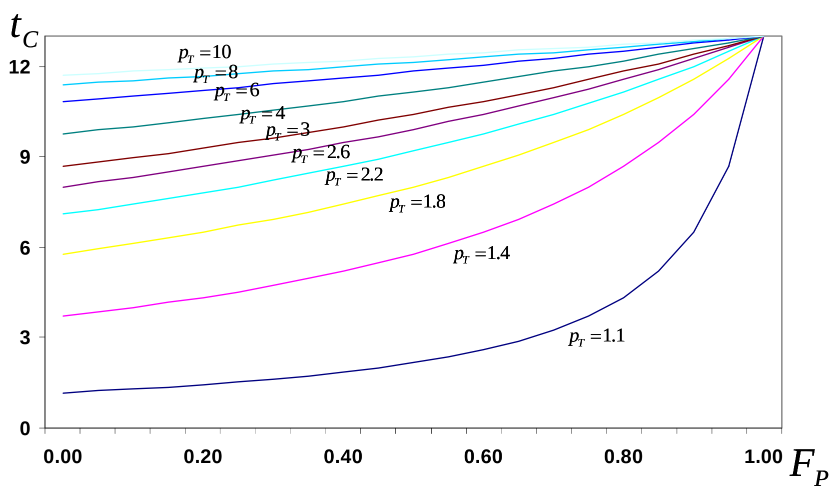

Figure A1. Critical times (t_C) as function of fraction of seeds can be positioned (F_P).

We substitute the expression for critical time on the equation for the return fraction.

$$r(s) = P_L + P_H \cdot Max\left(0{,}1 - \frac{A}{G/(1 - r(s-1))} \cdot Min\left(\frac{p_T - 1}{p_T - F_P} T, T\right)\right) \quad \text{(A11)}$$

We obtain the final result for $r(s)$ when we introduce the result for the value of the fraction of units that can be positioned (F_P) on the equation above:

$$r(s) = P_L + P_H \cdot Max\left(0{,}1 - \frac{A}{G/(1 - r(s-1))} \cdot Min\left(\frac{p_T - 1}{p_T - AT \Big/ \frac{G(1 + r(s-1))}{(1 - r(s-1))}} T, T\right)\right) \quad \text{(A12)}$$