Imputing Economic Returns to Entrepreneurial Behavior: A System Dynamics Model of Firm-Level Innovation and Arbitrage

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ABTRACT

Firms need to act entrepreneurially to compete in today ultra-competitive business environment. This requires firms to actively search for and exploit opportunities to increase revenues or decrease costs in an uncertain environment. Within a firm, these activities are the functions of the entrepreneur or the entrepreneurial resources. In return for their services, these resources receive payments known as entrepreneurial rents. These rents are the result of subjective judgments and the activities that generate them are subject to imitation. Thus, entrepreneurial rents are both ex ante non-contractible and temporary. These characteristics make their measurement difficult for managers. This paper is an attempt to measure entrepreneurial rents using a system dynamics framework. System dynamics models are uniquely positioned to capture the dynamic complexities of these rents. In doing so, I present a SD model of a three-site hog production operation and compute the entrepreneurial rents generated from several arbitrage and innovation activities.

KEYWORDS: entrepreneurial behavior, resource payments, innovation, arbitrage, system dynamics

Introduction

In a rapidly changing environment, firms must act to constantly renew and redeploy the sources of their competitive advantage (i.e. dynamic capabilities and core competencies) to sustain profits (Hitt, Ireland, Camp and Sexton, 2002). This requires that firms actively search for and exploit opportunities to increase revenues or decrease costs in an uncertain decision environment. In other words, firms must act *entrepreneurially*.

Within a firm, entrepreneurial behavior can be characterized as activities of one of two types – arbitrage or innovation (Ross and Westgren, 2005). The implementation of these types of activities may lead to either positive or negative (Alvarez and Barney, 2002) profits[1] for the firm and depend on the judgment and management capabilities of the firm in an uncertain environment. The profits resulting from these types of activities represent a return to entrepreneurial behavior. The payment[2] for entrepreneurial behavior is known as entrepreneurial rent.

The nature of entrepreneurial rent offers several challenges for measurement. In particular, how does one calculate the value of a resource such as an entrepreneur that is unpriced in factor markets and whose returns are *ex ante* uncertain? Furthermore, entrepreneurial rents are subject to dissipation in the market as the source -– innovation or arbitrage – is imitated by competitors. Although some rents are protected from swift and complete imitation by isolating mechanisms (Rumelt, 1984), rival firms will seek to exploit the same profit opportunities and the returns to the entrepreneurial activity will be eliminated over time. Thus, entrepreneurial rents are temporary and dynamic.

The question of how to value unpriced resources has been a focus of recent resource-based view of the firm literature (Barney, 1991; Lippman and Rumelt, 2003a, Lippman and Rumelt, 2003b, Denrell, Fang and Winter, 2003). However, these studies have either failed to explicitly impute returns to the entrepreneurial resources of the firm or have ignored the dynamic nature of such returns. This paper addresses these issues and

[1] Profits refer to the above average returns to the factors of production that are a result of the scarcity of the firm's resources and its entrepreneurial behavior.
[2] The use of "payment" is consistent with terminology used by Lippman and Rumelt (2004) in their "payments perspective". Their paper stresses the use of the full imputation of rents principle which suggests that payments should be allocated to firm resources equivalent to the revenues they generate, and that the total revenue stream should be exhausted by the payments.

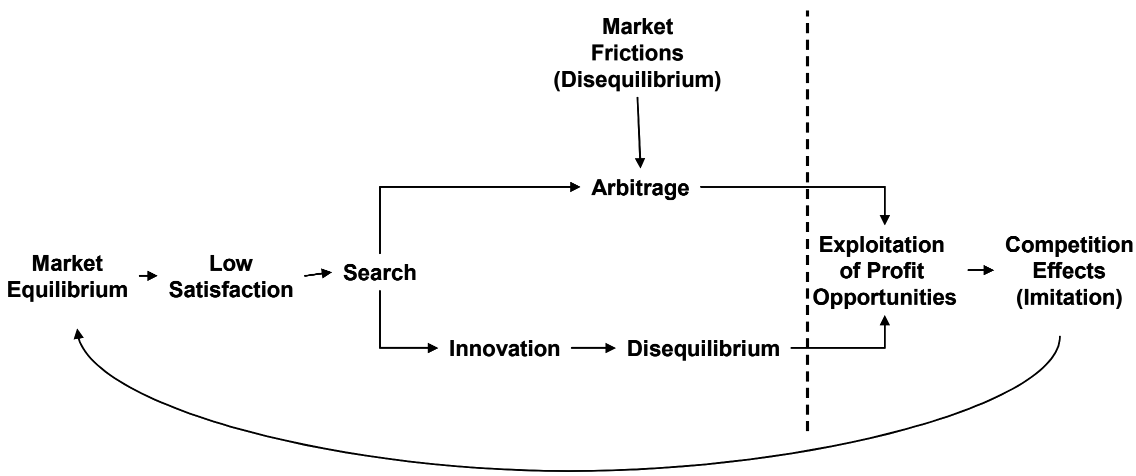
suggests that a system dynamics framework is well designed to allow for the valuation of entrepreneurial rents over the time path of exploitation and dissipation.

The first section of this paper will highlight the characteristics of entrepreneurial rent, and provide a systematic and generalized description of how these rents are created and subsequently dissipated in an economic system. Next, a system dynamics model of a modern agricultural operation is introduced: a three-site hog production system that incorporates technical and managerial innovations. This simulation model is used to compute the value of entrepreneurial rents arising from different arbitrage opportunities and innovations that can be exploited by the entrepreneurial manager. The third section reports the results of the various simulation experiments. Finally, I conclude by discussing several implications for this work and provide ideas for future research.

The Entrepreneurial Process

The process by which profit opportunities are searched for, discovered, exploited and by which the returns from such opportunities are eventually eliminated is known as the *entrepreneurial process* (see Figure 1). The search for new profit opportunities starts this process and is triggered by a firm's satisfaction level – the lower the satisfaction, the more searches a firm will undertake for alternative rent streams (March and Simon, 1958; Mahoney, 2005). Low satisfaction levels are a result of a firm's low expected returns relative to its aspiration levels (March and Simon, 1958; Mahoney, 2005). Since market equilibrium only allows firms to achieve normal economic returns, this condition often initiates a search process. This search process is characterized by a complex set of search rules and heuristics (Cyert and March, 1963).

Figure 1 - The Entrepreneurial Process



However, given that the focus of this paper is to capture the flow of returns to entrepreneurial behavior, these complex search heuristics are not considered herein. Instead, it is assumed that viable opportunities have already been discovered and implemented. The important point is that during the search process, a firm is in search for disequilibrium markets in which above average returns can be found (Kirzner, 2000, Schumpeter, 1934). In some cases, disequilibrium conditions may be created by structural frictions in the market process (Mahoney, 2005). In this case, price differentials may exist; a factor of production may be priced at different levels in different markets. Disequilibrium markets may also be created endogenously. By investing in innovation activities and introducing new technologies, entrepreneurial firms can disrupt the competitive equilibrium of a market and create the necessary conditions to earn above-average returns themselves. This is the essence of Schumpeter's 'process of creative destruction". In either case, firms alert to these opportunities can capitalize on them and earn above-average returns.

Profit opportunities are exploited by entrepreneurial activities. These activities include arbitrage and innovation. In either case, entrepreneurial firms seek to change some aspect of their business model in hopes of earning above-average returns. Areas in which arbitrage and innovation activities may lead to above-average returns include changes to revenue streams, production costs and transaction costs (Ross and Westgren, 2005). For example, firms may exploit new markets for their product (arbitrage), find new sources of inputs (arbitrage), and implement new production technologies (production innovation) or new organization structures (organizational innovation). To the extent that firms can increase revenues and decrease the costs of production and transactions costs, firms can achieve positive economic returns.

Ultimately, the appropriation of superior returns leads other entrepreneurial firms to imitate and exploit these same arbitrage and innovation opportunities. As this occurs these opportunities are removed, profits are eliminated and the market is driven towards equilibrium.[3] Thus, the competitive effects of the market attempt to balance the market system in the long run. Figure 1 illustrates the entire entrepreneurial process.

Entrepreneurial Rents

According to the resource-based view of the firm, firms consist of a complex bundle of heterogeneous productive resources; and when these resources are valuable, rare, and

[3] For arbitrage activities, the exploitation of price differentials alerts the market to its pricing mistakes. Conversely, the process of disrupting the competitive equilibrium by introducing new technologies and resource combinations (innovation) and the response of the market to drive it back to equilibrium is known as the 'process of creative destruction' (Schumpeter, 1934). This process is characterized by rent creation (equilibrium disruption) and the subsequent imitation of the rent creating behavior by other firms eliminating all profits from the system (equilibrium reestablishment). Notice that Schumpeter's "process of creative destruction" is encapsulated within Figure 1.

inimitable they lead to superior profitability (Barney, 1991). These resources are tied together by production technology and organizational structure either of which may also be a source of superior probability (Barney, 1991). Some resources are the familiar physical assets of economic theory: land and capital. Other resources include skill sets and labor productivity. Each of these resources must be compensated by wages, salaries, interest, capital payments, etc. After payments are made to these resources, any profits may be imputed to a less tangible resource of entrepreneurial behavior; these imputed payments are entrepreneurial rents. According to the full imputation of rent principle (Lippman and Rumelt, 2003a; Friedman, 1976), these rents are equivalent to the returns of an entrepreneurial firm's arbitrage and innovation activities. Since entrepreneurial activity refers to unique behavior by definition, the returns to these activities are similar to the Ricardian (monopoly) rents that firms earn when competition is limited (Von Thunen, 1826; Knight, 1942; Casson, 1995; Mahoney and Pandian, 1992).

However, unlike the payments to other firm resources, entrepreneurial rents are not easily valued using traditional market equilibrium methods. In fact, Casson (1995) and Klein and Foss (2004) have pointed to the fact that there are no well established markets for entrepreneurial resources as the *raison d'etre* for a firm[4].

The valuation of entrepreneurial rents is complex for several reasons, not the least of which is the uncertainty of the outcomes of entrepreneurial activities. A firm's decision to implement an arbitrage or innovation activity requires that it exercise judgment in an uncertain environment. Outcomes of entrepreneurial activities are unknown to firms

[4] To gain returns entrepreneurs must commercially exploit their ideas themselves (Casson 1995). This requires the entrepreneur to own and manage assets which is the crucial ingredient to firm organization (Klein and Foss, 2004).

prior to implementation. In this situation, firms are forced to make value judgments as to the returns they will receive from these activities (Knight, 1942). The uncertainty of the future returns to entrepreneurial behavior makes the payments to its services[5] *ex ante* incomputable and thus, non-contractible.[6] In general, however, superior value judgments will lead to positive economic profits and positive entrepreneurial rents (Knight, 1942), while poor value judgments will lead to economic losses and negative entrepreneurial rents (Alvarez and Barney, 2002).

In addition, the rents derived from these entrepreneurial activities are unsustainable without the use of isolating mechanisms (Rumelt, 1984). As stated previously, superior returns can only be achieved under conditions of disequilibrium (Kirzner, 2000; Schumpeter, 1934). As firms appropriate these rents, competitive effects work to return the market to an equilibrium position, and thus eliminate the returns to the innovation or arbitrage activity. Entrepreneurial rents, therefore, are temporary; and only exist during the short run period in which a market returns to its competitive equilibrium. Traditional static equilibrium models that ignore this process are thus ill suited to capture the flow of rents to entrepreneurial resources.

In light of these challenges, several approaches have been suggested to impute value to unpriced resources such as the entrepreneur. Lippman and Rumelt (2003b) emphasize

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[5] Under a resource-based framework of the firm, firms are comprised of a heterogeneous bundle of resources, and these resources provide productive services (Penrose, 1959). The entrepreneur can be thought of as a firm resource. Not all firms will possess the same levels of this resource, and the services of this resource are its alertness, judgment, access to resources and execution capabilities that allow a firm to discover and exploit new profit opportunities (Ross and Westgren, 2005).

[6] Friedman (1976) defines entrepreneurial rent as the 'expected' portion of the above-average return or in Friedman's terminology the expected noncontractual costs. The difference between the 'actual' and the expected' noncontractual costs Friedman states constitutes pure profits – an unanticipated residual arising from uncertainty. Thus, he solves the problem of calculating entrepreneurial rent under uncertain conditions by explicitly eliminating uncertainty from the calculation.

that payments be distributed among firm resources under a cooperative game theory framework. They argue that resources bargain for the excess returns generate by the discovery of their best use alternative. However, Lippman and Rumelt (2003b) fail to recognize the specific role of the entrepreneur in the firm. As Schumpeter (1934) argued the discovery and exploitation of new resource combination (i.e. best use alternatives) is the function of the entrepreneur. Thus, as Ross and Westgren (2005) have suggested the excess return generated by the entrepreneur's activities should be allocated as a payment to the services of the entrepreneur and not distributed among other firm resources.

Alternatively, Denrell, Fang and Winter (2003) propose that the valuation of complex resources can be solved by backwards induction and dynamic programming. Entrepreneurs use these tools to calculate the value of alternative resource uses. If these alternatives result in resource values different than the market values, profit opportunities exist (Denrell, Fang and Winter, 2003). If exploited the difference in value may be considered a return to the actions of the entrepreneur. The problem with this analysis however, is that alternative use payoffs are unknown *ex ante*. Furthermore, Denrell, Fang and Winter fail to attribute the excess return to the entrepreneur. Instead, these payments are received by the residual claimants of the firm. If we consider the case that the entrepreneur is not the residual claimant to the firm's returns, then what is the incentive for these resources to discover and exploit appropriate new profit opportunities?

To resolve some of these issues, Ross and Westgren (2005) explicitly allocated payments the entrepreneur as a return to the entrepreneurial behavior of the firm. In doing so, they developed a two-period model in which changes to a firm's revenue, cost and production functions are explicitly captured. In this model, entrepreneurial rents are calculated as the net changes in profits from the firm's actions. Although it does capture the uncertainty and judgment characteristics of these types of rents, such a model is unable to allow for the dynamic feedback process in which the returns to the entrepreneurial activities are dissipated in the marketplace.

Whether the entrepreneurial behavior excerised is an arbitrage or an innovation activity, the entrepreneurial rents that may be gained are temporary. The implication for this study is that any model of entrepreneurial rent valuation must be flexible enough to capture these complex dynamic processes. This paper suggests a system dynamics approach to impute value to entrepreneurial activities because it can explicitly incorporate the dynamics of inter-period changes in production costs and revenues. Moreover, the SD methodology permits us to examine the structural complexity of entrepreneurial activities within the firm. Feedback, time delays, and stochasticity in production processes contribute to the causal ambiguity[7] that protects entrepreneurial innovations from being imitated (Barney, 1991; Rumelt, 1984). The next section describes a system dynamic approach to incorporate this feedback and to impute value to the services of the entrepreneurial resources.

Entrepreneurial Rent Valuation: A System Dynamic Model

In this section, I build and use a system dynamics model to illustrate the flow entrepreneurial rents and impute these returns to the entrepreneurial resources of the firm. The model explicitly demonstrates five common arbitrage opportunities for inputs and

[7] Casual ambiguity refers to the unknown mechanisms or drivers within a firm that allow it to achieve superior profitability. In other words, it is unknown which resources, organization structures or combination thereof causes a firm to generate above-average returns. This causal relationship might even be unknown to the firm itself no to mention its competitors.

output and three innovation activities within a three-site hog production system. These activities give rise to transitory rents given uncertainty, causal ambiguity and competitive market forces. As such, the model emphasis the dynamic and *ex ante* non-contractible nature of these rents.

Model Description

System dynamics models have been recognized as a method in which researchers can model complex systems similar to those faced by firms in today's dynamic and ultra-competitive business environment (Sterman, 2000). "Dynamic models are those that try to reflect changes in real or simulated time and take into account that the model components are constantly evolving as a result of previous actions" (Ruth and Hannon, 1997, p.6). As such, they capture the "feedback" of certain events and incorporate these results into the model to determine their effects on other simultaneously occurring events.

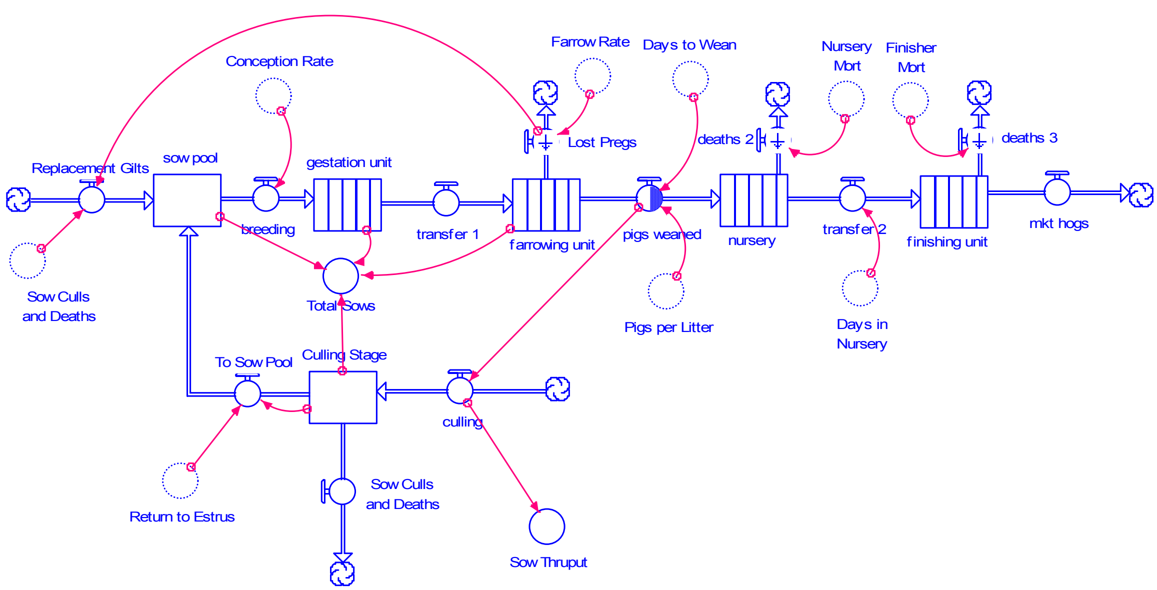
The STELLA® modeling environment is used here to depict the dynamic nature of entrepreneurial rents and to illustrate a methodology for their calculation. This software allows for a visual presentation of the way each model variable interacts with another and allows for the easy manipulation of model parameters so that various scenarios can be evaluated.

The base production model used in this study was adapted from Cozzarin (1998) and is used to capture the dynamic effects of several entrepreneurial shocks. Entrepreneurial behavior consists of participating in two distinct kinds of activities: arbitrage and innovation. Several examples of each are modeled for both of these activities. The model simulates the effects of these activities in a three-site hog production model over the 6-year period from 1989-1994 as per Cozarrin's (1998) origin specification with a time step of one day. This period in the U.S. hog industry[8] is particularly well suited to such an analysis because of the rapid structural changes that occurred in this industry during that time. Among these changes was the adoption of two significant innovations: segregated early weaning (i.e. production innovation) and production contracting (organizational innovation). Both of these innovations are modeled here.

Three-Site Pork Production

The dominant production model in the U.S. hog industry is the three-site production model (Purdue Cooperative Extensive Service, 1995). In this model, a traditional on-farm production operation is split into three units according to the different stages of production: breeding, gestation and farrowing; nursery; and finishing. Figure 2 illustrates the basic production model in the STELLA programming environment.

Figure 2 - Three-Site Hog Production System adapted from Cozarrin (1998)



[8] The use of the U.S. hog industry as a context for this research also follows in the tradition of a well known system dynamics study by Dennis L. Meadows entitled "Dynamics of Commodity Production Cycles".

The first stage of production – breeding, gestation and farrowing – models the flow of the breeding herd through the production system. The model considers an initial sow pool of 300 sows. These sows represent the breeding herd for the production system. Once these sows have been bred and become impregnated, they enter a gestation unit for 115 days after which time they are transferred to the farrowing unit to give birth. When their young are weaned, the sows then enter a culling stage at which time poor performing sows are removed from the herd. Sow mortality is also included in the model. The return of sows back to the sow pool to be bred finishes the sow production process and constitutes the first source of feedback in the model. Additional sows are then purchased to replace those sows that were lost (i.e. culled and died) during the production process. Given this process, the rate at which sows flow through the production system is dependent upon the production technology employed by the firm. In general, however, a technology that leads to greater herd health will increase the efficiency of the production system by increasing the number of pigs marketed per year and decreasing the number of replacement sows needed. See Table 1 for a list of the various sow production assumptions.

The second and third units of the production system are the nursery and the finishing units, respectively. These two units detail the growth of hogs from weaning age until they are marketed. Weaned hogs enter the nursery unit in groups (determined by their age cohort) to facilitate the use of all-in all-out (AIAO) production technology. This type of production is consistent with best management practices (Dall, 2000). During their time in the nursery, weaned pigs are fed several early growth rations until the group reaches a specified average weight. The duration a group spends in the nursery unit is shown in Table 1 and is dependent of the production technology utilized. Following the nursery stage, hogs enter a finishing unit and are fed several different rations. The AIAO production practice is continued in the finishing unit. After 126 days in the finishing unit hogs are marketed.

Table 1 - Comparison of AIAO and SEW Production Parameters

PRODUCTION PARAMETER	AIAO	SEW
Initial Sow Pool	300	300
Cull & Death Loss	22.5%	22.5%
Breeding Rate	1.94	1.94 (adj. 2.10)
Gestation Time	115	115
Gestation Capacity	264	264
Farrowing Rate (Range)	80-85%	78-85%
Sow Feed Intake (AIAO=100)	100	102.5
Return to Estrus (Days)	8	5
Days to Wean	20	11
Pigs Per Litter	9.0	8.2
Days in Nursery	70	56
Nursery Mortality	2.0%	1.0%
Nursery ADG	0.714	0.929
Nursery FC (AIAO=100)	100	95
Days in Finishing Unit	126	126
Finish Mortality	2.25%	1.50%
Finish ADG	1.508	1.508
Finish FC (AIAO=100)	100	95

Source: Lawrence (1996).

Sub-models

Sub-models for weight and financial calculations are also included and follow those developed by Cozarrin (1998) with one exception. The entire three-site operation is under the control of a sole producer. Consequently, all production costs and revenues associated with the three-site hog operation accrue to a single producer.

Data

The price data used in this model were also imported from Cozarrin (1998). In this model, the Omaha terminal market cash price $/cwt was used for the hog price, the East-Central Illinois cash price for #2 Yellow $/bushel was used for the corn price, and the Decatur Illinois cash price with 48% protein on the rail in $/ton was used for the soybean meal price. These prices were collected over the 7-year period beginning in January 1988. Costs for micronutrients, labor and capital were also borrowed from the Cozarrin (1998) model.

Entrepreneurial Activities

The production model described above is used to capture the results of several entrepreneurial activities. These activities can be categorized as one of two types: arbitrage or innovation. Rents accrue to arbitrage activities when an entrepreneurial firm exploits price differentials in the market for outputs and inputs. On the other hand, a firm may create entrepreneurial rents by participating in innovation activities that either change the production function or change the organizational structure of the firm. When the firm participates in one of these activities, the *status quo* of the system is shocked, and entrepreneurial rents are generated. The system dynamic model described above allows for these rents to be captured and valued as various activities are turned on and off.

Arbitrage Activities

Five different arbitrage activities are modeled. In all cases, the activities are modeled as if the entrepreneurial firm has discovered other markets in which to sell its output (i.e. market hogs) or to acquire inputs (i.e. corn, soybean meal, labor, capital). The price differential between the current market and the new market represents an arbitrage opportunity for the firm and its exploitation generates entrepreneurial rents.

Table 2 - Transaction Cost Values for Market vs Contract Exchange Mechanisms and Arbitrage Activities

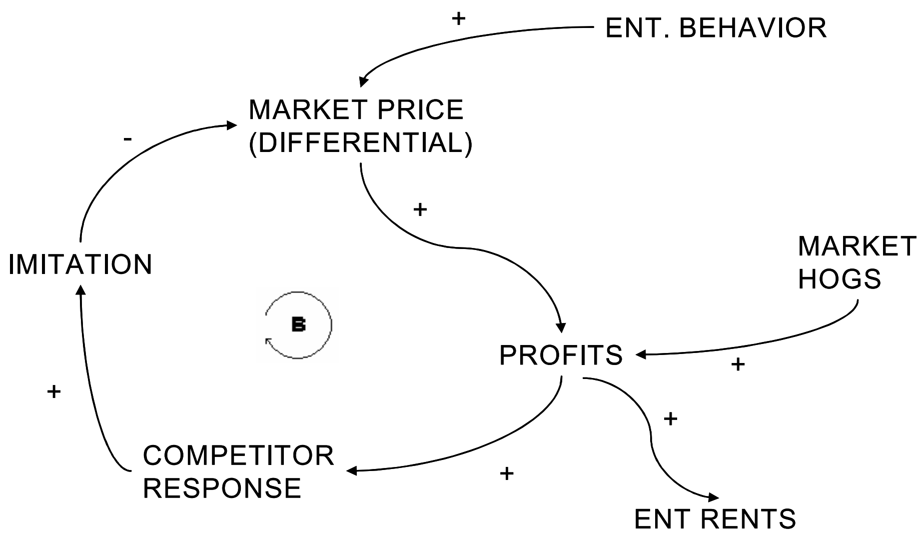
Transaction Cost	Value
Market Costs (per commodity per marketing)	
Search Cost	$10
Bargaining Cost	$10
Contract Costs (per commodity per contract)	
Design Cost	$2000
Monitoring Cost	$500
Arbitrage Costs (per commodity per arbitrage)	
Search + Contract Costs	$5000

It should be made clear, however, that arbitrage activities are not systemic. In other words, these types of activities do not result in changes to the structural complexity of the dynamic production system. Arbitrage activities only apply to the firm's interactions in factor and output markets (i.e. price discovery) and are thus, implicitly tied to the entrepreneurial search for and judgment of market opportunities. Search costs are explicitly included in the model (see Table 2).

Market Hogs

Entrepreneurial firms may discover alternative markets in which to sell their finished hogs. For example, the firm may discover it can sell its production to organic or foreign customers; each of which may be willing to pay a premium above the current market. This model assumes that the new market is willing to pay a firm a 10% premium over current spot market prices. Figure 3 provides a casual loop diagram to illustrate the rent generation process that occurs when a firm acts to exploit arbitrage opportunities in the hog market. This rent generation process is similar for all arbitrage activities.

Figure 3 - Casual Loop Diagram of Arbitrage Rent Creation in Hog Market



Feed Inputs (i.e. Corn and Soybean Meal)

Similarly, a firm may discover new suppliers of feed inputs. These suppliers may be able to provide corn and soybean meal at a significant discount compared to the hog producer's current supplier of these resources. Alternatively, it may be that the new source of feed inputs is located closer to the hog production system and thus transportation costs are smaller. In either case, the firm is able to substitute a low cost input for a high cost input, and thus is able to generate an entrepreneurial rent. This model assumes that the price differential between the old and new markets is 10%.

Labor

Arbitrage opportunities may also occur in the labor market. Firms that discover and utilize alternative labor sources will incur entrepreneurial rents from this activity. One example that is common in agriculture is the use of immigrant labor. To the extent that price differentials occur between one source and another (i.e. local labor versus immigrant labor), entrepreneurial rent may be achieved. In this model, it is assumed that another source of labor is discovered and would save the producer 5% in labor costs.

Capital

The final arbitrage opportunity available to the firm in this model is the found in the capital market. Entrepreneurial firms may discover other sources of funding. Different lending institutions may offer different interest rates, government grant programs not hereto utilized may be discovered and/or new investors may be attracted. The discovery of price differentials between existing capital sources and alternative capital sources may present the firm with an arbitrage opportunity. In this model, it is assumed that another source of capital exists such that capital costs may be reduced by 5%.

Table 3 below summarizes the assumed parameter values used for each of the arbitrage activities. Since the purpose of this exercise is to highlight the methodology for entrepreneurial rent valuation, I have chosen arbitrary values for the arbitrage opportunities that if exploited should intuitively lead to positive entrepreneurial rents.

Table 3 - Parameters for Arbitrage and Contracting Activities

Parameter	Arbitrage Value (Above(+)/Below(-) Price Series)	Contract Value (Average of Price Series)
Market Hogs	+10%	$45.97
Arbitrage Corn	-10%	$2.39
Arbitrage SBM	-10%	$190.05
Arbitrage Capital	-5%	
Arbitrage Labor	-5%	

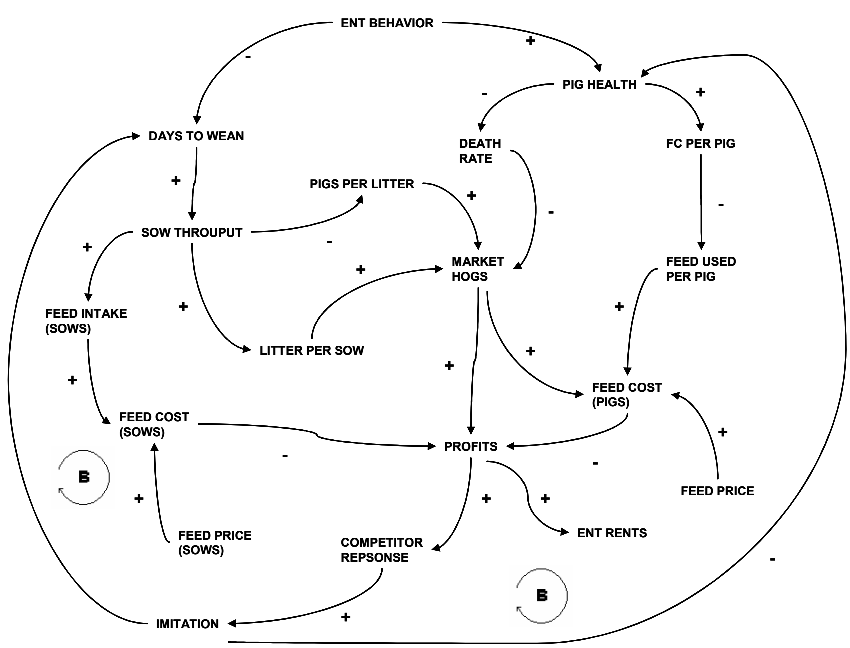
Innovation Activities

In search of profits, the hog firm may also participate in innovation activities. The model presented here illustrates three such innovations – segregated early weaning, contracting of inputs and output, and leadership. These innovations are of one of two types – production-oriented or organization-oriented.

Segregated Early Weaning (i.e. Production Innovation)

Segregated early weaning (SEW) was introduced in the early 1990s and refers to the management practice of weaning pigs before 21 days of age and placing them in a separate nursery unit located on a different site than the farrowing and finisher facilities. The objective of this technique is to separate wean-age pigs from any diseases in the breeding herd before the initial protection obtained from the mother's colostrum wears off. Figure 4 provides a casual loop diagram to illustrate the rent generation process that occurs when a firm introduces SEW production technology.

Figure 4 - Casual Loop Diagram of Rent Creation from Adoption of SEW Technology



Studies of the effects of SEW have found that pigs are healthier under such a system and express increases in average daily gain (ADG) and feed conversion (FC) and decreases in mortality rates in nursery and finisher units (Lawrence, 1996). Thus, the use of SEW technology can lead to significant increases in the number of pigs that can be marketed per year (i.e. lower death rates and shorter time to market) and decreases in the amount of feed required to grow pigs to market weight.

The reproductive capacity of sows has also been found to be affected by SEW technology. By decreasing the weaning time of piglets, SEW increases the turnover of sows in the farrowing unit and thus increases the number of litters per sow per year (Lawrence, 1996; Mabry, Culbertson and Reeves, 1996). Studies have also found that SEW can lead to a decrease in the wean-to-estrus interval[9] of sows (NPPC, no date). This increase in sow efficiency results a smaller number of culled sows (due to their inability to return to estrus) and leads to a steady flow of sows[10] thereby increasing the throughput of the total production system. However, SEW also increases the stress levels of sows which result in smaller sow litter sizes and more variable farrowing rates for early parity sows (Lawrence, 1996; Mabry et al., 1996). These affects are partially mitigated by increasing sow feed during the lactation period (Harper, 1999). See Table 1 for a comparison of the assumptions used in the base (AIAO) production and the SEW production models.

Contracting (i.e. Organizational Innovation))

A firm can either use the market mechanism or use contracts to procure production inputs and sell their output. By changing the organizational structure of the firm and

[9] The wean-to-estrus interval refers to the period of time between the when the sow leaves the farrowing unit until the time the sow is ready to be bred again.

[10] Dall (2000) found that SEW technology can lead to fewer empty farrowing crates in some weeks and few overcrowding problems in others. As a result, there are fewer capacity problems in the nursery and finishing units as well.

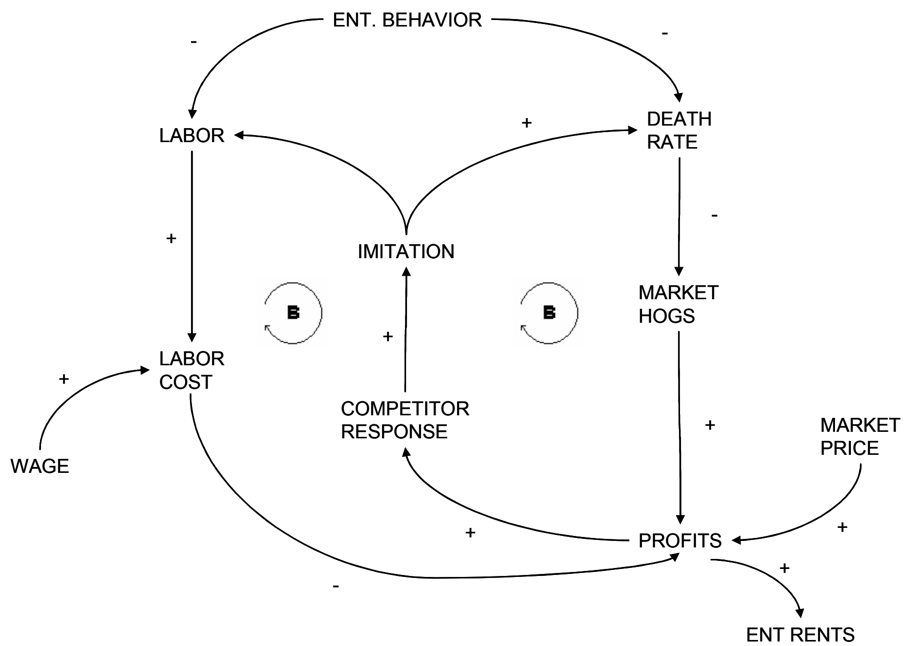
minimizing transaction costs, an entrepreneurial firm can generate rents. In the base production model presented above, hogs and feed inputs (i.e. corn and soybean meal) are sold and purchased using the market mechanism. However, the model allows for these commodities to the contracted during the simulation. The six-year average price for each commodity is used for the respective contract prices. The costs of searching and bargaining in the market, and of establishing and monitoring contracts are also explicitly incorporated in the model. Table 2 lists the values used in simulation for various transaction costs.

Leadership (i.e. Organizational Innovation)

Casson (1995) introduced the notion that leadership skills may be a source of entrepreneurial rent within a firm. In order to solve the agency problems related to asset ownership and the management of teams, firms incur costs associated with the monitoring of contracts (Alchian and Demetz, 1972). However, these costs may be mitigated by effective leadership. By exercising leadership, entrepreneurs are able to emphasize the importance of commitment to the task at hand and to motivate employees to put forth high effort. In essence, a strong leader increases the cost of slacking to employees by inducing guilt or a loss of self-esteem in those employees who are not performing to standards. To the extent that such leadership is effective, firms may be able to reduce the need to high addition employees to supervise the work of others (Ross and Westgren, 2005). In this form, leadership may be considered to be a form of organizational innovation in which labor is motivated to increase productivity and minimize slacking. For the purposes of this model, leadership is assumed to decrease mortality rates in the nursery and finisher units by 10% and decrease labor costs by 10%.

Figure 5 provides a casual loop diagram to illustrate how rents are generated from leadership innovations.

Figure 5 - Casual Loop Diagram of Rent Creation from Leadership



Rent Dissipation

The competitive forces of the market are another source of feedback in the system and balance the rent-generation process. The benefit of the system dynamics approach is that its makes the time path of rent dissipation more explicit with respect to revenues, costs, profit, and returns to entrepreneurship. This model uses S-shaped diffusion curves as a proxy for this rent dissipation process (Rogers, 1962). Thus, the rates at which profits dissipate are exogenous parameters of our model. To simplify the model further, these rates are used to return the system to its initial condition (i.e. to the BASE model). This is done so that the rents generated under the various entrepreneurial shocks can be dissipated and then compared to the base model. The following equation describes this dissipation process, where X_2 and X_1 are the new and original values of the applicable parameter, respectively, and r_t is the diffusion rate at time t[11]:

$$X_2 - (X_2 - X_1) * r_t \tag{0.1}$$

Different diffusion curves are specified for arbitrage and innovation activities. It is assumed that the mechanisms of arbitrage activities are easier to imitate than those of innovation activities. Innovation activities are more difficult to imitate for several reasons. For instance, significant capital startup costs may be required and the mechanisms by which profits are created from innovation activities are typically less evident to producers outside of the entrepreneurial firm than those used associated with arbitrage activities.[12] As such, this model assumes that arbitrage activities are imitated over a two-year period and innovation activities are imitated over a five-year period.

Results

The results of the 12 simulations reflect the dynamic nature of entrepreneurial rents. Profits are created by entrepreneurial activities and then eliminated over time by the competitive forces of the market. The results of the various simulations are compared to the base model (*status quo*) to calculate the associated entrepreneurial rent. Entrepreneurial activities that focused on the production and price of market hogs resulted in the largest entrepreneurial gains. Also, fluctuations in entrepreneurial rents

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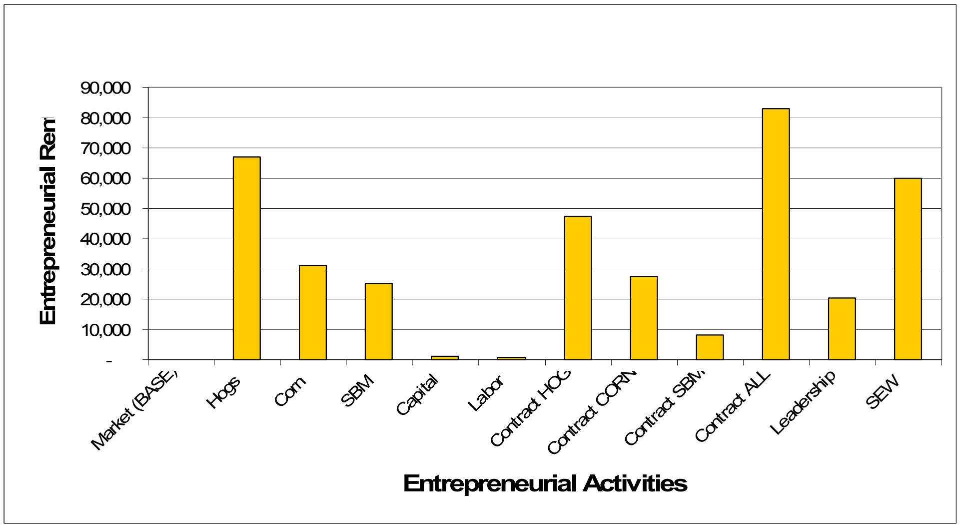
[11] For example if we consider hog market arbitrage, X_2 represents the premium price, X_1 the current equilibrium price and r_t the rate of diffusion at time t. Therefore, as time passes, the rate of diffusion increases (i.e. following an S-shaped diffusion curve) and the difference between the premium price and the original competitive equilibrium price is removed.

[12] This point refers to the causal ambiguity of the returns. In general, innovation activities are more complex to implement than arbitrage activities. Thus, the mechanisms by which superior returns are created from innovation activities tend to more causally ambiguous than those generated from arbitrage activities.

occur because of the uncertainty of market prices. Figure 6 and Appendix A present the results of the 12 simulations.

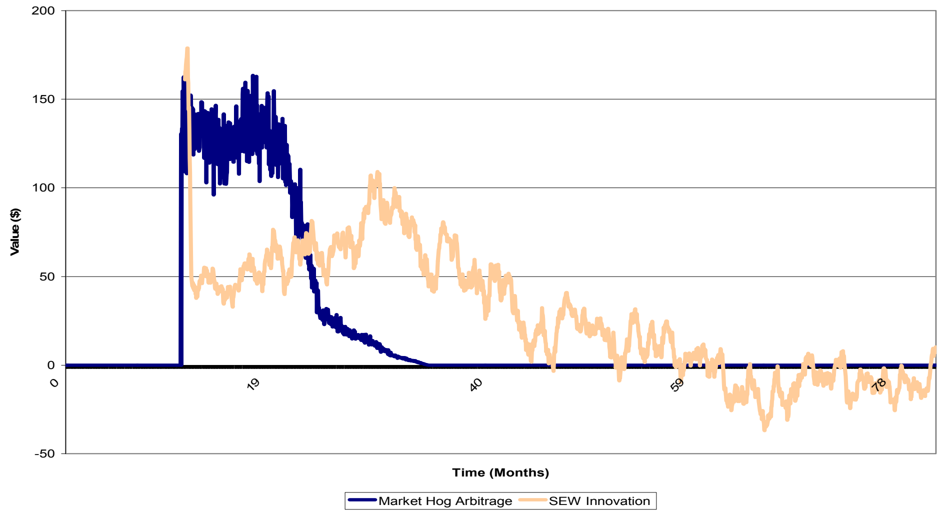
Figure 6 - Returns to Entrepreneurial Activities



Arbitrage Activities

Arbitrage opportunities were modeled for market hogs and four inputs – corn, soybean meal (SBM), capital and labor. As expected, the exploitation of these opportunities resulted in positive entrepreneurial rents for all cases. Arbitrage in the hog market resulted in the greatest return to entrepreneurial behavior. The exploitation of a 10% price differential between the arbitrage and the current price for market hogs increased profits by $67,013 over the simulation period. Since all other parameters remained consistent with the base model, these profits are attributed to the entrepreneurial activity of the firm. Figure 7 illustrates the entrepreneurial rents generated from market hog arbitrage in each period. As shown all rents have been removed from the system within two years as other producers imitate the entrepreneurial producer and exploit the price differential as well.

Figure 7 - Flow of Returns to Entrepreneurial Activities



Significant rents were also generated by realizing profits from input arbitrage opportunities. In particular, arbitrage activities in the market for corn and SBM resulted in entrepreneurial rents of $30,959 and $25,167, respectively. Rents were also generated in capital and labor markets, however, cost savings were largely offset by the costs of establishing these new markets.

Innovation Activities

In general, innovation activities generated the largest entrepreneurial rents. This result reflects the complexity of the innovation activities and the rate at which the associated entrepreneurial behaviors can be imitated. The implementations of both SEW and leadership (i.e. labor incentive programs) increased the number of hogs marketed over the simulation period, and resulted in positive returns of $60,042 and $20,555, respectively.

With the introduction of the SEW technology, market hogs increased from 29,957 market hogs (BASE) to 30,592 market hogs (SEW) This result reflects the increase in the number of litters per sow per year (as measured by sow throughput) and the increased efficiency of pigs in the nursery and finishing units (i.e. increased ADG and decreased mortality rate). However, these results required an adjustment to the size of the sow production facilities to allow for an increased flow of sows out of the breeding (sow) pool[13]. Under the original facility size specification, SEW led to significant bottlenecks in the breeding pool due to the 26 day reduction in the sow production cycle under this technology[14]. This suggests changes in organizational structure, in this case production capacity, may be required to fully appropriate the benefits of the SEW technology. The rents generated by this innovation are illustrated in Figure 7. As shown all rents are effectively eliminated by the fifth year of the simulation as the innovation is adopted by other producers in the industry[15].

Leadership, on the other hand, creates incentives for labor to work efficiently and empowers labor to improve the production process. The result is that labor costs are reduced (from 3.87 per market hog to 3.71) and the number of hogs marketed increases from 29,957 to 30,017.

Contracting in input and output markets also resulted in positive returns to entrepreneurial behavior for the hog producer. When all inputs were contracted from suppliers and market hogs were contracted to a packer, the result was an increase in profits of $82,837 and thus an entrepreneurial rent of the same amount was created. In

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[13] This adjustment was made by increasing the sow breeding rate to a point where the # of sows in the sow pool under SEW was consistent with the # of sows in the sow pool under the base model at full production. The need to increase the capacity of the hog production system at the same time as the introduction of SEW technology was also suggested by the Lawrence (1996).

[14] Using the original facility size specification, hogs marketed actually decreased to 29,236 and the entrepreneurial rent was 11,285.

[15] The 30-day moving average is used to illustrate the entrepreneurial rents generated from the SEW innovation. This is done for presentation purposes and is used to reveal the underlying trend by removing some of the variation in these rents.

fact, the use of the contract mechanism to procure and sell the firm's inputs and output resulted in positive entrepreneurial rents for each individual commodity as well. With respect to SBM, these rents were created even when the realized average soybean meal price was below the contract price (i.e. average price of the time series). This reflects the relative cost efficiency of the contract mechanism over the market. Notice Appendix B also illustrates that contracting decreases the price risk with respect to feed inputs and market hogs.

Discussion

Unlike the payments to other factors of production, entrepreneurial rents are not easily captured in traditional (static) equilibrium models. In fact, the central feature of entrepreneurial rents is that they do not exist in markets that are in equilibrium at all. Entrepreneurial rents are available to firms who actively participate in activities that either attempt to disrupt a market's competitive equilibrium (Schumpeter, 1934) or attempt to move a market towards equilibrium (Kirzner, 2000). These activities are based on innovation or arbitrage behaviors, respectively. The other unique feature of entrepreneurial rents is that they are dynamic and temporary in nature. Superior returns alert competing firms to the activities of the entrepreneurial firm. Competing firms will attempt to adopt these activities for themselves and compete for a share of the profits. This process by which profits are removed from the market is also not captured well in traditional equilibrium models.

Therefore, this paper has proposed a system dynamic approach to entrepreneurial rent valuation. This type of modeling is an appropriate tool for modeling the value of entrepreneurial behavior because it allows a manager or researcher to explicitly capture the dynamic complexities of rent creation and competition. In support of this claim, a system dynamic model of a three-site hog production operation was presented in which 11 entrepreneurial activities were explicitly modeled. Economic returns were calculated for each activity and the results reflect their dynamic and temporary nature. The change in profits was then specifically allocated to the entrepreneur as a payment for his services (i.e. rent creation), which is known as entrepreneurial rent. These rents were calculated *ex post* since the outcomes of the entrepreneurial activities are by nature uncertain and thus *ex ante* non-contractible. The simulation model also captured the dynamic process by which entrepreneurial rents flow to the entrepreneurial resources of the firm

A couple implications can be offered to managers from this analysis. For example, this study suggest that in the absence of isolating mechanisms (Rumelt, 1984), firms must continually search for and exploit new profit opportunities in order to achieve above-average returns. Existing profits are removed from the market over time as competition drives the market to equilibrium and a state of normal (zero) profits. Firms that can manage for constant renewal are more likely to be successful in rapidly changing environments where profits are quickly removed and isolating mechanisms are less relevant. Furthermore, this study also suggests that the existing organizational structure of the firm may limit a firm's ability to fully appropriate the rents from the introduction of new production technologies. Thus, the compatibility of production technologies and organizational structures should be considered in the decision-making process.

The model presented here also has several limitations. Since I am interested in the imputation of total returns to the resources of the firm, I do not model the entire entrepreneurial process. That is, I assume that the arbitrage or innovation decision has already been made and the concern is with the allocation of the *ex post* returns to the appropriate firm resources. Therefore, I assume that the outcomes of the specified entrepreneurial behavior parameters to be given. To further simplify the analysis and highlight the dynamic and temporary characteristics of entrepreneurial rents, these outcomes are assumed to be positive. Thus, this paper does not consider the search and decision-making sub-processes of the entrepreneurial process. As such, the riskiness of an entrepreneurial opportunity is not a considered in this study. In the entrepreneurial process, risk-taking is associated with the decision to execute the arbitrage or innovation activity, not with the allocation of *ex post* returns. Furthermore, as Freidman (1976) and Schumpeter (1934) point out, the entrepreneur is not a risk-taker; risk-bearing is a function borne by the providers of capital resources to the firm.[16] Future research may include the search for and the evaluation of potential profit opportunities. In the case where are objective was to model the search and decision-making process, outcome parameters would be unknown to the firm and entrepreneurs would make *ex ante* value judgments to determine if profit opportunities warranted exploitation. Explicit search and evaluation rules would need to be included to assess the expected returns of alternative decision payoffs. Such a model should explicitly consider the risk-return tradeoff. The system dynamics approach taken here could be adapted to include this process. Stochastic variables could be substituted for the outcome parameters and thus, this model could become a useful tool to evaluate the expected returns of specific entrepreneurial activities.

[16] Note that the services of the entrepreneur and the capitalist may be found in the same resource. However, risk-bearing is attributable to the capitalist function of this resource (Schumpeter, 1934).

Another limitation of this model is that the diffusion of innovation and arbitrage behavior is taken to be exogenous to the model. This assumption was also made to simplify the analysis and focus on the dynamic and temporary characteristics of the entrepreneurial returns. However, the dissipation of rents need not be exogenous to the system dynamics model. Future research may try to incorporate this diffusion process into the model endogenously. This task may highlight the key factors that determine the rate at which entrepreneurial behaviors are imitated and profits are dissipated. One factor to consider might be a rival firm's distance from the entrepreneurial firm who is the first-mover in the market. Here, distance may refer to either physical distance or figurative distance in product-market space.

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Appendix A

Summary Financial Tables for Entrepreneurial Rent Simulations

ENT ACTIVITY	RENT	MARKET HOGS	PROFIT	REVENUE	COSTS			
					Sow Unit	Nursery	Finish Unit	Transaction
Market (BASE)	-	29,957	(1,103)	3,280,210	941,148	509,837	1,760,197	70,130
Arbitrage								
Hogs	67,013	29,957	65,910	3,330,513	941,148	509,837	1,760,197	53,420
Corn	30,959	29,957	29,856	3,280,210	938,939	508,587	1,749,408	53,420
SBM	25,167	29,957	24,064	3,280,210	939,966	508,591	1,754,169	53,420
Capital	1,210	29,957	107	3,280,210	939,917	509,179	1,758,376	72,630
Labor	706	29,957	(397)	3,280,210	939,225	509,470	1,759,281	72,630
Organizational Innovation								
Contract HOG	47,418	29,957	46,315	3,308,418	941,148	509,837	1,760,197	50,920
Contract CORN	27,414	29,957	26,310	3,280,210	939,875	509,116	1,753,988	50,920
Contract SBM	8,006	29,957	6,903	3,280,210	942,705	511,477	1,768,205	50,920
Contract ALL	82,837	29,957	81,734	3,308,418	941,431	510,756	1,761,996	12,500
Leadership	20,555	30,017	19,452	3,287,628	931,204	508,313	1,758,528	70,130
Process Innovation								
SEW	60,042	30,592	58,939	3,370,568	965,023	508,726	1,767,661	70,220

$RENT(i) = PROFIT(i) - PROFIT(base)$, where i represents the associated entrepreneurial activity

Appendix B

Summary Tables for Price Parameters

	AVERAGES					STANDARD DEVIATIONS		
ENT BEHAVIOR	PRICE HOG	PRICE CORN	PRICE SBM	LABOR COST	CAPITAL COST	PRICE HOG	PRICE CORN	PRICE SBM
Market (BASE)	46.34	2.39	183.19	3.87	6.19	6.161	0.219	20.943
Arbitrage								
Hogs	47.04	2.39	183.19	3.87	6.19	(0.066)	-	-
Corn	46.34	2.35	183.19	3.87	6.19	-	(0.005)	-
SBM	46.34	2.39	179.70	3.87	6.19	-	-	(5.860)
Capital	46.34	2.39	183.19	3.87	6.14	-	-	-
Labor	46.34	2.39	183.19	3.84	6.19	-	-	-
Organizational Innovation								
Contract HOG	46.74	2.39	183.19	3.87	6.19	(0.415)	-	-
Contract CORN	46.34	2.37	183.19	3.87	6.19	-	(0.036)	-
Contract SBM	46.34	2.39	187.78	3.87	6.19	-	-	(2.125)
Contract ALL	46.74	2.37	187.78	3.87	6.19	(0.415)	(0.036)	(2.125)
Leadership	46.34	2.39	183.19	3.71	6.19	-	-	-
Process Innovation								
SEW	46.35	2.39	183.24	3.87	6.19	-	-	-

Summary Tables for Hog Production System

ENT BEHAVIOR	SOW THRUPUT	GILTS REPLACED.	DAYS TO WEAN	DAYS IN NURSURY	DEATH [N]	DEATH [F]
Market (BASE)	3,482	348	20.00	70.00	0.29	0.32
Arbitrage						
Hogs	3,482	348	20.00	70.00	0.29	0.32
Corn	3,482	348	20.00	70.00	0.29	0.32
SBM	3,482	348	20.00	70.00	0.29	0.32
Capital	3,482	348	20.00	70.00	0.29	0.32
Labor	3,482	348	20.00	70.00	0.29	0.32
Organizational Innovation						
Contract HOG	3,482	348	20.00	70.00	0.29	0.32
Contract CORN	3,482	348	20.00	70.00	0.29	0.32
Contract SBM	3,482	348	20.00	70.00	0.29	0.32
Contract ALL	3,482	348	20.00	70.00	0.29	0.32
Leadership	3,482	348	20.00	70.00	0.28	0.31
Process Innovation						
SEW	3,574	358	16	63.00	0.23	0.28