THREE ESSAYS ON ECONOMICS OF QUALITY IN AGRICULTURAL MARKETS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By
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* * * * *

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ABSTRACT

I simulate growth and quality changes for pens of cattle and derive the value of pre-harvest sorting and genetic selection under grid pricing in a deterministic setting featuring animals with heterogeneous growth and quality maturation paths. The key findings are: 1) both pre-harvest sorting and increased genetic uniformity could substantially affect an individual cattle feeder’s net revenues; 2) one could expect higher marginal revenue gains from the genetic uniformity than from pre-market sorting; 3) both methods exhibit diminishing marginal returns and 4) aggregate beef supply may increase as improving uniformity typically leads to later optimal marketing dates and, hence, heavier animals at slaughter.

Post-slaughter quality-based pricing of cattle is increasingly common. This quality, however, is dependent upon unobservable quality characteristics of the feeder cattle used as inputs and unverifiable effort exerted by feedlot managers. Through stochastic simulation I construct incentive compatible quality risk-sharing contracts based upon final grid-quality schedules in feeder cattle markets.

Darby and Karni suggest branding as means of solving the potential fraudulence problems in the credence good market. Umbrella branding is a common marketing
practice to promote new product and bond the product quality to the brand reputation.
However, while umbrella branding works well in the experience good market, no
evidence shows it would work in the credence good markets. I set up a framework for
discussing the effect of umbrella branding on the quality provision of credence good.
The results show that brand reputation, product similarity, probability of detection,
punishment severity, and exogenous quality noise all play important roles in determining
a firm’s decision on umbrella branding and fraud.
Dedicated to my wife:

For her continuous support
ACKNOWLEDGMENTS

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I want to thank Dr. Ian Sheldon, Dr. Steve Wu, Dr. Neal Hooker, Dr. Wen S. Chen and Dr. Lynn Forster for their useful comments and suggestions.

I am indebted to participants in the Ph.D. Seminar in Agricultural Economics for their excellent discussions.

I alone am responsible for remaining errors and shortcomings.
VITA

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FIELDS OF STUDY

Major Field: Agricultural, Environmental, and Development Economics
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CHAPTER 1

PROFIT MAXIMIZING BEHAVIOR ON THE FED CATTLE GRID:
THE VALUE OF PRE-HARVEST AND GENETIC SORTING
WITH IMPLICATIONS FOR AGGREGATE SUPPLY

Abstract:

We simulate growth and quality changes for pens of cattle and derive the value of pre-harvest sorting and genetic selection under grid pricing in a deterministic setting featuring animals with heterogeneous growth and quality maturation paths. The key findings are: 1) both pre-harvest sorting and increased genetic uniformity could substantially affect an individual cattle feeder’s net revenues; 2) one could expect higher marginal revenue gains from the genetic uniformity than from pre-market sorting; 3) both methods exhibit diminishing marginal returns and 4) aggregate beef supply may increase as improving uniformity typically leads to later optimal marketing dates and, hence, heavier animals at slaughter.

Key words: Aggregate beef supply, cattle, genetic uniformity, growth curve, optimal marketing date, quality, simulation, sorting.
Profit Maximizing Behavior On the Fed Cattle Grid: The Value of Pre-harvest and Genetic Sorting with Implications for Aggregate Supply

Introduction

The percentage of cattle marketed on a carcass basis has increased from 27% of slaughter to 44.2% over the past two decades (GIPSA) and will be an increasingly important facet in the future of US cattle marketing. Producers face a vastly different profit-maximization problem in a grid pricing system than in the more traditional uniform-pricing structure. Previous research on grid marketing strategies emphasizes the value of animal uniformity (Schroeder and Graff) because the profit from a pen of animals may be radically lowered from just a few animals that accrue penalties for missing key quality specifications. While the bulk of the research in this area has focused on simulating the relative profitability of sales under different pricing structures (Fuez, Fausti, and Wagner; Fuez; Ward and Lee), the first goal of this paper is to examine the benefits of improving uniformity via two avenues: 1) sorting feedlot animals before slaughter and 2) sorting feeder cattle based on common genetics before placement upon feed. Second, we investigate how different market timing and sorting strategies affect not only average net revenue but also the variance of net revenue and comment upon possible aggregate affects that may emerge as more cattle are priced upon a grid system.
Returns to Uniformity

Grid pricing is one of the several efforts that have been made to move toward value based marketing and pricing in the fed cattle sector (Feuz). It sends clearer price signals from the wholesale beef to the fed cattle market. This improves beef market coordination relative to pricing on a live or dressed weight basis (Ward, Feuz, and Schroeder). Given the penalties and premiums inherent in a grid system, it is necessary to consider the heterogeneity among animals in order to maximize profits.

Sorting large heterogeneous groups of animals into smaller, more uniform groups is one strategy for improving profits. Koontz, et al. examined the returns to a cattle feeding operation that sorts animals prior to marketing using ultrasound technology and show sorting returns between $11 and $25 per head, depending on the number of groups formed after sorting. They find that diminishing marginal revenues hold for sorting. Major profit increases come from reductions in meat quality discounts, increases in meat quality premiums, increases in beef carcass quality characteristics, and more efficient use of feed resources. They use slaughter characteristics to project live characteristics 80 days in the past and then simulate forward from these estimated starting points.

Another avenue for improving uniformity is to select feeder cattle groups based upon common genetics. In the short run this might simply mean keeping pens of cattle to a single breed while in the long run this might mean reducing the heterogeneity within a given breed via more deliberate genetic selection. We model this by tightening the
distribution from which we generate growth curve parameters in the simulation model: no
effort is made to place animals at a common starting weight, however.

We also explore the effect of grid pricing and individual sorting strategies on total
beef supply and discuss potential aggregate implications of wider implementation of grid
pricing schemes and adoption of sorting.

**Animal Growth and Quality Development Model**

We simulate the growth and quality changes of cattle pens and derive the value of
the two aforementioned sorting procedures under a typical price grid in a deterministic
setting featuring animals with heterogeneous growth and quality maturation paths. A
sample of animal feeding data was collected from institutional feeding trials (data
available to reviewers upon request) and used to estimate growth curve parameters.¹ The
quality maturation parameters are taken from existing animal science literature (Brethour

In most beef grid pricing systems, the value of an individual carcass is determined
by adjusting a base value with premiums that depend on weight,² quality grade and yield
grade of the carcass.³ The standard carcass weight is increasing in the number of days on
feed. Generally cattle are slaughtered such that the hot carcass weight falls between 550
and 950 pounds; carcasses outside this range typically receive a discrete price penalty.

The quality grade of a carcass attempts to capture the palatability of the lean,
which, for young cattle, is also increasing in the number of days on feed. The marbling
score, which refers to the flecks of fat interspersed among muscle fibers in the lean, is considered to represent the quality grade because it is highly positively related to the palatability. The price received per hundredweight of carcass increases as the quality grade passes from standard to select to choice to prime.

The yield grade indicates the proportionate amount of saleable retail cuts that can be obtained from a carcass. The yield grade is heavily dependent on the back fat thickness of the animals, which is also increasing in the number of days on feed. However, because more back fat implies a lower percentage of saleable meat, the price per hundredweight of carcass decreases as yield grade increases with the largest price penalty usually occurring when yield grade passes from category three to category four.

Because the three elements of pricing are all time dependent as is the cost of feeding and maintaining an animal, there exists a four-dimensional dynamic problem in choosing the optimal marketing date. The following section explicitly outlines the underlying equations that represent these dynamic processes and are used in the simulation analyses that follow.

*Growth function*

We represent animal weight (i.e., the growth curve) as a Gompertz function:

\[
W_t = m \cdot \exp(-k \cdot \exp(-c \cdot t))
\]

where \(W_t\) is the live weight of an animal (in pounds); \(m, k, c\) are positive parameters and \(t\) is number of days on feed. The parameters \(m\) and \(k\) can be used to determine the
initial weight of a animal because $W_t=(m*\exp(-k))$ when $time=0$. The limit of $W_t$ is $m$ because $\exp(-k*\exp(-c*time))$ approaches $m$ as $time$ approaches infinity.

Using experimental data, we estimate $m$, $k$ and $c$ for 35 animals using nonlinear least squares (NLS). The mean vector and covariance matrix for the three estimated parameters are listed in Table 1. In the simulation of animal growth, growth curve parameters are randomly drawn from a normal distribution that features this estimated mean and covariance structure.

**Quality grade**

The quality grade, which is translated from the marbling score curve, is assumed to follow the marbling score curve estimated by Brethour (1999):

\[(2) \quad Q_t = n((I-3.39)/n)^{(1/3.42) + time}^{3.42} + 3.39\]

where $Q_t$ is marbling score; $I$ is initial marbling score and $n=1.23642E-09$ is a parameter.

**Yield grade**

Determination of the yield grade is dominated by the amount of back fat. The assumed functional form of the back fat curve is a power function adopted from Brethour (1989) and calibrated using the experimental data:

\[(3) \quad Y_d = A*\exp(0.0072*\text{time}),\]

where $Y_d$ is the back fat thickness (millimeters) of the animal and $A$ is the animal’s initial back fat thickness (millimeters).

*The cost curve:*
Animal growth is a complex subject governed by physical processes that determine the amount of protein, energy and minerals needed to support an animal’s various functions (e.g., maintenance, growth, lactation, etc). Translating animal growth to appropriate feed intake combinations and levels, and hence cost, can be accomplished by assuming a detailed model of these processes (e.g., the National Research Council’s model of animal growth, 2000). However, to simplify the exposition of the paper a reduced-form total feed cost function, expressed as a polynomial in the number of days on feed, is postulated:

\[
TC = a_0 + a_1 \times time + a_2 \times time^2 + a_3 \times time^3 + a_4 \times time^4.
\]

This flexible function allows the marginal feeding cost for the older animals to be increasing in time. \(TC\) is the total feeding cost ($/day) of an animal that is on feed for \(time\) days. Feed cost parameter estimates for \(a_0, a_1, a_2, a_3,\) and \(a_4\) are listed in Table 2. Cost curve estimates are based upon the data from the experimental feeding trials from which the growth curve parameters were estimated from cattle exposed to the same feeding regimen.

The Simulation Model

The growth, quality, yield and cost curves are all expressed in \(time\); hence, for any given animal, revenue net of feed costs can be simulated for slaughter at any age and for any given grid structure. Figure 1 provides a visual overview of the simulation process. We calculate the animal weight by the growth curve. Multiplying live weight by the dressing percentage (which is assumed constant and equal to 62.83 percent) yields carcass weight. Then the weight, quality and yield premiums are taken from the price grid listed in Table 3, which was randomly selected from the USDA weekly summary of premiums and
discounts (13th week, 2000). Adding (subtracting) appropriate premiums (discounts) from the grid to the base price, which was assumed to be 109.4 dollars/cwt, gives us the market price. We multiply this price by the carcass weight then subtract the total cost of feeding animal to yield our net revenue figure.

To simulate different levels of heterogeneity, we simulate numerous pens of beef cattle with different levels of heterogeneity. We randomly generate 100 sets of growth and quality curve parameters (m, k, c, A and I) to represent the animals in one pen; five levels of heterogeneity used in the simulations are outlined in Table 4. Combination 2 in the Table 4 serves as a baseline pen for simulations. We generate growth parameters in the baseline pen using the mean vector and covariance matrix presented in Table 1. The means and variance of initial back fat is estimated using experimental data and is listed in the fourth row of Table 4. The mean and distribution of initial marbling score is arbitrarily assigned and listed in the fifth row of Table 4. All combinations use the same mean for generating parameters, however, each combination uses different standard deviations or ranges. For example, in order to simulate a pen with higher heterogeneity, the parameters in combination 1 are drawn from a distribution whose covariance matrix values have been increased by 50% as compared to the baseline. Covariances in combinations three, four and five are 50 percent, 10 percent and five percent of the covariance used in baseline case. Finally, a pen with no variation between animals represents the limiting case of a genetically uniform pen, which is not shown in Table 4.

In order to investigate the benefits of pre-harvest sorting, the pens of 100 simulated animals are sorted into 2, 3, 4, 5, 10, and 100 equally sized groups by the order
of their optimal marketing day. The differences in average net revenues among different levels of sorting are then compared. Comparing the maximum net revenues of the five combinations shows the benefit of genetic uniformity. In addition, we also compare the total supply effect of different scenarios by comparing the total carcass weight supplied to the market. Finally, we simulate five hundred pens of one hundred animals to acquire a set of average net revenues and standard deviation of net revenues at different marketing dates.

Results and Discussions

Benefits of pre-harvest sorting

Table 5 presents a comparison of the net revenue associated with the various pre-harvest sorting levels for animals exhibiting baseline levels of genetic heterogeneity and for two different values of the choice-select spread. For sake of brevity, we will center our discussion throughout this section on the case of the smaller choice-select spread (i.e., roughly six dollars). The average net revenue (i.e., carcass value less feed cost) for the unsorted pen is $648. If the pen is sorted into two groups, then the average net revenue will increase to $661, a 2.1 percent increase over the unsorted pen. Net revenue, which does not include the cost of sorting, is increasing in the number of sorted groups because by increasing the number of groups, more and more animals are slaughtered at days with higher net revenue. Under perfect sorting, every animal is slaughtered on its net revenue-maximizing day.
When the number of sorts increases, marginal improvements in net revenue are smaller. For example, net revenue increases 1.9 percent points (2.1 percent to 4 percent) from one sort (two groups) to four sorts (five groups); however, when the number of sorts increases from four (five groups) to nine (ten groups), the net revenue only increases 0.9 percent points, implying diminishing returns to sorting. Note that the marginal diminution of revenues is less pronounced when the choice-select spread is higher, suggesting that the optimal number of sorts may indeed change with the market conditions. Koontz et al. also find diminishing returns to pre-harvest sorting.

Benefits of genetic uniformity of feeder cattle

The net revenues from feeding pens of feeder cattle with different degrees of heterogeneity are shown in Table 6. The average net revenue of the baseline scenario is $658; note, to facilitate comparisons, this simulation utilized the same baseline assumptions used in the pre-harvest sorting examples from the unsorted groups in Table 5; the net revenues are slightly different due to the different random shocks used in this simulation, however. The optimal marketing time for the entire pen of 100 animals is 177 days. If the heterogeneity of growth and quality curve parameters equals 150 percent of the baseline pen's variance, the net revenue decreases to $601, an 8.66 percent loss. If we reduce the heterogeneity to 50 percent of the baseline, the optimal marketing date is at 187 days and the net revenue increases to $710, which is 7.92 percent higher than the baseline pen. If heterogeneity is reduced to 10 percent of the baseline, the optimal marketing date for this pen is in 203 days and the net revenue becomes $753, a 14.37
percent net revenue gain. In the limiting case of perfect uniformity net revenue is $754 and the optimal marketing date is 217 days.

By observing the simulated increases in net revenue, one can see that the marginal returns to increased genetic uniformity are also diminishing. As was the case with pre-harvest sorting, a larger choice-select spread causes the marginal value of improved genetic uniformity to decrease more slowly. One can also find that there is no marked difference in net revenue among pens with 10% heterogeneity, 5% heterogeneity and perfect uniformity, regardless of the choice-select spread used.

As animal growth and quality curve parameters become more uniform, the feedlot’s net revenue increases, while the optimal time on feed increases. The reason is that when the animals stay on feed longer, there will be three kinds of losses that can occur. The first one is from higher feed costs due to the additional time on feed and from lower feed efficiencies that usually occur for older cattle. The second one is the grid-based penalties for overweight cattle. The last one is the discount for greater back fat (i.e., higher yield grades). The only benefits of feeding cattle longer is the chance of increasing premiums paid for the higher quality grade and greater total carcass weight (so long as the weight-penalty threshold of 900 pounds is not surpassed). As a result, if one cannot market an animal at its optimal marketing date, a marketing date that is too early will yield fewer revenue penalties than a marketing date that is too late. In the perfectly uniform pen, every animal can hit its optimal marketing date because all animals are alike. As the heterogeneity increases, some animals hit optimal dates earlier than others; hence
the feedlot operator will market the whole pen earlier to avoid the larger potential losses associated with any animals that are marketed too late.

If we compare the results in this section to the pre-harvest sorting case, we find that reducing growth and quality curve heterogeneity by 50% would lead to higher net revenue than would perfect pre-harvest sorting. This begs the question, which avenue of accomplishing uniformity – pre-harvest sorting or decreased genetic uniformity – is more costly. While this paper does not focus on cost issues, we speculate that increasing genetic uniformity can take place in two steps. One is that of placing pens of feeder cattle that look alike; i.e., are all of a common breed and gender. While tedious, such sorts may be possible and could help accomplish some increases in growth parameter homogeneity. A second step involves choosing animals within the same breed that have common genetic lineage. Such a step would involve better genetic tracking systems than are currently available in much of the North American market. This step would involve substantial long-term industry-wide investments in universal animal identification systems that are still in early stages of development. Furthermore, it is the base assumption of this paper that genetic uniformity leads to increased uniformity of growth and quality curve parameters. Only when more integrated research in animal genetics and production takes place can we verify the strength of correlation between genetics and economically relevant growth traits.

The Supply Effect

Since the marketing date of animals on different pre-harvest sorting levels and different degrees of genetic heterogeneity varies, one could expect the total meat supplied to the
market would also vary. Table 7 and Table 8 present the total meat supplied by a pen of 100 animals at different levels of pre-harvest sorting and different levels of genetic heterogeneity, respectively. From Table 7 we find that the amount of meat supplied by the representative pen increases by 1.87 percent if a single sort is implemented and by 3.41 percent if each animal is marketed on its optimal day; the results are virtually unchanged when a wider choice-select spread is used. Note that sorting does not lead to monotonic increases in supply; total weight actually decreases after adding a second sort (three groups). This occurs as the third group allows cattle that can be marketed at very light weights to segmented more fully than could be accommodated by splitting the entire pen into merely two groups. After three groups, however, supply does increase monotonically. This means that sorting generally results in higher average carcass weights, which is consistent with the results of Koontz et al. From Table 8, one can see that the meat supply will increase by 4.39 percent if heterogeneity is reduced 50 percent and increase by 11.32 percent if animals are perfectly uniform. Note the marginal effects are smaller when the choice-select spread is larger. This is driven by the fact that the optimal marketing date for the baseline group is much later with a higher choice-select spread; hence, reductions in heterogeneity have ‘less room to operate’ and optimal behavior will not drive back the slaughter date as far as when the spread is narrow.

As the industry continues to adopt grid pricing and as feedlot managers adapt to the price incentives these grids transmit by applying more pre-harvest sorting, our results suggest that the beef supply should increase. If the industry achieves greater genetic uniformity, aggregate beef supply could also increase as heavier average weights can be achieved with fewer penalties. The figures that we simulate provide a maximum upper
bound, however, as these figures do not account for endogenous adjustments in either the base market price or the structure of grid pricing structures that would surely ensue. Such considerations, while relevant, are left to future research.

Multiple Pens Simulations

Many feedlot operators do not have the capacity to sort animals prior to slaughter; hence the optimal marketing date for a heterogeneous pen of cattle is of great significance. While much effort has been directed at understanding the slaughter date that would maximize net revenues of feeding, little attention has been given to how the variance of net revenues is affected by marketing date. In order to investigate the relationship between marketing date, expected net revenue, and the variance of net revenue, we simulate the growth and marketing of 500 pens of 100 animals and calculate the mean and standard deviation of net revenue among pens by the number of days on feed (Figure 2). Average net revenue initially increases in time and then monotonically decreases after reaching maximum net revenue on the 177th day on feed. Notice the average net revenue line drops precipitously about three to four weeks after the optimal date, which provides some margin of error to producers who might miss the optimal date due to miscalculation or bargaining tactics. Waiting more than four weeks, however, causes large losses on average and these losses are quite likely (i.e., the standard deviation is much smaller). The explanation of this steepness was discussed earlier: holding cattle longer can induce three negative grid effects (greater feed cost, overweight penalties and yield discounts) and only one positive grid effect (higher premiums for quality grade).
The standard deviation of the net revenue follows a path nearly parallel to the average net revenue for much of the relevant marketing time frame. Standard deviation is initially increasing, reaches the maximum around 167th day and then decreases. It reaches a local minimum at 208th day then climbs again. Hence we confirm a common finding that the mean and variance are positively correlated.

**Conclusions**

We have shown that both pre-harvest sorting and increased genetic uniformity could substantially affect an individual cattle feeder’s net revenues. One could expect higher marginal revenue gains from genetic uniformity than from pre-market sorting; however, the relative costs of implementing the two strategies is not well understood nor addressed in this paper. Both methods exhibit diminishing marginal returns though individual returns to sorting and genetic uniformity decrease more slowly as the choice-select spread increases. If either method were adopted on a widespread basis, aggregate beef supply may increase as improving uniformity typically leads to later optimal marketing dates and, hence, heavier animals at slaughter. General equilibrium effects and adjustments in grid structure would likely offset at least some of this supply effect in the long run, however.

If a farmer markets a whole pen of animal on the same day (no sorting), the marketing date is crucial. From our simulations, the expected net revenue of marketing one pen of animals is increasing over time at first. After reaching the day on which the net revenue is highest on average, the feeder has a window of three to four weeks before the average net revenue decreases dramatically. We also show that the standard deviation
of net returns is strongly correlated with average returns; hence there appears to be no mean-variance dominant marketing date. These results do suggest a simple maxim for the feedlot operator unsure of the optimal marketing date: when in doubt ship cattle out.
References


______. “Using Ultrasound Technology to Increase Cattle Feeding Profit.” Kansas Agricultural Experiment State Report of Progress No 833: Kansas State University, 1999.


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<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<td>-1.61*10^{-1}</td>
<td>-0.93</td>
<td>0.35</td>
</tr>
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<td>$a1$</td>
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<td>$a4$</td>
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R-squared 0.9999
Adjusted R-squared 0.9999
Log likelihood -92.40
Durbin-Watson 0.037993

Table 1.2: Estimate of the Cost Curve
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<th>Prem/Disc ($)</th>
<th>Yield Grade</th>
<th>Prem/Disc ($)</th>
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<td>5.33</td>
<td>YG 1</td>
<td>2.42</td>
<td>&lt;500 lbs</td>
<td>-22.33</td>
</tr>
<tr>
<td>Choice</td>
<td>0.00</td>
<td>YG 2</td>
<td>1.00</td>
<td>500-950 lbs</td>
<td>0.00</td>
</tr>
<tr>
<td>Select</td>
<td>-5.58</td>
<td>YG 3</td>
<td>-0.17~ -0.33</td>
<td>950-1000 lbs</td>
<td>-16.50</td>
</tr>
<tr>
<td>Standard</td>
<td>-15.42</td>
<td>YG 4</td>
<td>-16.67</td>
<td>&gt;1000 lbs</td>
<td>-22.33</td>
</tr>
</tbody>
</table>

Table 1.3: Dollars Per Carcass Weight (cwt) Premium and Discounts Used in This Paper

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Distribution</th>
<th>Mean</th>
<th>Combination 1</th>
<th>Combination 2</th>
<th>Combination 3</th>
<th>Combination 4</th>
<th>Combination 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Normal</td>
<td>2257.7</td>
<td>150% of C2**</td>
<td>C.M.*</td>
<td>50% of C2</td>
<td>10% of C2</td>
<td>5% of C2</td>
</tr>
<tr>
<td>k</td>
<td>Normal</td>
<td>1.2456</td>
<td>150% of C2</td>
<td>C.M.</td>
<td>50% of C2</td>
<td>10% of C2</td>
<td>5% of C2</td>
</tr>
<tr>
<td>c</td>
<td>Normal</td>
<td>0.00517</td>
<td>150% of C2</td>
<td>C.M.</td>
<td>50% of C2</td>
<td>10% of C2</td>
<td>5% of C2</td>
</tr>
<tr>
<td>A</td>
<td>Normal</td>
<td>3.5275</td>
<td>SD=0.556</td>
<td>SD=0.37</td>
<td>SD=0.185</td>
<td>SD=0.037</td>
<td>SD=0.019</td>
</tr>
<tr>
<td>I</td>
<td>Uniform</td>
<td>3.71</td>
<td>[3.41, 4.01]</td>
<td>[3.51, 3.91]</td>
<td>[3.61, 3.81]</td>
<td>[3.69, 3.73]</td>
<td>[3.70, 3.72]</td>
</tr>
</tbody>
</table>

*C2=Combination 2  
**C.M.=Covariance matrix in table 1  
***SD=standard deviation

Table 1.4: Parameter Combinations for the Simulations
Table 1.5: Net Revenues of Different Pre-harvest Sorting Level*

<table>
<thead>
<tr>
<th>Sorting Level</th>
<th>Average Net Revenue ($/head)</th>
<th>Difference from Un-sorted Pen ($/head)</th>
<th>Difference from Un-sorted Pen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsorted pen</td>
<td>647.71</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sorting into to 2 groups</td>
<td>661.33</td>
<td>13.62</td>
<td>2.09</td>
</tr>
<tr>
<td>Sorting into to 3 groups</td>
<td>667.78</td>
<td>20.07</td>
<td>3.08</td>
</tr>
<tr>
<td>Sorting into to 4 groups</td>
<td>671.46</td>
<td>23.74</td>
<td>3.64</td>
</tr>
<tr>
<td>Sorting into to 5 groups</td>
<td>673.97</td>
<td>26.26</td>
<td>4.03</td>
</tr>
<tr>
<td>Sorting into to 10 groups</td>
<td>679.87</td>
<td>32.16</td>
<td>4.93</td>
</tr>
<tr>
<td>Sorting into to 100 groups</td>
<td>687.33</td>
<td>39.62</td>
<td>6.08</td>
</tr>
</tbody>
</table>

*Based upon 1,000 simulated pens of 100 animals
<table>
<thead>
<tr>
<th>Hetero Level</th>
<th>Average Net Revenue ($/head)</th>
<th>Market Time (days on feed)</th>
<th>Difference from Baseline Pen ($/head)</th>
<th>Difference from Baseline Pen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150% Hetero.</td>
<td>601.10</td>
<td>181</td>
<td>-56.96</td>
<td>-8.66</td>
</tr>
<tr>
<td>Baseline Pen</td>
<td>658.06</td>
<td>177</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>50% Hetero.</td>
<td>710.20</td>
<td>187</td>
<td>52.14</td>
<td>7.92</td>
</tr>
<tr>
<td>10% Hetero.</td>
<td>752.64</td>
<td>203</td>
<td>94.58</td>
<td>14.37</td>
</tr>
<tr>
<td>5% Hetero.</td>
<td>753.51</td>
<td>211</td>
<td>95.45</td>
<td>14.51</td>
</tr>
<tr>
<td>Perfect Uniform</td>
<td>753.86</td>
<td>217</td>
<td>95.81</td>
<td>14.56</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hetero Level</th>
<th>Average Net Revenue ($/head)</th>
<th>Market Time (days on feed)</th>
<th>Difference from Baseline Pen ($/head)</th>
<th>Difference from Baseline Pen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150% Hetero.</td>
<td>561.54</td>
<td>195</td>
<td>-63.63</td>
<td>-10.18</td>
</tr>
<tr>
<td>Baseline Pen</td>
<td>625.17</td>
<td>198</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>50% Hetero.</td>
<td>695.46</td>
<td>198</td>
<td>70.28</td>
<td>11.25</td>
</tr>
<tr>
<td>10% Hetero.</td>
<td>753.54</td>
<td>203</td>
<td>128.37</td>
<td>20.54</td>
</tr>
<tr>
<td>5% Hetero.</td>
<td>754.00</td>
<td>210</td>
<td>128.83</td>
<td>20.61</td>
</tr>
<tr>
<td>Perfect Uniform</td>
<td>753.53</td>
<td>219</td>
<td>128.37</td>
<td>20.54</td>
</tr>
</tbody>
</table>

*Based upon 1,000 simulated pens of 100 animals

Table 1.6: Net Revenues of Different Heterogeneity Level*
<table>
<thead>
<tr>
<th>Sorting Level</th>
<th>Beef Supply (lb/pen)</th>
<th>Difference from Un-sorted Pen (lb/pen)</th>
<th>Difference from Un-sorted Pen (%)</th>
</tr>
</thead>
</table>
| **----------------Choice-Select Spread=$6/cwt----------------**
| Unsorted pen  | 81775.2             | 0.0                                    | 0.00                             |
| Sorting into to 2 groups | 83305.1           | 1529.9                                 | 1.87                             |
| Sorting into to 3 groups | 82854.5           | 1079.3                                 | 1.32                             |
| Sorting into to 4 groups | 83099.5           | 1324.3                                 | 1.62                             |
| Sorting into to 5 groups | 83283.3           | 1508.1                                 | 1.85                             |
| Sorting into to 10 groups | 83816.8           | 2041.7                                 | 2.50                             |
| Sorting into to 100 groups | 84558.1          | 2783.0                                 | 3.41                             |

| **----------------Choice-Select Spread=$15/cwt----------------**
| Unsorted pen  | 83031.6             | 0.0                                    | 0.00                             |
| Sorting into to 2 groups | 84674.0           | 1642.4                                 | 1.98                             |
| Sorting into to 3 groups | 84069.4           | 1037.8                                 | 1.25                             |
| Sorting into to 4 groups | 84309.9           | 1278.3                                 | 1.54                             |
| Sorting into to 5 groups | 84480.6           | 1449.0                                 | 1.75                             |
| Sorting into to 10 groups | 84926.2           | 1894.6                                 | 2.28                             |
| Sorting into to 100 groups | 85816.8          | 2785.2                                 | 3.36                             |

*Based upon 1,000 simulated pens of 100 animals

Table 1.7: Supply Effect of Pre-harvest Sorting*
<table>
<thead>
<tr>
<th>Hetero Level</th>
<th>Beef Supply (lb/pen)</th>
<th>Market Time (days on feed)</th>
<th>Difference from Baseline Pen (lb/pen)</th>
<th>Difference from Baseline Pen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150% Hetero.</td>
<td>83045.7</td>
<td>181</td>
<td>-2223.5</td>
<td>-2.61</td>
</tr>
<tr>
<td>Baseline Pen</td>
<td>85269.1</td>
<td>177</td>
<td>0.0</td>
<td>0.00</td>
</tr>
<tr>
<td>50% Hetero.</td>
<td>89009.8</td>
<td>187</td>
<td>3740.7</td>
<td>4.39</td>
</tr>
<tr>
<td>10% Hetero.</td>
<td>92089.3</td>
<td>203</td>
<td>6820.2</td>
<td>8.00</td>
</tr>
<tr>
<td>5% Hetero.</td>
<td>93382.2</td>
<td>211</td>
<td>8113.1</td>
<td>9.52</td>
</tr>
<tr>
<td>Perfect Uniform</td>
<td>94916.9</td>
<td>217</td>
<td>9647.8</td>
<td>11.32</td>
</tr>
</tbody>
</table>

---------Choice-Select Spread=$6/cwt---------

<table>
<thead>
<tr>
<th>Hetero Level</th>
<th>Beef Supply (lb/pen)</th>
<th>Market Time (days on feed)</th>
<th>Difference from Baseline Pen (lb/pen)</th>
<th>Difference from Baseline Pen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150% Hetero.</td>
<td>85524.8</td>
<td>195</td>
<td>-4482.6</td>
<td>-4.98</td>
</tr>
<tr>
<td>Baseline Pen</td>
<td>90007.3</td>
<td>198</td>
<td>0.0</td>
<td>0.00</td>
</tr>
<tr>
<td>50% Hetero.</td>
<td>91758.5</td>
<td>198</td>
<td>1751.2</td>
<td>1.95</td>
</tr>
<tr>
<td>10% Hetero.</td>
<td>92059.3</td>
<td>203</td>
<td>2051.9</td>
<td>2.29</td>
</tr>
<tr>
<td>5% Hetero.</td>
<td>93363.2</td>
<td>210</td>
<td>3355.9</td>
<td>3.73</td>
</tr>
<tr>
<td>Perfect Uniform</td>
<td>94916.8</td>
<td>219</td>
<td>4909.5</td>
<td>5.46</td>
</tr>
</tbody>
</table>

*Based upon 1,000 simulated pens of 100 animals

Table 1.8: Supply Effect of Genetic Uniformity*
Figure 1.1: The Simulation Process of Beef Cattle Growth
Figure 1.2: The Mean and Standard Deviation of Net Revenue on 500 Pens Simulation
Endnotes

1. Animals were placed on feed at an average weight of 630 lbs, remained on feed for an average of 170 days and gained an average of 3.5 lbs per day during the trial.

2. The carcass weight is the weight of slaughtered animal after the viscera; hide, head, feet and tail are removed.

3. Note that penalties are commonly assessed for several other binary quality issues (e.g., dark cutters) that are not addressed in this analysis.

4. The Gompertz functional form is one of several functional forms often used in the animal science literature to model animal growth (e.g., Perotto, Cue, and Lee). This form exhibits a concave growth curve, which is consistent with the growth patterns of the trial cattle.

5. It is assumed that perfect sorting takes place immediately prior to the marketing date of the group that would go to slaughter first. This is a best-case scenario because the best available technology for pre-harvest sorting, based on ultrasound technology, is imperfect and often miscalculates the number of additional days before optimal harvest time. However, the net revenue maximizing sorting procedure would not necessarily dictate sorting animals into equally-sized groups as is assumed here; hence, this aspect of the sorting procedure is likely to understate the benefits from sorting. On net, however, we believe the sorting algorithm utilized in this paper is likely to overstate the real-world benefits that would accrue to sorting.

6. Brethour (2000) used live animal ultrasound readings to determine whether or not a carcass would grade Choice and found the accuracy to be nearly 80%. Anderson, Ferguson, and Brethour found that a probability model incorporating a limited amount of ultrasound information could distinguish between Choice or Below Choice animals with 75 percent to 80 percent accuracy.
CHAPTER 2

OPTIMAL CONTRACTS FOR FEEDER CATTLE IN THE PRESENCE OF DOUBLE-SIDED MORAL HAZARD AND RISK AVERSION

Abstract:

Post-slaughter quality-based pricing of cattle is increasingly common. This quality, however, is dependent upon unobservable quality characteristics of the feeder cattle used as inputs and unverifiable effort exerted by feedlot managers. Through stochastic simulation we construct incentive compatible quality risk-sharing contracts based upon final grid-quality schedules in feeder cattle markets.

Key words: Feeder cattle, quality, incentive compatible contract, premium sharing, simulation, double-sided moral hazard.
Deriving Feeder Cattle Pricing Contracts from Fed Cattle Price Grids:
Simulation Results of Risk-Sharing Contracts

Introduction

More beef carcasses are priced using quality-based pricing grids than ever (GIPSA). Grid pricing improves information linkages between wholesalers and feedlots by rewarding desirable carcass traits and penalizing undesirable traits. However, the grid performance of a carcass is determined by many factors such as genetics, life-long feeding regimen, and health, which are jointly determined by the feedlot and feeder cattle supplier. To the extent that pre-feedlot decisions alter final quality, feeder cattle prices must reflect the quality differences among feeder cattle in order for the refined signals of grid pricing to transmit to those supplying cattle to feedlots. While hedonic analyses of feeder cattle sales data (e.g., Sartwelle et al.) has revealed that certain observable characteristics, which are roughly related to final quality (e.g., breed), are rewarded in auction settings, many unobservable traits that are more closely related to carcass qualities (e.g., marbling) are not directly influenced by such market forces. The market may induce production of desirable unobservable traits through reputation formation for individual feeder cattle suppliers (Turner et al.), but the formation of such reputation-based rents, and hence the speed by which suppliers provide such desirable traits, may be very slow.
An alternative solution might be the issuance of contracts by feedlots or integrators in which the parties jointly responsible for the production of quality (i.e., feedlots and feeder cattle suppliers) share final carcass premiums and discounts. What such a contract might look like is the subject of the present study. We simulate possible grid premium/discount-sharing contracts, which are widely seen in sharecropping (Allen and Lueck), franchising (Lafontaine) and niche beef markets (Laura’s Lean) and gauge if such arrangements provide better incentives with regards to matching feeder cattle with feedlots that can exploit animals’ unobservable quality traits. Bhattacharyya and Lafontaine suggest that a linear sharing contract could be optimal in the presence of double-sided moral hazard. We argue that, in the absence of rapid reputation formation by feedlots and feeder cattle sellers, the current set of market arrangements typically used in feeder cattle markets (detailed below) could be plagued by moral hazard. Linear premium sharing contracts may be attractive to feedlots to facilitate the sourcing of animals that will perform well within the context of the feedlot’s production program and within the premium/discount schedules used by its usual packing plant, while such contracts could be attractive to feeder cattle suppliers if average price received after premiums and discounts outpaces auction market prices plus a risk premium. The objective of this paper is to construct a feasible and reasonable feeder cattle carcass quality incentive contract through stochastic simulations based upon historical feeder cattle prices, fed cattle prices, input prices and quality premiums and discounts.

We will compare our proposed scheme with two other common business arrangements between feedlots and feeder cattle suppliers. In the first the cow-calf operator sells feeder cattle to the feedlot at the spot market price and there are no
interactions thereafter. In other words, the feeder price is independent of the unobservable qualities of feeder cattle in the short run (current period). In the case where the cow-calf operator does not quickly form a reputation, there is a moral hazard problem in that the cow-calf operator has an incentive to reduce effort that would improve unobservable animal quality.

The second arrangement involves the cow-calf operator retaining ownership of cattle and paying a feedlot to feed the cattle until slaughter. The payment to the feedlot involves a set of fees which are based, in part, upon feed cost plus a typical industry markup. The cow-calf operator may face a moral hazard issue as feedlot operators may be tempted to keep animals on the feedlot longer than necessary in order to increase final payment and, in the process, harm final animal quality by overfeeding.

Our proposed feeder cattle carcass quality incentive contract could prevent moral hazard problems from both sides by sharing the premiums/discounts from the output. Such a contract makes both sides benefit from actions that improve cattle quality regardless of the interim transparency of these qualities. Participation incentives are crucial in the set of contracts we devise and may dictate whether such contracts will emerge more broadly in the US cattle sector.

Factors that Determine Feeder Cattle Prices

Many feeder cattle are sold at auction markets and their prices are determined during a rapid auction process that allows brief visual inspection. Three observable value-determining characteristics of feeder cattle, according to the official United States Standard for Grades of Feeder Cattle, include frame size, thickness and thriftiness.
Previous research suggests that a broader set of traits can marginally affect feeder cattle prices, including sex, weight, breed, lot size, visible health (an animal that is visibly healthy today may not be healthy tomorrow, however), uniformity (within a group of cattle), condition, fill, muscling, frame size, breed and presence of horns (Sartwelle *et al.*, Rawls *et al.*).

All the characteristics mentioned above are observable. However, several unobservable traits are involved in the determination of the final carcass quality. For instance, the initial marbling of feeder cattle will affect the final quality grade of a carcass but it is not observable at the time when the sale is made. Observable traits are only indirectly related to the final carcass quality; hence, rewards for feeder cattle based on those characteristics may be biased. A feeder-cattle pricing system that rewards the actual carcass performance could compensate for this sort of bias. Since the final performance of a carcass dictates whether it will receive a premium or a discount, a premium/discount-sharing contract might be the proper arrangement to reveal a true price of feeder cattle.

**Incentive Compatible Risk Sharing Contracts**

*Double-sided moral hazard*

Double-sided moral hazard problems exist in many contractual relationships in which the outcomes are jointly determined by the efforts of two actors and in which each actor cannot directly monitor the other’s effort level. Examples include franchising, sharecropping, licensing, commercial leasing, author-publisher relationships, and so on.
Sharecropping and franchising are two important examples of the double-sided moral hazard problem. Reid first used this idea to explain the existence of sharecropping contracts; Eswaran and Kotwal later formalized this representation. Agrawal developed a generalized double-sided moral hazard model for contract choice in agricultural production. Bhattacharyya and Lafontaine found that the optimal second-best contract could be implemented via a linear profit sharing contract. They also showed that share parameters are rather constant across the agents (in the case of multiple agents) if the technology could be described as Cobb-Douglas production function.

In the cattle feeding business feeder cattle are a major, necessary input into the feedlot production process and the quality of feeder cattle plays a very important role in determining the final carcass quality and, hence, the revenue generated by individual animals. As a result, we can treat the pre-feedlot and feedlot stages of beef cattle production as one single operation where both the feeder cattle supplier and feedlot simultaneously contribute their efforts. Although these two stages are sequential, the lack of transparency of effort by both parties is the critical driver of the double-sided moral hazard formulation. A feeder cattle supply contract made between the two parties could formalize this argument by building a principal-agent relationship. In a principal-agent relationship, contracts are often designed so that the agent has an incentive to produce unobservable effort that is valued by the principal. The agent and principal both have incentives to shirk in order to decrease the cost or disutility of effort given the effort of his counterpart. In spot market transactions between the cow-calf operator and the feedlot the cow-calf operator may not provide the level of effort needed to produce the level of quality desired by the feedlot because the feedlot is the residual claimant of rents
to quality. Alternatively, in a retained ownership contract, in which the feeder cattle supplier retains ownership of cattle and appoints a feedlot to finish the feeding phase, the feedlot may not provide optimal effort to feed and manage efficiently because the feeder cattle supplier is the residual claimant of quality rents. Both situations lead to the result that the final carcass grid performance does not reach its potential. A premium/discount-sharing contract provides incentives for both parties to increase effort level in order to maximize their share of premiums or to minimize their share of discounts. Bhattacharyya and Lafontaine prove that a linear sharing contract could be optimal based on a double-sided moral hazard problem.

Risk-sharing

Risk sharing is another possible motivation for contracts (Newbery). Sources of risk in the cattle feeding business include fed cattle price risk, feed price risk, cattle weight-gain performance risk and health risk. For cattle marketed using grid pricing, there is an additional risk because the level of premiums and discounts are subject to change and animals’ quality status (marbling and yield grade) are also volatile. The effort levels of both parties affect the carcass quality status. Arrangements in which only one party bears all the quality risk can lead to the moral hazard from his counterpart. Hence, feedlots might be willing to buy feeder cattle from suppliers who accept a risk-sharing contract. Also, cow-calf operators are more likely to provide high quality feeder cattle if they share quality risk because it could decrease the risk of receiving discounts. A risk-sharing contract that shares carcass quality risk can provide both sides with the incentive to exert more effort toward the production of quality than existing arrangements (hence, it appears such contracts would be incentive compatible) and dilute risk between
the parties. However, both parties must find the contract to be better than existing arrangements in terms of expected utility; i.e., the participation constraint must be satisfied. Existing arrangements (sales and retained ownership) may not entice total effort to be as high as the risk-sharing contract and typically leave one party to bear all quality risk.

Theoretical framework for a sharing contract

Following Bhattacharyya and Lafontaine, the production function of carcass quality could be written as

\[ Q = f(l, c) + \varepsilon \]  

(1)

where \( Q \) is the total monetary return produced by an animal and \( l \) and \( c \) are the effort levels of the feedlot and cow-calf operator, respectively. The production function, \( f \), is assumed to be increasing, concave and twice differentiable in \( l \) and \( c \). \( \varepsilon \) is a random shock with zero mean and variance \( \sigma^2 \). In the case of beef production, \( Q \) could be a vector including elements such as premiums for quality grade, yield grade, etc. For the time being, we’ll just treat it as one premium.

Both parties know the distribution of \( \varepsilon \) but the actual value for the period is unknown. The cost of effort function of the feedlot and feeder cattle supplier are given by \( U(l) \) and \( V(c) \) respectively; both are increasing and convex in effort.

Using \( w(.) \) to denote the feeder cattle supplier’s share of profit, the Pareto-optimal program for this problem may be written as

\[
\max_{w(), l, c} \left\{ E[w(f(l, c) + \varepsilon)] - U(l) \right\} 
\]

(2)

subject to
\[
\frac{\partial}{\partial l} E[w(f(l,c) + \varepsilon)] = U'(l)
\]

\[
\frac{\partial}{\partial c} E[(f(l,c) + \varepsilon) - w(f(l,c) + \varepsilon)] = V'(c)
\]

\[
E[(f(l,c) + \varepsilon) - w(f(l,c) + \varepsilon) - V(c)] \geq k(c)
\]

where \(k(c)\), the reservation value for the feeder cattle supplier, indicates the highest possible payout from a retained ownership contract or spot market transaction. Equation (i) and (ii) are the feedlot and the feeder cattle supplier’s incentive-compatibility constraints respectively while (iii) is the feeder cattle supplier’s participation constraint.

Because an optimal outcome could be implemented via a linear contract (Bhattacharyya and Lafontaine), we can rewrite feedlot’s problem as

\[
\max_{\beta, \lambda, \xi} \{ -F + \beta \cdot f(l,c) - U(l) \} \tag{3}
\]

subject to

\[
\beta f_\xi(l,c) = U'(l)
\]

\[
(1-\beta)f_\xi(l,c) = V'(c)
\]

\[
(1-\beta)f(l,c) - V(c) \geq k(c)
\]

where \(F\) is a lump-sum payment to the cow-calf operator for participate in the contract. \(\beta\) is the premium sharing rate for feedlot, i.e., \((1-\beta)\) is the ratio that feedlot will pay to feeder cattle supplier. The Lagrangian for this problem and the related first-order conditions are

\[
L = -F + \beta \cdot f(l,c) - U(l) - \lambda[U' - \beta f_\xi] - \mu[V' - (1-\beta)f_\xi] - \phi[k(c) - (1-\beta)f - F + V(c)] \tag{4}
\]
(i) \[
\frac{\partial L}{\partial F} = \phi - 1 = 0
\] (5)

(ii) \[
\frac{\partial L}{\partial l} = \beta f_i - U^* - \lambda U^* - \beta f_i + \mu [(1 - \beta) f_{cl}] + \phi (1 - \beta) f_i = 0
\] (6)

where \(\lambda\), \(\mu\) and \(\phi\) are non-negative Lagrangian multipliers. The first term of the right-hand side of (6) is zero given the feedlot's incentive compatibility constraint, so we have

\[- \lambda [U^* - \beta f_i] + \mu [(1 - \beta) f_{cl}] + \phi (1 - \beta) f_i = 0\] (7)

(iii) \[
\frac{\partial L}{\partial c} = \beta f_c + \lambda [(1 - \beta) f_{cc}] - \mu [V^* - (1 - \beta) f_{cc}] + \phi [(1 - \beta) f_c - V^* - k'(c)] = 0
\] (8)

The last term of left-hand side of (8) is equal to \(-k'(c)\) because of the feeder cattle supplier’s incentive compatibility constraint. So we have

\[
\frac{\partial L}{\partial c} = \beta f_c + \lambda [(1 - \beta) f_{cc}] - \mu [V^* - (1 - \beta) f_{cc}] - k'(c) = 0
\] (9)

(iv) \[
\frac{\partial L}{\partial \beta} = f + \lambda f_i - \mu f_c - \phi f = 0
\] (10)

From (5) we know that \(\phi = 1\), hence (10) can be written as

\[
\lambda f_i = \mu f_c
\] (11)

Therefore, \(\lambda\) and \(\mu\) must both be nonzero in order for (11) to hold.

With well-defined production and utility functions, one can find a Pareto optimal sharing percentage \(\beta^*\) by using equation (7), (9) and (11). However, a production function based upon knowledge of animal growth that represents carcass value is highly nonlinear in effort levels and does not yield analytical solutions for the optimal sharing percentage. Instead, we implement a numerical search algorithm to identify the parameters of an optimal sharing contract.
Numerical Methodology

Equation (12) provides a general representation of a stochastic function that relates effort levels to carcass value. To develop a specific representation of this model we first specify four arguments to this function that directly map into the profits obtained by the seller of fed beef cattle and that may be affected by the effort levels of feeder cattle supplier and feedlot managers. The first three arguments are key beef carcass characteristics that determine most fed cattle grid prices, i.e., weight \( Wt \), back fat thickness \( BF \), and marbling score \( MS \). The last variable is total feedlot costs \( TFC \), which include feeder cattle procurement costs, feed costs, management costs and miscellaneous costs. This yields:

\[
Q = f(Wt(l,c), BF(l,c), MS(l,c), TFC(l,c)) + \epsilon
\]

(12)

The effort exerted by the feedlot manager in this model is the timing of feedlot sales, i.e., a discrete decision to sell the cattle at time \( t \) or to keep the cattle for an additional time period. While a myriad of other management decisions can alter the four arguments outlined above, e.g., feeding regimen, health management, bunk management, we take these as observable, predetermined effort levels for the feedlot. That is, given that one feedlot deals with many different feeder cattle suppliers, some who supply cattle via spot sales and some retain the ownerships of cattle it is unlikely to customize any of these components to one particular group of cattle. However, the sales timing of any animal or group of animals is easily customized. Furthermore, each of the four arguments is strictly monotonic in timing of sales, i.e., backfat, marbling score, weight and total feedlot costs each strictly increase the later the sales date.
The feeder cattle supplier’s efforts include improving genetics, providing preventative health treatments, and pre-feedlot feeding regimen, and each of these efforts can alter the four arguments in (12). Specifically, genetics and feeding regimen can improve quality by increasing the marbling score of animals when they enter the feedlot and by decreasing the initial levels of backfat. Furthermore, feeding regimen and preventative health can improve an animal’s stock of health, which lowers the total costs incurred for treating the animal once in the feedlot. These efforts also affect the initial weight of the feeder cattle however, this is observable to the feedlot and there is no strict preference for a particular starting feeder cattle weight. Weight is included because weight at slaughter is a key factor used in determining carcass premiums. Live weight and dressing percentage (which is assumed constant and equal to 62.83 percent in our simulation) determine the carcass weight. It is also strictly increasing in the number of days on feed (t). Carcasses that are too heavy or too light are severely penalized.

The marbling score, which refers to the flecks of fat interspersed among muscle fibers and is considered to represent the quality grade because it is positively related to the palatability, is also increasing in the number of days on feed. The price received per hundredweight of carcass increases as the quality grade passes from standard to select to low choice to high choice to prime.

The yield grade is heavily dependent on the back fat thickness of the animals, which is also increasing in the number of days on feed. However, because more back fat implies a lower percentage of saleable meat, the price per hundredweight of carcass decreases as yield grade increases with the largest price penalty usually occurring when
yield grade passes from category three to category four. In most beef grid pricing systems, the value of an individual carcass is determined by adjusting a base value with premiums that depend on weight, quality grade and yield grade of the carcass.⁴

The three beef carcass characteristics are determined by growth function, back fat thickness function and marbling score function, respectively. We make all three functions piecewise linear in our setup. They have different slopes, which represent the growth rate, in the different stages of feeding. We also assign different slopes in each stage for “good animals” and “bad animals”. A good animal has higher initial value for marbling score, higher growth rates for total weight and marbling score, lower initial value for back fat thickness and a lower growth rate for back fat thickness (see Table 1).

We create three different kinds of feeder cattle groups: high quality pens, medium quality pens and low quality pens. A high quality pen consists of 90 percent good animals and 10 percent bad animals; a medium quality pen has 50 percent good animals and 50 percent bad animals while a low quality pen consists of 10 percent good animals and 90 percent bad animals. Health conditions are also different among different pens with higher quality cattle having lower morbidity and conditional mortality rates (Table 2). Feedlots are assumed not to know the quality of a pen of feeder cattle until they finish the feeding process because the driving characteristics are unobservable.

Cattle grid prices based on historic data from 1990 to 2000 is then used to estimate the profit of high, medium and low quality pens of cattle. Specifically, we assume 150 pens of 100 500-pound feeder steers (50 high quality pens; 50 medium quality pens and 50 low quality pens) are placed on feed at the beginning of November each year from 1990 to 2000. The base price and Choice-Select spread for each
simulated pen is assumed to exactly follow the prevailing national weekly prices for each year while all other grid values, which showed significantly less variation over the past decade, are assumed to take the average values expressed in Table 3. We choose a November placement data because this is a common marketing time for many cow-calf producers. Our simulated feedlot producer chooses the marketing date based on his expectations on base price and quality premium. The feedlot operator in our simulation does not base marketing decisions upon perfect foresight of prices and the premium/discount schedule. Rather, for each year of data used, we estimate simple regressions of the base price as function of time and assume the feedlot operator uses these regression coefficients to predict prices upon which marketing decisions are made while the expected choice-select spreads are the weekly averages across the years. That is, we assume the feedlot operator has a general idea about the direction of market prices but will be unable to predict prices perfectly. We felt this was an appropriate middle ground between perfect market foresight and naïve expectations.

We explore the payout of feedlot and feeder cattle supplier under three different feeder cattle transaction scenarios. 1) A spot market sales; 2) the retained ownership contract and 3) premium/discount sharing contract.

**Scenario 1. Spot Market transaction**

In scenario 1, the feedlot’s problem is to maximize its expected profit under three different effort levels from feeder cattle supplier.

\[
\max EQ_{1,\text{sms}} = f(W_t(l,c), BF(l,c), MS(l,c), TFC(l,c))
\]  

(13)
$Q_{t,sm}$ denotes the feedlot’s profit under spot market sales. The differences of profit among pens of varying quality levels indicate the strength of the incentive that feedlots have to procure high quality feeder cattle. The feeder cattle supplier’s payout has nothing to do with this maximization process.

**Scenario 2. The retained ownership contract**

In this scenario, we want to solve the feeder cattle supplier’s maximization problem which is shown as in equation (14).

$$\max EQ_{c,ro} = f (Wt(l,c), BF(l,c), MS(l,c), TFC(l,c)) - Pf$$  \hspace{1cm} (14)

subject to:

$$Pf = LS + FCM(t) + YDC(t)$$

$Q_{c,ro}$ denotes the feeder cattle supplier’s profit under retained ownership contract. $Pf$ is the payment to feedlot for feeding the cattle until slaughter. It consists of lump-sum payment ($LS$), feed cost markup ($FCM$) and yardage cost ($YDC$). The latter two are increasing in time of stay on feed.

**Scenario 3. The premium/discount sharing contract**

It is reasonable to assume that the feedlot would be the contract issuer of a premium/discount sharing contract. The maximization problem of this scenario is as equation (15).

$$\max_{w(.)} \{ (Q - w(Q)) \}$$

subject to cow-calf operator’s participate constraint:

$$E[V(w(Q))] \geq k$$  \hspace{1cm} (16)
where \( w(.) \) is the optimal sharing rule and \( k \) is the highest possible expected utility the cow-calf could receive from a retained ownership contract or spot market transaction.

We assume that the utility function of the cow-calf operator is

\[
V(w) = -e^{-rw}
\]  

(17)

\( r = 0.01 \) which is the coefficient of the constant absolute risk aversion. We also assume that the payout for the cow-calf operator is normally distributed. Then the expected utility of the cow-calf operator is

\[
EV(w) = - \int e^{-rw} f(w) dw = -e^{-r[\bar{\pi} - r\sigma_w^2/2]}
\]

(18)

A monotonic transformation gives us an expected utility function of

\[
V(\bar{w}, \sigma_w^2) = \bar{w} - \frac{1}{2} r\sigma_w^2
\]

(19)

**Simulation and Maximization Results**

Tables 4- Table 7 show the simulation results for 1650 pens over 11 years (150 pens each year) under the three forms of feeder cattle transactions: (1) fall cash spot market sales by cow-calf operators, (2) retained ownership by the cow-calf operator through slaughter and pays the feedlot a $10 per head lump-sum payment and 20% of the feed cost markup, (3) premium sharing contracts between cow-calf operators and feedlots. In scenario 1 the cow-calf operator sells feeder cattle to the feedlot during the fall at the spot market price and there are no cash transfers thereafter. The feedlot executes one sorting of the pen of cattle (i.e., markets two separate groups of finished cattle) and chooses the profit-maximizing marketing date for each group given the expectation process outlined in the previous section. As shown in Table 4, under scenario 1 the
feedlot’s profit would be $64.60 per head if it purchases a group of high quality cattle and $10.30 if it purchased a group of medium quality cattle. A low quality group of feeder cattle loses $43.64 per head. The margin of profits between the high quality and the medium quality pen ($54.30/head) shows a strong incentive for the feedlot to procure high quality feeder cattle.

Unless reputation can be formed, the cow-calf operator has little profit-based incentive to exert quality related effort under this type of transaction because the payment does not depend on unobserved feeder cattle quality traits. To the extent that cattle procured from the spot market fall below the medium quality level used in this study, i.e., to the extent that the spot market transacts only low quality cattle, feedlots may find it difficult to be profitable from spot market transactions due to the moral hazard (or adverse selection).

Tables 5 and Table 6 show the simulation results of scenario 2 where the cow-calf operator retains the ownership of cattle and pays feedlots to feed the cattle until slaughter. We consider two sub-scenarios: A) The feedlot picks the optimal marketing date given the price expectation; B) The feedlot intentionally delays the marketing date by 1 week later than optimum. The results (see Table 5) show that if the feedlot can pick the optimal marketing date based on the expected grids, he could receive $40.48 per head as a payment by raising a group of high quality animals while the cow-calf operator earns $24.12 per head. A feedlot would receive $40.92 per head and $40.97 per head by raising medium and low quality cattle, respectively. However, the cow-calf operator would lose money by providing a group of cattle whose quality are lower than average.
In this case, a lower effort level by the cow-calf operator is nearly completely internalized because the feedlot’s payment is largely independent of feeder cattle quality.

Given that the payment to the feedlot is based upon feed cost plus a typical industry markup, a longer cattle finishing period will yield a larger payment for the feedlot. Therefore, the feedlot has an incentive to keep cattle longer than what would be optimal in the eyes of the cow-calf operator. Scenario 2B simulates the situation of feedlot moral hazard by assuming they always keep the cattle for too long. From Table 6 one can see that the profit for a cow-calf operator who provides high quality cattle is $23.46 per head, about $0.66 lower than the case without moral hazard while the feedlot operator would net $1.56 per head by extending the marketing date beyond that which is optimal. One can see the dead weight loss is $0.90 per head. While $1.56 is not a large figure, the average profits of custom feedlots over time are quite small; hence even small increments to profits over time could be relatively lucrative. Consequently, even though the cow-calf operator will always provide a high effort level (due to the magnitude of the profit margin between different quality levels), the moral hazard by the feedlot could yield sub-optimal profits.

Scenario 3 is the proposed risk-sharing contract. We use the results from scenario 2 to solve the participation constraints in the maximization problem and get the optimal premium/discount sharing rate. In this optimal contract a feedlot that draws high quality cattle would need to pay the cow-calf at least $18.04 per head of premium and keep a profit of $46.56 per head (see Table 7). A medium quality feeder cattle producer would make more than $6.30 per head under this contract and the cow-calf operator earn $4.00
per head while, if low quality animals were provided, the cow-calf supplier would lose at least $7.70 per head and the feedlot would lose $35.94 per head.

Sensitivity Tests for Optimal Sharing Rate

We change the cow-calf operator’s degree of risk aversion and the lump-sum payment in the retained ownership contract in order to see how the optimal sharing rate would vary on these two factors. The results are shown in Table 8 and 9.

If the lump-sum payment from cow-calf operator to the feedlot under the retained ownership contract is kept constant (currently $10.00/head), the optimal sharing rate is decreasing in the degree of absolute risk aversion. When the risk aversion coefficient is equal to 0.020, the Cow-calf operator would provide high quality feeder cattle without asking sharing the quality grade premium. On the other hand, when the degree of risk aversion is very low, say, cow-calf operator is risk neutral (r =0.00), the optimal sharing rate would be as high as 85.20% (see Table 8).

The sensitivity test on lump-sum payment is actually a sensitivity test on feeder cattle supplier’s reservation utility level. A higher lump-sum payment from the feeder cattle supplier to the feedlot indicates a higher reduction in the supplier’s reservation utility level. In other words, the participation condition would be easier to be satisfied if the lump-sum charge is higher. The result is shown in Table 9. When the risk aversion degree is constant (currently r =0.005), the optimal sharing rate is decreasing in the lump-sum payment under retained ownership contract. The optimal sharing rate is 85.20% if there is no lump-sum payment while it could be as low as 28.40% if the lump-sum payment is $20 per head.
Discussions

From the above analysis, one can see that the premium/discount-sharing contract provides both the feedlot and the cow-calf provider incentives to make high levels of effort to improve final cattle quality. Under the assumptions used in the analysis this type of contract also yields the highest level of average profits for the suppliers of high quality feeder cattle and for the suppliers of medium quality feeder cattle. Feedlots would find the contract advantageous because high quality feeder cattle suppliers self-select into the contract, and these cattle provide a higher average profit for the feedlot. The suppliers of low quality cattle would never want to enter such a contract, which helps feedlots avoid unprofitable pens of cattle.

The format of the sharing contract could also include features that ease cash flow constraints for cow-calf operators who are used to receiving cash from fall sales of feeder cattle. For instance, the feedlot could pay the cow-calf operator 90 percent of the spot market price for feeder cattle at the time of purchase and then, after the cattle are slaughtered, the feedlot could pay the cow-calf the remainder of the base price plus premium or minus the appropriate discount.

Summary and Conclusions

Our analysis suggests that there is the potential for moral hazard in typical forms of feeder cattle transactions. The potential exists for moral hazard on the cow-calf operator side of a simple spot market transaction because the cow-calf operator has little incentive to exert effort to improve unobservable quality traits. The potential exists for moral hazard on the feedlot side of retained ownership contracts because feedlot operators may
not profit from effort spent on sorting or may increase profits by delaying slaughter dates. A linear premium/discount sharing contract can circumvent the double-sided moral hazard problem because it provides both parties incentives to make high levels of efforts.

The satisfaction of the participation condition and the optimal sharing rule in the proposed risk-sharing contract highly depend on the expected payout from a retained ownership contract and the risk aversion degree of the cow-calf operator. The higher the payout from the retained ownership contract is, the less attractive a given sharing contract will be. The more risk averse a cow-calf operator is, the more attractive a risk-sharing contract will be. The gain of feedlot for issuing sharing contract to draw high quality feeder cattle is not much higher than the profit from a retained ownership contract ($6.08/head without considering moral hazard of feedlot). If we consider a risk-averse feedlot, the profit difference would become even less attractive. This might explain why these types of contracts are not seen in the market place.

Other mechanisms have also emerged in the marketplace to address the lack of incentives for all parties to exert effort to improve quality. Certified feeder cattle sales are becoming increasingly popular. These sales feature feeder cattle for which certain characteristics that are usually unobservable (preventative health treatments and more subtle genetic traits) have been verified by an independent third party before the sale of the feeder cattle. Future research should compare the relative efficacy of premium sharing contracts and certified feeder cattle sales in circumventing the incentive issues in this market.

Further analysis is also warranted to consider the aggregate institutional implications that might arise if linear premium sharing contracts or certified feeder cattle sales prove
popular. Current auctions may become an outlet for only lower quality of animals as contracts or certified sales draw higher quality cattle away from general markets.
References


Laura’s Lean Beef Company Cow-Calf Bonus Program,


<table>
<thead>
<tr>
<th>Time Period (days on feed)</th>
<th>Weight (lb/day) Good</th>
<th>Weight (lb/day) Bad</th>
<th>Marbling Score Good</th>
<th>Marbling Score Bad</th>
<th>Back Fat (mm/day) Good</th>
<th>Back Fat (mm/day) Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>500</td>
<td>500</td>
<td>3.5</td>
<td>2.5</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>0-100</td>
<td>3.5</td>
<td>2.8</td>
<td>0.01</td>
<td>0.01</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>101-145</td>
<td>3.5</td>
<td>2.8</td>
<td>0.04</td>
<td>0.02</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>145+</td>
<td>3.5</td>
<td>2.8</td>
<td>0.02</td>
<td>0.01</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Units for weight are in pounds, for marbling score are expressed in an industry standard scoring system and for back fat are in millimeters.

Table 2.1: Initial Value and Slope (Growth Rate) for Three Cattle Quality Functions

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>% Good Animal</th>
<th>% Bad Animal</th>
<th>Morbidity Rate</th>
<th>Mortality Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>90%</td>
<td>10%</td>
<td>35.7%</td>
<td>2%</td>
</tr>
<tr>
<td>Medium</td>
<td>50%</td>
<td>50%</td>
<td>56.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Low</td>
<td>10%</td>
<td>90%</td>
<td>77.3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* Mortality rate is conditional upon becoming sick.

Table 2.2: The Combination of Pens of Varying Quality Level
<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Prem/Disc ($)</th>
<th>Yield Grade</th>
<th>Prem/Disc ($)</th>
<th>Carcass Weight</th>
<th>Prem/Disc ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime</td>
<td>5.57+Sp*0.4</td>
<td>YG 1</td>
<td>2.24</td>
<td>&lt;500 lbs</td>
<td>-22.18</td>
</tr>
<tr>
<td>CAB</td>
<td>3.00+Sp*0.4</td>
<td>YG 2</td>
<td>1.00</td>
<td>500-550 lbs</td>
<td>-17.79</td>
</tr>
<tr>
<td>Choice</td>
<td>Sp*0.4</td>
<td>YG 3</td>
<td>-0.21</td>
<td>550-600 lbs</td>
<td>-0.57</td>
</tr>
<tr>
<td>Select</td>
<td>-Sp*0.6</td>
<td>YG 4</td>
<td>-15.27</td>
<td>600-900 lbs</td>
<td>0.00</td>
</tr>
<tr>
<td>Standard</td>
<td>-17.81-Sp*0.6</td>
<td>YG 5</td>
<td>-20.87</td>
<td>900-950 lbs</td>
<td>-0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>950-1000 lbs</td>
<td>-14.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;1000 lbs</td>
<td>-21.63</td>
</tr>
</tbody>
</table>

B- Sp: Choice-Select spread; the price different between Choice grade and Select grade beef.

Table 2.3: Dollars Per Carcass Weight (cwt) Premium and Discounts Used in This Paper

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Feedlot Profit ($/Head)</th>
<th>Average Optimal Marketing Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>64.60</td>
<td>172</td>
</tr>
<tr>
<td>Medium</td>
<td>10.30</td>
<td>174</td>
</tr>
<tr>
<td>Low</td>
<td>-43.64</td>
<td>174</td>
</tr>
</tbody>
</table>

Table 2.4: Feedlot Profit in Scenario 1.
<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Feedlot Profit ($/Head)</th>
<th>Cow-Calf Profit ($/Head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>40.48</td>
<td>24.12</td>
</tr>
<tr>
<td>Medium</td>
<td>40.92</td>
<td>-30.62</td>
</tr>
<tr>
<td>Low</td>
<td>40.97</td>
<td>-84.61</td>
</tr>
</tbody>
</table>

Table 2.5: Feedlots and Cow-calf Operators’ Profit in Scenario 2A.  
(Feedlot Picks Optimal Marketing Date given Price Expectations)

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Feedlot Profit ($/Head)</th>
<th>Cow-Calf Profit ($/Head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>42.04</td>
<td>23.46</td>
</tr>
<tr>
<td>Medium</td>
<td>42.49</td>
<td>-32.65</td>
</tr>
<tr>
<td>Low</td>
<td>42.55</td>
<td>-88.35</td>
</tr>
</tbody>
</table>

Table 2.6: Feedlots and Cow-calf Operators’ Profit in Scenario 2B.  
(Feedlot Always Keep Cattle Too Long)
<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Feedlot Profit ($/Head)</th>
<th>Cow-Calf Profit ($/Head)</th>
<th>Sharing Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>46.56</td>
<td>18.04</td>
<td>63.72</td>
</tr>
<tr>
<td>Medium</td>
<td>4.00</td>
<td>6.30</td>
<td>63.72</td>
</tr>
<tr>
<td>Low</td>
<td>-35.94</td>
<td>-7.70</td>
<td>63.72</td>
</tr>
</tbody>
</table>

Table 2.7: Feedlots and Cow-calf Operators’ Profit in Scenario 3 under Maximization and Participation Constraint. (Feedlot Picks Optimal Marketing Date given Price Expectations)

<table>
<thead>
<tr>
<th>Coefficient of Absolute Risk Aversion $r$</th>
<th>Optimal Sharing Rate (%)</th>
<th>Cow-Calf Share ($/head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.020</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.015</td>
<td>20.73</td>
<td>5.87</td>
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<tr>
<td>0.010</td>
<td>42.21</td>
<td>11.95</td>
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<tr>
<td>0.005</td>
<td>63.72</td>
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<td>0.001</td>
<td>80.89</td>
<td>22.90</td>
</tr>
<tr>
<td>0.000</td>
<td>85.20</td>
<td>24.12</td>
</tr>
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</table>

Table 2.8: Sensitivity Test of the Optimal Sharing Rate under Different Degrees of Risk Aversion. (Lump-Sum Payment = $10/head)
<table>
<thead>
<tr>
<th>Lump-Sum Charge ($/head)</th>
<th>Optimal Sharing Rate (%)</th>
<th>Cow-Calf Share ($/head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.00</td>
<td>28.40</td>
<td>8.04</td>
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<tr>
<td>15.00</td>
<td>46.04</td>
<td>13.04</td>
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<td>5.00</td>
<td>81.38</td>
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<tr>
<td>0.00</td>
<td>99.05</td>
<td>28.04</td>
</tr>
</tbody>
</table>

Table 2.9: Sensitivity Test of the Optimal Sharing Rate under Different Lump-Sum Payments (Coefficient of Absolute Risk Aversion $r = 0.005$)
Endnotes

1. Auction sales featuring feeder cattle that are third-party certified to meet a subset of unobservable traits (e.g., health) are becoming more popular, however.

2. Emerging technologies may allow for noisy observation of these underlying traits in the future. The current ability of this technology to identify these traits at such young ages is quite limited while its cost is still prohibitive.

3. The carcass weight is the weight of slaughtered animal after the viscera, hide, head, feet and tail are removed.

4. Note that penalties are commonly assessed for several other binary quality issues (e.g., dark cutters) that are not addressed in this analysis.
CHAPTER 3

SUPPORTING MARKETS FOR CREDENCE GOODS
WITH UMBRELLA BRANDING

Abstract:
Darby and Karni suggest branding as means of solving the potential fraudulence problems in the credence good market. Umbrella branding is a common marketing practice to promote new product and bond the product quality to the brand reputation. However, while umbrella branding works well in the experience good market, no evidence shows it would work in the credence good markets. The author sets up a framework for discussing the effect of umbrella branding on the quality provision of credence good. The results show that brand reputation, product similarity, probability of detection, punishment severity, and exogenous quality noise all play important roles in determining a firm’s decision on umbrella branding and fraud.

Key words: Umbrella branding, credence good, auto repair, advertising, information asymmetry, product quality.
Supporting Markets for Credence Goods with Umbrella Branding

Introduction

With credence goods, such as medical care, legal services or car repairs, a consumer is never sure about the extent of the good he needs nor the extent he receives, while the firm or the specialist who provides the good or service has perfect information about both. In the case of auto repair, for example, two separate information problems exist. First, when a consumer perceives a problem with his car, he cannot clearly know the source of the problem while a mechanic could have the full knowledge after inspection. Secondly, upon receiving the diagnosis, if the consumer agrees to have the car repaired by the mechanic, he would not know if the extent of service he receives is as much as the mechanic promised.

With the existence of these sorts of information asymmetries, there is an incentive for the firm to cheat the consumer. Darby and Karni (1978) first coined the term “credence” to describe such goods. They stated that when goods bearing credence qualities are sold in the market, branding is a tool commonly used in monitoring the qualities provided. Umbrella branding or brand extension is a marketing practice in which a firm introduces a new product using the name of an existing product; the practice is widely used in the marketing of experience goods (Degabra and Sullivan, 1995; Choi, 1998). The benefit of brand extension has been investigated by several studies. Tauber
(1988) finds that introducing a new product via brand extension could get immediate consumer awareness and impressions communicated by the brand. Smith and Park (1992) also showed that firms using brand extension spend less on advertising than firms with comparable new name products.

A firm with a good reputation may not brand a low quality new product because a failure of the new product would not only hurt the sale of the new product but could also diminish sales of established products. A multi-product firm would try to maintain the quality level of all their products because a deviation of quality in one product could ruin its reputation and hurt sales of other products. This kind of bonding makes the brand extension a guarantee for product quality (Klein and Leffler, 1981; Milgrom and Roberts 1986; Wernerfelt 1988).2

All the studies on umbrella branding consider only experience goods because the bonding is effective only when the consumer can detect the quality after purchasing or consuming the product, yet Darby and Karni hold branding as a possible means to support credence good markets. With a credence good, consumers may not be able to detect the quality level of the product or service, and revelation of the true quality of the good may occur only rarely, e.g., in instances where consumer watch dog groups undertake private investigations (Feddersen and Gilligan). Even if the detection is feasible, the monitoring cost might be very high.

A recent example of the failure of umbrella branding to act as a bond for a credence good is the Sears Auto Repair Center fraudulence case. Founded in 1886, Sears, Roebuck & Co. is a well-known brand name in the United States. It has portrayed itself for years as a family store that stands behind its merchandise -- a trustworthy pillar of the
retailing community (Meyers, 1992). In fact, early on Sears established its reputation through sales of clothing and durable goods through its mail-order catalog business, a classic example of an experience good market. In the 1930’s, soon after the widespread adoption of automobiles in the United States, Sears extended is product line into the auto repair service business. In June 1992, after an unprecedented 18-month undercover investigation, the California State Department of Consumer Affairs accused Sears’ Auto Centers of systematically defrauding California consumers. The department said Sears charged its agents an average of $223 for unneeded repairs (Gellene, 1992)\textsuperscript{3,4}. In order to minimize negative exposure, the company settled the case by offering consumers $46 million in coupons. Before the settlement, their auto centers suffered 20 percent sales decrease in California and 15 percent drop in the US. Sears department stores also bore a sales loss and there was a drop in stock value.\textsuperscript{5}

Analysts attributed the fraudulent behavior to Sears’ use of sales quotas and bonuses: service advisors received commissions from product-specific quotas per shift and dollar volume quotas per hour, which can promote overselling. Sears altered these selling policies but admitted to no wrongdoing. Despite the charge in 1992, Sears Auto Center was sued again by the state of New Jersey in October 2002. The 2002 lawsuit claims that Sears routinely charged for performing "four-wheel alignments," even though only the front wheels can be aligned on many vehicles. The suit also charges that mechanics told customers they would conduct a "free" vehicle inspection but then went on to charge for unauthorized repairs supposedly discovered during the inspections (Associated Press, 2002). There were other chain stores caught defrauding consumers by California's Bureau of Automotive Repair: Econ Lube ‘N Tune in 1995, Purrfect Auto
Service in 1996 and Midas Muffler & Brake Shops in 1997. There are also class-action lawsuits against Goodyear & Kmart Auto Centers because of the selling of unnecessary parts and services. Similar to the Sears case, the alleged sales of unnecessary repairs were blamed on the companies' use of commissions, contests, and/or quotas that encouraged employees to sell additional parts and services.

Sears cheated consumers despite having other services sharing the same brand name (Sears Department Stores). While sales and stock value suffered, it appears these penalties were short-lived, contrary to the severe penalties hypothesized for cheaters in the theoretical literature. For example, Shapiro (1983) and Anderson (2002) both use a ‘death sentence’ type of penalty (i.e., total loss of future sales) to make the model work. Hence, the efficacy of umbrella branding as a strategy for circumventing the credence good problem as first suggested by Darby and Karni must be called into question if firms regularly continue to flourish after being discovered systematically cheating consumers.

This leads to the central question of this essay and a question not yet addressed by the literature: Can umbrella branding of credence goods be an effective tool for ensuring product quality? To address this question, I analyze how a credence good monopolist would make decisions regarding umbrella branding and fraud during the introduction of a new credence good. The results suggest that the amount of brand reputation of the established good, the functional difference between the old good and the newly developed credence good, and the probability of being caught cheating are all important factors influencing the firm’s strategy.

In some cases a firm cannot make sure the output is of high quality even though it is not its intention to produce low quality goods. For example, even with well-run
meatpacking operations, a meat packer could still accidentally allow *Listeria* in his products. This is the case where an exogenous quality breakdown may exist which is independent of the firm’s effort. An exogenous failure is inserted into the model in order to see the effect of it on the firm’s branding and fraud decisions.

The remainder of the essay is structured as follows. A review on related literature consists of studies on credence good markets and umbrella branding is laid out. Then the analytical model and numerical examples follow. Finally conclusions are drawn based on our results.

**Literature Review**

Many of the studies in the information economics literature focus on the signaling from the firm to consumers under imperfect information. A firm with unobservable product quality could still communicate product quality with some observable signals. The most commonly studied signals include advertising, price, warranties, brand equity and umbrella branding. Umbrella branding is the focus of this paper. Although several papers have provided theoretical and empirical evidence of its benefits and limitations, none of them apply it in a credence good market. In addition, there is little research in the credence good literature that applies umbrella branding concepts in its model formation. In this section some important literatures in both credence good and umbrella branding are reviewed.

*Credence Goods*

Since Darby and Karni coined the term “credence good,” several papers have discussed firm behavior in credence good markets. Pitchik and Schotter (1987)
developed a discrete model of strategic information transmission. They found a mixed-strategy equilibrium where the firm randomizes between honesty and cheating while the customer randomizes between acceptance and rejection of the firm’s recommendation on a major treatment. In their stylized model, the firm’s average rate of cheating depends on the objective probability of a car breaking down and the price of minor and major repairs. In their setup a deceiving firm cannot be detected once the recommendation is accepted, as a result, there is no reputation consideration in the model.

One remedy for the credence good problems is the use of a second opinion. Wolinsky (1993) investigates how information asymmetries affect the organization of markets in which sellers are also experts who determine customers’ needs. Besides seller concern for reputation, he considers consumer search for multiple opinions as another force that mitigates experts’ incentives to cheat on consumers. He shows that experts are more likely to be disciplined by customer search or by reputation according to whether these costs are lower or higher. He also shows that there is a negative search externality that tends to raise prices when experts are liable to make diagnosis errors.

Dulleck and Kerschbamer (2001) show that the majority of previous credence good models can be organized into a unifying framework. Their analysis suggests that market institutions solve the fraudulent expert problem at no cost if the following conditions are satisfied: (i) expert sellers face homogeneous consumers, (ii) there exist large economies of scope between diagnosis and treatment, and (iii) either the type of treatment is verifiable, or a liability rule is in effect protecting consumers from obtaining an inappropriate treatment. Their model provides a useful benchmark for the development of more general frameworks to be considered in the proposed essay.
Umbrella Branding

There is an abundance of theoretical and empirical papers involving umbrella branding in experience good markets. Sullivan (1990) provides empirical evidence showing that a poorly performing product could cause spillover costs to other products that share the same brand name. A ‘sudden acceleration’ incident in Audi cars in 1986 caused the increase in depreciation rate of three models of used Audi cars. In contrast, the introduction of Jaguar’s new model in 1988 led to a significant decrease in depreciation rate of its two models of cars selling in used car markets.

Erdem (1998) used market data to assess the extent in which consumers’ quality perceptions of a brand in one category are affected by their experience with the same brand in another category. An econometric model is estimated on panel data for toothpaste and toothbrushes. The results showed that consumers expect the quality levels of products that are umbrella branded to be highly correlated.

Wernerfelt (1988) presented a theoretical model to show the possibility of signaling by posting a bond in the context of umbrella branding. The product quality in his model is exogenous and known to the firm but not to the consumers. The firm could decide whether to brand the new product according to its quality. The consumers infer the quality of the old product based on the performance of the new product and vice versa. In this setting, the signal can be credible without excessive sunk costs, as long as the bond posted is sufficiently large. Following this work, Montgomery and Wernerfelt (1992) developed a model of firms’ branding decision. In contrast to other advertising literature, they predicted that branded products would have lower average quality than
unbranded products. It is counterbalanced by lower variance in product quality, giving branding a quality-homogenizing rather than a quality-enhancing function.

Choi (1998) considered the experience good markets in an infinite horizon model where a multi-product monopolist is endowed with a chance to develop a new product in each period. The quality of each new product is exogenous and the firm needs to decide whether to brand this new product. In contrast to Wernerfelt, Choi’s model uses profits from future products as a bond instead of using future profits of the old product. In other words, cheating would hurt the firm’s ability to introduce future new products under the same brand name. He shows that brand extension helps a multi-product monopolist introduce a new product with less price distortion. Most recently, Anderson (2002) uses a reputation model to show that there are economies of scope in carrying a reputation that provides a rationale for multi-product firms in the absence of technological or organizational economies. He also showed that a reputation for producing high quality in an old good might be necessary to introduce and maintain the production of a new good.

Some of the articles assume the quality of newly introduced products is endogenous while others assume new products have an exogenous quality and the firm’s only choice is whether to brand the product or not. If it is endogenous then the firm’s decision is whether or not to deviate from the promised quality and make present period profits by lying to consumers and facing possible consequences in future periods. If quality is exogenous then the firm needs to decide the quality threshold above which to use its brand.

All those studies found that it is optimal for a firm not to include new products of low quality under an existing brand or it will cause the loss of its future profits. The key
element is that their products are an experience good. It is easy to uncover the dishonesty in the market for experience goods because the base assumption is that a cheating firm is always revealed eventually. In the Sears auto center fraudulence case, however, the credence good property of auto repair service makes it difficult for consumers to ever identify deception.

In models of experience goods markets, the probability of a cheating firm getting caught is one although it does not happen until after purchase. As a result, umbrella branding provides a bond to assure that a product sold by a branding firm is of high quality because it puts the sales of its other products at the risk. In a repeated game framework, the firm would consider the loss of future sales of its all product lines and its sunk cost in the reputation building process. What if the product is a credence good and the consumer can only detect the fraud with a small probability? The low probability of being caught gives a cheating firm a sizeable chance to survive, i.e., expected returns may increase with cheating. The motivation to deceive the consumers is hence increased. In such a case, can umbrella branding reduce the risk of getting a low quality good?

One important assumption in this essay, which is equally applicable to both experience and credence goods cases, is that the more similar are the product categories for the old and new products, the more severe are the consequence of failure. This is a commonsense assumption around which to devise an analytical model, but it has not yet been used in this literature. 

For example, if the old product is a tire and the new product is a car battery then a failure in producing high quality batteries would certainly cause the loss in tire sales because the two products are in the same subgroup of products. Consumers might
assume the same systems of management and quality control govern their production. On the other hand, suppose the old product is a tire and the new one is a potato chip. It is not clear that a bad tasting potato chip would hurt tire sales too much because they are not in the same subgroup of product category. In this case, a firm using umbrella branding for two very different goods may deceive his customers since the penalty is not so severe. If there exists an equilibrium that those kinds of firms always cheat, then the optimal behavior for the consumer should be to ignore the quality signal provided by umbrella branding. That is, the umbrella branding won’t add any value to the new product because the consumer will treat the new product the same as an unbranded new product. However, umbrella branding may still reduce the fixed costs of launching a new product and, hence, still be a commonly used tactic for reasons other than quality guarantees. The goal of this essay is to develop a theoretical model to meet these stylized facts.

In the following sections, I will model the umbrella branding problem with the case that the new product is a credence good since previous studies focus mainly on experience goods. The many examples of auto repair fraudulence by well-known brand names make this an interesting issue. Also in this model I will incorporate the effect of product similarities or differences on the umbrella branding. The constructed models will be used to recreate the stylized facts of the Sears auto case. Furthermore, the model will be used to draw inferences about the type of behavior that might be expected in two emerging cases in global food markets. The first is that of foods that might contain ingredients that have been genetically engineered (GE). The second is that of foods in the ready-to-eat deli meats category. In both cases, these are product categories in which
consumers treated the foods as experience goods. That is, consumers could try the foods and decide whether they were of a high quality before purchasing the food again. However, both food categories have recently emerged to have credence attributes. In the first case consumers cannot cheaply verify the presence of GE ingredients while in the second case consumers cannot easily verify the presence of the food pathogen *Listeria*. A famous case for the former one is that Taco Bell brand taco shells, produced by Kraft Foods (a subsidiary of Philip Morris) were found to be contaminated with a variety of genetically engineered corn not approved for human consumption, known as StarLink in 2002. StarLink, developed by the biotech firm Aventis, was approved for animal feed, but not for human consumption because of questions about its potential to cause allergies. It was sampled and tested by a coalition of environmental and food safety groups called GEFood Alert. The credence good property of this ingredient makes it impossible for individual consumers to find out the problem. The role of government intervention will be discussed.

**The Model**

The quality level of a product can be either endogenous or exogenous within a model. In the case of endogenous quality choice, a firm could intentionally produce low quality product and grab the *fly-by-night* profit. The Sears Auto Center fraudulence could be treated as endogenous quality reduction. In the case of exogenous quality reduction an exogenous failure could still happen even though the firm has made the effort to produce a high quality product. The incident where the Taco Bell brand taco shell contained GM
corn StarLink could be treated as exogenous quality reduction. Both scenarios will be discussed in our models.

**Endogenous quality reduction**

Suppose a monopolist who owns a successful brand product has developed a new product (or service). The quality level of this product is discrete and endogenous; it is either high quality \( Q=H \) or low quality \( Q=L \). There is a fixed cost \( C \) \((C > 0)\) for producing the high quality product and no fixed cost for producing the low quality one. Consumers have no direct information about the real quality level or the underlying cost of the firms. A firm decides whether or not to invest \( C \) and produce the high quality product at the beginning of the period. Then the firm decides whether or not to brand the product. As will be demonstrated below, the firm will be either truthful \((x=0)\) or deceitful \((x = 1)\). A truthful firm either invests a fixed cost \( C \) to produce a high quality product and then advertises it as high quality or produces a low quality product and does not advertise. A deceitful firm produces a low quality product and then advertises it as high quality in order to deceive consumers and generate profits (which, as is assumed below, will equal \( C \), the fixed cost for producing high quality product). Both the truthful firm and deceitful firm need to decide if they should umbrella-brand their products.

The firm’s profit on its old product is a function of its reputation \( s \), which is the perceived probability that the product quality is high.

\[
\pi_0 = \pi_0(s) \quad 0 \leq s \leq 1
\]

(1)

*Assumption 1*: Profits are increasing and concave in reputation.
\[ \pi_o'(s) > 0, \pi_o''(s) < 0 \]

**Assumption 2**: The probability that consumers perceive the firm’s other product is also of high quality, \( r \), depends on the reputation \( s \) and the advertising expenditure spent on the new product \( A \), and is determined via a transformation

\[ r = r(e^{-\delta} s, A) \quad (2) \]

where \( \delta \) denotes the closeness or similarity of the two products and \( 0 \leq \delta < \infty \). \( \delta \) equals zero when the two products are identical.

**Assumption 3**: The probability that the consumer perceives the new product to be of high quality is non-decreasing in brand reputation, i.e. \( r'(s) > 0 \) for all \( s \).

It is assumed that if the firm experiences bad publicity (e.g., it is caught cheating), the profit of its old product would become \( \pi_o(1 - \theta e^{-\delta}) \) where \( 0 < \theta \leq 1 \). Call \( \theta \) the punishment coefficient; it indicates the severity of punishment a firm receives after being caught cheating by its consumers and may vary across industries or markets. The probability that a deceitful firm is caught is denoted as \( p \). As a result, the profit on the old product is

\[ \pi_o = \begin{cases} 
\pi_o(s) & \text{when } x = 0 \\
\pi_o(s)(1 - \theta \eta e^{-\delta}) & \text{with prob. } = p \text{ when } x = 1 \\
\pi_o(s) & \text{with prob. } = 1 - p \text{ when } x = 1 
\end{cases} \quad (3) \]

where \( \eta = 1 \) if umbrella branding is used on the new product and \( \eta = 0 \) otherwise. Note that the profit received from the old product is only at risk when the firm is deceitful and when it uses umbrella branding.
Assumption 4: A truthful firm makes no less profit from producing a high quality than producing a low quality product.

This assumption makes sure the truthful firm produces only a high quality product.

Assumption 5: New product sales are non-decreasing and concave in the consumer’s perceived probability that the new product is of high quality, \( r \), i.e. \( R_r \geq 0; R_{rr} < 0 \).

As a result, the profit for the new product is

\[
\pi_N = \begin{cases} 
R(r(\eta e^{-\delta} s, A)) - A - C & x = 0 \\
R(r(\eta e^{-\delta} s, A)) - A & x = 1 
\end{cases} 
\]  \hspace{1cm} (4)

where \( R \) is the sales for the new product, which depends on \( r \) and \( A \). Equation (4) can be simplified to

\[
\pi_N = \begin{cases} 
R(\eta e^{-\delta} s, A) - A - C & x = 0 \\
R(\eta e^{-\delta} s, A) - A & x = 1 
\end{cases} 
\]  \hspace{1cm} (5)

Assumption 6: \( R_{rA} \leq 0 \), \( R_{Ar} \leq 0 \) and \( R_{Ar} = R_{rA} \) for all \( A > 0, r \geq 0 \).

Equations (3) and (5) show how umbrella branding is a double-edged sword: the closer are the two products, the more damaging is cheating if you use the umbrella brand but the more helpful is the umbrella brand for generating sales. The firm will suffer a revenue loss of \( \theta R(e^{-\delta} s, A) \) if the firm is caught cheating. The payout for a deceitful firm in a given period is

\[
\pi_o(s)(1 - \theta \eta e^{-\delta}) + (1 - \theta)R(\eta e^{-\delta} s, A) - A \quad \text{with probability } p;
\]

\[
\pi_o(s) + R(\eta e^{-\delta} s, A) - A \quad \text{with probability } 1 - p.
\]

The expected reward of the monopolist is
The firm must decide on three decisions at once: 1) be truthful or deceitful; 2) to use umbrella branding or not and 3) how much to spend on advertising.

First, optimal advertising levels are derived for four scenarios: 1) a firm being truthful and not using umbrella branding, 2) a firm being truthful and using umbrella branding, 3) a firm being deceitful and not using umbrella branding, and 4) a firm being deceitful and using umbrella branding.

A firm being truthful and not using umbrella branding \((x=0, \eta =0)\).

The firm’s problem is to maximize

\[
f(A) = \pi_o(s) + R(0, A) - A - C \tag{7}
\]

The first order condition with respect to \(A\):

\[
\frac{\partial f}{\partial A} = R_A(0, A) - 1 = 0 \tag{8}
\]

A firm being deceitful and not using umbrella branding \((x=1, \eta =0)\).

The firm’s problem is to maximize

\[
f(A) = \pi_o(s) + (1-\theta p)R(0, A) - A \tag{9}
\]

The first order condition with respect to \(A\):

\[
\frac{\partial f}{\partial A} = (1-\theta p)R_A(0, A) - 1 = 0 \tag{10}
\]

Assumption 7: Consumers can detect the level of monopoly advertising and accurately compare it to the level that would be spent by a truthful firm.
Proposition 1. A deceitful monopolist will choose a higher level of advertising under Assumption 7 than would be optimal if consumers could not use the level of advertising to detect cheating.

From equation (8) and (10), one can see that

\[
R_A(0, A)_{t=1, p=0} = \frac{1}{1 - \theta p} > R_A(0, A)_{t=0, p=0} = 1
\]

which means \( A_{t=1, p=0} \leq A_{t=0, p=0} \) because \( R_{AA} < 0 \). The optimal advertising expenditure for the truthful firm is higher than when it is deceitful. In this situation, a deceitful firm will have to increase advertising, and hence lower profits, in order to avoid being detected as a ‘cheater’ because it is assumed earlier that consumers can use advertising as a means for detecting cheaters. As a result, the firm spends more expenditure in advertising than it would if consumers were incapable of interpreting advertising levels as signals of truthfulness.

A firm being truthful and using umbrella branding \((x=0, \eta =1)\).

The firm’s problem is to maximize

\[
f(A) = \pi_o(s) + R(e^{-\delta} s, A) - A - C
\]

The first order condition with respect to \( A \):

\[
\frac{\partial f}{\partial A} = R_A(e^{-\delta} s, A) - 1 = 0
\]

A firm being deceitful and using umbrella branding \((x=1, \eta =1)\).

The firm’s problem is to maximize

\[
f(A) = \pi_o(s)(1 - \theta e^{-\delta} p) + (1 - \theta p)R(e^{-\delta} s, A) - A
\]
The first order condition with respect to $A$:

$$\frac{\partial f}{\partial A} = (1 - \theta p) R_A(e^{-\delta}s, A) - 1 = 0$$

(15)

**Proposition 2.** A firm that uses umbrella branding spends less on advertising than when it does not umbrella brand the new product.

From equations (10) and (15) one can see that

$$R_A(e^{-\delta}s, A_{\eta=1}) = R_A(0, A_{\eta=0})$$

(16)

Given $e^{-\delta}s \geq 0$ and $R_{A_{\eta}} \leq 0$, it is obvious that $A_{\eta=1} \leq A_{\eta=0}$. In other words, the optimal advertising expenditure for an umbrella branded product is less than a product not using umbrella branding. This provides a motivation for umbrella branding beyond quality bonding for a firm producing credence goods.

**Firm’s decision on fraud**

When the firm does not use umbrella branding, $\eta=0$, the condition for the firm to be truthful is

$$\theta p[R(0, A)] \geq C$$

(17)

It becomes a single product quality choice problem. Equation (17) is a rather simple condition: the firm will be truthful if and only if the expected loss of cheating is greater than or equal to the expected gain. When there is no detection ($p=0$) or there is no punishment ($\theta=0$), this condition cannot be satisfied. The firm will always cheat.

When the firm uses umbrella branding, $\eta=1$, the condition for the firm to be truthful is

$$\theta p[e^{-\delta}\pi_o(s) + R(e^{-\delta}s, A)] \geq C$$

(18)
where the left hand side is the expected cost of cheating and the right hand side is the expected gain from cheating. As in equation (17), if \( p=0 \) or \( \theta=0 \), equation (18) cannot be satisfied under any circumstances and the firm will always cheat. If \( p>0 \) and \( \theta>0 \), the firm’s decision is unclear.

The closeness or similarity of the two products also affects the value of the left hand side of equation (18). When \( \delta \) is large, the new product is extremely different from the old product. The condition for a firm being truthful is close to

\[
\theta p[R(0, A)] \geq C
\]

which is identical to the truthful condition for an unbranded product.

Let equation \( G = \theta p[e^{-\delta} \pi_o(s) + R(e^{-\delta} s, A)] - C \). The firm is indifferent when \( G=0 \) and will cheat when \( G<0 \). The first order conditions of \( G \) with respect to \( s \) is

\[
\frac{\partial G}{\partial s} = \theta p[e^{-\delta} \pi_o(s) + R, (e^{-\delta} s, A)] \frac{\partial r}{\partial (e^{-\delta} s)} e^{-\delta} \geq 0
\]

This shows the firm with a higher brand reputation is more likely to be truthful.

The first order condition of \( G \) with respect to \( \delta \) is

\[
\frac{\partial G}{\partial \delta} = (-1)\theta p e^{-\delta} [\pi_o(s) + R, (e^{-\delta} s, A)] \frac{\partial r}{\partial (e^{-\delta} s)} s \leq 0
\]

It shows that the firm is more likely to be truthful if the two products have more similar attributes (are more alike).

It is obvious that the value \( G \) is increasing in \( \theta \) – a more severe punishment gives the firm less incentive to cheat.
**Firm’s decision on umbrella branding**

In the case where the product quality is endogenous, and given our assumptions, a truthful firm will always produce a high quality product and use umbrella branding if the following condition were satisfied.

\[
[R(e^{-\delta s}, A_{|p=1}) - R(0, A_{|p=0})] - (A_{|p=1} - A_{|p=0}) \geq 0
\]  \hspace{1cm} (23)

It is known that \( R(e^{-\delta s}, A_{|p=1}) \geq R(0, A_{|p=0}) \), hence the first term in the left hand side is greater than or equal to zero. According to **Proposition 2**, \( A_{|p=1} \leq A_{|p=0} \), so the second term is always less or equal to zero. As a result, equation (23) is always satisfied.

A deceitful firm decides to use umbrella branding if and only if the following condition is satisfied.

\[
(1 - \theta p)[R(e^{-\delta s}, A_{|p=1}) - R(0, A_{|p=0})] - (A_{|p=1} - A_{|p=0}) \geq \theta p e^{-\delta \pi_0}(s)
\]  \hspace{1cm} (24)

One can see that the satisfaction of this condition depends on the relative value of both sides of (24). The probability of being caught, \( p \), and the punishment ratio, \( \theta \), are important in deciding the relative value between the expected gain from branding and the expected loss from the old product if the firm were caught cheating. The effects of brand reputation and product closeness on the branding decision are not apparent here. A clearer look will be given when this issue is revisited later with the use of a numerical example.

**Exogenous quality reduction**

Suppose the fixed cost a firm invests is not a guarantee of high quality. There is always an uncertainty between the firm’s effort and output (product quality). For
example, using irradiation can usually eliminate bacteria in the meat. However, there might be a small chance the bacteria are re-introduced during the handling process after irradiation. When this kind of rare incident happens and is detected by consumers or the third parties, the firm will lose profits even though it is not an intentional failure. The firm may also endure losses on other products if the failed product is umbrella branded.

Suppose the failure rate for the product is $\varepsilon$. The payout for a truthful firm is

$$\pi_o(s)(1-\eta\theta e^{-\delta}) + (1-\theta)R(\eta e^{-\delta}s, A) - A - C$$

with probability $\varepsilon p$;

$$\pi_o(s) + R(\eta e^{-\delta}s, A) - A - C$$

with probability $1-\varepsilon p$.

The expected reward of the monopolist is

$$f(x, \eta, A) = \begin{cases} 
\pi_o(s)(1-\theta\eta e^{-\delta}\varepsilon p) + (1-\theta\varepsilon p)R(\eta e^{-\delta}s, A) - A - C, & x = 0 \\
\pi_o(s)(1-\theta\eta e^{-\delta}p) + (1-\theta p)R(\eta e^{-\delta}s, A) - A, & x = 1 
\end{cases}$$

$x=0,1; \eta=0,1; A\geq 0$ (25)

**Firm’s decision on fraud**

When the firm does not use umbrella branding, $\eta=0$, the condition for the firm to be truthful is

$$(1-\varepsilon)\theta\varepsilon p[R(0, A)] \geq C$$

(26)

One can see that equation (26) is more difficult to satisfy than equation (17) because the left hand side of it is smaller than that of equation (17).

**Proposition 3.** The exogenous failure of quality increases the incentive for a firm who does not use umbrella branding to cheat.

That is, in this model, a monopolist does not exert extra quality effort to offset the inherent noisiness in product quality, but rather, chooses behavior that reinforces the
likelihood of lower quality products by taking advantage of a noisy environment to hide his own behavior.

When the firm uses umbrella branding, \( \eta = 1 \), the condition for the firm to be truthful is

\[
(1 - \epsilon) \Phi[e^{-\delta} \pi_o(s) + R(e^{-\delta} s, A)] \geq C
\]  

(27)

Again, this is a stricter condition than that in the case where there is no exogenous failure (equation (18)). As a result, a higher exogenous failure rate would discourage the firm from being truthful.

*Proposition 4. A firm using umbrella branding experiences greater additional temptation to cheat when product quality can suffer exogenous failures.*

By comparing equation (26) and (27), one sees that the left hand side of equation (27) diminishes more rapidly than the left hand side of equation (26) in response to the exogenous failure in quality. It means the expected loss from cheating for an umbrella branding firm decreases more than that of a firm not using umbrella branding as the level of exogenous quality failure increases. For example, if a type of product, like food, begins to experience an exogenous quality problem – like pathogens – one would expect umbrella branded firms to be more tempted to begin cheating because they can claim the failure as exogenous than would a non-umbrella branded firm.

Let \( G' = (1 - \epsilon) \Phi[e^{-\delta} \pi_o(s) + R(e^{-\delta} s, A)] - C \). The firm is indifferent to cheating or telling the truth when \( G' = 0 \) and likely to cheat when \( G' < 0 \). The first order conditions of \( G' \) with respect to \( s \) is

\[
\frac{\partial G'}{\partial s} = (1 - \epsilon) \Phi[e^{-\delta} \pi_o(s) + R(e^{-\delta} s, A) \frac{\partial r}{\partial (e^{-\delta} s)} e^{-\delta}] \geq 0
\]  

(28)
Equation (28) shows that the old product’s brand reputation still has a positive effect on the firm’s truthful behavior, however the marginal impact is smaller than the one without exogenous failure shown in equation (21).

The first order condition of $G'$ with respect to $\delta$ is

$$\frac{\partial G'}{\partial \delta} = (1 - \varepsilon) \theta \rho [e^{-\delta} \pi_o(s)(-1) + R_s(e^{-\delta}s, A) \frac{\partial r}{\partial (e^{-\delta}s)}e^{-\delta}s(-1)] \leq 0 \quad (29)$$

This shows that the marginal effect of product similarity also has smaller effect on truthful behavior than the one without exogenous failure although it still has positive impact.

Proposition 5. *The exogenous quality failure would reduce the effects of brand reputation and product similarity on encouraging truthful behaviors.*

**Firm’s decision on umbrella branding**

In the case where there exists a risk of exogenous failures in quality, given our assumptions, a truthful firm will always use umbrella branding if the following condition were satisfied.

$$(1 - \theta \varepsilon) \{ [R(e^{-\delta}s, A_{qs=1}) - R(0, A_{qs=0})] - [A_{qs=1} - A_{qs=0}] \} \geq \theta \varepsilon \pi_o e^{-\delta} \quad (30)$$

Different from equation (23), equation (30) may not always be satisfied. As a result, the exogenous failure may discourage a truthful firm from using umbrella branding.

Proposition 6. *The exogenous quality failure might lead to the loss of brand name value.*

From equation (30) one can see that the exogenous failure of quality would discourage a truthful firm from using umbrella branding to signal high quality in order to avoid hurting its reputation. The value of a brand name thus suffers a loss regardless of
the actions of the firm. For example, in the meat packing business, microbial resistance could lead to more quality failures and limit a firm’s ability to market the product by utilizing its existing brand.

**Proposition 7.** A cheating firm would not change its branding decision because of the existence of the exogenous failure of quality.

When the risk of an exogenous failure in quality exists, a deceitful firm decides to use umbrella branding if and only if the following condition is satisfied.

\[
(1 - \theta)(R(e^{-\delta} s, A_{q=1}) - R(0, A_{q=0})] - (A_{q=1} - A_{q=0}) \geq \theta \delta e^{-\delta} \pi_0(s)
\]  

(31)

This is identical to equation (24) because \(\varepsilon\), an exogenous failure, can only occur if a firm initially chooses high quality or, in other words, the low quality firm has no quality investment at stake. The exogenous failure rate on quality would not affect this result since the quality is already low. As a result, a cheating firm will not change its behavior because of exogenous failure.

In both of the previous models, analysis provided only limited insight into how brand reputation and product similarity affects the resulting decisions regarding quality and umbrella branding. In order to get better insights numeric examples are used to enhance and visualize the previous results. Although the functional forms in this example may be particular, the deduced conclusions are consistent with the spirit of the previous results.
A Numerical Example

Suppose the fixed cost for producing high quality product \((C)\) is equal to 10. The profit functions for the old product is equation (32), the revenue function for the new product is (33) and the reputation function is assumed as equation (34).

\[
\pi(s) = 15 + 60s - 15s^2 \quad (32)
\]

\[
R(r) = 5 + 40r - 20 \cdot (r - 0.5)^2 \quad (33)
\]

\[
r = \eta e^{-\delta} (s - 0.5) + 0.5 \cdot e^{-s/A} \quad (34)
\]

The first set of parameters interactions to be explored is how the product difference and brand reputation affects the value of \(G\) in equation (21), which indicates the firm’s incentive to be honest or deceitful. Suppose the value of \(s\) ranges from 0.5 to 1.0 because only brand reputation higher than average (0.5) is meaningful in the umbrella branding study. The probability of a cheating firm being caught, \(p\), is set as 0.25, the punishment coefficient as 1 and \(\delta\) as ranging from 0.0 (identical) to 4.0 (very different).

The firm is indifferent when \(G = 0\) and will cheat when \(G < 0\). Figure 1 (a) shows that the value of \(G\) is decreasing in \(\delta\) and figure 1 (b) shows that it is increasing in \(s\). In other words, a monopolist with a higher brand reputation is more likely to be truthful while a monopolist is more likely to cheat when the two products are more different. Both of the main effects are quite intuitive, but one feature that needs to be noticed in these two figures is the interaction between the two factors. First of all, the \(dG/d\delta\) is steeper for higher \(s\). It means that the marginal effect of product difference to encourage deception is larger for a firm who has higher brand reputations. Secondly, the \(dG/ds\) is
steeper for lower $\delta$. It means that the marginal effect of brand reputation to promote honesty is larger when the two products are very alike.

Figure 3.1. The relationship between product difference, brand reputation and value of $G$

**Firm’s decision on fraud and umbrella branding**

Besides the product differences ($\delta$) and brand reputation of the old product ($s$), there are three elements affecting firm’s decision on fraud and umbrella branding: the probability of being caught when cheating ($p$), severity of the punishments and
exogenous failures of quality. The results of numerical examples help us better understand the effects of these elements.

*Effects of probability of being caught*

Figure 2 shows a monopolist’s choice under different combinations of $p$, $\delta$ and $s$. One can see that when $p$ is less than 0.05, the firm will always cheat and use umbrella branding regardless of the value of $\delta$ and $s$. When $p$ is greater than 0.15, the firm would be truthful and use umbrella branding $(x=0, \eta=1)$ only when the brand reputation is very high and the product difference is very small. When $p$ is greater than 0.05, a cheating firm will avoid umbrella branding $(x=1, \eta=0)$ if its brand reputation is low regardless of the level of product similarity. As the value of $p$ increases, the reputation needed for the firm to be truthful decreases. As a result, the area of $(x=0, \eta=1)$ increases in the decision space. Also as the $p$ increases, a deceitful firm would start to chose not using umbrella branding because the probability that its old brand reputation getting hurt increases. The firm will always be truthful and use umbrella branding when $p$ is greater than 0.6. Consistent with the result of equation (23), a truthful firm would always choose umbrella branding because it would only benefit from it. The product similarity, however, does not affect a deceitful firm’s decision on umbrella branding.

In the case of “pure” credence good where the probability of a deceiving firm being caught is very small, a firm would always take advantage of it. The consumers would deduce that only cheating firms would emerge. They will never buy the product under this scenario. As a result, in equilibrium there will be no market for such a product. In order to overturn this undesirable equilibrium, public intervention is considered
necessary to raise the probability of detection to a minimum level. Without public intervention, the industry may also prefer to form certain kind of self-disciplined organization to monitor the product quality provided by members in order to raise the probability of detection. The thresholds are 0.15 before a truthful firm would emerge and 0.6 before a cheating firm will never emerge. However, these threshold values depend upon other assumptions in the model, e.g., the severity of sales lost (punishment) if cheating, the existence of exogenous failure and so on.
\[ \delta: \text{Product similarity.} \]
\[ s: \text{Brand reputation for the old product (perceived probability that the product quality is high).} \]
\[ p: \text{The probability that a deceitful firm is caught.} \]
\[ x: \text{Firm’s decision on fraud, i.e. } x=1 \text{ when cheating and } x=0 \text{ when truthful.} \]
\[ \eta: \text{Firm’s decision on umbrella branding, i.e. } \eta=1 \text{ when using it and } \eta=0 \text{ when not using it.} \]

Figure 3.2. Firm’s decision under different combinations of \( p, \delta \) and \( s \).

**Effects of punishment severities**

Sears did not lose all sales in their auto centers after it was caught cheating; as a result, the assumption of \( \theta=1 \) might not be realistic in this or other industries. The value of \( \theta \) in the example is alternated to see how it affects a firm’s decision in cheating and branding.
Figure 3 shows us a monopolist’s choices under different combinations of $\theta$, $\delta$ and $s$. The value of $p$ is imposed as 0.2 and there is no exogenous failure in quality. One can see that when the value of $\theta$ decreases, the area in which the firm will be truthful and use umbrella branding ($x=0, \eta=1$) also decreases in the decision space. The firm will always cheat when $\theta$ is less than 0.6 while they may or may not use umbrella branding depend on the brand reputation. A firm with a low brand reputation tends not to umbrella-brand the new product. When $\theta$ is equal to 0, the firm will always cheat and use umbrella branding regardless of the value of $\delta$ and $s$.

\[\delta: \text{Product similarity.}\]
\[s: \text{Brand reputation for the old product (perceived probability that the product quality is high).}\]
\[\theta: \text{The punishment coefficient.}\]
\[x: \text{Firm’s decision on fraud, i.e. } x=1 \text{ when cheating and } x=0 \text{ when truthful.}\]
\[\eta: \text{Firm’s decision on umbrella branding, i.e. } \eta=1 \text{ when using it and } \eta=0 \text{ when not using it.}\]
Effects of exogenous quality failure

It was shown that the existence of exogenous failure would alter a firm’s incentive to be truthful and the value of a brand name. Different values of the probability of exogenous quality failure (ε) are used in this example to give us a visualized description of its effect on firm’s behaviors.

Figure 4 shows us a monopolist’s choices under different combinations of ε, δ and s, where the value of p = 0.2 and θ = 1.0. When the value of ε increases, the area in which the firm will be truthful and use umbrella branding (x=0, η=1) decreases in the parameter space. The firm will always cheat when ε is greater than 0.4, hence the only choice for the firm is whether or not to use umbrella branding. The effect of high brand reputation to encourage truthful behaviors disappears in this situation. In other words, the value of brand reputation in helping to signal firm effort in producing a high quality product is lost when ε is high. This result is consistent with Proposition 5 and Proposition 6. One can also see that a cheating firm does not change its branding decision under different level of exogenous failure which supports Proposition 8.
\[ \delta: \text{Product similarity.} \]
\[ s: \text{Brand reputation for the old product (perceived probability that the product quality is high).} \]
\[ \varepsilon: \text{The probability that an exogenous failure in quality occurs.} \]
\[ x: \text{Firm’s decision on fraud, i.e. } x=1 \text{ when cheating and } x=0 \text{ when truthful.} \]
\[ \eta: \text{Firm’s decision on umbrella branding, i.e. } \eta=1 \text{ when using it and } \eta=0 \text{ when not using it.} \]

One more intuitive result one can draw from the existing model is as follows. In experience goods models, the penalty for cheating is always assumed to be the highest possible when results are derived showing that quality above the minimum is supported by the market. However, a numerical example shows that lower levels of penalty can also support this. Figure 5 shows a monopolist’s decision under different combinations of \( p, \delta \) and \( \theta \). One can see that when the product is an experience good \((p=1)\), a punishment coefficient \((\theta)\) as low as 0.2 could be effective to prevent a firm from cheating. One can also see that as a good moves from experience \((p = 1)\) to credence \((p < 1)\), the penalty must get higher to be as effective as the experience good case. In terms of
umbrella branding, it is clear that a deceitful firm would not be afraid to use it under a low probability of detection. When the detection probability increases to 0.3, with severe punishment, a deceitful firm would stop using umbrella branding to avoid damages on its old product. As the product moves from credence to experience, the punishment needed to prohibit a cheating firm from employing umbrella branding decreases. According to these results, Sears could use umbrella branding despite the fact that it was cheating because the detection probability is very low and the actual penalties suffered by Sears seem no worse than penalties suffered by experience good firms for a similar degree of product similarity. Hence, Sears probably wasn’t using umbrella branding as a bond for its credence goods, but rather as a source of cost efficiencies in advertising and marketing.
Conclusions

In this study I explore how brand reputation, product similarity and the specifics of product quality affect a monopolist’s decision on fraud and umbrella branding. A firm with a better reputation for product quality is less likely to reduce quality on a new
product because the expected loss if caught is high and it is hard to be compensated by
the expected revenue from cheating. Meanwhile, increased dissimilarity between the
new and old products increases the incentive for the monopolist to cheat because the
detection of quality failure in the umbrella-branded new product will not lead to
substantial losses in the old product sales. A truthful monopolist would always use
umbrella branding because they can only benefit by this marketing strategy due to our
assumption that the brand reputation of an old product could benefit a new high quality
product that shares the same brand name. However, a deceitful monopolist may or may
not use umbrella branding, depending on the interaction effects of many factors such as
severity of punishment, brand reputation and probability of detection but not product
similarity.

The probability of the fraudulence being caught is crucial for the monopolist’s
decision making. If the probability is equal to zero, i.e., a pure credence good case, the
firm will always cheat and there will be a degenerate market for the credence goods
where only low quality is provided. As a result, public intervention should be a useful
means to increase the probability and discourage the cheating behaviors. The case that
agents of California Department of Consumer Affairs employed “undercover cars” to
reveal the cheating behaviors of Sear Auto Center showed us how important the public
monitoring is for some credence goods. Although obvious, it is worth a mention that the
fixed cost for producing high quality good is also crucial in fraud decision because higher
cost means higher payout for the cheating firm.

The severity of punishment to a cheating firm significantly affects a firm’s
behavior. When a product is an experience good, a minor punishment might be enough
to prevent a firm from cheating and using a brand name for disguise. However, as the product moves towards true credence attributes, a more severe punishment would be essential to limit the fraudulences in the market. If consumers are unable or unwilling to exact a large enough penalty via reduced sales, there may be room for regulators to ratchet up regulatory penalties.

The assumption that there is no exogenous failure in high quality good is also loosened in the study. The results showed that exogenous quality failures discourage the monopolist from being truthful. That is, additional exogenous quality noise induces cheating, not compensating quality effort from the firm. Also, it discourages a truthful firm from using umbrella branding because the exogenous product failure may cost them the brand reputation. The implication for the firm is not to brand a new product which has a lot of noise on output quality. Since there are many uncontrolled factors in the production process of GM-free product and “safe food”, one can expect the producers of those products to be less likely to use the strategy of umbrella branding in the market. Hence the shadow value of the brand reputation would decrease in such markets where the magnitude of the exogenous failure rate increases.

Another point one should note is that umbrella branding could be used to reduce the advertising expenditure even when it has few quality implications. In the Sears Auto Center fraudulence case, the firm cheated on consumers in spite of the use of umbrella branding. Two possible explanations are drawn from our results. First, although the Sears’ auto repair is an umbrella branded service, the huge differences of product properties (such as tire alignments and cookware) lower the expected loss of other products under the same brand name to a limited amount. Secondly, the credence
attribute of the auto repairing business gives the firm substantial incentives to cheat since
the detection probability is very low. Moreover, the punishments for cheating seem
somewhat mild once a firm is caught. A remedy for this situation would be the
interference of the public agency with severe punishment, say, losing the license for the
business. Without that, the fraudulences in New Jersey in 2002 may not be a coincident
but a pattern.

The functional forms used in example fit the properties required in the model
adequately. Although altering the value of parameters would lead to different set of
specific numerical results, these would continue to support the analytical propositions.

Perhaps the most important contribution of this essay to the literature is turning a
critical eye to Darby and Karni’s idea that umbrella branding can support truthful quality
revelation in credence good markets. The model provides sensible explanations for the
stylized facts of a vivid counterexample: the Sears’ fraudulence case. This study also
tries to explore a model where both endogenous and exogenous quality reduction exist
while existing studies discussed only either the effect of exogenous quality defects or the
endogenous quality reductions.

Several future avenues for expanding this research exist. A more explicit model
with price level built in should be considered. Also a multi-period dynamic model would
be a popular choice to farther the applications of the model. An empirical study also
could be considered when usable data are available.
References


Endnotes

1. Choi (1998) defines brand extension as a marketing practice that uses an established brand name in one category to introduce products in totally different categories. However, other articles do not require the new products be in different categories from the old one.

2. Montgomery and Wernerfelt (1992) have a contradicting conclusion.

3. Unnecessary car repairs were recommended by Sears mechanics in 90 percent of the test cases run by officials of Department of Consumer Affairs (DCA) throughout California.

4. There were also fraud revelations at Sears Auto Centers in New Jersey and Florida in the same year.

5. The publicity of Sears Auto Center fraud began on June 11, 1992 (Sears’ DCA investigation, 1992). The stock price of Sears (NYSE: S) started to drop on the same day (from 42 to 41.38). The lowest point is 38.0 on July 7, July 8 and July 24. However, it climbed back to 42.0 again on August 24. In the same time, competitors like JCPenny had an increase in stock value.

6. An empirical study by Park, Milberg and Lawson (1991) did find that in identifying brand extensions, consumers take into account both product-level feature similarity and concept consistency between the new and old product.

7. There are many studies (Shapiro 1982, 1983; Milgrom and Roberts 1986) on this issue and many of them use reputation formation to explain the truthful condition. We will not explore this further in this essay. Here we are only interested in how a firm can utilize the established reputation on the newly developed product.
8. Sears, Roebuck and Co. generate over one billion dollars net income per year while it only gave up $46 million in coupon in 1992.
BIBLIOGRAPHY


Sartwelle, James D., Frank K. Brazle, James R. Mintert, Ted C. Schroeder and Michael R. Langemeier. *Buying and Selling Feeder Cattle: The Impact of Selected*
Characteristics on Feeder Cattle Prices. MF-2162, Cooperative Extension Service, Kansas State University, 1996.


