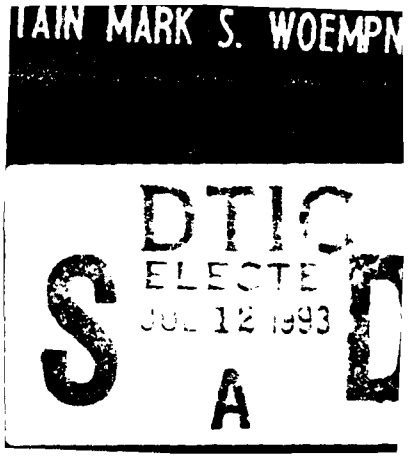
TAIN MARK S. WOEMPN
DTIC
ELECTE
JUL 12 1993
S
D
A

T-4367

A Linear Regression and Markov Chain Model For the Arabian Horse Registry

BY:

Captain Mark S. Woempner

T-4367

A thesis submitted to the Faculty and Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science (Mathematics).

Golden, Colorado

Date 1 APR 93

Signed: Mark S. Woempner
Mark S. Woempner

Approved: Ruth A. Maurer
Dr. Ruth A. Maurer

Golden, Colorado

Date 1 Apr 93

Dr. Ardel J. Boes
Professor and Head
of Mathematics and
Computer Science

ABSTRACT

This thesis is based on a project done for the Arabian Horse Registry, which needed to forecast its future registration of purebred Arabian horses. A linear regression model was utilized to forecast future registration of purebred Arabian horses. This forecast will enable the Registry to identify future revenues for its operation. Additionally, the Registry wants to increase Pure-bred Arabian's share of the horse market. A Markov chain model was developed to forecast the future horse market based on an independent survey conducted by Elrick & Lavidge Marketing Research Inc. This model forecasts which horse breeds will increase and decrease within the horse market.

The Arabian Horse Registry has registered fewer foals every year since 1986. Using regression analysis, we forecast this trend to continue for the next three years. The forecasted foal registrations with a 95% prediction interval are:

1991 - 13,969 ± 1596

1992 - 11,103 ± 1843

1993 - 8,237 ± 2119

This forecast does not include any changes in registration fees for blood typing requirements; such changes will probably lower the numbers further. Utilizing the linear regression model, the three year forecast from 1991 to 1993 shows a loss of revenues of approximately $120,000

per year.

According to the survey, the purebred Arabian breed constitutes approximately 17.4 % of the horse market. The Markov chain model predicts the relative numbers of breeds in the future assuming the survey was a random selection of horse owners. This model predicts that the purebred Arabian breed will constitute only 9.9% of the horse market within the next five years. The categories of horses which will take the purebred Arabian share of the market are the Western (Paint, Appaloosa) and English (Morgan, Saddlebred) .

The foal registration forecast and the horse market sales forecast are correlated. The purebred Arabian stands to lose approximately 40% of their present market. This implies registrations will continue the present trend downward until registrations reach the 7000-9000 foal per year range before leveling off. It should reach this level of registrations within the next three to four years.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

I want to thank and acknowledge Dr. Ruth A. Maurer, Dr. Robert E. D. Woolsey, and Professor William R. Astle for their enduring patience and understanding as they guided me in my graduate learning. Their perseverance molded a student into an applied mathematician and problem solver.

I want to thank the Arabian Horse Registry for their assistance and support for a project I found interesting and a learning experience. Special thanks to Ralph F. Clark the general manager and Matthew Woempner the administrative assistant at the Registry.

Most importantly I want to thank my wife Carrie for her strength, understanding and support throughout the trials and tribulations of my graduate school experience.

Chapter 1
INTRODUCTION

1.1 Background Information

The Arabian Horse Registry is a non-profit organization which registers purebred Arabian horses for the United States and its Territories. Purebred Arabian horse registrations have steadily declined since 1986. The Arabian Horse Registry became concerned about this decline in 1990 when the registration of purebred Arabians were 60% of the peek registration year of 1986. Elrick & Lavidge Marketing Research Inc. conducted a survey for the Registry in April 1991. This survey was a marketing based study conducted to identify

1) The best way to market sales of Arabian Horses;

2) How to capture a larger percentage of the horse industry;

3) Loss of market value of the Arabian horse beginning in 1987.

The Registry contracted this survey to fulfill the above objectives. The Elrick & Lavidge Marketing Research Inc. compiled the raw data from the survey and provided sample statistics in percentages of how horse owners answered questions on the survey. It is unknown if the registry's objectives were accomplished using methods of sample statistics[1].

The author learned there was a twelve volume compilation of data in the general manager's office at the Registry from Matthew Woempner

(the administrative assistant for the Registry) in September 1991 [16]. Ralph F. Clark, the general manager of the Arabian Horse Registry, was asked if he wanted some analysis performed on the data they recently collected in a survey. Mr. Clark desired some unbiased and independent analysis performed on a Horse Owner Survey II [17]. The original compilation of survey results had not been utilized as it was complicated and lengthy. Additionally, analysis of the data with respect to the objectives established for the survey was never conducted. In September 1991, this author volunteered to organize and analyze this survey. That project was a precursor to this thesis.

To further assist in the reading of this thesis the following information is provided. In the Horse Owner Survey II statistical results; horse owners were divided into eight categories:

Type of Category	Breed of Horse
purebred Arabians	purebred Arabian
Western horses	Appaloosa and Paint
Quarter Horses	Quarter Horse
Thoroughbreds	Thoroughbred
half Arabians	half or more purebred Arabian
Warmbloods	Warmblood
English	Morgan and Saddlebred
Standardbred	Standardbred

The delineation of these categories is made using the criteria of common areas of interest for the breed and type shows each breeds attends[1].

1.2 Objectives of the Study

The objectives of this study are twofold. The first objective is to determine short range forecasts of purebred Arabian horse registrations. The second objective is to determine the short range forecasts of the horse market in general. Once the horse market forecast is determined, it will be used to find breeds that will be successful and focus advertising dollars in these areas.

1.3 Goal of the Study

The first goal of this project is to determine the best mathematical tools to use in accomplishing the objectives of the horse market study. Once the best models are determined, future purebred Arabian horse registrations can be forecast and the general horse market anticipated for the next three years. Another goal is to provide a report of these forecasts to the Arabian Horse Registry in a short concise framework for easy reference and utilization. Finally, this study will make recommendations for capitalizing on the forecasts provided to the Registry.

This evaluation for the Arabian Horse Registry addresses, in no specific order, the following:

1. Short and long term horse registrations
2. Evaluation of the horse registry survey
3. Determination of the future horse market
4. Evaluate the loss of Arabians in the horse market

5. Horse market niche evaluation

1.4 Purpose of Thesis

The purpose of this thesis is to provide forecasting information to the Arabian Horse Registry. This information will be used to make decisions concerning expenditures of dollars related to revenues beyond operating costs. The forecasting information provided to the Registry is:

1) Forecast registrations of purebred Arabian foals

2) Forecast future horse market sales

Chapter 2

DEVELOPMENT OF THE LINEAR REGRESSION MODEL

2.1 Background Discussion

There are many ways to forecast time series data. This project will concentrate on determining which forecasting model to use in projecting future purebred Arabian horse registrations. The most common forecasting models are naive forecasts, moving average, single and double exponential smoothing, Winters' method, and linear regression[6, 8, 9]. A comparison of these forecasting models is located in section 2.3.

There are several ways to compare the effectiveness or "fit" of each of the forecasting models. The mean absolute deviation (MAD) method determines the absolute difference or error (e_i) between the actual (D_i) data and the forecasted data ($\hat{D}_i$), then $e_i = (D_i - \hat{D}_i)$. This absolute error is then summed and divided by the number of observations, i.e. $\left(\frac{1}{n}\left(\sum_{i=1}^{n}|e_i|\right)\right)$. Mean square error (MSE) determines the difference or error (e_i) between the actual (D_i) and the forecasted data ($\hat{D}_i$), $e_i = (D_i - \hat{D}_i)$; e_i is then squared and summed. MSE then divides this number by the number of observations, i.e. $\left(\left(\frac{1}{n}\right)\sum_{i=1}^{n} e_i^2\right)$. Mean absolute percentage error (MAPE) determines the absolute difference or error (e_i) between the

actual (D_i) and the forecasted data ($\hat{D}_i$), $e_i = (D_i - \hat{D}_i)$, then divides the error by the actual data (e_i/D_i) to form a percentage. It sums this percentage and divides by the number of observations, i.e. $\left(\left[(1/n)\sum_{i=1}^{n}\left|e_i/D_i\right|\right]\times 100\right)$[6]. MAD, MSE, and MAPE will be used for comparing several forecasts in the ensuing paragraphs.

The data in this study form a time series. There are several types of patterns that arise most often in time series related data. These patterns are trend, seasonality, cycles, and randomness[9]. As seen from figure 2.1 the data shows definite signs of trends, slightly upward until 1986 then clearly downward to present.

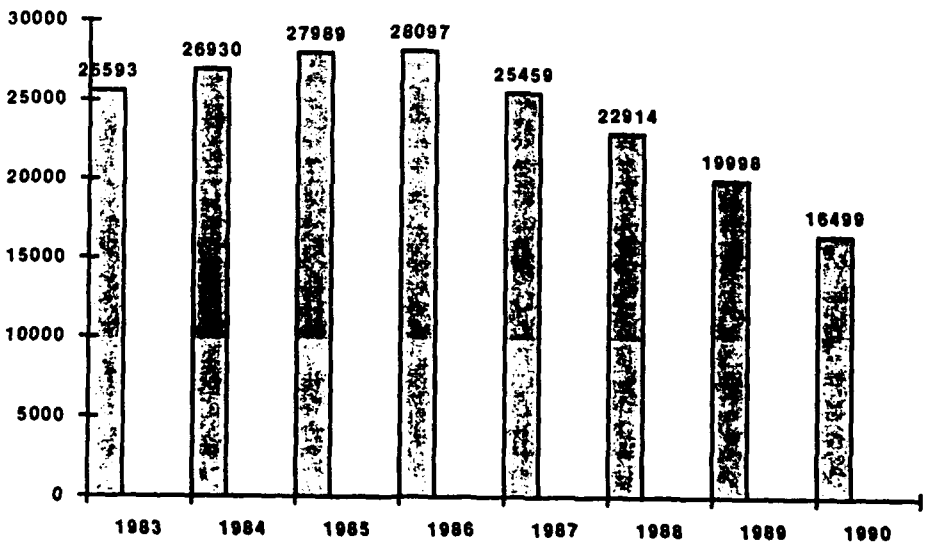

Figure 2.1 Plot of registration of horses vs. time

The available data trends upward from the beginning of the Arabian Horse Registry in 1960 until 1986. In 1986 there was a change in agricultural tax laws within the United States which limit the amounts of deductions allowable in agricultural business. Additionally, the number of allowable years for business loss "write-off" is limited at this time. Due to this change in the agricultural tax laws, registration data prior to 1986 is dismissed as not relating to the present situation.

2.2 Data Collection

The time series data on the registration of purebred Arabian horses was provided by the administrative specialist at the Arabian Horse Registry, Matthew R. Woempner. The data consisted of the number of purebred Arabian foals registered by the Arabian Horse Registry from years 1983 to the present. This information was given as of 1 October 1991.

Table 2.1: Number of registrations from 1983 to present

Year	# of registrations	Year	# of registrations
1983	25,593	1987	25,459
1984	26,930	1988	22,914
1985	27,989	1989	19,998
1986	28,097	1990	16,499

The Arabian Horse Registry requested a forecast of future foal registrations from this information. The registration data is time series data since historical values of a variable (registrations) have been recorded at periodic intervals (i.e. years)[9].

There are several problems with data collection for registrations that need to be identified. The first is inaccurate records by horse breeders as to the parenting of the foals (i.e. placing several stallions among a herd of mares to be serviced, then naming the most prestigious stallion for the sire on all registrations). This brought about blood typing of new foal registrations beginning in 1991. The blood typing requirement increased registration fees from $35 to $100 per animal.

Tardy registrations are another significant problem in presenting accurate data. A tardy registration is defined as any registration not completed within the year of birth for a particular foal. Registrations of foals are tardy for many reasons. The first is that many horse owners put off registration of foals until a couple of months prior to the sale of the foal (a foal is usually sold during its second year). Secondly, the new requirement for blood typing requires a qualified veterinarian take the blood sample and validate the registration. Therefore many larger breeders wait until all foals drop for a particular year, then blood type them at the same time to save on veterinary bills. Thirdly, the late fees assessed for late registration are not large enough to entice horse breeders to register their horses on time.

2.3 Comparison of Forecasting Techniques

The forecasting techniques mentioned in section 2.1 will be compared using the registration data from 1986 to present. The techniques to be compared are naive forecasts, moving average, single exponential smoothing, double exponential smoothing (Holt's method), and Linear Regression[6, 9]. We will compare these models using MAD, MSE, and MAPE utilizing forecasted data vs. actual data from 1986 to 1991.

The other model mentioned in section 2.1 is triple exponential smoothing (Winter's method). Triple exponential smoothing is used to predict a seasonal time series with a trend[6,9]. The reasons for not comparing triple exponential smoothing is the lack of data points and the graph of the data (figure 2.1) does not show signs of seasonality.

Linear regression, which fits a curve to a set of data, is a useful method to forecast trend-based time series data [3, 10]. The data used in the study appears linear from 1986 to present and therefore the linear regression model should forecast the data accurately. The regression equation derived utilizing MINITAB is $y = 274775 - 2866 * (\text{years})$[13]. The results of the linear regression forecast are given in table 2.2.

To ensure the regression analysis is valid, testing the slope of the regression equation is required. This test is accomplished using hypothesis testing with a one tailed t-test.

Table 2.2: Actual vs. forecasted data using linear regression

Year	Actual	Forecasted	Error(e_i)	$(e_i)^2$	($\|e_i\|$ / $\|D_i\|$)
1986	28,097	28,299	-202	40,804	0.0072
1987	25,459	25,433	26	676	0.001
1988	22,914	22,567	-347	120,409	0.015
1989	19,787	19,701	86	7,396	0.0043
1990	16,887	16,835	52	2,704	0.0031
1991	*12,966	13,969	-1003	1,006,009	0.074
MAD = 286		MSE = 196,333		MAPE = 1.74	

* This number includes approximately 1529 pending 1991 registrations.

The results of this hypothesis testing of the regression equation slope follows.

H_o: $m \geq 0$

H_a: $m < 0$

* Reject H_o if $|T_{est}| > T_{crit}$

$|T_{est}| = -2866/109.5 = |-26.18| = 26.18$

$|T_{crit}| = T_{.05,\ 5-1-1} = T_{.05,\ 3} = 2.353$

$|T_{est}| > T_{crit}$ since $26.18 > 2.353$

where m is the slope of the regression equation.

Reject Ho, which indicates there is a linear association between registrations and years. It is therefore valid to use regression analysis with this data if the model makes sense, since there is a statistical relationship between these two variables.

Double exponential smoothing (Holt's method) is designed to account for trends in time series data. Double exponential smoothing uses the last period's forecast and the present demand to derive the next period's forecast[6, 9]. In fact, ultimately this model incorporates all prior data into a given forecast value. The equations used to forecast using double exponential smoothing are:

$$S_t = \alpha D_t + (1-\alpha)(S_{t-1} + G_{t-1}) \qquad \text{for the value of the series}$$

$$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1} \qquad \text{for the trend of the series}$$

$$F_{t,t+\tau} = S_t + \tau G_t \qquad \text{for the forecast } \tau \text{ steps ahead}$$

where: $0 \le \alpha \le 1$, $0 \le \beta \le 1$, and $\tau = 1$

There is a definite trend in the registry data beginning in 1986 and continues downward. Choose $\alpha = .1$ and $\beta = .1$; these low values of α and β ensure the model is dynamic and responds quickly to changes. Additionally, the forecasts needed are one-step-ahead therefore $\tau = 1$. The initial G_0 used in the model is -2500. By assumption the forecast for 1986 is equal to the demand. This allows initiation of the model for S_{t-1}[6]. The double exponential smoothing forecast results are presented in Table 2.3.

Single exponential smoothing is the next forecasting technique described. Single exponential smoothing uses the last period's forecast and the present demand to derive the next period's forecast and is appropriate for a stable time series.

Table 2.3: Actual vs. forecasted data using double exponential smoothing

Year	Actual	Forecasted	Error(e_i)	$(e_i)^2$	$(\lvert e_i \rvert / D_i)$
1986	28,097				
1987	25,459	23,372	2087	4355569	0.0820
1988	22,914	21,165.4	1748.6	3057602	0.0763
1989	19,787	19,009.1	777.9	605128	0.0393
1990	16,887	16,917.9	-30.9	954.81	0.0018
1991	*12,966	14,967.2	2001	4004001	0.1543
MAD =	1329.1	MSE =	1,864,651	MAPE =	7.07

* This number includes approximately 1529 pending 1991 registrations.

The equation used to forecast using single exponential smoothing is

$$F_t = \alpha D_{t-1} + (1-\alpha) F_{t-1}$$

where $0 \leq \alpha \leq 1$ is the smoothing constant, D_{t-1} is the demand this period, F_{t-1} is the forecast for this period, and F_t is the forecast for the next period. This period's demand will project the next period's forecast better then this period's forecast since the actual data trends downward, therefore an $\alpha = .9$ is used in the comparison[6,9]. If any higher values of α are used, then the model essentially becomes the naive forecasting method, since $F_t \cong D_{t-1}$. For vales of $\alpha < .9$ there is higher error (e_i). By assumption the forecast for 1986 is equal to the demand. This allows

initiation of the model. The single exponential smoothing forecasting results are shown in Table 2.4.

The moving average is the next forecast to be considered. The moving average forecast uses a number of the most recent actual data values in generating a forecast data point. To compute the moving

Table 2.4: Actual vs. forecasted data using single exponential smoothing

Year	Actual	Forecasted	Error(e_i)	$(e_i)^2$	($\lvert e_i \rvert / D_i$)
1986	28,097	28,097			
1987	25,459	28,907	-3448	11888704	0.1354
1988	22,914	25,803.8	-2889	8346321	0.1261
1989	19,787	23,203	-3416	11669056	0.1726
1990	16,887	20,128.6	-3241.6	10507971	0.1919
1991	*12,966	17,211.2	-4245.2	18021723	0.3274

MAD = 3447.96 MSE = 12,086,755 MAPE = 19.07

* This number includes approximately 1529 pending 1991 registrations.

average forecast the following formula is used:

$$F_t = \left(\frac{1}{n}\right) \sum_{i=t-n}^{i=t-1} D_i$$

where:

i = the periods of the actual data (i.e. i=1 is 1986)
n = the number of periods in the moving average
D_i = actual value at period "i"
t = period of the forecast

An MA(2) will be used in calculating the forecasted data. An MA(2) is a moving average forecast derived using the previous two periods. It is the most responsive type of moving average forecast. Additionally, only five points are used in this forecast, therefore an MA(2) allows for the largest number of forecasted data points for the comparison[6,9]. The moving average forecast results are presented in Table 2.5.

Table 2.5: Actual vs. forecasted data using moving averages

Year	Actual	Forecasted	Error(e_i)	$(e_i)^2$	$(\|e_i\|/D_i)$
1986	28,097				
1987	25,459				
1988	22,914	26,778	-3864	14930496	0.1686
1989	19,787	24,186.5	-4399	19351201	0.2223
1990	16,887	21,350.5	-4463.5	19922832.3	0.2643
1991	*12,966	18,337	-5371	28847641	0.4142
MAD = 4,524.38		MSE = 20,763,042.58		MAPE = 26.74	

* This number includes approximately 1529 pending 1991 registrations.

Naive forecasting is the simplest of the forecasting methods. A naive forecast for any period equals the previous period's actual value[9]. The naive forecasting model results are shown below.

Table 2.6: Actual vs. forecasted data using the naive forecast method

Year	Actual	Forecasted	Error(e_i)	$(e_i)^2$	($\|e_i\|/D_i$)
1986	28,097	27,989	108	11,664	0.0038
1987	25,459	28,097	-2,638	6959044	0.1036
1988	22,914	25,459	-2,545	6477025	0.1111
1989	19,787	22,914	-3,127	9778129	0.1580
1990	16,887	19,787	-2,900	8410000	0.1717
1991	*12,966	16,887	-3,921	15374241	0.3024
MAD = 2539.83		MSE = 7835017.17		MAPE = 14.18	

* This number includes approximately 1529 pending 1991 registrations.

To compare the six different forecasting models or courses of action, they are tabulated using MAD, MSE, and MAPE in Table 2-8. The smallest value in each column designates the best forecasting model for the actual data.

Table 2.7: Comparison of all forecasts using MAD, MSE, and MAPE

Model Type	MAD	MSE	MAPE
Linear Regression	571.7	119,836	5.25
Double Exponential Smoothing	1,329.1	1,864,651	7.07
Single Exponential Smoothing	3447.96	12,086,755	19.07
Moving Averages	4,524.38	20,763,042.58	26.74
Naive Forecast	2,539.83	7,835,017.17	14.18

The comparison of the different types of forecasting models using mean absolute deviation, mean square error, and mean absolute percent error shows linear regression as the best forecaster for this study. Double exponential smoothing is second best, followed by the naive forecasting model. A visual representation of Table 2.8 is shown in Figure 2.2.

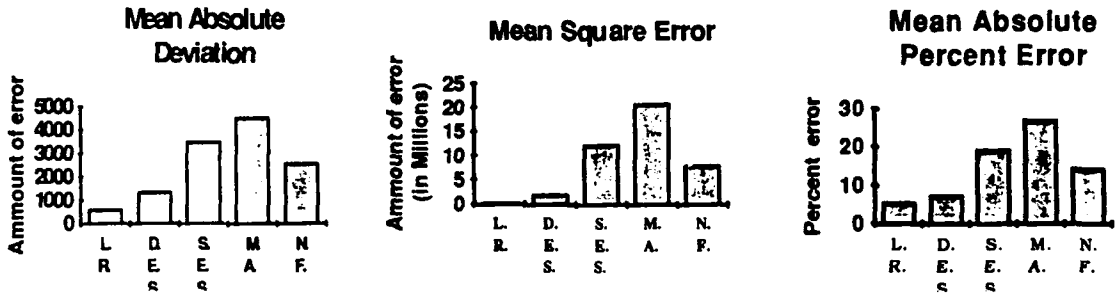

Figure 2.2 Visual plotting of MAD, MSE, and MAPE

Linear regression has the smallest values in all three columns. It is therefore chosen to forecast the registrations of purebred Arabian horses.

2.4 Problem Formulation

Linear regression was chosen as the preferred forecasting tool. This type of forecasting model performs well since the data portrays no seasonal variation and has a specific trend since 1986. A statistical computer program, MINITAB, was used to generate the regression equation which derived the forecasted data[13].

There are several assumptions which underlie the use of linear regression. For each value of x (years), there is a distribution of possible y values (registrations) that has a mean equal to the expected value (the regression line) and the conditional distributions are normal. The error terms of the conditional distributions are uncorrelated. The conditional distributions for all values of x (years) have the same dispersion, a condition called homoscedasticity, which means that for each value of x (years) there is equal variance in the y distributions[3, 9].

The linear regression model utilizes data from 1986 to present. The reason no previous data was utilized for this short term forecast are twofold. First, the tax laws changed for agricultural business in 1986 and there was a downward trend in the economy. Secondly, there is a good first degree polynomial curve fit for data from 1986 to present (adjusted R^2 of 99%), see Appendix D. A second degree polynomial fits the data well for 1983 to the present (adjusted R^2 of 98%), see Appendix E. Unfortunately, the forecast projects zero registrations within the next four and one half years. This seems unrealistic, since there are 30,000 active members of the Arabian Horse Registry. Additionally, the curve would be fitted across two different environments of agricultural business, before and after 1986. Due to the changed environment in the production of horses, only five data points are used in the regression model. This creates an artificially high R^2, but does not invalidate the model for predicting short term forecasts. Therefore a first degree polynomial model was chosen to determine the registry forecast.

This model works strictly with the registration data and does not take into consideration other variables which may impact on the forecast. Examples of some of these outside influences are the present and future state of the economy, tax laws governing agricultural businesses, significant increases in registration fees, and blood typing requirements for registration.

Using the regression analysis on the number of foals registered for the last five years, the model projected the number of 1991 foal registrations to be 13,969. Since this is a prediction estimate derived from sample data there is a prediction interval associated with the computation[3].

To derive this prediction interval the analyst must have the number of years of data used (n), the Mean Square Error (MSE), the year's data being projected (X_h), the mean of the years the data was taken (μ_X), and the years over which the data was taken (X_i)[3]. The following data was taken for the regression analysis conducted on the computer program MINITAB.

$n = 5$

MSE = 119,836

$X_h = 91$

$\mu_X = 88$

$X_i = 86, 87, 88, 89, 90$

$S^2(y)$ is the variance of the number of foals registered.

$$S^2(\hat{Y}_{h(new)}) = MSE\left(1+\frac{1}{n}+\frac{(X_h-\mu_x)^2}{\sum_{i=1}^{n}(X_i-\mu_x)^2}\right) \quad [3]$$

S^2 = 251,655.6

S = 501.653

Degrees of Freedom = 4

$$Y_{h(new)} = \pm t\left(1-\frac{.05}{2};n-2\right)\times S$$

Using the above equations the following intervals can be projected at 95% confidence.

- for 1991: $Y_{h(new)}$ = 13,969 ± 1596
- for 1992: $Y_{h(new)}$ = 11,103 ± 1843
- for 1993: $Y_{h(new)}$ = 8,237 ± 2119

2.5 Application to Registry Revenues

The Arabian Horse Registry revenues are derived from three main sources.

1) Interest on surplus capital from previous years, called revenue beyond operating cost.

2) Net revenues from present year registrations.

3) Revenue generators such as yearly membership dues, registration transfer fees, and fees for duplicate copies of registration forms.

Net revenues from horse registration can be derived by subtracting blood typing cost and registration costs from gross revenues per horse. Presently the Registry has three major fee levels for horses. For members of the registry, there is a $50 fee for gelded horses and a $100 fee for non-gelded horses. For non-members of the Registry there is a $130 fee for all registrations[15]. They utilize this triple fee level to promote registry membership and gelding many stallions whose bloodlines or markings are marginal to average. There are two main costs associated with registration of purebred Arabian horses. The cost of the blood typing is $32 and the administrative cost of the registration (i.e. input into the computer and registration forms etc.) is $17. The net revenue for gelded horses is:

$$\$50 - (\$17 + \$32) = \$1$$

Gelded horses make up approximately 10% of the total yearly foal registration crop. The net revenue for non-gelded horses is:

$$\$100 - (\$17 + \$32) = \$51$$

Non-gelded horses comprise approximately 90% of the total yearly foal registration crop. There are also several costs in the registration process not covered in the above equations. These are problem horse registrations where additional research and validation is required. Approximately 5% of the horses registered require additional research

and validation at an average additional cost of $75 per horse. Net revenue beyond operating cost (RBOC) per year, utilizing the above revenues and costs relating to registrations, are listed in table 2.8.

Table 2.8: Forecast of revenues beyond operating costs.

Year	Revenues Beyond Operating Cost
1991	$ 522,759.25 ≤ RBOC ≤ $ 657,621.25
1992	$ 391,226.55 ≤ RBOC ≤ $ 546,976.95
1993	$ 258,493.11 ≤ RBOC ≤ $ 437,533.40

Chapter 3

DEVELOPMENT OF THE MARKOV CHAIN MODEL

3.1 Background Discussion

To develop the Markov chain model two questions were utilized from the Horse Owner Survey II. Question 1 identifies the present state of the horse market or breed of horse each owner possesses. The information from this question sets up the initial state matrix discussed in section 3.6. Secondly, question 6 identifies the type of horse breed purchased by a particular owner. The information from question 6 sets up the transition matrix discussed in section 3.6.

A Markov chain model is utilized because it is a model that describes, in probabilistic terms, the dynamic behavior of certain types of systems over time[2, 4, 5]. This model utilizes a state matrix or "now" matrix which describes the state of the horse market in terms of percent controlled by each horse category and a transitional matrix which describes by percentage the category of horse purchase by each type of owner[4]. The main assumption in a Markov chain model is that knowledge of the current state occupied by the process is sufficient to describe the future probabilistic behavior of the process. Another unique property of this Markov chain model is the existence of a steady state matrix [5]. This Markov chain model is developed to take probabilities

derived from the Horse Owner Survey II and forecast future trends in the horse market.

There are several assumptions made in this model. First, assume the survey is a randomly selected group of horse owners and can therefore be considered a sample set. Second, assume this sample set represents the horse owner population in general. Third, assume that the owner will actually purchase the horses they said they would consider buying in the future (question 6). Fourth, assume there will be no major changes in the transition matrix through advertising and marketing by other non-Arabian breed associations. Finally, assume there will be no significant changes in the economy or tax laws governing agricultural business.

3.2 Data Collection

The data collected from January to March 1991 by Elrick & Lavidge Marketing Research Inc. for the Horse Owner Survey II were utilized in building the Markov model. This survey was oriented toward the general population of horse owners and was created by the Arabian Horse Registry to gain information about the general horse owner population. The survey was mailed to subscribers of non-specific horse magazines in an attempt to keep the data unbiased. The survey had a 73% response rate, which was noted by the Elrick & Lavidge Marketing Research Inc. within the final report[1]. The selection of respondents

appears to be random within the horse owner population when compared to figures produced by the American horse counsel[14].

There were two additional surveys. These two surveys were directed at Arabian horse owners in general and Arabian racehorse owners in particular. These surveys were not useful as data collection for this study since one of the assumptions is a random selection of the general horse population. This study requires this assumption allowing utilization of the raw data as a sample of all horse owners.

The raw data from respondents is found in Appendix B and is derived from question and question 6 of the Horse Owner Survey II, found in Appendix A. The following numbers represent respondents to the Horse Owner Survey II for a total of 1774 owner responses[1].

Owner Type	Number of respondents
Purebred Arabian horse owners	309
Western horse owners	304
Quarter horse owners	566
Thoroughbred horse owners	196
Half Arabian horse owners	182
Warmblood horse owners	45
English horse owners	89
Standardbred horse owners	83
Total Responses	1774

The sample for this problem consists of all respondents to the survey.

3.3 Formulation of the State Matrix and Transition Matrix

To derive the state matrix and transition matrix the raw data is changed into percentages. For the state matrix, raw data information is changed into percentages by dividing each breed owner population by the total sample size (i.e. for the purebred Arabian it is: 309/1774=17.4%). For the transition matrix each row represents a particular breed owner and each column represents the breed to be purchased by that owner within the next year[2]. The percentage is derived by the number of horses of breed j purchased by owner X_{ij} divided by the total number of horses to be purchased by breed owner X_{ij}.

$$P_{ij} = X_{ij} \Big/ \sum_{j=1}^{n} X_{ij}$$

Where n is the number of breeds purchase by owner i, in this model n=8. These percentages are then placed into matrix form. Each row represents an owner of breed i. Each column represents a breed j purchased in the next year. Therefore each a_{ij} of the transition matrix is represented by the P_{ij} (percentage) shown above. The sum of each row's P_{ij} is one (100%)[7].

3.4 Simplest Case Explanation

This model in its simplest case assumes that the horse market has only two states from year to year, own a purebred Arabian or own another non-purebred Arabian breed. It further assumes that there is a

certain probability that a purebred Arabian will still be owned in the next period and that there is also a certain probability that the owner will sell their Arabian horse and buy another non-Arabian breed[4].

Let's assume probability for a purebred Arabian horse owner to own a purebred Arabian in the next period is 22%. Therefore, we know they have a 78% probability of going from purebred Arabian breed to a non-purebred Arabian breed within the next period, since the sum of the probabilities for these courses of action must be one (100%)[4].

Let's further assume the non-purebred Arabian owner has a 10% probability of switching to own a purebred Arabian in the next period. We therefore know there is a 90% probability they will still own a non-purebred Arabian horse. This may be shown in a table like that below:

	Arabian	Other
Arabian	.22	.78
Other	.1	.9

Now assume that, at the start of the year, the portion of the horse market sample is 18 purebred Arabian horse owners, and 82 non-purebred Arabian horse owners control the rest of the horse market. If we want to know what the next period will look like (assuming we believe our probabilities above) all we do is multiply the number of horse

owners in each state by the yield table or transition matrix above which gives:

$$(18 \quad 82) \times \begin{pmatrix} .22 & .78 \\ .1 & .9 \end{pmatrix} \cong (12 \quad 88)$$

The purebred Arabian horse has decreased its portion of the market from 18 to 12 purebred Arabian horse owners in the first year. Let's look at the next period, continuing to round off to the nearest horse owner.

$$(12 \quad 88) \times \begin{pmatrix} .22 & .78 \\ .1 & .9 \end{pmatrix} \cong (11 \quad 89)$$

The Arabian is losing more ground in the market during the second period. Looking at the next period,

$$(11 \quad 89) \times \begin{pmatrix} .22 & .78 \\ .1 & .9 \end{pmatrix} \cong (11 \quad 89)$$

there is no change in the state matrices. Checking the next period,

$$(11 \quad 89) \times \begin{pmatrix} .22 & .78 \\ .1 & .9 \end{pmatrix} \cong (11 \quad 89)$$

again there is no change in the state matrices during this period. By looking at one more period,

$$(11 \quad 89) \times \begin{pmatrix} .22 & .78 \\ .1 & .9 \end{pmatrix} \cong (11 \quad 89)$$

it is apparent that the state matrix has reached steady state. The market will stabilize with purebred Arabian horse owners controlling about 11% of the horse market.

3.5 Steps of the Markov Chain Model

The Markov chain model in this study is comprised of five steps. Initially the state and transition matrices must be derived as describe in section 3.3. Then the state matrix is multiplied by the transition matrix to derive the next state matrix. Finally when no change is noted from state to state, then the model has reached steady state.

The steps to the model are as follows:

Step 1) Create initial state matrix:

Creation of the initial state matrix is attained by dividing each category of horse owner by the total owner responding to the survey.

Step 2) Create the transition matrix:

Creation of the transition matrix is accomplished utilizing P_{ij} 's discussed in section 3.3.

Step 3) Multiply the initial state matrix and the transition matrix:

Doing this obtains the state matrix at time period 1:

(initial state matrix) * (transition matrix) = (next state matrix)

Step 4) Continue iterating through step 3:

Use period 1, period 2, etc. as the state matrix multiplied by the transition matrix. Once the period (n-1) state matrix equals the period (n) state matrix, the situation has reached steady state.

Step 5) The final (state matrix) in period (n) is the steady state matrix.

3.6 Progressive States of the Market

The state matrix is derived as described in section 3.3 of this chapter. It is comprised of eight variables which are described below.

$X_i = [X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8]$

X_1 = Purebred Arabians - PA

X_2 = Western (Paint and Appaloosa) - W

X_3 = Quarter Horses - QH

X_4 = Thoroughbreds - TB

X_5 = Half Arabians - HA

X_6 = Warmbloods - WB

X_7 = English (Morgan and Saddlebred) - E

X_8 = Standardbred - SB

Current state matrix is:

PA	W	QH	TB	HA	WB	E	SB)	from the market survey.
(.174	.174	.319	.11	.102	.025	.050	.046)	By market percentage
(309	304	566	196	182	45	89	83)	By number of horses

The transition matrix is derived using the method described in section 3.3 of this chapter. This gives the new yield table or transition matrix shown below:

	PA	W	QH	TB	HA	WB	E	SB
PA	.22	.17	.11	.07	.16	.07	.18	.02
W	.08	.33	.2	.05	.06	.06	.15	.03
QH	.07	.3	.23	.1	.07	.06	.14	.03
TB	.06	.2	.16	.2	.06	.17	.12	.03
HA	.18	.18	.13	.07	.16	.08	.17	.03
WB	.06	.2	.18	.17	.06	.21	.11	.01
E	.1	.18	.15	.08	.09	.07	.29	.04
SB	.05	.13	.12	.17	.05	.03	.12	.33

Utilizing this transition matrix to determine purebred Arabian share of the market, after the first period (year) we have:

$$(.174 \quad .171 \quad .319 \quad .11 \quad .102 \quad .025 \quad .05 \quad .046) \times \begin{pmatrix} .22 & .17 & .11 & .07 & .16 & .07 & .18 & .02 \\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03 \\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03 \\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03 \\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03 \\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01 \\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04 \\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33 \end{pmatrix} \cong (.11 \quad .24 \quad .18 \quad .1 \quad .09 \quad .08 \quad .16 \quad .04)$$

The Arabian horse is losing its portion of the market from 17.4% to 11%, similar to the simplest case model. The Western and English categories have increased significantly from 17.4% to 24% and 5% to 16% respectively. Checking the next period, it shows:

$$(.11\ \ .24\ \ .18\ \ .1\ \ .09\ \ .08\ \ .16\ \ .04)\times\begin{pmatrix}.22 & .17 & .11 & .07 & .16 & .07 & .18 & .02\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\equiv(.10\ \ .24\ \ .17\ \ .11\ \ .09\ \ .09\ \ .17\ \ .04)$$

The purebred Arabian has lost an additional 1% of the horse market. Percentages of 1% or more are significant if the horse market sales total more than 200,000 horses. Looking at the next period:

$$(.10\ \ .23\ \ .17\ \ .11\ \ .09\ \ .09\ \ .17\ \ .04)\times\begin{pmatrix}.22 & .17 & .11 & .07 & .16 & .07 & .18 & .02\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\equiv(.099\ \ .237\ \ .173\ \ .109\ \ .085\ \ .088\ \ .169\ \ .041)$$

The state matrices are settling down to near steady state conditions with only small increments of change within each category. Reviewing one additional period:

$$(.099\ \ .237\ \ .173\ \ .109\ \ .085\ \ .088\ \ .169\ \ .041)\times\begin{pmatrix}.22 & .17 & .11 & .07 & .16 & .07 & .18 & .02\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .16 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\cong(.099\ \ .237\ \ .173\ \ .109\ \ .085\ \ .088\ \ .169\ \ .041)$$

The model has reached steady state. Unfortunately, in this case the purebred Arabian horse lost a portion of the horse market totaling 7.6%. This example portrays a no change in the marketing strategy approach. The percentages in the state matrix and transition matrix are derived from the Horse Owner Survey II. The net market change can be shown by subtracting the steady state matrix from the initial state matrix. In this case the change in X_i as a percentage of the market over a four year period is:

From the market survey:

PA	W	QH	TB	HA	WB	E	SB
17.4%	17.4%	31.9%	11%	10.2%	2.5%	5%	4.6%

---Minus---

The steady state matrix:

PA	W	QH	TB	HA	WB	E	SB
9.9%	23.7%	17.3%	10.9%	8.5%	8.8%	16.8%	4.1%

The change in X_i as a percentage of the market is:

PA	W	QH	TB	HA	WB	E	SB
-7.6%	+6.6%	-14.7%	-.02%	-1.8%	+6.3%	+11.8%	-.05%

3.7 Verification and Validation

The following table was acquired from the American Horse Council. It reflects 1989, 1990 and 1991 registrations of the breeds/categories of interest[14]. The last two columns of the table shows the actual trends and the Markov chain projected trends.

Table 3.1: Comparison of the Markov chain forecast to registrations

Category	1989	1990	1991	Actual Trend	Markov Projected Trend
Purebred Arabian	21,723	17,676	12,993	down	down
Western	25,136	26,822	28,550	up	up
Quarter Horse	123,294	110,597	101,390	down	down
Thoroughbred	48,218	43,571	37,442	down	down
Half Arabian	4,775	4,276	4,251	down	down
Warmblood	2,054	2,098	2,102	up	even
English	7,440	7,187	6,962	down	up
Standardbred	16,896	16,576	13,617	down	down

The state vector for horse market sales compares to the 1991 registration state vector as follows:

(.174, .174, .319, .110, .102, .025, .050, .046) State vector sales

(.062, .137, .493, .180, .020, .010, .033, .065) State vector registrations

These vectors are similar, although it appears Arabian percentages are inflated. The state vector for horse market sales could still be accurate when sales of mature animals are taken into consideration.

Registration of horses should lag behind the Markov chain projections, since the model projects future purchases. There must be a demand for a horse breed before breeders will produce and register a horse. Additionally, sales of mature horses are not accounted for in the registration of foals above. Therefore the validation numbers available in Table 3.1 lag behind projections made by the Markov chain model.

Chapter 4

FUTURE HORSE MARKET EXAMPLES

4.1 Background Discussion

In the All Breeds Horse Marketing Survey, the horse owners were divided into eight categories: purebred Arabians, Western, Quarter Horses, Thoroughbreds, half Arabians, Warmbloods, English, and Standardbred. Therefore the transition matrix or yield table will have eight columns and eight rows. This is much more complex than the two column and two row table used in section 3.4, the simplest case .

The market portion each category controls is derived from the number of respondents owning a particular breed (i.e. purebred Arabian owners) divided by the total number of survey respondents which owned a horse (any breed). The information on the probabilities which are inserted into the eight column and eight row transition matrix are derived from the all breed survey question la. (for type of breed owned) and question 6 (for type of breed an owner will purchase in the future).

4.2 No Change in Marketing Strategy

If there is no change in marketing strategy by the purebred Arabian Registry and its affiliates, then the purebred is projected to lose approximately 7.6% of the horse market it once held as shown in section 3.6, progressive states of the market. This market loss percentage will be

used later for comparisons with the other two courses of action in this chapter(i.e. "stay Arabian" and "go Arabian").

4.3 Increase of Arabian Owners to Stay Arabian

Suppose that the desire of purebred Arabian owners to stay Arabian can be increased through an Arabian Horse Registry or Association sponsored advertising (i.e. youth group trail ride, free show, or advertising in Arabian type magazines etc.) enough to change purebred Arabian owner to stay a purebred Arabian owner chance from .22 to .41. This will cost (estimated by a marketing group) about $100,000. This gives the new yield table shown below:

	PA	W	QH	TB	HA	WB	E	SB
PA	.41	.14	.08	.04	.13	.04	.15	.01
W	.08	.33	.2	.05	.06	.06	.15	.03
QH	.07	.3	.23	.1	.07	.06	.14	.03
TB	.06	.2	.16	.2	.06	.17	.12	.03
HA	.18	.18	.13	.07	.16	.08	.17	.03
WB	.06	.2	.18	.17	.06	.21	.11	.01
E	.1	.18	.15	.08	.09	.07	.29	.04
SB	.05	.13	.12	.17	.05	.03	.12	.33

Note the changes in the first row required to increase the a_{11} position to .41 probability. This transition matrix is used to determine the Arabian

share of the market after the first period (year). The result is shown below.

$$(.174 \quad .174 \quad .319 \quad .11 \quad .102 \quad .025 \quad .05 \quad .046) \times \begin{pmatrix} .41 & .14 & .08 & .04 & .13 & .04 & .15 & .01 \\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03 \\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03 \\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03 \\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03 \\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01 \\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04 \\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33 \end{pmatrix} \cong (.14 \quad .24 \quad .17 \quad .09 \quad .09 \quad .08 \quad .16 \quad .03)$$

The Arabian portion of the market is still declining, similar to the "no change" in marketing strategy in section 3.6. This occurs because changing the probability along the diagonal within the transition matrix operates on the specific category of owners (i.e. for purebred Arabians this is initially 309 owners) vs. changing the probabilities for an entire column of the matrix which consists of separate probabilities of all owners surveyed (i.e. 1774 owners initially).

Checking the next period, gives:

$$(.14\ \ .24\ \ .17\ \ .09\ \ .09\ \ .08\ \ .16\ \ .03)\times\begin{pmatrix}.41 & .14 & .08 & .04 & .13 & .04 & .15 & .01\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\cong(.13\ \ .23\ \ .17\ \ .09\ \ .09\ \ .08\ \ .17\ \ .04)$$

Again the purebred Arabian is losing market share percentage from 14% to 13%. Checking period three:

$$(.13\ \ .23\ \ .17\ \ .09\ \ .09\ \ .08\ \ .17\ \ .04)\times\begin{pmatrix}.41 & .14 & .08 & .04 & .13 & .04 & .15 & .01\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\cong(.13\ \ .23\ \ .17\ \ .09\ \ .09\ \ .08\ \ .17\ \ .04)$$

There is no noticeable change in the state matrices during period three at the level of full percentages. Also, the next period does not show any changes in the state matrices.

$$(.13\ \ .23\ \ .17\ \ .09\ \ .09\ \ .08\ \ .17\ \ .04)\times\begin{pmatrix}.41 & .14 & .08 & .04 & .13 & .04 & .15 & .01\\ .08 & .33 & .2 & .05 & .06 & .06 & .15 & .03\\ .07 & .3 & .23 & .1 & .07 & .06 & .14 & .03\\ .06 & .2 & .16 & .2 & .06 & .17 & .12 & .03\\ .18 & .18 & .13 & .07 & .16 & .08 & .17 & .03\\ .06 & .2 & .18 & .17 & .06 & .21 & .11 & .01\\ .1 & .18 & .15 & .08 & .09 & .07 & .29 & .04\\ .05 & .13 & .12 & .17 & .05 & .03 & .12 & .33\end{pmatrix}\cong(.13\ \ .23\ \ .17\ \ .09\ \ .09\ \ .08\ \ .17\ \ .04)$$

Since there are no changes in the state matrices from period to period the model has reached steady state. Unfortunately, the strategy cost $100,000, and still a portion of the market was lost.

4.4 Increase of Non-Arabian Owners to go Arabian

The Marketing group says that if $100,000 is spent for advertising in non-Arabian magazines showing the purebred Arabian as a great horse for the same primary interests and uses as the non-purebred Arabian horse they own, then the probabilities that these non-purebred Arabian owners will go Arabian vs. Western or English will change as follows: the Western category to purebred Arabian probabilities change from .08 to .25 and the English category to purebred probabilities change from .1 to .24. Additionally, some percentages of the Western and English purchased by other owners will change to purebred Arabian as in columns 1, 2, and 7 from the original yield table as a result of our advertising efforts. This gives the new yield table of

	PA	W	QH	TB	HA	WB	E	SB
PA	.22	.17	.11	.07	.16	.07	.18	.02
W	.25	.21	.2	.05	.06	.06	.1	.03
QH	.21	.2	.23	.1	.07	.06	.1	.03
TB	.16	.1	.16	.2	.06	.17	.12	.03
HA	.33	.1	.13	.07	.16	.08	.1	.03
WB	.17	.1	.18	.17	.06	.21	.1	.01
E	.24	.15	.15	.08	.09	.07	.2	.04
SB	.1	.1	.12	.17	.05	.03	.1	.33

Once more we are seeking a larger portion of the market. After one period the result is

$$(.174 \quad .174 \quad .319 \quad .11 \quad .102 \quad .025 \quad .05 \quad .046) \times \begin{pmatrix} .22 & .17 & .11 & .07 & .16 & .07 & .18 & .02 \\ .25 & .21 & .2 & .05 & .06 & .06 & .1 & .03 \\ .21 & .2 & .23 & .1 & .07 & .06 & .1 & .03 \\ .16 & .1 & .16 & .2 & .06 & .17 & .12 & .03 \\ .33 & .1 & .13 & .07 & .16 & .08 & .1 & .03 \\ .17 & .1 & .18 & .17 & .06 & .21 & .1 & .01 \\ .24 & .15 & .15 & .08 & .09 & .07 & .2 & .04 \\ .1 & .1 & .12 & .17 & .05 & .03 & .1 & .33 \end{pmatrix} \cong (.21 \quad .17 \quad .19 \quad .1 \quad .09 \quad .08 \quad .12 \quad .04)$$

The purebred Arabian market share has increased from 18 to 21. The second period the state matrices changes as follows:

$$(.21\ \ .17\ \ .19\ \ .10\ \ .09\ \ .08\ \ .12\ \ .04)\times\begin{pmatrix}.22 & .17 & .11 & .07 & .16 & .07 & .18 & .02\\ .25 & .21 & .2 & .05 & .06 & .06 & .1 & .03\\ .21 & .2 & .23 & .1 & .07 & .06 & .1 & .03\\ .16 & .1 & .16 & .2 & .06 & .17 & .12 & .03\\ .33 & .1 & .13 & .07 & .16 & .08 & .1 & .03\\ .17 & .1 & .18 & .17 & .06 & .21 & .1 & .01\\ .24 & .15 & .15 & .08 & .09 & .07 & .2 & .04\\ .1 & .1 & .12 & .17 & .05 & .03 & .1 & .33\end{pmatrix}\cong(.22\ \ .16\ \ .16\ \ .10\ \ .10\ \ .09\ \ .13\ \ .04)$$

Again there is an increase from 21% to 22% of the horse market. Observing the state matrices in the next period shows no change.

$$(.22\ \ .16\ \ .16\ \ .10\ \ .10\ \ .09\ \ .13\ \ .04)\times\begin{pmatrix}.22 & .17 & .11 & .07 & .16 & .07 & .18 & .02\\ .25 & .21 & .2 & .05 & .06 & .06 & .1 & .03\\ .21 & .2 & .23 & .1 & .07 & .06 & .1 & .03\\ .16 & .1 & .16 & .2 & .06 & .17 & .12 & .03\\ .33 & .1 & .13 & .07 & .16 & .08 & .1 & .03\\ .17 & .1 & .18 & .17 & .06 & .21 & .1 & .01\\ .24 & .15 & .15 & .08 & .09 & .07 & .2 & .04\\ .1 & .1 & .12 & .17 & .05 & .03 & .1 & .33\end{pmatrix}\cong(.22\ \ .16\ \ .16\ \ .10\ \ .10\ \ .09\ \ .13\ \ .04)$$

The market has reached steady state with the matrix projecting improvement in the horse market from 17% to 22%, and same amount of advertising dollars were spent to do it as with the previous option.

4.5 Gains and Losses with each Marketing Strategy

The national registrations for the eight categories discussed above in 1991 is 205,205. Suppose the estimated annual sale of horses in the

horse market to be the same as the registrations in 1991. The yearly sale of horses within the total market would then equate to approximately 200,000 horses. Assuming this number of yearly horse sales remains relatively constant over a four year period, the results to the purebred Arabian owners and breeders is quite significant as shown below.

If the Arabian Horse Registry and its affiliates do not change their marketing strategy, then from section 3.6, this model projects a loss of 6% the first year, 1% the second year, .3 % the third year and .3% the fourth year. This equates to a decreased demand of 7.6% over a period of four years or 15,000 horses. If the average price of a purebred Arabian is $2000, then the loss in dollars is approximately 30 million dollars. These dollars will be lost to breeders and owners of purebred Arabians.

If the Arabian Horse Registry and its affiliates change their marketing strategy to increase the number of purebred Arabian owners to stay Arabian, section 4.3, then this model projects a loss of 3% the first year, 1% the second year, 1% the third year and 0% the fourth year. This equates to a decreased demand of 5% over a period of four years or 10,000 horses. If the average price of a purebred Arabian is $2000, then the loss in dollars is approximately 20 million dollars. Again, these dollars will be lost to breeders and owners of purebred Arabians.

If the purebred Arabian Horse Registry and its affiliates change their marketing strategy to increase the number of non-purebred Arabian owners to go Arabian, section 4.4, then this model projects a gain of 3%

the first year, 1% the second year, 0% the third year and 0% the forth year. This equates to a increased demand of 4% over a period of four years or 8,000 horses. If the average price of a purebred Arabian is $2000, then the gain in dollars is approximately 16 million dollars. These dollars will be gained by breeders and owners of purebred Arabians.

The above alternatives are mutually exclusive events. Therefore the net change in dollars from no market change (alternative ˙) to increase non-purebred Arabian owners to go Arabian (alternative 3) is 30 million + 16 million dollars. Remember these numbers are hypothetical and are based on a percentage of 1991 registrations to portray future total sales of horses in the market. The Registry must also consider the net gains and losses portrayed in these examples are to the owner and breeder, not the Registry. The Registry would lose or gain only a fraction of these dollars since its income is derived from registration fees.

Chapter 5

WHERE TO FOCUS ADVERTISING DOLLARS

5.1 Why Spend Registry Dollars on Advertising

The Arabian Horse Registry receives a majority of its operating budget through the registration of purebred Arabian horses. If the number of horses to be registered decreases significantly in the next several years, the Registry would be adversely effected financially. The projected forecast for future purebred Arabian registrations from chapter 2 shows a decrease of percent. The results of the Markov model in chapter 3 gives an indication of why these registrations are down. The Markov model indicates purebred Arabian Horses will lose 7% of the horse market within the next 5 years. Since there is less demand for purebred Arabian horses, purebred Arabian breeders cut back the number of foals dropped per year. This therefore decreases the Registry's operating budget.

It is in the best interest of the Registry to fund advertising to increase sales of purebred Arabian horses. These increased sales will in the long term increase registration dollars.

5.2 The Present Horse Market

The present horse market is in general decline from changes in the economy and agricultural tax laws. Presently there are eight major

categories of horse breeds. These are the purebred Arabian, Western, Quarter horse, Thoroughbred, half Arabian, Warmblood, English, and Standardbred. The following table delineates the present horse market shares in accordance with the Horse owner II survey.

Horse Category	Present Share of the Horse Market
Purebred Arabians	17%
Westerns (Appaloosa and Paint)	17%
Quarter horses	32%
Thoroughbreds	11%
Half Arabians	10%
Warmbloods	3%
English (Morgan and Saddlebred)	5%
Standardbred	5%

5.3 Comparison of Arabians to Other Breeds for the next Five Years

The Markov model predicts changes in the horse market over the next five years. These changes to the market are plotted in figure 5.1 to better place the data in a visual perspective. This allows one to see the general trends of the market for each breed. Figures 5.2 through 5.7 compare all other horse categories in the market to the purebred Arabian.

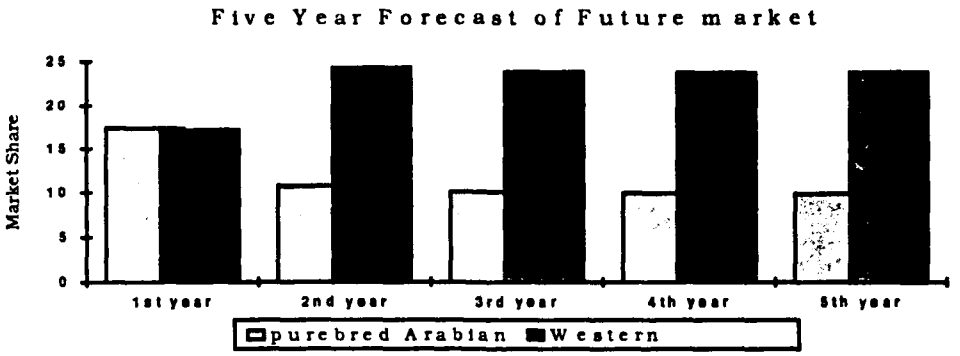

Figure 5.1 Purebred Arabian vs. Western horse market shares

The Western horse presently owns approximately the same market share as the purebred Arabian. Unfortunately the Western horse appears to out perform the purebred Arabian over the next five year according to our Markov model. This is significant since the Western horse occupies some of the same niches as the purebred Arabian within the horse market.

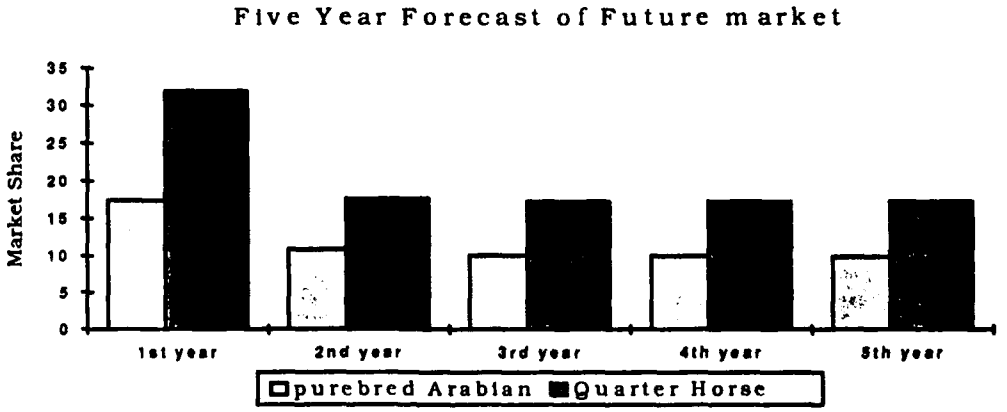

Figure 5.2 Purebred Arabian vs. Quarter horse horse market shares

The Quarter horse presently owns the largest portion of the horse market at approximately 32%. This breed is generally used as a work horse and pet in addition to racing. The Markov model predicts the Quarter horse has fallen on hard times and will loose its horse market dominance to the Western (Appaloosa and Paint) horse. The Quarter horse occupies some of the same niches as the purebred Arabian within the horse market.

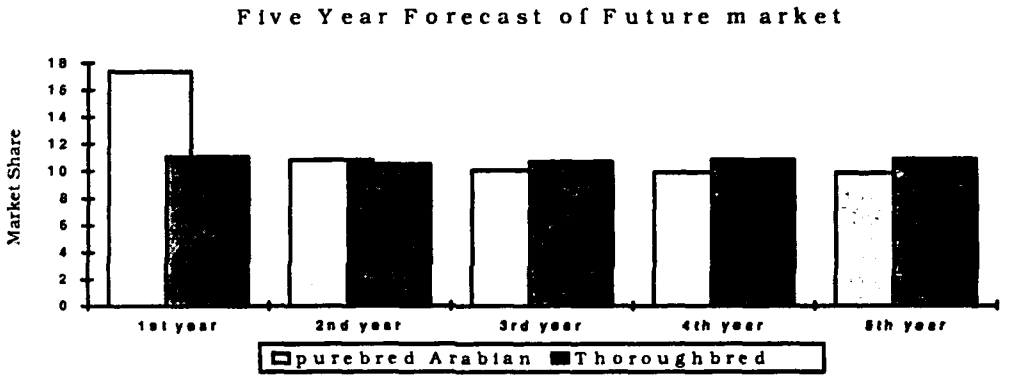

Figure 5.3 Purebred Arabian vs. Thoroughbred horse market shares

The Thoroughbred breed has been a flat market previously and will continue in that vein. The Thoroughbred and purebred Arabian breeds do not intersect in most niche horse market arenas. The only niche market they now share is horse racing. It appears the Thoroughbred niche market is not expanding and will be difficult to enter.

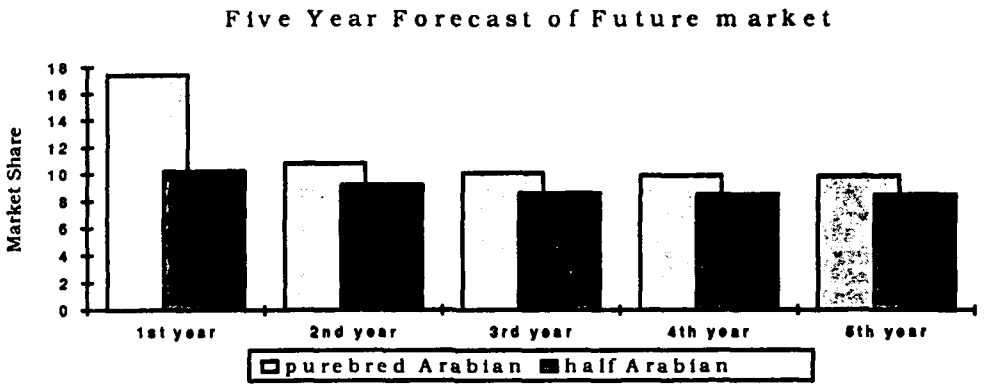

Figure 5.4 Purebred Arabian vs. half Arabian horse market shares

The half Arabian horse is a spin-off of the purebred Arabian and as with the purebred Arabian will lose horse market share over the next several years according to the Markov model. The half Arabian breed fills the same horse market niche as the purebred Arabian.

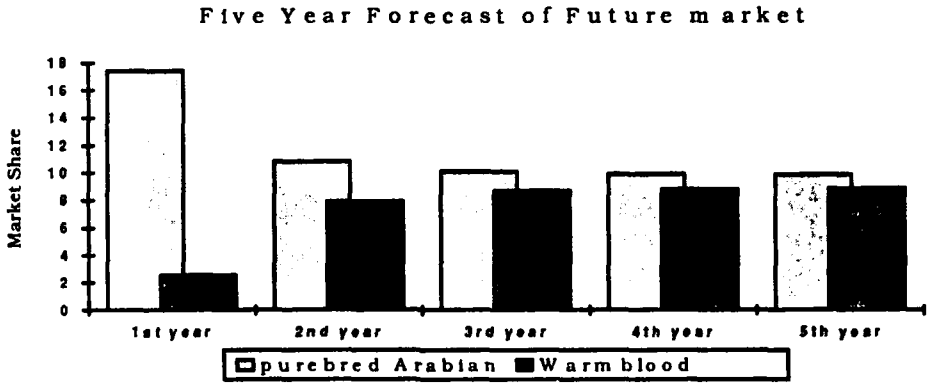

Figure 5.5 Purebred Arabian vs. Warmblood horse market shares

The Warmblood breed is a recent arrival to the horse market; it originated in the Americas and appears it will mainly compete for market

share with the non racing Thoroughbred Horses. It is not a breed the purebred Arabian should compete against in the near future. The Warmblood breed is increasing in the horse market, and will capture approximately 9% of the market within 5 years according to the Markov model.

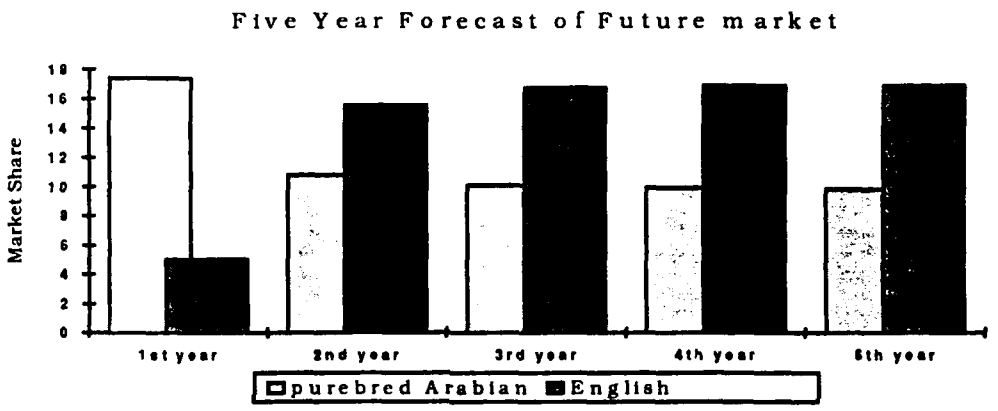

Figure 5.6 Purebred Arabian vs. English horse market shares

The English horse presently owns approximately the same market share as the purebred Arabian. Unfortunately the English (Morgan and Saddlebred) category of horse appears it will out perform the purebred Arabian over the next five year according to our Markov model. This is not good because the English and purebred Arabian horses both fill the same niche of English pleasure riding.

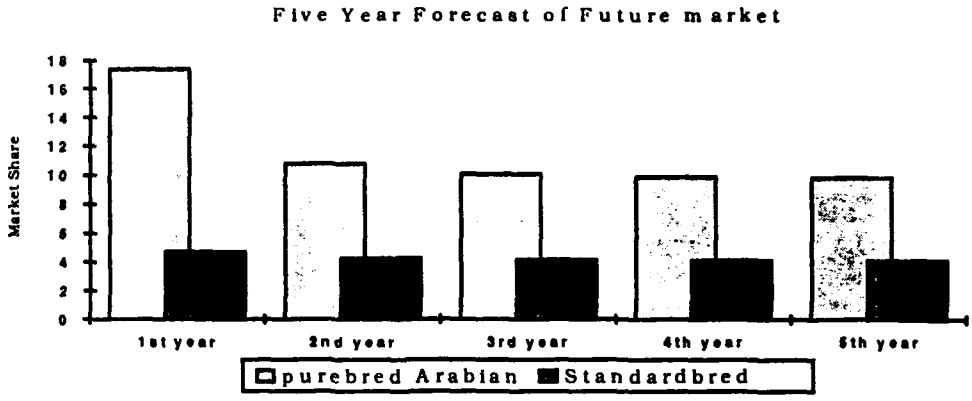

Figure 5.7 Purebred Arabian vs. Standardbred horse market shares

The Standardbred breed has been a flat market previously and will continue in that vane. The Standardbred and purebred Arabian horses do not intersect in any niche horse market arenas. The Markov model predicts little change in the Standardbred horse market.

5.4 Who is Gaining in the Horse Market and Why

There are three horse categories that are making significant increases in the horse market according to the Markov model. These categories are the Western, the English and the Warmblood breed. The Warmblood does not share many of the same niche markets with the purebred Arabian and will not be addressed in this section. The Horse Owner Survey II indicates the purebred Arabian fills the market niches of:

1) Pleasure riding

2) Pet/hobby
3) Horse showing
4) Endurance trail riding
5) English hunter/jumper
6) Horse racing (new entrant)

The Western and English categories are increasing significantly. Western horses will increase from 17% to 24%. English horses will increase from 5% to 17%, probably because the major niche markets these horses occupy are pleasure riding and hobby (showing), which will increase during the next decade.

The Western category of horse comprised of the Appaloosa and Paint breeds is among the least expensive horses to purchase on the market (average cost of $ 1000). Similarly the English horse is a moderately expensive horse to purchase, usually under $1,500. The purebred Arabian average cost is between $2,500-3,000 (Horse Owner Survey II, Question 16). Cost may be a factor in the purchasing decision, since all three of the categories fill the same expanding niche markets (Horse Owner Survey II, question 1d).

5.5 How to Capture a Larger Base of the Horse Industry

To compare and market the purebred Arabian horse, we must first decide which niche market it presently occupies. Additionally, we should research which additional markets it can move into. Presently the

purebred Arabian occupies the horse market niches of hobby/pet, show horse, English hunter/jumper, pleasure riding, endurance trail riding, and is moving into horse racing. These niches are listed in order of importance to the breed and breed population (Horse Owner Survey II, questions 7, 14, and 15).

In three of the most important horse market niches (i.e. hobby/pet, horse showing and English hunting/jumping) Western and English horses compete directly with the purebred Arabian. Additionally, these two breeds will increase their share of the horse market, while the purebred Arabian will decrease according to the Markov model. This indicates the Western and English breeds are taking horse market shares from the purebred Arabian. The purebred Arabian breed must focus advertising at non-purebred Arabian owners that are prospective Western and English buyers. The Western and English horses also have smaller average cost compared to the purebred Arabian.

5.6 The Best Way to Market Sales of Arabian Horses

According to the Markov model, it appears that Western and English breeds will capture more and more of the niche markets the purebred Arabian breed presently occupies. This is due to lack of knowledge by the prospective buyer of the attributes and purchasing price range of the purebred Arabian. The Arabian Horse Registry has a vested interest in the future of the purebred Arabian breed. They should therefore advertise in journals and magazines which accommodate horse

owners in these particular niche markets (i.e. Appaloosa Journal, Horse and Rider, Horse Play, The Paint Horse, Spur, and Western Horseman).

The niche marketing the advertisements should focus on family riding and fun, pleasure riding, pets, showing and the relative inexpense of the breed to own. If no interest is taken by the Registry to promote their breed there is a potential loss of yearly revenues in the six figure range.

Chapter 6

Summary

The Arabian Horse Registry wants to forecast the future registration of purebred Arabian Horses. Additionally, the Registry wants to increase purebred Arabian's share of the horse market. A linear regression model was utilized to forecast future registration of purebred Arabian Horses. This forecast will enable the Registry to identify future revenues for its operation. A Markov chain model was developed to forecast the future horse market based on an independent survey conducted by Elrick & Lavidge Marketing Research Inc. This model forecasts which horse breeds will increase and decrease within the horse market.

The Arabian Horse Registry has registered fewer foals every year since 1986. Using regression analysis, we forecast this trend to continue for the next two years. Foal registrations are forecasted with a 95% confidence interval to be:

Year	Confidence Interval
1991	13,969 ± 1,596
1992	11,103 ± 1,843
1993	8,237 ± 2,119

This forecast does not include any changes in registration fees for blood typing requirements; such changes will probably lower this number further. Utilizing the linear regression model, the three year forecast from 1991 to 1993 shows a loss of revenues of approximately $120,000 per year.

According to the survey, the purebred Arabian breed constitutes approximately 17.4 % of the horse market. The Markov chain model predicts the relative numbers of breeds in the future assuming the survey was a random selection of horse owners. This model predicts that the purebred Arabian breed will constitute only 9.9% of the horse market within the next five years. The breed of horses which will take the purebred Arabian share of the market are the Western (Paint, Appaloosa), Warmblood and English (Morgan, Saddlebred) breeds.

Further research lies in the areas of multiple regression and marketing strategies. There are several outside influences impacting on these two models. Identification of these variables and incorporation within a multiple regression model appears to be the next logical step for this analysis. Additional marketing analysis is required to determine the most effective method for interesting non-Arabian owners to go Arabian; chapter five identifies one approach in this arena.

References

1. Elrick & Lavidge Marketing Research. April 1991. Arabian Horse Study Report for The Arabian Horse Registry of America, Inc.. Atlanta, Ga.: Equifax Information Inc..

2. Ben Noble and James W. Daniel. 1988. Applied Linear Algebra. Englewood Cliff, New Jersey 07532: Prentic-Hall.: (pp. 43-48)

3. John Neter, William Wasserman and Michael H. Kutner. 1990. Applied Linear Statistical Models. Homewood, IL 60430: Richard D. Irwin, Inc..: (pp. 75-83)

4. Robert E. D. Woolsey and Huntington S. Swanson. 1975. Operations Research for Immediate Application a Quick & Dirty Manual. New York, Evanston, San Francisco, London: Harper & Row Publishers.: (pp. 77-83)

5. Hans G. Daellenbach and John A. George. 1978. Introduction to Operations Research Techniques. 470 Atlantic Avenue, Boston Ma. 02210: Allyn and Bacon, Inc..: (pp. 261, 264, 270).

6. Steven Nahmias. 1989. Production and Operations Analysis. Boston Ma. 02116: Richard D. Irwin, Inc..: (pp. 38, 41, 52, 54, 57)

7. Sheldon M. Ross. 1989. Introduction to Probability Models. San Diego, Ca. 92101: Acedemic Press, Inc..: (pp. 141-146, 184)

8. Richard J. Schonberger and Edward M. Knod Jr. 1991. Operations Management. Boston Ma. 02116: Richard D. Irwin Inc..: (pp. 174-177, 179-182)

9. William J. Stevenson. 1989. Management Science. Boston Ma. 02116: Richard D. Irwin Inc..: (pp. 428-436, 445, 451, 456, 466, 750, 752, 756, 769)

10. Wayne L. Winston. 1987. Operations Research: Applications and Algorithms. Boston Ma. 02116: Prindle, Weber, and Schmidt Publishers.

11. Microsoft Corporation. 1992. Micrsoft Word for Windows; version 2.0a.

12. Design Science Corporation. 1991. Math Type for DOS; version 1.1a.

13. MINITAB Statistical Software. 1990. Minitab Inc.; version 8.0

14. American Horse Counsel. 1992. Breed Registration Figures 1960 - 1991.

15. Arabian Horse Registry. 1991. Arabian Horse Registry Fee Schedule.

16. Matthew R. Woempner. Sep 91. Private conversation.

17. Ralph F. Clark. Sep 91. Private Conversation.

Appendix A

HORSE OWNERS SURVEY II

1a. How many horses and which breeds do you currently own? (Record the number of horses you own next to the appropriate breed.)

	No. Own		No. Own
Appaloosa	_____	Saddlebred	_____
Half-Arabian	_____	Standardbred	_____
Morgan	_____	Thoroughbred	_____
Paint	_____	Warmblood	_____
Purebred Arabian	_____	Other breed(s) (specify)	
Quarter Horse	_____	_____	

1b. Who is responsible for first getting you interested in horses? (Please mark one answer)

Parents/Child/Spouse	_____	Other reason (specify)
Friend/Relative	_____	_____
Business Associate	_____	_____
Yourself	_____	_____
Existing breeder	_____	_____
Have always owned horses	_____	

1c. What factors influenced the decision to buy a horse?(Please mark all that apply)

Recreation	_____	Investment Potential	_____
Racing	_____	Have always owned horses	_____
Shows	_____	Love of the horse	_____
Publications	_____	Other (Specify)	
Riding Lessons	_____	_____	

1d. How did you determine which breed of horse to purchase? (Mark all that apply)

Breed suited specific purpose _____
Liked the appearance _____
Bargain Price _____
Always wanted that breed _____
Friend/Relative owns breed _____
Best investment/Business potential _____
Tax Incentive _____

Other reason (Specify)
_____
_____
_____

1e. Of the horses you own, please identify how or where they are kept.

Home _____
Owned farm/ranch _____
_____
(nonresidence)
Rented facility _____
Race trainer _____
_____
Owner maintained on other's property _____

Show trainer _____
Other competitive trainer
Other (Specify)
_____

2a. Have you ever owned a particular breed of horse and then switched to a different breed?

Yes _____
No _____ (Please go to question 3a.)

2b. Please complete the following grid:

Breeds Once Owned:	Breed Switched To:
_____	_____
_____	_____

2c. Why did you switch breeds of horses? (Please be specific as possible)

_____
_____

3a. Have you ever owned a particular breed of horse and then purchased an additional, different breed?

Yes _____
No _____ (Please go to Question 4a)

3b. Please complete the following grid:

Breed(s) Owned:	Breed Added:
_____	_____
_____	_____

3c. Why did you purchase a different breed of horse? (Please be as specific as possible)

_____

_____

4a. Have you ever considered owning a particular breed of horse but then decided to purchase a different breed?

Yes _____

No _____ (Please go to Question 5a)

4b. Please complete the following grid:

Breed(s) Considered	Breed Actually Purchased
_____	_____
_____	_____

4c. Why did you decide to purchase that breed and not one of the others you considered? (Please be as specific as possible)

_____

_____

5a. Which of the following breeds have you never considered owning? (Please mark all that apply)

Appaloosa	_____	Saddlebred	_____
Half-Arabian	_____	Standardbred	_____
Morgan	_____	Thoroughbred	_____
Paint	_____	Warmblood	_____
Purebred Arabian	_____	None	_____
Quarter Horse	_____	(Go to Question 6)	

5b. Why didn't you consider owning this/these breed(s)? (Please specify which breed is being discussed)

_____

_____

6. Which of the following breeds would you consider purchasing in the future? (Mark all that apply)

Appaloosa	_____	Saddlebred	_____
Half-Arabian	_____	Standardbred	_____
Morgan	_____	Thoroughbred	_____
Paint	_____	Warmblood	_____
Purebred Arabian	_____	None	_____
Quarter Horse	_____	(Go to Question 6)	

If you bred mares in 1990 or will breed in 1991 (for 1991 or 1992 foals) please answer Question 7.

7. What are the three main reasons you breed horses? (Mark 3 answers)

To show them	_____
To race them	_____
Produce a horse for own/family pleasure riding	_____
Produce a horse for own competitive trail riding/endurance	_____
To sell them for show	_____
To sell them for family/pleasure riding	_____
To sell them for competitive trail riding/endurance	_____
Investment/Business	_____
To improve the breed	_____
Family project	_____
Enjoy the experience of breeding/birth/raising	_____
Tax benefit	_____
Other reasons (specify) _____	
(please go to Question 9)	

8. If you do not breed, why have you chosen not to? (Mark all that apply)

Cheaper to buy a horse than breed and raise	_____
Have all the horses I need	_____
Value of a foal did not justify the investment	_____
Lack of confidence in future market	_____
No longer interested	_____
Was never interested	_____
Other (specify) _____	

9. Do you show any of your horses?

Yes _____ No _____ (Please go to Question 11)

10a. Why do you show your horses? (Mark all that apply)

Enjoy the competition _____
To increase value _____
Owner/Farm promotional benefit _____
Prize money _____
Social benefits and activities _____
Other (specify) _____

10b. Are your horses shown by . . .

Yourself/Family member _____
A professional _____
Friend/Relative _____

10c. In an average year, how often are your horses shown?

Less than 7 shows _____ 7 or more shows _____
(Go to Question 12a)

11. If you do not show horses, why do you choose not to? (Please be specific)

_____

_____

12a. Do you race any of your horses?

Yes _____ No _____ (Please go to Question 13a)

12b. What breed(s) of horse do you race? (Mark all that apply)

Purebred Arabian _____
Quarter Horse _____
Thoroughbred _____

13a. If you do not race horses, why do you choose not to?

No chance to win, others have an advantage _____
Too expensive _____
Horses are not treated well _____
Races are "fixed" _____
Not enough prize money _____
Tracks are not conveniently located _____
Dislike gambling _____
Don't like racing _____
Do not own a breed of horse that is usually raced _____
Other reasons (specify) _____

13b. What events or things would need to happen to get you more interested in racing? (Mark all that apply)

More convenient locations for races _____
Higher purse prizes _____
Offer more races _____
Increase availability of qualified trainers _____
More ethical treatment of horses _____
Greater participation by owners _____
Increased education/availability of information _____
Social benefits and activities _____
Improved return on investments _____
Other (specify) _____

14. What are your main interests and uses for each of the horse breeds you own?

	Breeds
Breeding	_____
Showing	_____
Racing	_____
Family riding/fun	_____
Friends/pleasure riding	_____
Competitive trail riding/ Endurance	_____
Sell them	_____
Investment	_____
Family project	_____
A pet	_____
Educational	_____
Other (specify) _____	_____

15. Next, we'd like to know what you think about various breeds of horse. For each breed, read the statements on the left and record the number of how well you feel that statement describes each breed. Even if you are not very familiar with a particular breed, we'd like to get your overall opinions about that breed. Please use the following scale:

1 = Does not describe the breed at all
2 = Describes the breed a little
3 = Describes the breed a lot

	{ Types of Breeds							}
High intelligence	-	-	-	-	-	-	-	-
Versatile	-	-	-	-	-	-	-	-
Attractive appearance	-	-	-	-	-	-	-	-
Good for racing	-	-	-	-	-	-	-	-
Hunter/Jumper	-	-	-	-	-	-	-	-
Investment Quality/ profit potential	-	-	-	-	-	-	-	-
Family horse	-	-	-	-	-	-	-	-
Suitable for youth	-	-	-	-	-	-	-	-
Competitive trail riding/endurance	-	-	-	-	-	-	-	-
High quality breed assoc./organization	-	-	-	-	-	-	-	-
Level good disposition	-	-	-	-	-	-	-	-
Pleasure riding	-	-	-	-	-	-	-	-
Easy gait	-	-	-	-	-	-	-	-
Expensive to purchase	-	-	-	-	-	-	-	-
Tax benefit	-	-	-	-	-	-	-	-

16c. During the past 12 months, how many horses did you buy? (Please specify number and breed)

	Number of each breed			
Breed:	_____	_____	_____	_____
Mares:	_____	_____	_____	_____
Geldings	_____	_____	_____	_____
Stallions	_____	_____	_____	_____

Total Purchases _____ (If none, go to Question 16c.)

16b. In the past 12 months, what was the highest, lowest, and average price you paid for each of the horses you purchased? (Specify breed - Answer below)

Breed:	_____	_____	_____	_____
Highest:	$ _____.00	$ _____.00	$ _____.00	$_____.00
Lowest:	$ _____.00	$ _____.00	$ _____.00	$_____.00
Average:	$ _____.00	$ _____.00	$ _____.00	$_____.00

16c. During the past 12 months, how many horses did you sell? (Please specify number and breed)

	Number of each breed				
Breed:	_____	_____	_____	_____	_____
Mares:	_____	_____	_____	_____	_____
Geldings:	_____	_____	_____	_____	_____
Stallions	_____	_____	_____	_____	_____

Total sold: _____ (If non go to Question 17)

16d. In the past 12 months, what was the highest, lowest, average price you received for each horse you sold? (Specify breed - Answer below)

Breed:	_____	_____	_____	_____
Highest:	$ _____.00	$ _____.00	$ _____.00	$_____.00
Lowest:	$ _____.00	$ _____.00	$ _____.00	$_____.00
Average:	$ _____.00	$ _____.00	$ _____.00	$_____.00

17. Approximately what is the current value of your total herd of horses?
$_____.00 Don't know _____

18. During the past 12 months, has the value of your total herd of horses increased, decreased or remained the about same? (Please mark one answer below and specify a percentage, if appropriate)

Value increased _____ Increased by _____%
Value decreased _____ Decreased by _____%
Value remained the same _____

19. To which equine breed associations do you belong?

American Quarter Horse Association _____
American Horse Shows Association _____
The Arabian Horse Registry _____
The International Arabian Horse Association _____
Appaloosa Horse Club, Inc. _____
American Morgan Horse Association _____
American Paint Horse Association _____
American Saddlebred Horse Association _____
US. Trotting Association _____
The Jockey Club _____
The American Warmblood Society _____
None _____
Other (specify) _____ _____

20a. Which of your horses are registered with an association? (Mark all that apply)

Appaloosa	_____	Saddlebred	_____
Half-Arabian	_____	Standardbred	_____
Morgan	_____	Thoroughbred	_____
Paint	_____	Warmblood	_____
Purebred Arabian	_____	Other breed(s)	_____
Quarter Horse	_____	(Specify)	_____

20b. Are any of your horses not registered with any association?
Yes _____ No _____ (Go to Question 21)

20c. Why? (Please be specific)

_____

_____

21. Using a scale from 1 to 5, please indicate how frequently you read each of the following publications and whether or not you subscribe to the magazines.

1 = Don't read any issues
2 = Read or scan some issues occasionally thoroughly
3 = Scan every issue
4 = Read portions of every issue
5 = Read every issue thoroughly

	Frequency	yes	no
The American Saddlebred	_____	___	___
Appaloosa Journal	_____	___	___
Arabian Horse Times	_____	___	___
Arabian Horse World	_____	___	___
AHSA Horse Show	_____	___	___
Blood Horse	_____	___	___
Chronicle of the Horse	_____	___	___
Equus	_____	___	___
The Horse Digest	_____	___	___
Horse and Rider	_____	___	___
HorsePlay	_____	___	___
The Morgan Horse	_____	___	___
Quarter Horse Journal	_____	___	___

	Frequency	yes	no
The Paint Horse	_____	___	___
Saddlebred Report	_____	___	___
Spur	_____	___	___
Thoroughbred Times	_____	___	___
Western Horseman			
Other equine magazines read (Specify)			
_____	_____	___	___

22a. What is the age and sex of each person in your household?

22b. Which of your household members ride? (Please mark one answer for each member in your household)

	Age	Male	Female	Rides	Does Not Ride
You	___	___	___	___	___
Person 2	___	___	___	___	___
Person 3	___	___	___	___	___
Person 4	___	___	___	___	___
Person 5	___	___	___	___	___
Person 6	___	___	___	___	___
Person 7	___	___	___	___	___
Person 8	___	___	___	___	___
Person 9	___	___	___	___	___

23. What is your current occupation? (Please be specific)

_____

24. In what state do you currently reside?

_____

25a. Have you ever taken any equine expense as a tax deduction?
Yes _____ No _____ (Go to Question 26)

25b. In the past year, have you taken any equine expense as a tax deduction?
Yes _____ No _____

26. Regardless of previous equine tax deductions, do you consider your current horse activities to be . . . (Mark one answer)

Primarily a business _____
Primarily a hobby _____

27. Which of the following best describes your annual total estimated household income before taxes?

Less than $15,000	_____	$40,000 to $69,999	_____
$15,000 to $24,999	_____	$70,000 to $119,999	_____
S25,000 to $39,999	_____	$120,000 or more	_____

THANK YOU VERY MUCH FOR YOUR INPUT!

Appendix B

The following information is compiled from question 6 of the horse owners survey. The question reads, "Which of the following breeds would you consider purchasing in the future?(Mark all that apply)". This information will be utilized to derive the Markov Chain Model.

Question 6 data answered by Purebred Arabian horse owners.

	Owners of herd with:		
Will Buy	Purebred only	Purebred and Others	Total Respondents
Total	120	189	309
Purebred Arabian	96	119	215
Half Arabian	59	98	157
Morgan	36	77	113
Paint	31	76	107
Quarter Horse	28	79	107
Warmblood	19	54	73
Thoroughbred	27	43	70
Appaloosa	15	49	64
Saddlebred	26	34	60
Standardbred	7	15	22

Question 6 data answered by Western(Paint and Appaloosa) horse owners.

	Owners of herd with:		
Will Buy	With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	43	261	304
Purebred Arabian	30	55	85
Half Arabian	21	45	66
Morgan	24	82	106
Paint	28	172	200
Quarter Horse	23	198	221
Warmblood	14	58	72
Thoroughbred	9	98	107
Appaloosa	23	148	171
Saddlebred	6	54	60
Standardbred	5	29	34

Question 6 data answered by Quarter horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	64	502	566
Purebred Arabian	36	90	126
Half Arabian	27	99	126
Morgan	28	146	174
Paint	33	311	344
Quarter Horse	42	386	428
Warmblood	20	98	118
Thoroughbred	13	171	184
Appaloosa	25	189	214
Saddlebred	11	78	89
Standardbred	4	43	47

Question 6 data answered by Thoroughbred horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	34	162	196
Purebred Arabian	18	22	40
Half Arabian	14	23	37
Morgan	13	34	47
Paint	15	61	76
Quarter Horse	16	88	104
Warmblood	21	89	110
Thoroughbred	19	110	129
Appaloosa	13	39	52
Saddlebred	8	20	28
Standardbred	5	16	21

Question 6 data answered by Half Arabian horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	91	91	182
Purebred Arabian	69	42	111
Half Arabian	62	43	105
Morgan	36	34	70
Paint	35	37	72
Quarter Horse	31	54	85
Warmblood	24	26	50
Thoroughbred	19	27	46
Appaloosa	20	20	40
Saddlebred	17	20	37
Standardbred	7	11	18

Question 6 data answered by Warmblood horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	7	38	45
Purebred Arabian	4	5	9
Half Arabian	5	4	9
Morgan	3	11	14
Paint	3	15	18
Quarter Horse	3	25	28
Warmblood	3	29	32
Thoroughbred	1	26	27
Appaloosa	2	12	14
Saddlebred	1	3	4
Standardbred	0	1	1

Question 6 data answered by Morgan and Saddlebred horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	12	77	89
Purebred Arabian	7	23	30
Half Arabian	8	22	30
Morgan	9	48	57
Paint	2	33	35
Quarter Horse	3	43	46
Warmblood	3	20	23
Thoroughbred	3	22	25
Appaloosa	1	20	21
Saddlebred	3	32	35
Standardbred	2	11	13

Question 6 data answered by Standardbred horse owners.

Will Buy	Owners of herd with: With Purebred Arabians	Without Purebred Arabians	Total Respondents
Total	7	76	83
Purebred Arabian	2	7	9
Half Arabian	3	6	9
Morgan	3	9	12
Paint	3	11	14
Quarter Horse	2	20	22
Warmblood	1	5	6
Thoroughbred	0	32	32
Appaloosa	1	9	10
Saddlebred	1	9	10
Standardbred	0	60	60

Question 6 data compiled into totals.

Will Buy	Total Respondents
Total	1186
Purebred Arabian	396
Half Arabian	338
Morgan	373
Paint	540
Quarter Horse	667
Warmblood	287
Thoroughbred	392
Appaloosa	360
Saddlebred	211
Standardbred	150
Will not Purchase	86

Appendix C

Year	Registrations	Year	Registrations	Gelding
1970	8770	1981	22326	
1971	9949	1982	24031	
1972	11309	1983	25594	
1973	12837	1984	26937	
1974	14593	1985	27993	5830
1975	15674	1986	28097	5403
1976	16774	1987	25459	4516
1977	17758	1988	22914	3694
1978	18066	1989	19998	2777
1979	19900	1990	16499	1937
1980	21164	1991	12966	1291
		1992	8817	147

Appendix D

MINITAB output for regression of registrations and time from 1986 to present using a linear form of the regression equation:

MTB> REGR C2 2 C1 C3 C4

The regression equation is

Foals = 274775 - 2866 Year

Predictor	Coef	Stdev	t-ratio	p
Constant	274775	9635	28.52	0.000
Years	-2866	109.5	-26.18	0.000

s = 346.2 R-sq. = 99.6% R-sq.(adj.) = 99.4%

SOURCE	DF	SS	MS	F	p
Regression	1	82122368	82122368	685.29	0.000
Error	3	359508	119836		
Total	4	82481880			

MTB> PRINT C1-C4

ROW	YEAR	FOALS	Std Res	Fitted y
1	86	28097	-1.04047	28324.8
2	87	25459	-0.00034	25459.1
3	88	22914	1.03544	22593.4
4	89	19998	0.93326	19727.7
5	90	16499	-1.65799	16862.0

MTB> DESCRIBE C1 C2 C3 C4

	N	MEAN	MEDIAN	TRMEAN	STDEV
Year	5	88.000	88.000	88.000	1.581
Foals	5	22593	22914	22593	4541
Std Res	5	-.146	-0.000	-0.146	1.190
Fitted y	5	22593	22593	22593	4531

	SEMEAN	MIN	MAX	Q1	Q3
Year	0.707	86.000	90.000	86.500	89.500
Foals	2031	16499	28097	18248	26778
Std Res	0.532	-1.658	1.035	-1.349	0.984
Fitted y	2026	16862	28325	18295	26892

MTB> NOPAPER

Appendix E

MINITAB output for regression of registrations and time from 1983 to present using linear and quadratic forms of regression equations:

MTB> REGR C2 2 C1 C3 C4

The regression equation is:

Foals = 2771727 - 1383 Year

Predictor	Coef	Stdev	t-ratio	p
Constant	2771727	779382	3.56	0.012
Years	-1383.1	392.3	-3.53	0.012

s = 2543 R-sq. = 67.4% R-sq.(adj.) = 62%

SOURCE	DF	SS	MS	F	p
Regression	1	80345384	80345384	12.43	0.012
Error	6	38790344	6465058		
Total	7	119135728			

MTB> PRINT C1-C4

ROW	YEAR	FOALS	Std Res	Fitted y
1	1983	25594	-1.76766	29025.8
2	1984	26937	-0.3289	27642.6
3	1985	27993	0.75048	26259.5

ROW	YEAR	FOALS	Std Res	Fitted y
4	1986	28097	1.3587	24876.4
5	1987	25459	0.82929	23493.3
6	1988	22914	0.34879	22110.2
7	1989	19998	-0.33650	20727.1
8	1990	16499	-1.46500	19344.0

MTB> DESCRIBE C1 C2 C3 C4

	N	MEAN	MEDIAN	TRMEAN	STDEV
Year	8	1986.5	1986.5	1986.5	2.4
Foals	8	24185	25526	24185	4125
Std Res	8	-0.076	0.010	-0.076	1.113
Fitted y	8	24185	24185	24185	3388

	SEMEAN	MIN	MAX	Q1	Q3
Year	0.9	1983	1990	1984.2	1988.8
Foals	1459	16499	28097	20727	27724
Std Res	0.393	-1.768	1.359	-1.183	0.810
Fitted y	1198	19344	29026	21073	27297

MTB> REGR C2 2 C1 C3 C4 C5

The regression equation is

FOALS = -3368453 + 79883 YEAR - 470 YEAR^2

Predictor	Coef	Stdev	t-ratio	p
Constant	-3368453	338386	-9.95	0.000
Year	79883	7828	10.2	0.000
Year^2	469.74	45.24	10.38	0.000

s = 586.4 R-sq. = 98.6% R-sq.(adj.) = 98.0%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	2	117416176	58708088	170.71	0.000
Error	5	1719554	343911		
Total	7	119135728			

SOURCE	DF	SEQ SS
Year	1	80345384
Year^2	1	37070792

MTB> PRINT C1-C3

ROW	YEAR	FOALS	-YEAR^2
1	83	25593	-6889
2	84	26930	-7056
3	85	27989	-7225
4	86	28097	-7396

5	87	25459	-7569
6	88	22914	-7744
7	89	19998	-7921
8	90	16499	-8100

MTB> DESCRIBE C1 C2 C3 C4 C5

	N	MEAN	MEDIAN	TRMEAN	STDEV
Year	8	86.5	86.5	86.5	2.449
Foals	8	24185	25526	24185	4125
Year^2	8	-7488	-7482	-7488	424
Std Res	8	0.045	-0.472	0.045	1.076
Fitted y	8	24185	25790	24185	4096

	SEMEAN	MIN	MAX	Q1	Q3
Year	0.866	83.0	90.0	84.25	88.75
Foals	1459	16499	28097	20727	27724
Year^2	150	-8100	-6889	-7877	-7098
Std Res	0.380	-1.178	1.752	-0.708	1.205
Fitted y	1448	16056	27669	21073	27212

MTB> NOPAPER

END