The Impact of Stochastic Reproductive Efficiency on Economic Returns amongst a Sample of Thoroughbred Mares in Central Kentucky

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Abstract

Although a mare is managed to maximize the likelihood of producing a live foal, there is no guarantee she will produce a live foal every year. This uncertainty is illustrated in recent studies examining reproductive efficiency among well-managed Thoroughbred mares where between 78% and 83% of mated mares produced a live foal. Published data on reproductive efficiency over multiple years of a mare's production history are not available. The economic consequences of stochastic reproductive efficiency have been extensively studied in livestock species, including cattle and swine, but not Thoroughbred mares. The objectives of the present study were to: (1) assess mare productivity over time, (2) examine factors pertaining to the mare influencing the likelihood of producing a registered foal, and (3) to analyze economic consequences of differences in reproductive efficiency and mare financial value over different investment periods. A series of scenario analyses were developed to demonstrate economic consequences of stochastic reproductive efficiency in mares. Economic consequences were evaluated using multi-year capital budget methods as a framework, incorporating the mare's individual characteristics and reproductive efficiency over time. Mares valued at $1,000,000 had a positive NPV of $639,710 and the IRR was 13.01% over the 7 year investment horizon. Maximum cash outlay before generating revenue was $1,623,176 for the $1,000,000 mare. Mares valued $150,000 or higher, all produced a positive net cash flow. However, the IRR was low for mares valued between $150,000 and $300,000. Broodmares valued $100,000 or less were not profitable. The high proportion (69%) of mares drifting in their foaling dates between successive foaling seasons represents an area impacting productivity over time.

Key Words: Reproductive Efficiency, Mare, Profitability, Thoroughbred, Production Records

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Introduction

Although a mare is managed to maximize the likelihood of producing a live foal, there is no guarantee she will produce a live foal every year. This is known as a stochastic process. This uncertainty is illustrated in recent studies examining reproductive efficiency among well-managed Thoroughbred mares where 82.7% (Morris and Allen 2002), 79.8% (Hemberg et al. 2004), and 78.3% (Bosh et al. in press) of mated mares produced a live foal. Published data on reproductive efficiency over multiple years of a mare's production history are not available.

The economic consequences of stochastic reproductive efficiency have been extensively studied in livestock species, including cattle and swine (Holt and Moschini 1992; Frasier and Pfeiffer 1994; Mathews and Short 2001; Rodriguez-Zas et al. 2003), but not Thoroughbred mares. Baker et al. (1993) commented on the importance of understanding economic aspects of mare reproductive efficiency, but other than analyzing equine tax management issues and auction price determinants little work has been performed. The reason economic outcomes may not have been extensively explored in the Thoroughbred mare is because mare ownership is often undertaken for reasons other than profit, such as a recreational hobby or sentiment for a mare from a line that has been mated and raced with success by the same owners over an extended period. However, even those not participating purely to profit financially in the Thoroughbred breeding industry generally want to minimize financial losses.

The costs of producing a foal can be divided into several categories: (1) daily maintenance cost of the mare, (2) mare replacement costs and insurance, (3) costs associated with mating activities (i.e., veterinary, transportation), (4) routine health and farrier work, and (5) stud fee. Combining all categories, Kirkpatrick (2001) calculated the cost to produce a foal at $29,632, but did not include the annualized replacement cost of the mare or costs associated with maintaining the foal until it is sold as a yearling. This figure also fails to account for the inability of the mare to produce a foal every year. Thalheimer and Lawrence (2001) estimated the cost of producing a foal up to its sale as a yearling at $85,142 which assumed 1.5 mares were required to produce a foal every year. In both cases the assumed stud fee was less than $20,000. The cost to produce a foal varies greatly depending on stud fee and annualized replacement cost of the mare.

The objectives of the present study were to: (1) assess mare productivity over time, (2) examine factors pertaining to the mare influencing the likelihood of producing a registered foal, and (3) to analyze economic consequences of differences in reproductive efficiency and mare financial value over different investment periods.

Methods

A list of 1,292 mares mated during the 2004 and/or 2005 breeding season on thirteen farms in Lexington, KY was sent to the United States Jockey Club to obtain production records through 2005. This cohort of mares was in a parallel study to assess reproductive efficiency using farm-level data on management and veterinary practices (Bosh et al. in press). The following information was received from the Jockey Club for all mares: mare’s year of birth, all years mated, foal names, foaling dates, foal sexes, and information related to mating outcomes (i.e., aborted, foal born dead, mare died, mare exported, etc.). In total, production records were available for 1,176 mares mated over 7,244 mare-years. Production records were not available for 107 maiden mares and 9 non-maiden mares.

Mare production information was imported into SAS (Version 8.0, DataFlux Corp., Cary, NC, USA). The data were checked to ensure all years from the first time the mare was mated until the 2005 foaling season were present for each mare. If a year was missing, the year was inserted into the mare's record, and it was assumed no registered foal was produced that year. Foaling information was not available during the periods a mare was mated outside North America. Mating outside of North America occurred infrequently.

Data were checked for consistency with farm records. Age of mare, foaling outcomes, and foaling dates in the 2004 and 2005 foaling seasons were compared between the two datasets and inconsistencies were investigated and resolved.

An indicator variable was created to determine the foaling outcome of the mare in each year mated (0=No foal, 1=Foal). A discrete variable was created to capture the number of foals a mare produced in sequence before not producing a registered foal. For example, in the first year of a mare's production history, 0 foals were produced in sequence. If she produced a live foal following mating the first year, at the beginning of the second year she produced 1 foal in sequence. If she did not produce a live foal in the second year, at the beginning of the third year she produced 0 foals in sequence. If she produced live foals in years 3 to 5, in the sixth year she produced 3 foals in sequence. A low number of foals in sequence could represent a mare mated a limited number of years, or an older mare that was frequently barren. When foals were produced in consecutive years the difference in foaling dates was calculated. Mares with foaling dates on Southern hemisphere time were excluded. Data to calculate the drift in the foaling dates were available in 3,559 mare-years.

The influence of mare age, foaling date (before or after April 1), number of foals produced in sequence, and total number of cycles mated during the 2004 season on the probability of producing a registered foal in 2005 were modeled using logistic regression. The likelihood ratio χ^2 was used to determine the individual p values for first stage analysis. Mare age, the number of foals produced in sequence, and total number of cycles mated during the 2004 season were modeled as linear explanatory variables. Foaling date (before or after April 1) was modeled as a dichotomous explanatory variable. Stepwise elimination was used in the second stage for all variables related to producing a registered foal. The final multiple logistic regression model included variables related to producing a live foal with $p<0.05$ in the second stage.

A series of scenario analyses were developed to demonstrate economic consequences of stochastic reproductive efficiency in mares. A broodmare is a long-term capital investment because she produces several foals in the future. The economic methodology to analyze investments that generate net cash flow over time in the future is called capital budgeting and uses the tools net present value, NPV and the internal rate of return, (Keown et al. 2008). The NPV is an investment's net profit after paying the investment's purchase cost and discounting the investment's future cash flows to the present time. The future net cash flows are discounted using the time value of money principle, which means future cash receipts are worth less than the cash held today. Both NPV and IRR take into account future values are worth less than present values due to inflation, risk, and not being able to earn interest on future values. A negative NPV indicates the investment was not profitable at the given discount rate. See the equation used to calculate NPV below incorporating the mare's individual characteristics and reproductive efficiency over time. The equation calculates the NPV of the ith mare at time 0 using a discount rate of r, the expected net cash flows from producing foals over time given the broodmare's reproductive efficiency, and selling the culled broodmare at the end of the investment. A discount rate of 5% was assumed for the NPV calculation in all scenarios in this study

The IRR calculates the investment's rate of return using the investment's expected future cash flows. Mathematically IRR is the discount rate that equates the investment's purchase cost to the present value of the investment's expected future cash flows. A higher IRR indicates higher investment profitability.

$$NPV_{i,t=0} = -PC_{i,t=0} + \sum_{t=1}^{z} \sum_{j=1}^{z} \frac{prP_{i,j,t}(\text{revenue j} - \text{cost j})_t}{(1+r)^t} + \frac{cull_{i,z}}{(1+r)^z}$$

<u>Model variables</u>
NPV = Net present value
PC = Purchase cost of mare entering breeding herd
prP=Probability of the i^{th} mare producing the j^{th} yearling relative to time t
revenue = sale of offspring
cost = cost of production
cull = cull sale value
r = percent discount rate (time value of money)

<u>Model subscripts</u>
i = individual mare
t = time
z = investment time horizon in years
j = individual yearling produced by the ith mare in time t, j = 1…z

A series of assumptions were developed for analysis. Assumptions were related to status of the mare at the beginning of the analysis, her initial purchase price, stud fee of the stallion that the mare was mated to in each year, costs associated with mating the mare, costs associated with maintaining the mare, costs of weanling and yearling production, an estimation of yearling sales revenue, an estimation of the mare's cull sale value, and discount rate.

Costs of all treatments and procedures billed for veterinary attention were obtained from the veterinary practice used to recruit farms to the study. Costs associated with procedures billed by the farm were obtained from two farms, and when differences occurred the average cost was used. A typical calendar of events over a one-year period was created for each mare status. The events in the calendar were based on average frequencies of occurrence using information from the 2004 and 2005 breeding seasons. The calendar of events represented costs of best management practices associated with mating and maintaining the mare. Average expected mating and maintenance costs were calculated using a weighted average of annual mating and maintenance costs based on the proportion of mares mated in each cycle during the 2004 season by mare status. Average expected mating and maintenance costs were $10,883, $11,480, and $11,009 for maiden, foaling, and barren mares respectively.

Costs associated with the stud fee and mare value were based on industry standards that the stud fee should range from one-fourth to one-third of the mare's value. For the seven scenarios where mare financial value was assumed constant, the stud fee of $30,000 was used based on the median stud fee among the cohort of mares mated during the 2004 and 2005 breeding seasons. Mare financial value was assumed to be $120,000 (i.e., four times the stud fee).

Results

Produce History

Mare average production history length was 6.2 mating seasons (±4.7 s.d.). Number of years of production history ranged from 1 to 22 years. Average number of registered foals produced was 4.8 (±3.6 s.d.). Total number of registered foals produced by a mare over her reproductive life ranged from 0 to 19 foals.

Of 1,176 mares, 440 (37.2%) produced registered foals in every year of their production history. Average number of years of production histories for these mares was only 2.9 (±2.2 s.d.) years. Total years of production history for this group of mares ranged from 1 to 13 years.

The other 739 (62.8%) mares did not produce a registered foal in at least one mating season during their reproductive lives. Average total years of production history was 8.1 (±4.7 s.d.) years. Total years of production history ranged from 1 to 22 years. The mean number of years these mares were mated before not producing a registered foal was 3.4 (±2.5 s.d.) years. Number of years mated before not producing a registered foal ranged from 1 to 16 years.

There were 438 mares with at least 7 years of production history. Only 96 (21.9%) mares produced live foals continuously over the first 7 years of their production histories.

Drift in Foaling Dates

When mares foaled in consecutive years, the average drift in the foaling date was 13.4 (±23.2 s.d.) days later in the subsequent year. Drift in foaling dates ranged from foaling 41 days earlier in the subsequent year to foaling 142 days later. Drift was divided into 3 categories: (1) no drift (i.e, foaling on the same day or earlier in the subsequent year) (n=1,106, 31.1%), (2) drifting 1 to 30 days later in the subsequent year (n=1,785, 50.2%), and (3) drifting more than 30 days later in the subsequent year (n=668, 18.7%).

Factors Influencing the Probability of Producing a Registered Foal

In the first stage logistic regression model (i.e., bivariate comparisons), a foaling date before April 1 ($p<0.0001$) increased odds of producing a registered foal in the subsequent year. An increase in age of the mare ($p<0.0001$) and an increase in number of cycles the mare was mated in 2004 ($p<0.0001$) decreased odds of producing a registered foal. Number of foals produced in sequence ($p=0.6097$) did not influence odds of producing a registered foal. In the second stage logistic regression model all four variables were significantly associated with odds of producing a registered foal in 2005 (Table 1).

Economic Model Results

A base scenario was developed to examine the economic consequences of stochastic reproductive efficiency over a 7 year mating period. The base scenario assumed a maiden mare was purchased for $120,000 at the end of year 0, mimicking a mare purchased at the November breeding stock sale. The mare was mated to a stallion with a $30,000 stud fee. The annual expected costs for mating and mare maintenance was $10,883, based on average expected veterinary management and maintenance costs. Additional weanling and yearling production costs were assumed to be $12,084 (Thalheimer and Lawrence 2001). Revenue generated from selling the yearling was estimated using a 3.25 stud fee multiple (i.e., $97,500). A sales commission cost of 9.5% ($9,262) was assumed at the yearling sale. The mare was mated in all 7 years of the investment, and sold in foal for $36,000 in year 7. The sale price of the mare at the end of the investment period was estimated based on the average sale price among mares 10 to 12 years of age sold in foal between $10,000 and $120,000 at the Keeneland sale in Kentucky in November 2001. This represents mares purchased as 3, 4, and 5 year olds for $120,000 that depreciated in value after mating for 7 years before being sold while in foal. The average was rounded to 30% of the mare's purchase price. The final yearling produced was sold in year 8. It was assumed the mare was barren only once following mating in year 4. A 5% discount rate was used in calculating the net present value (NPV).

Figure 1 illustrates the cumulative cash flow timeline of the base scenario. Total costs in year 0 included purchase price of the mare and daily board costs for 1.5 months. In year 1, costs were associated with mating, mare maintenance, and stud fee. The stud fee is typically paid in the fall of the year the mare is mated. If there is a guaranteed live foal agreement the stud fee is refunded if the mare does not produce a live foal. In year 2, the costs of production were slightly higher due to the addition of foaling and foal maintenance costs. Costs of mating, maintenance of the mare, and stud fee were also incurred. In year 3, sale of the first yearling resulted in the first positive cash flow. Costs of mating, maintenance of mare and foal, foaling costs, and stud fee were incurred. In year 4, revenue was generated from sale of the second yearling. Costs were associated with mating, mare and foal maintenance, and foaling. Positive cash flow was slightly higher in year 4 because stud fee cost was not incurred, as the mare was assumed barren. In year 5, revenue was generated from sale of the third yearling. Costs of mating, mare maintenance, and stud fee were incurred. In year 6, cash flow was negative because there was no yearling to sell. Costs of mating, mare and foal maintenance, foaling, and stud fee were incurred in year 6. In year 7, positive cash flow resulted from sale of the in-foal mare and her fourth yearling. Costs of mating, mare and foal maintenance, foaling, and stud fee were still incurred. Additional revenue was generated in year 8 due to the sale of the fifth yearling.

In the base scenario the net investment cash flow was $38,772, but the investment did not break even until the final yearling was sold in year 8 (Figure 1, Table 2). The maximum cash outlay before generating revenue was $212,484. The NPV was negative ($13,633) representing the discounted value of the mare's future yearling sales over the investment period less the mare's purchase price. A negative NPV means the initial mare's purchase price was greater than the discounted value of the yearling sales. The IRR on the investment was 3.45%. It means the investment earned a rate of return of 3.45% which can be compared to the rate of return from other investments such as a bank savings account.

Additional scenarios were developed to examine the economic consequences of stochastic reproductive efficiency over varying mating period lengths and different levels of reproductive efficiency for the maiden mare purchased in year 0 (Table 2). Scenario 1 was the base scenario described above. All additional scenarios used the assumptions of mare purchase price, mating costs, mare and foal maintenance costs, stud fee, yearling sale price, mare sale price (except scenario 5), and discount rate as the base scenario presented above. In Scenario 5, the mare was sold in year 3 before the year she was barren so the sale price of the mare was adjusted upward to

$100,000 to capture selling a younger mare as illustrated in Table 2. The most profitable scenarios involved a mare that produced a registered foal in all 7 years mated before being sold (NPV=$16,982, IRR=6.73%), and a mare mated for 9 years before being sold, who was only barren one time 4 years into her production history (NPV=$17,472, IRR=6.55%).

The economic consequences of stochastic reproductive efficiency over a 7 year investment horizon by mare financial value were examined, assuming the mare was barren in year 4 (Table 3). The assumptions of mating costs, mare and foal maintenance costs, weanling and yearling production costs, and discount rate were the same as the base scenario. However, stud fee, yearling sales price, purchase price of the mare, and mare's sale price varied depending upon the mare's value. Greatest profitability was obtained among highest valued mares. Mares valued at $1,000,000 had a positive NPV of $639,710 and IRR was 13.01% over the 7 year investment horizon. Maximum cash outlay before generating revenue was $1,623,176 for the $1,000,000 mare. Mares valued $150,000 or higher, all produced a positive net cash flow. However, the IRR was low for mares valued $150,000 and $300,000. Mares valued $100,000 or less were not profitable.

Discussion

The estimation obtained from the Jockey Club records of a mare not producing a registered foal after 3 to 4 years of mating fits the industry rule of thumb a mare will be barren 2 out of every 7 years. Scenarios examining a mare barren twice over a 7 year investment horizon were not profitable.

The high proportion (69%) of mares drifting in their foaling dates between successive foaling seasons represents an area impacting productivity over time. Although drift in foaling dates can result from mating the mare multiple times during the season due to a failure to establish pregnancy, drift can also result from delay in mating the mare post-foaling. During the 2004 breeding season, 32% of mares were mated on multiple cycles. In order to avoid drift in foaling date, mares must be mated within approximately 25 days of foaling (Loy, 1980). It is important that foaling mares are carefully and appropriately managed to try to achieve mating within this window as loss in productivity over time can impact profitability.

This study indicated each of the following decreased the odds a mare would produce a registered foal in 2005, while controlling for the influence of other listed factors: increasing age, foaling after April 1, being mated at more than one cycle during the season, and a lower number of foals continuously produced in sequence during previous years. For example, among two mares of the same age, both foaling after April 1 and mated twice during the season, the probability of producing a live foal the next year will be lower for the mare that previously produced one foal in sequence compared to the mare that previously produced two foals in sequence. Similar results were obtained using complete production history for all mares, except the number of cycles mated could not be analyzed in this model. Since reproductive efficiency is closely tied to profitability, these readily available factors can be used to help modify management practices and determine culling strategies.

Veterinary management of mating costs comprise a small proportion (i.e., <1% to 5% for mares valued at $10,000 or higher) of total annual production costs for the majority of mares, but mating management can greatly affect reproductive efficiency. Results emphasize the importance of performing all necessary, evidence-based veterinary treatments to improve reproductive efficiency and ensure a high standard of the mare’s health and welfare. The conclusions do not hold among mares of lower financial value, as veterinary management of mating costs represent a larger proportion of total production costs.

Revenue generated from the foal is necessary to recover production and investment costs. Although important to minimize the number of times the mare is mated during the season to maximize efficiency over time, in terms of recovery of the investment, it may be necessary to mate the mare on several cycles to produce a live foal. The small increase in additional costs associated with mating the mare during multiple cycles is generally heavily outweighed by future sales revenue of the offspring. Some consideration however must be given to this conclusion since yearling sales prices are often lower for those with later foaling dates (Commer 1990; Buzby and Jessup 1994; Robbins and Kennedy 2001), and multiple matings during the season increase drift in the foaling date, which can affect the mare's productivity over time. Multiple matings are an indicator of reduced fertility in the mare, stallion, or both. Management should examine the reason mares were mated multiple times, as profitability over time is related to the consistent production of registered foals under the assumption of this study.

The scenario for a maiden mare valued at $120,000 showed the highest profitability among mares that consistently produced live foals over a 7 year period. Profitability was also improved by extending the holding period over the traditional 7 year investment, assuming the mare continues to produce live foals consistently. It was not profitable to invest in the mare for a short period and sell the mare before she was barren, although this conclusion may vary with individual mare qualities and successful racing performance of her offspring.

Profitability was highest among mares of greatest financial value under the assumptions of this study. However, the high initial cash outlay excludes many potential investors. Mares of lower financial value (i.e., $100,000 or less) were not profitable over a 7 year period, assuming mares were barren once in year 4. Profitability among mares of lower financial value could be attained by: (1) selling yearlings above the market average stud fee multiples used in the scenario, (2) holding the mare longer than the traditional 7 year investment period, assuming consistent reproductive efficiency is maintained, or (3) decreasing mating and maintenance costs.

In cattle and swine operations, barren animals are generally culled to maximize profitability. Thoroughbred mares do not fit this scenario because of the high value of individual mares and large differences in the mare’s low cull value and high replacement cost. In addition, profitability is not the only reason for mare ownership, unlike other livestock species. Understanding the factors influencing production of a live foal along with the mare’s value may be useful to determine management strategies and culling procedures to attain the level of profitability desired by the mare owner.

This study began exploring the economic consequences associated with variation in reproductive efficiency and financial value of the mare. The conclusions are based on a large number of assumptions, and are aimed only as a starting point into the interesting, but complex area of relating mare reproductive efficiency and management strategies to economic outcomes. There are a wide variety of additional scenarios and modeling factors that could be examined that could alter the economic results. For example, changing the mare’s cull sale value will impact the mare’s profitability. Variations in stallion fertility were not addressed in this study, although it is an area that can impact the likelihood of producing a live foal. Mares were assumed to be mated to a fertile stallion in this study. More work is needed to test the robustness of the conclusions of this study when the cost and revenue assumptions are varied. Additional work should also examine scenarios involving a larger group of mares to simulate conclusions at the farm level.

References

Baker, C.B., Little, T.V., and McDowell, K.J. (1993) The live foaling rate per cycle in mares. *Equine vet. J., Suppl.* 15, 28-30.

Bosh, K.A., Powell, D., Shelton, B., and Zent, W. (in press) Reproductive Performance Measures among Thoroughbred Mares in Central Kentucky, during the 2004 Breeding Season. *Equine vet. J.*

Buzby, J.C., and Jessup, E.L. (1994) The relative impact of macroeconomic and yearling-specific variables in determining thoroughbred yearling price. *Appl. Econ.* 26, 1-8.

Commer, M. (1990) The effect of nonphenotypic data on thoroughbred prices in the mid-Atlantic market. *Prof. Anim. Sci.* 7, 18-24.

Frasier, W.M., and Pfeiffer, G.H. (1994) Optimal replacement and management policies for beef cows. *Am. J. Agric. Econ.* 76, 847-858.

Hemberg, E., Lundeheim, N., and Einarsson, S. (2004) Reproductive performance of Thoroughbred mares in Sweden. *Reprod. Dom. Anim.* 39, 81-85.

Holt, M.T. and Moschini, G. (1992) Alternative measures of risk in commodity supply models: an analysis of sow farrowing decisions in the United States. *J. Agric. Res. Econ.* 17, 1-12.

Keown, A.J., Martin, J.D., Petty, J.W., and Scott, D.F. (2008) In: The foundations of finance: The logic and practice of financial management, 6th edn, Pearson Prentice Hall, Upper Saddle River, New Jersey. pp. 259-331.

Kirkpatrick, A. (2001) What does it cost to participate. In: *Investing in Thoroughbreds Strategies for Success*, 1st edn, The Blood-Horse Inc., Lexington. pp. 226-250.

Loy, R.G. (1980) Characteristics of postpartum reproduction in mares. *Vet. Clin. N. Am.: Large Anim. Pract.* 2, 345-359.

Mathews, K.H., and Short, S.D. (2001) The beef cow replacement decision. *J. Agribus.* 19, 191-211.

Morris, L.H.A., and Allen, W.R. (2002) Reproductive efficiency of intensively managed Thoroughbred mares in Newmarket. *Equine vet. J.* 34, 51-60.

Robbins, M., and Kennedy, P.E. (2001) Buyer behaviour in a regional thoroughbred yearling market. *Appl. Econ.* 33, 969-977.

Rodriguez-Zas, S.L., Southey, B.R., Knox, R.V., Connor, J.F., Lowe, J.F., and Roskamp, B.J. (2003) Bioeconomic evaluation of sow longevity and profitability. *J. Anim. Sci.* 81, 2915-2922.

Thalheimer, R., and Lawrence, R.G. (2001) The economic loss to the Kentucky equine breeding industry from mare reproductive loss syndrome (MRLS) of 2001. Department of Equine Business, University of Louisville.

Table 1. Probability of producing a registered foal in 2005 among Thoroughbred mares on 13 farms in Kentucky, USA (n=1,083) using second stage multivariable stepwise elimination logistic regression analysis

Variable	OR (95% CI)[a]	p Value
Foaling date (before April 1)	3.003 (2.053,4.405)	<0.0001
Foals produced in sequence (increase of 1 foal)	1.118 (1.020,1.226)	0.0175
Age of mare (increase of 1 yr)	0.928 (0.901,0.957)	<0.0001
Number of cycles mated in 2004 (increase 1 cycle)	0.595 (0.509,0.695)	<0.0001

[a] Results are odds ratios (OR) and 95% confidence intervals (CI)

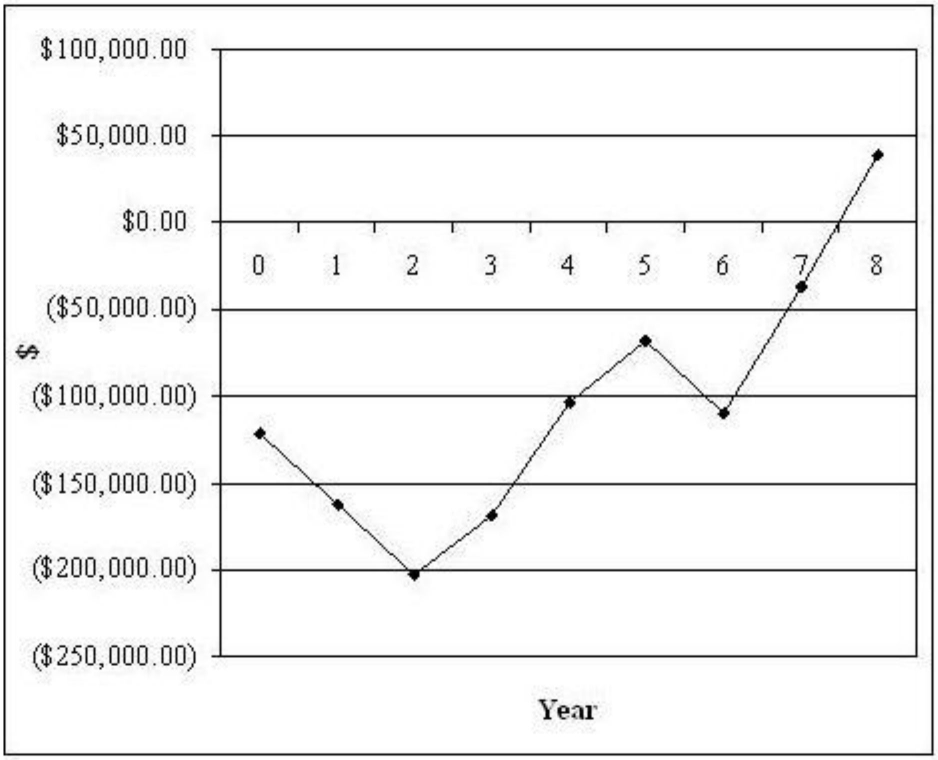

Figure 1. Cumulative cash flow time line over investment horizon under the base scenario assumptions of a maiden mare purchased in year 0, barren only once in year 4, and sold in-foal in year 7.

Table 2. Economic model results for scenarios involving the purchase of a maiden mare in year 0 with varying levels of reproductive efficiency over time

Scenario	Description	Net Cash Flow	NPV[a]	IRR[b]
1	Base	38,722	(13,633)	3.45%
2	mate mare 7 years-100% foals	84,925	16,982	6.73%
3	mate mare 8 years-barren yr 4	68,767	2,204	5.22%
4	mate mare 9 years-barren yr 4	98,763	17,472	6.55%
5	sell mare before barren-year 3	7,803	(17,405)	1.38%
6	mate mare 7 years-barren year 4 & 6	(7,382)	(41,402)	na
7	mate mare 7 years-barren year 1 & 5	(7,382)	(47,569)	na

[a] NPV=Net present value. A discount rate (r) of 5% was used in the calculation.
[b] IRR=Internal rate of return.

Table 3. Mare reproductive profitability by mare financial value[a]

Mare Value	Stud Fee	2005 Stud Fee Multiple[b]	Maximum Cash Outlay	Net Cash Flow	NPV[c]	IRR
$1,000,000	300,000	2.88	1,623,176	1,331,184	639,710	13.01%
$600,000	150,000	3.16	923,176	686,434	311,226	11.89%
$300,000	80,000	2.30	483,176	10,184	(93,215)	0.01%
$150,000	40,000	2.88	253,176	40,864	(22,506)	2.94%
$100,000	25,000	3.15	173,176	(2,072)	(37,352)	na
$60,000	15,000	3.20	113,176	(53,216)	(62,345)	na
$30,000	7,500	3.14	68,176	(97,852)	(85,704)	na

[a] Using base scenario assumptions of a maiden mare purchased in year 0 that is barren once in year 4 over her 7 year investment horizon

[b] Source: 2005 Stud Fee Multiple, 2005 Auction Review, Thoroughbred Times, Table 5 pg. AR-5, January 7 2006

[c] NPV=Net present value. A discount rate (r) of 5% was used in the calculation.