Pricing Stallion Seasons for an Individual Stallion: The Existence of Top Tier Pricing and Market Power

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17 April 2020

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Abstract

This paper is an academic treatment of the pricing of stallion seasons (a "season[1]" confers the right to breed a mare to a stallion) The commercial stallion seasons market can be represented schematically as a triangle that normally has a single-digit number of stallions offering high-priced seasons in the narrow apex, a moderate number of stallions composing the middle section, and over 150 in the $5,000-$10,000 range.[2] We argue that it is logical for profit-maximizing stallion managers, most especially those in the apex of the stallion seasons triangle, to charge different prices for different groups of buyers of the same stallion seasons. Some of the reasons are straightforward: seasons are worth less as the breeding season progresses because foals produced later in year from those seasons are worth less. Other reasons have more to do with the somewhat monopolistic nature of the market for stallion seasons as explained in this paper. This market power, in turn, creates multiple demand curves for different market segments.

As for artificial insemination (AI), the economics of this analysis suggests that breeders significantly benefit from the introduction of AI because costs tend to fall and the choices of potential stallions available to mares would be expanded as better stallions breed more mares. Though the average breeder would benefit, there would be losers from a change in the status quo. Not surprisingly, those who stand to would lose from a move to AI argue against such a move.

Keywords: artificial insemination, breeding, competition, monopolistic competition, monopoly, oligopoly, seasons contracts.

JEL codes: L1, L8, Q12, Q19

April 16, 2020

[1] A "season" to a Thoroughbred stallion typically confers the right to breed one mare as many times during the February to June breeding season that are necessary to impregnate the mare. Various arrangements are made for payment of the breeding season, but the most prevalent arrangement is that the season is due if the mare has a live foal that stands and nurses LFSN).

[2] For the 2019 breeding season there were nine stallions listed in the Blood-Horse Stallion Register offered for a fee of $100,000 or more in the United States, with the highest price being War Front's $250,000. There were approximately 160 in the $5,000 to $10,000 range.

Introduction and Background

A stallion can be viewed as a "firm" in the economic sense.[3] Though a horse lover might decry this impersonal viewpoint, it is not unreasonable to view the stallion as analogous to a patented hobby horse stamping "machine" at a factory that produces designer label hobby horses. The analogy is more apt if we assume that the designer label hobby horses, though they share many similarities, are nevertheless all different in various ways. They may vary in color, in size, by the types of wood that are used in their production, and more[4]. Similarly, a stallion's foals, though similar, vary significantly in many attributes, including color, size, temperament, and perhaps most importantly, ability to perform.

It seems appropriate to classify both the hobby horse firm and the stallion firm as examples of monopolistic competition, but this classification is not without its complications. The term itself, "monopolistic competition," suggests that the monopolistically competitive firm shares some of the features of monopoly and some of the features of (perfect) competition. If there is a line drawn between monopoly and perfect competition, and the closer on that line a firm is placed to the monopoly-anchored end of the line the more it resembles a monopoly, and the closer the firm is placed on the perfect competition-anchored end of the line the more it resembles perfect competition, then a monopolistically competitive firm should be placed somewhere near the middle of the line connecting monopoly and perfect competition.

Classic textbook writer C. E. Ferguson (1972, page 319) points out that, like monopoly firms, monopolistically competitive firms have differentiated products that have no perfect substitutes. But, unlike the usual representation of monopoly, where there are no close substitutes, in monopolistic

[3] A stallion will often be boarded along with other stallions at a farm that is a specialized breeding farm. An economics student's first inclination might be to view the farm as the "firm" so often discussed in the microeconomic literature. However, in many cases each stallion at the farm will be owned by a different group of breeders (syndicate) and the stallions on the same farm will compete against each other, at least to a limited extent (though many farms attempt to minimize this competition by choosing a roster of stallions that are significantly differentiated one from the other). So from this perspective it seems reasonable to view the stallion as a "firm" (or maybe a subsidiary firm of the farm) for which we can depict schedules and diagrammatic representations of demand for the seasons that the stallion produces, along with marginal revenue, and marginal, average and total cost curves.

[4] Perhaps the hobby horse differentiation occurs because of additional personalized work by factory artisans.

competition, there are close substitutes. However, the degree of substitutability stops short of the perfect competition case. The market for many farm products is considered to fit the perfect competition mold as well as any products where goods produced by different firms are virtually homogeneous, and thus perfect (or near-perfect) substitutes. Like Ferguson, David Kreps (2004, page 285) suggests that "A monopolistically competitive industry comprises many suppliers (producers) and many demanders, but…the good in question is…differentiated.[5]"

Other writers have noted the ability of firms to price differentiate or discriminate according to market segments or differentiated products or services. Musa and Rosen (1978) discuss how monopolists can vary product quality so as to segment markets and to engage in price discrimination. Varian (1992, pages 241-242) notes Pigou's classic work (1920) on price discrimination and writes about first, second, and third-degree price discrimination. An important consideration in price discrimination is the inability of a buyer to re-sell the product or service. First degree price discrimination or perfect price discrimination is when the firm charges a price according to each consumer's maximum willingness to pay.

$$p(x) = u(x) \tag{1}$$

where p(x) is the commodity's price and u(x) is the consumer's maximum utility. This is approximated in horse breeding by top tier stallion owners to a certain degree through their ability to negotiate individual contracts with mare owners. A more likely market condition in horse breeding is third-degree price discrimination where different customers pay different prices according to their elasticities of demand. Mare owners' elasticities can be said to vary according to how early or late it is in a particular horse breeding season as well as whether the stallion's geographical location is near or far from the mares (geographic price segmentation). Under third degree price discrimination the firm's profit maximization is given by

[5] Ferguson and many other economists would argue that we would be better off characterizing monopolistic competition as a group of firms producing a "product group" rather than calling it an industry. This view is based on the argument that the products, though similar, are sufficiently differentiated that calling a group of firms that produce close but imperfect substitutes an "industry" is stretching the definition of "industry."

$$p(x)[\ 1 - 1 / \varepsilon\ ] = c \qquad (2)$$

where ε is the absolute value of the product's price elasticity and c is marginal cost. The smaller ε or the more inelastic demand is for a particular market segment, the greater the price. One form of market segmentation according to elasticity is geographic market segmentation in which elasticities vary in different regions (Hoover 1937). Finally, in some ways the unique DNA of each stallion can be likened to a firm having a patent on a unique product, and this in turns gives a patent holder monopoly or near monopoly pricing power (Scherer 1980), power that we argue that top tier owners possess when it comes to negotiating prices since there are no close substitutes for what they are offering. Lower tier stallions have no such market power.

An example of a group of closely related monopolistically competitive firms that is often cited is competition among different restaurants in an urban environment. Locally owned, "five-star" restaurants offer an intimate dining service, ambience and hard to find menu items that are often prepared by top notch chefs. Menu prices for these reasons are often high for different entrees, and this market serves a small, upscale market niche. At the other end of the spectrum, national level, "chain" fast food restaurants engage in some sort of mass production for mass production, offer low price menus, and target a wider audience than the top scale restaurants. Each of these types of firms has some pricing power, that is to say, although the lower end cannot raise its price too much because it has more competition and a greater amount of elasticity of demand for its products. Each could raise price but continue to sell product (though sales volume would be expected to fall) but this pricing power is intermediate between the strong market power a monopoly firm has and the absence of market power that a perfectly competitive firm has. Said another way, each firm faces a downward sloping demand curve, but the curve has more elastic points than the curve facing a monopolist. Then again, it is not the completely flat curve or perfectly elastic configuration facing a perfectly competitive firm.

A seller of a stallion season faces many of the market conditions that a monopolistically competitive firm does, but there is an important exception: Each stallion is a unique individual producing seasons that have unique characteristics. Unlike two boxes of a name brand detergent coming off the

assembly line that are perfect substitutes, even twins produced by a mare[6] are always different, and every horse is different in a variety of ways. The stallion seasons sold by the stallion firm provide the male zygote (sperm) that unites with a mare's ovum to produce a fertilized egg that results in a foal eleven or so months later. But, because each sperm carries a different combination of the genes of the stallion, each season is a unique product. Thus, unlike products produced by the typical monopolistically competitive firm, the products (foals) produced by mating a stallion to a mare always are unique. But, since there are typically many close substitutes for most seasons and for the foals that result from seasons, the fact that each season results in a foal that is unique often does not differentiate it enough to move this market type significantly toward monopoly and away from perfect competition on the line connecting the two market types. Moreover it can be argued that even though every foal is different, and every set of genes delivered by a stallion breeding a mare will be different, the buyers of seasons to a particular stallion view each season by that stallion as one and the same product. This is because the buyers do not know which set of genes their foal will receive, thus each season buyer can reasonably expect that (s)he is buying the average set of genes produced by the stallion in question. True, they will find out when the foal develops that they almost certainly did not receive the "average" set of genes, but this cannot be determined when the season is sold.

If we view a stallion as a firm, we can use the diagrammatic representation that we observe in virtually all microeconomics texts to represent costs, revenues, and equilibrium conditions. An example follows in Figure 1, but first a discussion is necessary about the costs and revenues associated with a stallion.

(Insert Figure 1 around here)

The costs associated with the "machine", that is, our stallion and the major asset of the breeding "firm," can be broken down into the usual fixed and variable costs. Perhaps more so than is the case for most firms, most of the costs are fixed. The major costs will typically be the sunk fixed costs associated

[6] Twins born to mares are almost invariably fraternal rather than identical twins, hence only 50% of their genes (on average) are the same.

with buying the stallion. Other fixed costs arise from having to house and feed the stallion. Only a small fraction of the costs of running the breeding firm centered around stallions are variable costs: the costs of disposable products used in the breeding process, some of the veterinary costs, perhaps a portion of the marketing expenses, and possibly the breeding crew's expenses.

Consider in more detail the costs of the breeding crew that handles a thoroughbred stallion when he services mares (or the costs of the collecting semen when AI is used for other breeds). If the stallion is contracted to breed one mare per season (which would be so uneconomical as to make no sense for a profit-maximizing operation, but is useful to consider for purposes of explaining this example), and presuming that this stallion is the only stallion at the farm where the stallion boards, then the farm might rent a crew from another farm for the one breeding. The cost of the crew and related variable costs might run a hundred dollars or more.

However, if the stallion breeds a significant number of mares, the farm will be more likely to hire an additional worker or two at the farm and also teach one or two regular farm hands how to manage a breeding stallion . Under this scenario these costs can probably best be viewed as fixed costs because the crew is hired for the entire breeding season. But, even if one wishes to argue that the crew could be let go on a moment's notice if the stallion cannot breed, and thus that their costs are variable costs, the cost per service for an active stallion will be so low as to be a tiny fraction of the fixed costs of standing a valuable stallion.

We thus represent the marginal costs of providing a season to an additional mare as dropping to very small amounts very quickly as more mares are bred. If we view a portion of the marketing costs as fixed, and a portion as variable, then the costs of setting up to breed the first mare are high, but the marginal costs are extremely low once a stallion crew is contracted for the breeding season. It thus seems logical to represent the marginal costs as dropping precipitously to almost nil for even a small number of mares bred (seasons sold), and staying low for the first hundred or so mares.

A healthy and fertile stallion can typically naturally service a hundred or more mares without undue stress on him and without creating significant problems for stallion management or for season

buyers[7]. However, as incremental mares are contracted to breed (without using AI) past a hundred or so, the breeding process becomes more and more a juggling act. Multiple requests by mare owners are inevitably made to breed on the same day and queues have to be formed and managed by the stallion manager. This may mean that some mares do not get bred at the optimal time. Mare owners are not happy when this happens. Postponing a breeding to a less optimal time decreases the chances of getting an early (and generally more valuable) foal, and decreases the chances of getting any foal at all. If there is full information available, the effects on stallion season demand of breeding a large number of mares will most likely have been reflected in pushing the demand curve to a lower level than would be the case if the queuing phenomenon were not a factor. The authors are of two minds as to how to show the effects of fertility on the cost and revenue curves of the stallion firm. It is reasonable to argue that there is a demand curve for seasons contracted, and a lower "shadow" average revenue curve that reflects the decreasing probability of mare owners paying for seasons because the probability of producing live foals falls as more seasons are sold.

An alternative way to deal with the effects of the decreasing probability of producing live foals is to view this as a cost (due primarily to the lower percentage of foals produced) associated with breeding the stallion more frequently and breeding some mares at suboptimal times.

For the stallion represented in Figure 1, it is argued that the marginal costs of selling more seasons (which means breeding more mares) becomes increasingly significant once the stallion is contracted to breed 120 or so mares. Past 180 mares the marginal cost skyrockets. In effect the stallion depicted has a ceiling of 180-185 mares that would rarely be exceeded even if the demand for the stallion increased substantially.

If the stallion from Figure 1 is a Thoroughbred stallion he would be in the top two or three percent of stallions by stud fee. The demand curve represented shows that some mare owners would be

[7] Because a stallion's semen can be divided into multiple (three or four) portions without affecting the likelihood of impregnating a mare when artificial insemination (AI) is used, the "congestion" problem associated with large numbers of breeding sessions is greatly diminished when AI is utilized.

willing to pay $50,000 or more and that the equilibrium price if 180 mares are to be bred is $40,000 per season. Terms for breeding contracts vary slightly from farm to farm, but a standard breeding contract would require that the $40,000 would be paid either when the foal stands and nurses or in the fall of the year that the mare was bred. In the latter case, which fell out of favor during the "great recession" of 2009-2011/12, the early fee payment would be refunded if a live foal is not born that stands and nurses.

The equilibrium price is determined as per standard microeconomic analysis. The breeding farm maximizes profit if it operates where marginal cost equals marginal revenue. If the farm manager limits seasons sold to fewer than 180 mares the stallion firm foregoes some profits that would have been available because an additional mare would have added fewer costs than the additional revenue that would have been expected to be generated. Breeding the 181st mare would be expected to lower profits because the marginal cost exceeds the marginal revenue from adding the 181st season contract to the stallion's book.

As represented in Figure 1, a hypothetical stallion, Forty Karets, "breaks even" in the sense that if 180 seasons are sold, and revenues equal costs. One might ask why a stallion whose stud fee is in the top two percent or so of stallions only breaks even. One possible explanation is that Forty Karets was purchased just prior to the breeding season at a price that allows him to "break even."[8]

There are a variety of considerations that one might argue are glossed over by using the standard microeconomic treatment as per Figure 1. It may be that the number of mares bred this year to the stallion affect the prices for seasons in future years. This could happen for either of the two reasons explained below.

1A. Normally we would expect that the greater the number of mares bred the lower their average quality (because the quality mares attracted at the lower prices necessary to induce more breedings is lower). This typically translates into lower quality foals on average and a less successful race record for the stallion's average runner in future years.

[8] Recall from a principles of economics course that "breaking even" is defined as making a "normal" profit. So, Forty Karets is assumed to make a profit that is in line with the risk of his business.

1B. More mares will mean a greater absolute number of foals running in the future. More runners mean more winners, and probably more stakes winners as well.

So what will be the effects from having more runners that on average are less successful? The answer is not obvious. The response of potential buyers of stallion seasons and of the foals produced via these stallion seasons will depend on whether the absolute number of good runners is more or less important to buyers than the average success of a stallion's runners.

A second complication, already briefly alluded to, relates to the effects of larger numbers of mares being bred to the stallion (larger books) on the stallion's success at getting mares pregnant and the related question of the response of breeders to large books. Larger books will almost certainly lower the percentages of mares that get in foal, will result in some foals being born later than they would had the stallion had a smaller book, and will almost certainly decrease the desirability of breeding to the stallion.[9] It is the our view that the last of these three potentially negative factors should be reflected in the demand curve. The negative effects of large books on the desire to breed to a stallion can be represented as causing the demand curve to be lower than it would be in the absence of this effect. Perhaps then, the demand curve (and thus the marginal revenue curve), rather than being the straight line depicted in Figure 1, should be bowed toward a rainbow shape.

The effect of larger book size on the stallion's ability to impregnate mares, and also the effect of larger book size in pushing some mares back to later breeding dates will adversely affect revenues.[10] However, perhaps it is reasonable to also view these negative effects on revenues as costs, and thus to reflect these effects in the shape of the marginal cost curve.

This analysis represents the stallion as the lone major asset in a profit-maximizing firm. The product that the firm sells is stallion seasons. The analysis views the firm as operating in a market setting

[9] In a conversation that one of the authors had with a colleague in which he inquired as to why the colleague thought that the percentage of foals produced per mare bred was lower in recent years than fifteen or so years ago, his responses could be summarized in two words, "Bigger books!"

[10] One way to represent this would be to depict "net" average revenue and "net" marginal revenue curves that are adjusted for the fact that less than 100% of the mares contracted at the $40,000 stud fee will in fact end up paying the stud fee.

very close to monopolistic competition. There are many sellers and many buyers (though not as many as in a perfectly competitive market) and the stallion/firm markets seasons that are different in some way from those produced by any other stallion, hence the market type cannot be perfect competition. But the market type cannot be monopoly either, for a monopolistic firm produces goods that have no close substitutes, and that is not the case for the stallion/firm. One hundred and eighty or so seasons are contracted for that are initially indistinguishable, and typically the majority of those seasons will result in production of foals for which there are good substitutes produced by other stallions, hence the seasons of our stallion have close substitutes for sale by other stallions.

At the upper price levels for thoroughbred stallion seasons, there may be only a few stallions that are good substitutes for each other, in which case the market has some elements of oligopoly. But, since stallions compete with other stallions with the same prices and also those that are both substantially lower and higher priced, applying the standard oligopoly model to thoroughbred stallions is complicated. In the major market for Thoroughbred stallions, which is Kentucky, involving moderately-priced stallion seasons, and certainly in the markets for stallion seasons for breeds that allow artificial insemination, there are too many stallion/firms competing against each other to consider the situation oligopolistic, hence the monopolistic competition classification fits better.

But, as previously mentioned, there is one deviation from the usual case under the monopolistic competition classification. In many classical examples cited in the literature, monopolistic competitors produce multiple units of a homogeneous product that competes with similar but slightly different multiple homogeneous units of a closely related product. However, because every sperm cell has different DNA, every season provided by a stallion is a unique product. The authors of this analysis feel that this difference, though worthy of further analysis, creates only minor impediments to treating the stallion/firm as fitting into the monopolistic competition market type at lower and mid-level price ranges.

The stallion/firm is reasonably represented by Figure 1 in which we show demand and marginal revenue curves that are downward sloping, and we represent marginal cost as having the usual U-shape (albeit with a lower value at its low point than in representations of many other products). The

equilibrium price, which is the price on the demand curve associated with the quantity of output where marginal cost equals marginal revenue, represents a logical approach to depicting the optimal level of output and the optimal price for the stallion/firm.

True, there are some complications, most especially the fact that each stallion season contracted does not result in a payment to the seller because some mares do not produce a foal, that perhaps can be treated in a more sophisticated manner in a follow-on analysis of the stallion/firm. But, the approach taken provides a logical framework for analyzing the stallion/firm.

This said, we move on to make the analysis more realistic and more useful by considering additional related topics. First let us consider some of the decisions that go into setting the advertised price for stallion seasons, then we discuss the related topics of price discrimination and segmented markets.

Pricing, Segmentation, and Price Discrimination

One of the factors that complicates a stallion manager's life is that (s)he must decide on the "farm" or advertised price that will appear in the stallion register applicable to the breed, whether *Quarterhorse, Warmbred, Thoroughbred*, or some other breed well before the breeding season starts. The latest date that this decision has to be made varies with the date that the stallion register is published, though in most cases the stallion register will be published in the late fall, and a decision must be made perhaps three to four weeks prior to the publication date in order to meet production deadlines.

Even experienced stallion managers know that the price they post will not necessarily be the "right" price. If the posted price turns out to be considered too high by most potential buyers, then the stallion manager will have to scramble to find enough mares to breed. Occasionally an advertised price will be rescinded, and a new price announced, a phenomenon that is relatively rare. More than a few advertised prices turned out to have been set too high for the 2009 breeding season after the financial crisis that hit full force in the United States in the fall of 2008 caused most breeders to revise downward how much they would be willing to pay for seasons. As a result, more stallion managers marked down official season prices relative to those posted in stallion registers for the 2009 season than any time in

recent history. And many of the farms that did not publicly announce price declines worked behind the scene to provide inducements and deals that amounted to de facto price declines.

Stallion managers know that they may misestimate the appropriate price for stallion seasons, but when they do, they seem to prefer to err on the high side. There is logic to this preference, and an analogy to pricing in some financial markets serves to illustrate this preference. Large banks post rates (which amount to posting prices) that they are willing to pay on certificates of deposit. In many cases these posted rates are lower (the prices are higher) than the rates that the banks are willing to accept. All a customer (especially a good customer) has to do is to ask for a better rate and in many cases the higher rate (lower price) will be granted. But you ask, "why didn't the bank just post the rate it would pay and save everybody time and effort? The answer is that banks, like stallion managers, know that sometimes the rates they post will turn out to be too low. Perhaps a surprise announcement from the Fed causes rates to drop and the bank finds that before it can post a new lower rate it gets "hit" by customers asking for the posted rate. The bank could say, "Well, we were just kidding – those rates were designed to generate customer traffic…" or some other rationalization. The stallion manager could do something similar. But, customers might consider such a reaction with disdain, and the reputations of the bank and stallion manager might be impaired. Instead, what we see is that banks and stallion managers both tend to post prices that are above market, but are willing to negotiate downward, especially for good customers.[11] This way both the bank and the stallion manager don't have to sell seasons at bargain prices because the market changed quickly or because the advertised price was an underestimate of the value placed by potential buyers on the stallion's seasons.

There are other reasons why stallion managers prefer to post prices that are on the high side of market value. One reason why high prices are posted is because some (especially new) buyers don't stop to ask if the price can be negotiated downward. A quick story suffices to illustrate the logic of posting

[11] "Good" customers might be long-term customers, new customers with multiple mares, or a customer with an especially good mare that might have a good chance of "helping" the stallion in the sales ring or on the track. Or, if the stallion manager has badly overestimated the market price of his stallion, the definition of a good customer might be revised to "anyone remotely interested."

above-market prices. An acquaintance whom one of the authors has helped with her breeding plans once remarked to me that she rarely tries to negotiate for lower stallion season prices. She went on to say that she felt that stallion managers should post the "right" price and save her the time and effort involved in a negotiating process in which she really did not like to get involved. It was pointed out to her that she was not alone in disliking the process, but that one of the reasons stallion managers posted above-market prices was because they know that some buyers make no effort to negotiate.

This example can be viewed as one type of price discrimination by stallion managers, in this case discrimination against non-negotiating buyers. Stallion managers often post above-market prices, then charge customers who accept posted prices more than they charge savvier customers who bargain for lower prices. Stallion managers are able to do this in part because of differences in customer attitudes, but also because stallion managers often negotiate one-on-one with each individual customer[12]. Being able to negotiate one-on-one allows the stallion manager to try to "size the customer up" much as a used-car salesperson sizes up the walk-in looking for a car. Does the customer look/sound like (s)he (1)has a lot of money? (2) has shopped around for good buys elsewhere? (3) is a knowledgeable buyer? (4) has a strong preference for the product on the sales floor? The sales person who can make good assessments of the traits of each customer stands a better chance of extracting the maximum price from each customer. But, unless an above-market price had been posted in the first place, the room for negotiation (and profit to the seller) will be lessened.

Asymmetric information in economic markets is defined as a situation where buyers and sellers have different levels of information about a product being sold. In almost all cases the seller knows more

[12] The term "discriminating monopolist" is used here even though we have characterized the stallion seasons market as monopolistic competition. The point though, is that any time a seller has a unique product, the seller has a degree of monopoly power. For astute customers the degree of monopoly power will be small, as the astute customer will walk away if prices are unreasonable. However, the customer who walks in feeling that (s)he just has to have a season in the stallion "Speedball" because he is the only stallion that really matches well with her mare puts the customer into a position where the seller has substantial monopoly power, and the result will usually be a higher price than for other customers.

about the product (and what it is worth) than the buyer.[13] However, some potential customers know more about the stallion than others. For racing stallions, the customer who knows that the stallion won that "grade 1 race" such as the Kentucky Derby or the Breeders' Cup because the pre-race favorite was scratched, or the best horse was carried five wide by a horse that bore out, or the favorite "jumped a shadow" will probably not be willing to pay as high a price as the customer who doesn't know this. Additionally, as Stowe (2013) has written, aggregate progeny winnings of a particular sire are a better predictor of a stallion's stud fees than winnings per progeny, a fact which seems to indicate some variation in quality that mare owners or later buyers receive and see when the foals go on to compete.

Sellers use price discrimination because they know that different customers have different prices they are willing to pay for seasons. It is often possible to segregate potential buyers into categories where it is logical to charge different prices. Some of the reasons for price discrimination by groups are more obvious than others. A sprinting thoroughbred stallion might be equally successful as a sire of both thoroughbred and quarter horse runners. But chances are that the Quarterhorse breeders will be unwilling to pay as much as Thoroughbred breeders, with the explanation having two strands of reasoning:

1) The average Thoroughbred runner makes more money than the average Quarterhorse runner, hence the demand from Quarterhorse breeders will be less.
2) Quarterhorse mares do not have to have a "live cover" (they use artificial insemination [AI]) and the economics of AI are such that lower prices prevail. More on this later.

Thoroughbred stallion managers could set the same price for any mare bred to their stallions and tell the Quarterhorse breeders to "take it or leave it." We show later in this paper that this would normally be a mistake.

A second type of price discrimination can be based on geographic location. Market segmentation based on geography became more prevalent during the 2009-2011 downturn in the Thoroughbred market. All types of price discrimination, if logically based, reflect differences in the demand by different

[13] There are exceptions when the buyer benefits by asymmetric information. The expert buyer of rare books might find a book at a yard sale priced at $1 that is in fact a rare edition worth thousands.

individuals or different groups. Thoroughbred breeders in Kentucky generally breed better and more expensive mares, and expensive mares tend to be owned by wealthy owners. Thoroughbred breeders in Pennsylvania, Ohio, Indiana, Illinois, and every other state tend to have less expensive mares and tend to be less wealthy. (Similar reasoning may help explain why prescription drug prices are lower in less affluent countries).

(Insert Figures 2 and 3 around here)

Though there are exceptions, the generally less-wealthy breeders outside Kentucky have relatively lower demand for stallions in Kentucky than do Kentucky breeders. Relative wealth explains part of the difference. Distance from Kentucky necessitating van and hauling costs plus boarding costs explain much of the remainder of the differences in demand. Figure 1 reflected an overall demand curve, whereas Figure 2 segments the demand from Kentucky and from out of state for the stallion from Figure 1.

If we return to Figure 1 and consider the equilibrium conditions, the equilibrium quantity is 180 mares when the stallion manager considers the demand for Forty Karets seasons as a whole rather than considering Kentucky and out-of-state demand separately. If the Kentucky and out-of-state demand are broken out and appear as in Figure 2, a price of $40,000 charged in both markets would result in approximately 175 KY mares and 5 out-of-state mares.[14] But a discerning economics student is likely to argue that the equilibrium number of Kentucky mares should be fewer than 175 and out-of-state mares should be greater than 5.

A look at the orange horizontal line in the two diagrams representing a price of $40,000 reveals that it intersects the in-state demand curve at a quantity of 175 mares and the out-of-state demand curve at 5 mares. But that combination does not fulfill the classic equilibrium conditions that have the marginal revenue (rather than price) equal in both market segments in order to maximize the stallion firm's profits. And since the in-state MR is less than the out-of-state MR at 175 in-state and 5 out-of-state mares, the

[14] These diagrams may be improperly scaled, but hopefully that does not make interpretation difficult.

firm could make more money by contracting to breed fewer in-state mares and more out-of-state mares. The black numbers (160 and 20) rather than the orange numbers (175 and 5) reflect revenue maximizing quantities of in and out-of-state mares respectively.[15]

Note that in all figures we have to this point assumed that the stallion/firm does not practice price discrimination vis-à-vis individuals a la the used car salesman approach. Practicing individual price discrimination by negotiating individually with each potential purchaser could mean even greater profits, and in effect means that the stallion manager further subdivides the in-state and out-of-state markets based on his/her perception of the demand for seasons from sub-groups of potential buyers.

How would the stallion/firm implement the market segmentation strategy? There are several ways to do this, but the simplest would be to announce an advertised season price of $42,000. This would mean that exactly the right number of in-state seasons would be sold. As for out-of-state seasons, where the demand is less, rigidly adhering to the $42,000 price would mean that sales of out-of-state seasons do not generate sufficient volume. A careful reading of Diagram 1B by this writer suggests that the number of seasons sold out-of-state at a price of $42,000 would be zero.

What the stallion manager must do is find a way to lower the price for out-of-state sales so that the marginal revenue in both markets is equated. The most direct way to do this is to publish two prices, one for in-state and one for out-of-state breeders. If the demand from in-state breeders is greater the in-state price will be higher than the out-of-state price. Note that it is possible that the opposite pricing strategy makes sense if in-state demand is lower. Posting different prices is sometimes done, but rarely as discussed above.[16]

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[15] If 180 mares are bred at a contractual price of $40,000 each, the potential revenue (if all produce a foal for which the stud fee is paid) will be 180 x 40K = $7.2 million. If 165 in-state mares are bred at a price of $42,000 each and 15 out-of-state mares at $36,000 each, the potential revenue is 165 x $42K + 15 x $36K = $7.47 million. More realistically the likely revenue must be decreased to adjust for unpaid stud fees because of barren mares or non-paying customers. This adjustment does not change the logic of this analysis.

[16] In states that have breeder funds that pay stallion owners a percentage of the winnings of in-state runners, the extra potential earnings from this source makes it logical to encourage in-state breeders by charging them lower fees for stallion seasons than are charged to out-of-state breeders who will not race locally. This approach is taken by many stallion managers in Pennsylvania.

A seller who uses price discrimination faces several potential negative reactions. Breeders talk to each other, and if they see that a lower price is charged in one market they will attempt to access the lower price. A Kentucky breeder with a friend in Pennsylvania will ask the friend to write to the Kentucky farm to obtain Pennsylvania prices for seasons for his Kentucky mare. Perhaps more importantly, if breeders observe direct price discrimination, which is most obvious when two different prices are quoted, they may balk at paying the higher price. Stallion managers know this, and to decrease adverse customer reactions they are likely to undertake more subtle methods of segmenting markets for price discrimination purposes. Instead of posting two prices, stallion managers might instead obtain a list of out-of-state breeders and offer them less obvious concessions. Free board during the breeding season and compensation for vanning bills from out-of-state are two of several possible ways that the posted price is effectively discounted.

(Insert Table 1 around here)

Preliminary data analysis supports several of our arguments. Table 1 shows that in using breeding data from Bloodhorse.com (2019), we find that around 75% of the variation in the natural log of a stallion's stud fee in 2018 can be explained by three variables:

1. the log of the total earnings of the stallion's offspring from the previous year. This variable is used to indicate consumer or mare owner expectations regarding the stallion. Similar to Stowe (2013), average earnings per progeny which entered races the year before is found to be a weaker predictor of stud fees than total earnings. Perhaps mare owners dwell more on the latter than considering the former, which could perhaps imply some type of irrationality in purchasing and signing a contract for stud services.
2. the log of the portion of all mares bred by each horse listed as a share of all horses. The top 20 sires accounted for around 50% of all mares bred indicating some type of control over "output/production", which is a characteristic of some type of market concentration; and

3. a dummy variable where 1 = Kentucky and 0 = all other states where the hypothesis is that Kentucky based stallions have a greater share of the market and more inelastic supply. Stowe (2013) found this to be a statistically significant factor in predicting stud fees in her sample.

Because of problems of heteroscedasticity, robust standard errors are used in the model developed. No evidence of collinearity was found. All three variables are statistically significant at $\alpha < 0.05$ with the coefficient for 2017 earnings showing that on average a 10% increase in earnings yields a 14.6% increase in stud fees. The coefficient for mares bred shows that a 10% increase in the number of mares bred yields a 2.8% increase in stud fees, which indicates some degree of market power and market concentration. And the coefficient for the dummy variable indicates that a potential sire based in Kentucky is associated with 0.74% higher stud fee than stallions in other parts of the US. Therefore, Kentucky stallion owners appear to be able to charge higher prices than their counterparts in other states.

In accounting for the concentration of breeding among top stallions, it has been found using Bloodhorse.com records that the overall number of stallions offered for stud services has gradually and dramatically declined from 3098 in 2005 to 1136 in 2019. (Bloodhorse.com 2005-2019). Parallel to this, 840 foals were born from stallions who mated with 140 or more mares in 2005 whereas in 2019 there were 1397 foals sired by stallions who mated with 140 or more mares that year. More importantly, the number of foals produced by the top 20% of the stallions accounted for around 69% of the mares mated in 2005 whereas in 2019 the top 20% were matched with 75% of the mares bred. Concentration among the stop stallions appears to have increased.

At the same time, overall foal production has declined dramatically since 1990. The website of the Jockey Club shows that US foal output has gone from 40,333 in 1990 to an estimated 19,225 in 2019, and this is reflected in Figure 4 (Jockey Club Fact Book 1990 to 2019). Correspondingly, the number of races held in the US on annual basis has also declined dramatically as shown in Figure 5 (Jockey Club Fact Book 1990 to 2019) as inflation adjusted purses per race have stagnated after adjusting for inflation. Therefore, tough times and a decline in the racing industry have sunk the demand for foals in general with fewer stallions participating in the market, and this in turn has resulted in even greater concentration

among the top stallions. Given the high aggregate earnings of their offspring and fewer competitors over time, it is understandable that their numbers of customers have gone up despite increasing stud fees.

Conclusion: Implications and Questions Regarding Artificial Insemination

Students of equine studies know that thoroughbred breeding requirements, which are set by the Jockey Club, require that mares be bred in the natural fashion, and any foal that results from an artificial method of insemination is banned from being registered. In contrast, almost every other breed allows artificial insemination, which typically involves shipping cooled or frozen semen from the farm where the stallion resides to the farm where the mare is boarded. What follows is a preliminary analysis of the economics of artificial insemination (AI) that builds on the previous analyses.

Recall that in Figure 1, which assumed that current breeding rules prevailed, we represented the equilibrium for Forty Karets as the level of output (number of seasons sold) where marginal cost and marginal revenue were equal. This resulted in an equilibrium price of $40,000 and at a quantity of seasons sold (mares bred) of 180. What would be different if AI were allowed?

If AI is allowed, it will not be restricted to one stallion. But, it is useful to consider this intermediate condition as a stepping stone in the analysis that follows. This will assist in understanding what will ultimately result if AI is allowed for all Thoroughbred stallions. Juxtaposed to Figure 1, Figure 3 is modified for the obvious changes that will occur for a stallion/firm that operates exclusively using artificial insemination. There are two significant differences under AI:

1. The demand curve, though sloping downward, will not drop off as fast at higher numbers of seasons sold.[17] This is because under AI the probability of your mare being queued is significantly diminished. While even the most fertile stallion can provide only four covers a day, and very few do that on a regular basis, an AI stallion can be collected and the sample split so that many more mares can be serviced. As a result, there is less chance under AI that a mare will not be bred at the optimal time because of a breeding shed queue, and thus mare

[17] Recall that this concern was discussed, but that the demand curve in Figure 1 was not drawn to reflect a significant concern about a mare being queued.

owners booking to AI stallions with large books do not discount what they will pay for season prices as much because of the decreased probability of getting a mare bred at the right time.

2. The marginal cost curve under AI will differ in at least two respects.

   A. It may tend to be a bit higher in the middle ranges because of the cost of the technology for breeding under AI guidelines. Whether cooled or frozen semen is used there will be a significant cost to providing transportation for its storage and delivery.

   B. The marginal cost curve will be closer to flat over a wider range than for natural breeding. This is because there will be little to no decline in the incidence of pregnancy for mares as more mares are bred. The higher percentages of mares that produce live foals will mean fewer costs to the stallion/firm associated with breeding higher numbers of mares. However, the marginal cost will turn up because a milder case of the queuing problem will occur as large numbers of seasons are sold. And, under AI, if stallion managers try to adjust by skimping on the amount of semen they ship they may find that there will be a cost in terms of lower numbers of pregnant mares. (Note that if "regulators" such as the Jockey Club restrict the number of mares bred under AI the queuing problem diminishes or disappears.)

3. The average cost curve will change little for lower levels of season sales, but will be lower at higher quantities of seasons sold under AI. This occurs because the lower marginal cost of production under AI pulls the average cost down at these higher levels of season sales.

In Figure 3, when Forty Karets is the only stallion using AI, the result is a lower marginal cost of production at higher levels of output, and the lower marginal cost curve pulls the average cost curve down below the average revenue curve. At the new (higher) equilibrium of output Forty Karets now makes more than the normal profit assumed in Figure 1. In summary, under the Figure 3 conditions, Forty Karets has the same demand curve as in Figure 1, but lower marginal and average costs. The marginal

cost curve intersects the (unchanged) marginal revenue curve at a higher level of output (higher level of season sales), and this higher level of season sales can only be sold at a lower price than under Figure 1. But costs are lowered more than revenues, and thus Forty Karets is now projected to make an above average economic profit.

If Forty Karets is one of many stallions in his price range, then the increased market share he garners as a result of AI will have a negligible effect on demand for other stallion seasons, and the profits of his competitors will diminish slightly as Forty Karets attracts a small number of mares from each close substitute stallion. In the price range ($40,000 or so) used in this example however, Forty Karets is likely to be one of only a relatively small number of stallions, and Forty Karets' lower price and higher volume of season sales will have a noticeable (and negative) effect on his closest competitors' profits and volumes of season sales.

The Jockey Club would not put themselves in the position of favoring one stallion by allowing it to use AI and not another. The analysis just completed was an interim step to the solution that will result if all stallions can use AI. The analysis to this point has, among other things, utilized standard tools of microeconomic analysis in diagramming plausible scenarios for revenues, costs and prices. But before proceeding further we need to be more specific about assumptions. More specifically the assumptions regarding the demand for stallion seasons should be discussed. Figures 1 and 3 show the quantity demanded for an individual stallion's seasons to be downward sloping with respect to price. Said another way, if a stallion manager lowers price, the number of seasons demanded by buyers will be greater. What was discussed only peripherally was the effect on demand if the prices of competitors' stallion seasons change. In one extreme case this discussion would not be necessary. That would be the case where there are no substitutes for the stallion seasons of a particular stallion (and no substitutes from the perspective of buyers of foals for the foals produced by this particular stallion). This argument is equivalent to arguing that the stallion operates as a monopoly.

In this (admittedly extreme) case, the demand for "NOSUB" stallion seasons will be steeper than that of a stallion whose seasons have substitutes. The assumption of no substitutes for seasons or foals

produced from these seasons implies that the no-substitutes stallion's seasons and foals trade in a market that is insulated from the market for other seasons and foals. The normal expectation is that the market-clearing price for a stallion's seasons will drop in sympathy when the prices of competitors' seasons fall. This logic assumes that if Stallion A's season price was not lowered in response to declines in competitors' prices, then buyers who were on the fence about whether to breed to stallion A or stallion B would move to stallion B if its seasons were offered at lower prices as long as stallion A's seasons are unchanged. But, if no one is ever on the fence (as will be the case with the no-substitutes stallion) then the prices of other stallion seasons are not a factor in the pricing for a NOSUB stallion.

More realistically, the demand for a stallion's seasons is a function of not just one, but two major (and many other perhaps less important) factors. In addition to the price of the stallion's seasons breeders also consider the prices of other stallions' seasons. The quantity demanded is expected to decrease as the quoted (own-price) of a stallion's seasons increase, and the quantity demanded is expected to increase as the prices of competitor stallion seasons increase.

When we consider the case in which all stallions move to AI, we will have to rethink Figure 3. If all stallions move to AI, the decline in the marginal cost curve will cause all stallions to want to move down their demand curves to an increased level of stallion seasons sales at a lower price (as is shown for Forty Karets in comparing Figure 1 with Figure 3, where the optimal level of output changes from 180 seasons to 280 seasons). But, if all stallions are making similar adjustments, the new equilibrium depicted in Figure 2 is not possible. More particularly, the market will be flooded with seasons that were not available previously, with the result that the demand curve for Forty Karets and the demand curves for all other stallions will drop due to the lower prices available from competitors. Each stallion for which there is considerable demand will be likely to sell more seasons, but at lower prices. The demand for some stallions that bred significant numbers of mares (30-50?) will drop so low that they will breed few (or no) mares. Detractors of AI will argue that the gene pool will be narrowed. We would argue that breeders could (and probably would) breed to more proven stallions because of lower prices, and that the quality of the breed will improve as a result. Moreover, breeders will be well aware of the possibility of a

narrowing gene pool, and it will be in their best interests to widen the gene pool when it will result in better foals. However, there are many unanswered questions, and these are:

1. Will the use of proven stallions increase relative to young unproven stallions?

   Almost certainly since their lower prices and increased availability will tend to attract breeders – the Thoroughbred industry has seen a variation on this theme over recent decades as improved veterinary practices has allowed stallion book sizes to increase dramatically.

2. Will the quality of foals increase or decrease?

   Quality is likely to increase modestly for several reasons – Proven stallions produce higher quality foals than the average unproven stallion.)

3. Will the quantity of foals increase or decrease? Will the cost of producing foals increase or decrease?

   AI will probably lower cost of producing foals by making using a van to/from the stallion farm unnecessary. Out-of-state owners will not have to pay board in Kentucky and other breeding centers. AI will also diminish the probability of sexually-transmitted diseases that have periodically plagued the Thoroughbred industry. Lower costs and greater access to quality stallions will tend to increase the average quality and lower the average cost of producing foals. This will tend to increase the attractiveness of breeding and thus the number of foals produced.

4. Will resources be freed up to make the overall economy more efficient?

   Though van drivers, Kentucky boarding farms and Kentucky vets will have less to do, savings to breeders will stimulate sales in other areas.

5. Why doesn't the Thoroughbred industry move to AI?

   Almost certainly a part of that answer is related to a phenomenon that Milton Friedman (1984) labeled "The Tyranny of the Status Quo." Will not the many good folks who are members of the Jockey Club that governs the Thoroughbred industry either consciously or unconsciously try to protect their own and their friends interests, which more often than not will mean protecting large Kentucky breeding farms, often to the detriment of the average breeder and racing fan? Such was

the argument made by Coelho and McClure over 30 years ago from the time of this writing, and the evidence presented in this article tends to support them.

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Figure 1: Equilibrium Conditions for the Stallion "Forty Karets"

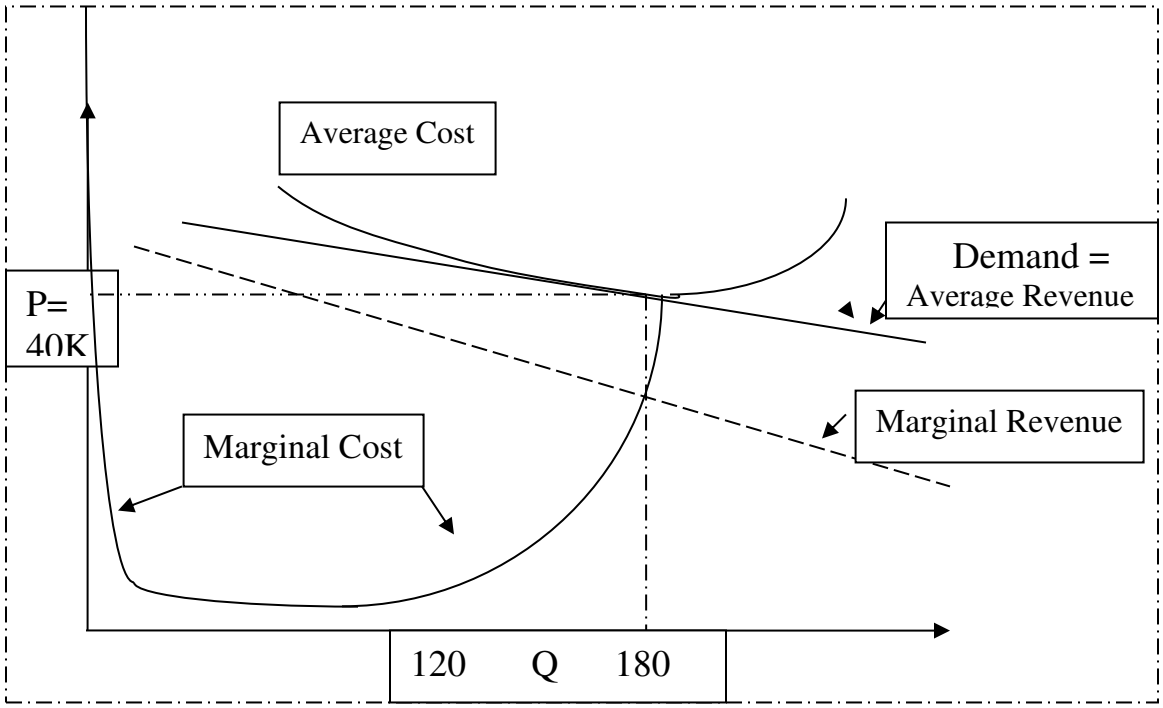
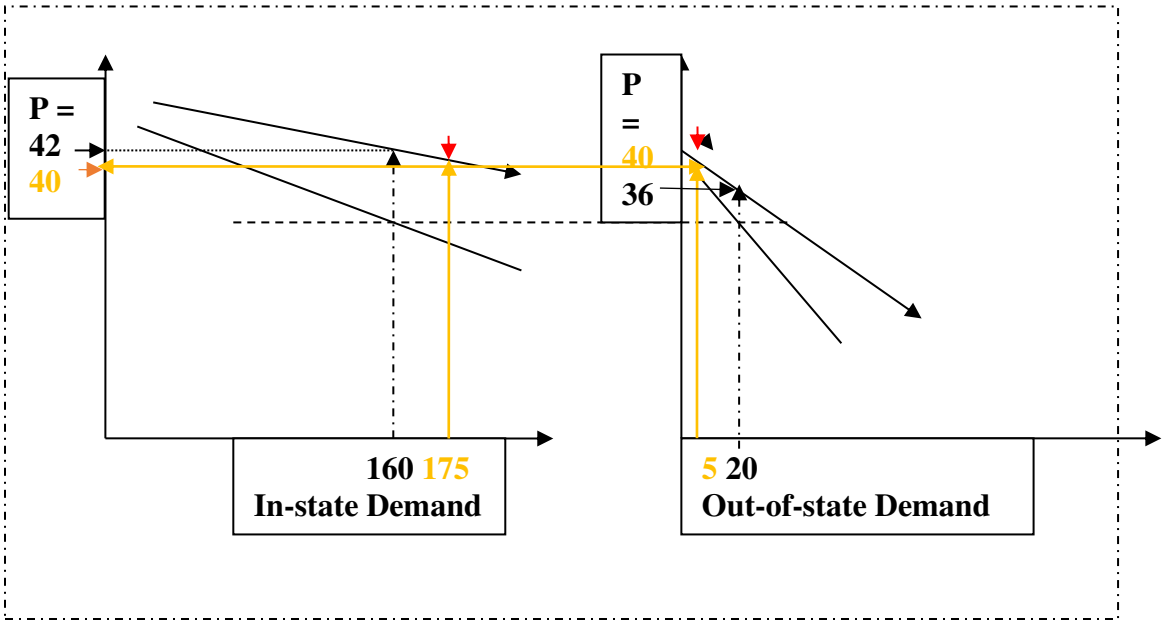
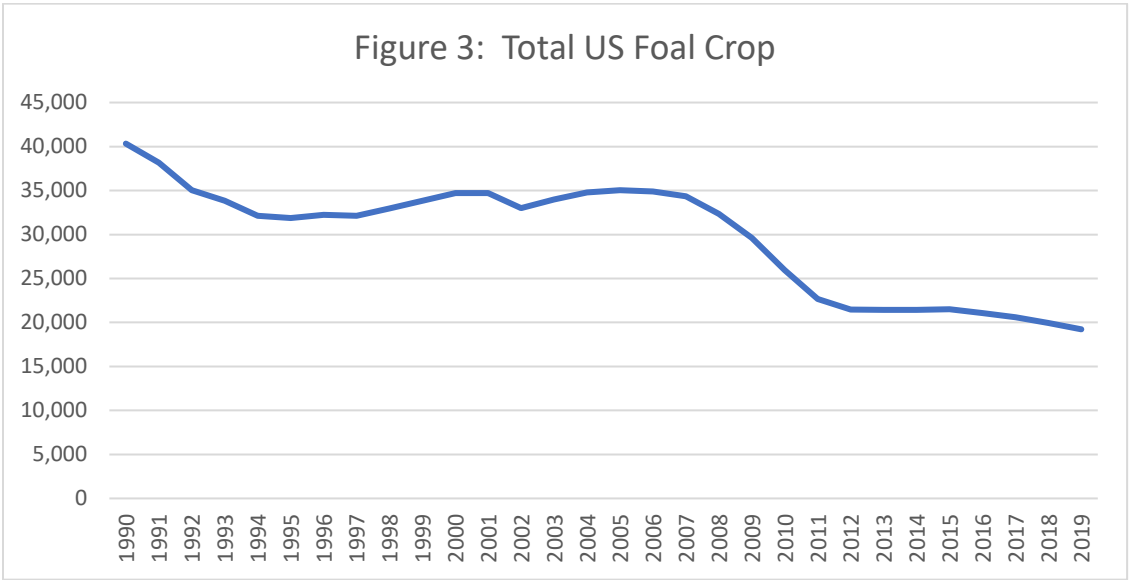
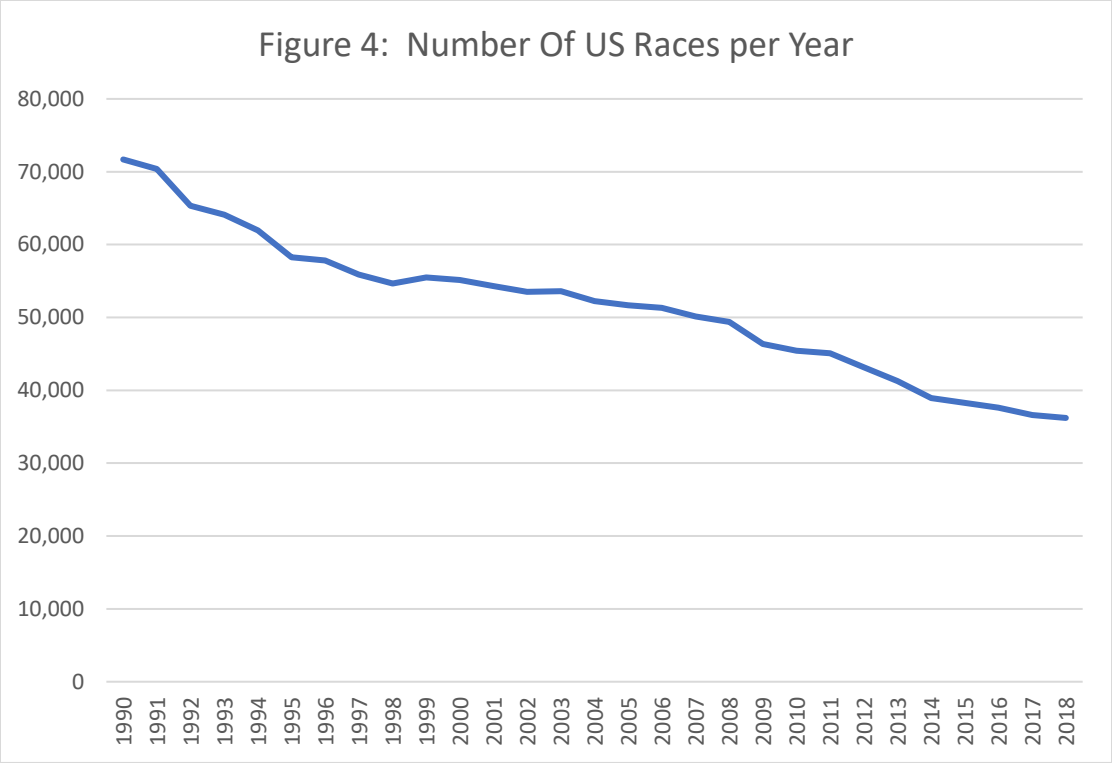


Figure 2: Segmenting Demand for Forty Karets





Source: Jockey Club Fact Book, 1990 to 2019. http://www.jockeyclub.com/default.asp?section=Resources&area=11



Source: Jockey Club Fact Book, 1990 to 2019. http://www.jockeyclub.com/default.asp?section=Resources&area=11

Figure 5: Revenues and Costs Under AI for Forty Karets Only

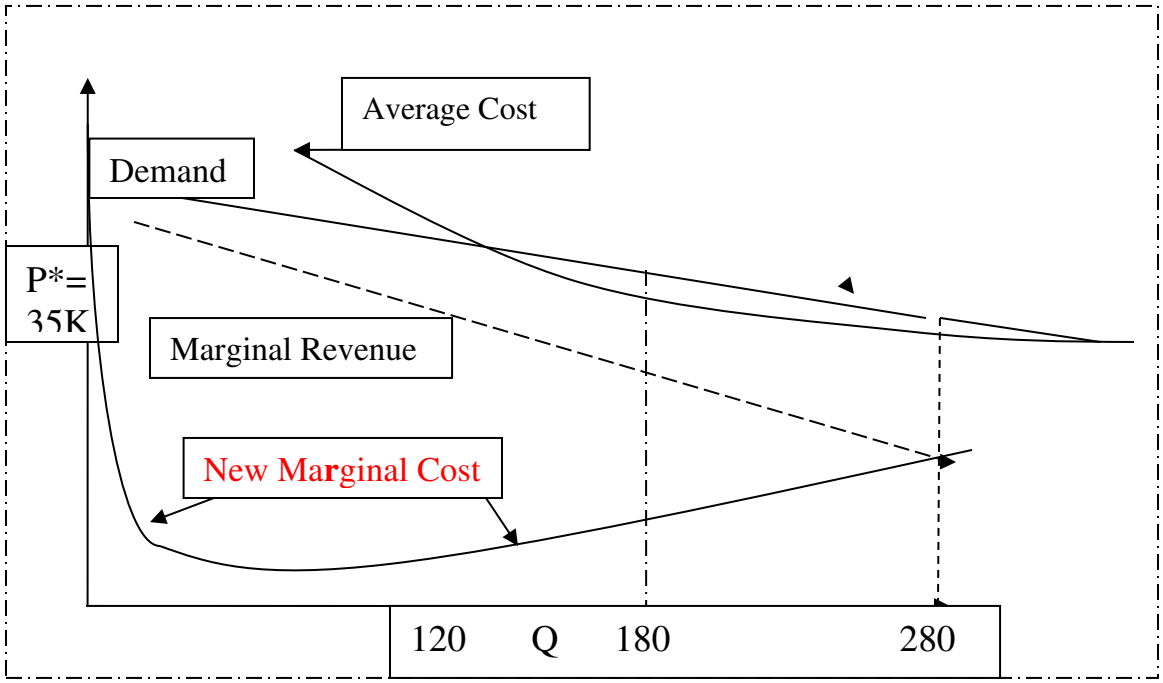


Table 1: Least Squares Regression Output with Robust Standard Errors

Dependent Variable: Ln of Stud Fee

	b (robust s.e)
Ln Mares Bred % Total	0.28** (0.11)
Ln 2017 Earnings	1.46*** (0.19)
Geographic Dummy Variable	0.74*** (0.13)
Intercept	-14.44
Adj. r-sq.	0.75

***p<0.01
**p<0.05

n = 80