Overproduction of Yearling Thoroughbred Racehorses

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ABSTRACT

The world market for unbroken yearling Thoroughbred racehorses has exhibited signs of overproduction for some years. This paper explains why, by extending the theory of monopolistic competition to a market for a group of heterogeneous products, ordered by quality, and characterised by perfect price discrimination. The industry demand curve is found to be the marginal revenue curve. The industry supply curve is shown to be downward-sloping and the absence of barriers to entry causes suppliers to continue to produce beyond the point which maximises the social rent. Thus intra-marginal losses are caused by a market failure.

1. INTRODUCTION

DIXIT AND STIGLITZ (1977) stated that the basic issue in welfare economics is whether a market solution yields socially optimal kinds and quantities of commodities and that problems can arise for three broad reasons: distributive justice, external effects, and economies of scale. This paper demonstrates a fourth — the presence of heterogeneous, irreplicable products constituting a group.

The markets for yearling Thoroughbred racehorses especially in the USA and Europe have been the subject of persistent complaints of overproduction for some years. Overproduction is defined as a situation where the marginal profit of the industry is negative. While some would try to control the situation by regulation, it is feared that these would be the subject of legal challenge on competition grounds. The only solution suggested is that market forces and education must be allowed to solve the problem (Thoroughbred Breeders' Association 2009). The heroic assumption is that they can, but finding a solution is an imperative because of the animal welfare implications.

Such markets may be characterised by ordered supply and ordered demand within a monopolistically competitive structure. Buyers purchase these horses, unbroken and therefore unknown quantities in their intended

use, on the basis of phenotypic and genotypic factors, mainly their pedigree and conformation (Love *et al* 2006). As each animal offered for sale is unique, each obtains its own price and the product may therefore be considered heterogeneous. An ordered market emerges, ranging first from those perceived as best finally to the least attractive. De Meza (1983) showed that the Chamberlinian model is sufficient to illustrate that under- or overproduction may occur in monopolistic competition (Chamberlin 1950). However, the output of the products in the group he discussed was capable of being expanded or contracted by participating firms. The heterogeneity of young Thoroughbred racehorses means that in this group that process is impossible as a mare can produce only one foal per year.

The standard market incentives, demand and profit, ensure more horses can be produced but they will be of declining quality. Since the market is ordered it follows that suppliers will strive to supply the best quality. This means that marginal additions to supply will be successively inferior. This has consequences for the market.

Industry complaints of overproduction are only *prima facie* evidence that it exists. However, examination of sales data suggests that they have substance and the theory developed in this paper shows that it is endemic. Stallion profitability tables show that stallions at stud in Great Britain and Ireland are estimated to have produced between 17.4 per cent and 92.5 per cent profitable foals, with notably poorer percentage returns among the least expensive stallions (Anon 2009).

Attempts to determine the profitability are beset by the identification problem. There is a thirty or so month period between the initial covering of a mare and the foal being sold. Breeders' decisions are therefore heavily dependent on their expectations of demand. Between the covering decisions in the winter of 2007 and the sale of the yearlings in the fall of 2009 the recession induced by the banking crisis of 2008 had a major impact on the position of the demand curve and average prices obtained. Up to then, the market had enjoyed a period of stable growth and there is every reason to believe that in 2007 breeders could know little better than that it would continue. During that time there were continuing complaints of over-production and it appears highly unlikely, especially with the conclusions of this paper, that the results for 2009 were attributable to the economic downturn alone.

The purpose of this paper is to test the validity of complaints of overproduction by providing a theoretical foundation to an explanation of the market. The remainder of the paper is divided as follows: in Sections 2 and 3 the characteristics of demand and supply are considered. Section 4 examines the impact of perfect price discrimination, perfect product differentiation, and the ordered market on the behaviour of the Thoroughbred breeding industry. In addition to the perceived demand curve being the marginal revenue curve, it is shown that the average cost curve is the industry supply curve, is downward sloping and leads to a market failure, resulting in an equilibrium where

industry profits are dissipated and there is overproduction. In Section 5 the contribution to social welfare is examined and it is concluded that the social optimum lies at a point of greater output than where industry marginal revenue equals marginal cost. This occurs where the increment to consumer surplus equals the marginal loss.

2. Characteristics of demand

Ordinal demand develops because purchasers will attempt to obtain for their available money the animal displaying the best quality defined by pedigree and conformation. If another purchaser outbids them they have to settle for the next best. While within this there will be some variation of preferences brought about by subjective judgement of the qualities of an individual, it is nevertheless possible to identify a clear structure of preferences revealed by the price that each horse is able to fetch. For the firm selling yearlings each element of output has its own price. The particular selling price of each animal accumulates to total revenue and there is no common price shared among a brand of products. Robinson (1969) concluded that under such perfect price discrimination the marginal revenue curve becomes the firm's demand curve. However, the marginal revenue curve amounts to a hedonic price schedule reflecting both supply and demand (Lansford *et al* 1998). In this paper the supply and demand curves are disentangled.

Breeders face a restriction on output because of the heterogeneity of each product. This makes the Thoroughbred-producing firm's marginal revenue curve only its perceived demand curve. Commer (1994) noted the importance of perceived quality factors in determining the price a yearling obtained at the Fasig-Tipton Inc. Sales in Maryland, USA, noting that financial rewards will arise from adhering to buyer preferences. Vickner and Koch (2001) identified hedonic preferences in the Keeneland, Kentucky, USA yearling sales. Neibergs and Thalheimer (1997, 1999) constructed a supply and demand model but omitted a critical factor, the heterogeneity of each yearling, in determining the market equilibrium by using an average price for yearlings.

The true demand curve will be located somewhere above the perceived demand curve. The open ascending auction method widely used for selling yearlings leaves the purchaser with an element of consumer surplus which will also be present in sales by private treaty. The consumer surplus attributable to each yearling will be the difference in price between it and the next best animal in the market since, with the ordered market showing revealed preferences, the purchaser could be expected to be the underbidder for the next best. For example, suppose Bidder A bids £10,000 for a yearling, is outbid by Bidder B at £11,000 and decides not to go on. Bidder B might have been willing to bid £12,000, the sale price of the next best in the ordered market when B was this time the underbidder but has not had to go that far. The total consumer surplus in this perfectly ordered market is, thus, the sum of the price decrements.

3. Characteristics of supply

Supply is also governed by the characteristics of each animal and an ordered structure may again be observed. Pedigree is partly known when the decision is taken to breed. However, the breeder faces a series of unknowns created by the lag of thirty months or so that elapses before the result of a mating is offered for sale. Previous progeny of the mare may add value to a yearling by performing well or vice versa. Conformation is wholly unknown at that stage but on average better pedigrees produce better conformation.

In general, in an attempt to produce foals of the highest possible quality, the better mares will be mated to the better stallions, and with perfect information, each successive mating as output expands to meet demand should be anticipated to produce an animal of lesser quality than the previous. The best mares will be the first to be chosen for covering. In the model developed here, it is assumed that a higher quality mare is never, for economic reasons, left uncovered while a lesser mare is used as it would be irrational, given her input to the price fetched for her yearling. This means that the only way the industry can expand is to produce lower quality animals. Firms will compete for the better quality mares, but a firm which improves its position forces another to lower the quality of its production.

While the explanatory model developed in this paper rigidly assumes this, in practice there are two important reasons why this may not be wholly true. First, imperfect knowledge means that breeders may not know exactly the structure of supply and, secondly, frictions created by the choices associated with exclusive ownership may mean that a stud operating at the higher end of the market may temporarily leave a mare barren while another at the lesser end covers its poorer quality mares. A high quality mare would not be left uncovered because the cost of a nomination to a stallion of appropriate quality was too high. She would be sent to one whose cost was expected to leave the breeder with a profit. In general, then, the pattern is of the best quality mares being the first to be chosen for covering. Because of this, there may also be assumed to be a gradation in the cost of a nomination to a stallion which follows the pattern where those perceived as best by the market fetch the highest fees.

The gradation of foals on the supply side is less strict than on the demand side because of uncertainty. The foals produced by each mare vary considerably in conformation from year to year, and the value of the pedigree changes as the performance on the racetrack of the parents' previous foals emerges. Mares will be taken out of production if the breeding firm makes losses. In trying to maximise profits the firm will also discard mares which offer no prospect of producing a profitable foal but this is notoriously difficult to determine and can only be judged after several foals have raced — at least five years elapses in such cases. Likewise, stallions will command a similar fee from mare-owners so that there will be a stepped structure in costs. However, this will be most marked at the higher quality end of the market and hardly noticeable at the lower end.

The opportunity cost of each mare, which can produce at most only one marketable foal each year, will similarly be higher or lower according to her perceived quality. This has the effect of producing a marginal cost curve with a permanent downward gradient.

The model developed here assumes that to increase the supply of yearlings less and less has to be paid for the stallion nomination because the last available are of the least quality. Similarly, the cost of the marginal mares is assumed continually to decline because the last brought into production are also of the least quality. While neither of these is absolutely true in the real world they reflect the flavour of the market structure. Thus the supply curve of the Thoroughbred breeding industry is downward-sloping over the area in which the industry operates. Ultimately, demand for the factors of production might become sufficiently strong to cause the cost of expansion to rise. This throws up an interesting consequence of ordinality; an increase in supply is represented by a lengthening of the supply and marginal cost curves not a rightwards shift.

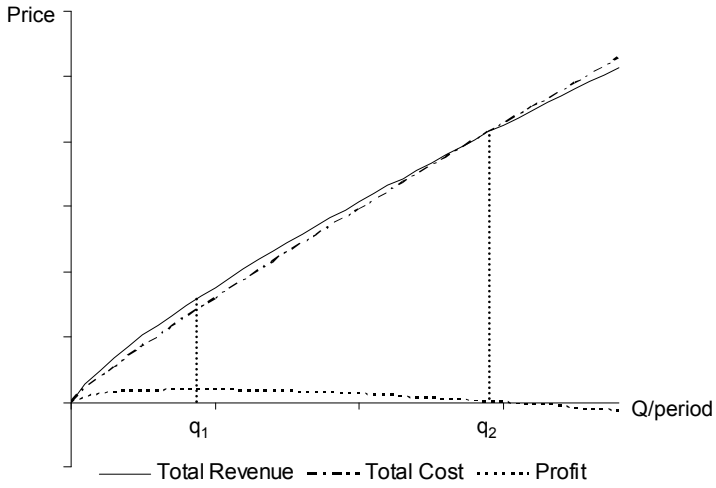
4. The Thoroughbred breeding industry in monopolistic competition

These issues can be considered using deductive logic.[2] Competition and the absence of barriers to entry mean that industry profit will be maximised at the level of output where marginal revenue, demand, equals marginal cost, shown as q_1 in Figure 1. The profit is an incentive to others to enter the market, and in the absence of barriers to entry, an externality is created which leads to the dissipation of the profit. This incentive may be exaggerated by strong short term demand and *vice versa*. A cyclical pattern may well underlie the response of supply. Strong demand will encourage increased supply but there is a lag of about three and a half years between breeders observing the strength of demand and yearlings being marketed in response to it. A similar lag will greet slackening demand.

Equilibrium develops at q_2 where the industry's average revenue equals its average cost. The marginal yearlings are sold at a loss. No individual firm can remove the market failure and self-imposed attempts to limit production will prove fruitless owing to the absence of entry barriers.

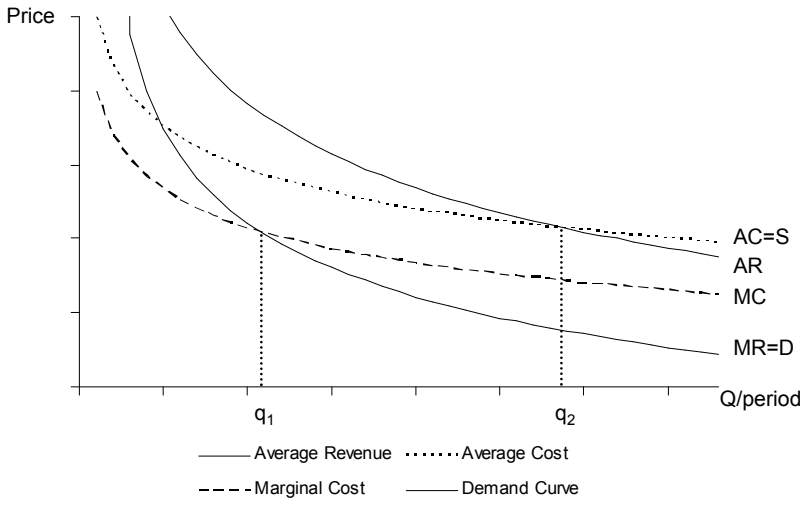
The industry supply curve is thus given by the average cost curve which is the locus of the point of equilibrium for any given level of demand. Because only inferior animals, each progressively less costly than their intramarginal counterparts, can be added to productive capacity in order to increase supply, the industry supply curve retains a downward gradient throughout its length.

Figure 1: Revenue, Cost and Profit of the Thoroughbred Breeding Industry



The case of the average cost curve serving as the supply curve is not unique. It has been found previously in self-renewing natural resources such as open access fisheries (Copes 1970) where there is also a market failure present. The market position with demand and supply is shown in Figure 2. The standard competitive market equilibrium condition, average revenue equals marginal cost, does not apply in this market and occurs to the right of the Figure. It does not apply because the demand curve with perfect price discrimination is the marginal revenue curve rather than the average revenue curve.

Figure 2: Equilibrium of the Thoroughbred Racehorse Breeding Industry



This leaves the profit maximising point to occur at q_1. However, nor is this an equilibrium point because average revenue is greater than average cost and the signal the market sends to breeders is that there are profits to be made from joining the market. As more breeders join the market, or the existing ones expand their production, the profit is dissipated. This is a congestion externality and expansion will continue until, at a level of output q_2 where the average revenue equals the average cost, the profit is wholly lost.

It is argued above that the marginal cost curve has a downward gradient, owing to the impact of quality on the order of supply and demand. The assumption that over the area of the marginal cost curve where the industry operates it is downward sloping is derived from observation and amounts to an assertion which may be challenged when further empirical evidence emerges. However, it is not crucial to the argument. It just affects the degree of overproduction, not its presence. It can be seen from Figure A2.1 in Appendix 2 that even if the marginal cost curve were to assume its normal upward slope, q_1 would not represent an equilibrium point. The profit would still be dissipated but the extent of overproduction would be reduced and depends on the relative price elasticities of demand and supply.[3]

5. Discussion

This paper characterises over-production as a market failure. It may be attributed to a series of unusual features derived from the heterogeneity of each product within the group. It should be noted that the effect of perfect heterogeneity is to make it impossible to define any of the revenue and cost curves for the firm or industry because we are dealing with a group of products. Only with the addition of the assumption of ordinality can this be done. This means that the supply and demand curves investigated have been defined by the writer. The firm and industry marginal revenue curves are the perceived demand curves. The industry supply curve is the average cost curve. These features and the absence of entry barriers mean that industry equilibrium is not reached until a level where the profit has been dissipated. This explains why overproduction exists, manifested as losses on the marginal yearlings, and that it is caused by perverse market forces. It also indicates why market forces have failed to remove the problem of losses on marginal animals. Overproduction is ineradicable if market forces are allowed to prevail unconstrained.

In a perfectly competitive market, the contribution to social welfare, the economic rent, is the sum of the consumer and producer surpluses. Each is obtained coincidentally at the market equilibrium, which, hence, offers the social optimum. Leeson and Sobel (2007) contend that perfect price discrimination is always socially inefficient for the monopolistic competitor because of the costs of discriminating compared to uniform pricing.

In the market for yearlings, however, breeders have no choice and consumer surplus is maximised where average revenue equals average cost.

Producer surplus is at its greatest where marginal revenue equals marginal cost. Each extra yearling beyond that point reduces the profit until at the market equilibrium it equals zero. The social optimum therefore lies at the level of output where the marginal contribution to consumer surplus equals the marginal loss (*MC*>*MR*), q_2, to the industry. This point is hidden from consumer and producer alike and so the market is unable to send a signal to limit production to that point. The problem is compounded by the uncertainty relating to the conformation of yearlings produced and the consequent unpredictability of the market order at the time of mating. The conclusion is, therefore, that the equilibrium is socially inefficient and neither market forces nor education can solve the problem of overproduction of Thoroughbred yearlings.

The analysis suggests that overproduction is a problem only of the supply side. Breeders lose their intra-marginal super-normal profits but racehorse trainers, their staff and owners benefit from the availability of below-cost inputs to the market downstream. If this alone were the situation then breeders might simply have to beware the market and compete to produce the higher class yearlings where individual firms could still make profits, presumably with a continual exit and entry of firms at the lower end of the market. However, the analysis is only partial. Effectively the breeding industry hands its producer surplus to the training industry.

The availability of cheap yearlings at below their cost of production alters the decision between keeping an older horse in training and buying a yearling. The point of indifference is shifted towards purchase of the new animal. This distorts the age-structure of horses in training, skewing it towards the younger animals. It explains why the flat-racing industry is so heavily concentrated on two- and three-year olds, which are frequently discarded well before they reach a horse's age of maximum strength at five. A second inefficiency thence relates to the animal welfare effects on the social welfare function.

The economically undesirable effects of overproduction of yearlings are therefore not confined to the breeding industry but extend into racing and to society as a whole by fostering a misallocation of resources. It is clear that market forces cannot solve the problem; indeed, they create it.

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APPENDIX 1

Theorem: That the equilibrium point in the market for Thoroughbred yearlings given by the equality of average cost and average revenue is at a greater level of output than the profit-maximising level given by the equality of marginal revenue and marginal cost.

Let the Total Revenue function be $TR = \alpha_0 Q^{\alpha_1}$ (1)

where TR is total revenue, Q is the number of yearlings, and the αs are parameters

and let the Total Cost function be $C = \gamma_0 Q^{\gamma_1}$ (2)

where C represents total costs and the γs are parameters such that

$$\alpha_0 > \gamma_0$$

$$\alpha_1 < \gamma_1$$

$$\alpha_0, \gamma_0 > 0$$

$$0 < \alpha_1 < 1$$

and $$0 < \gamma_1 < 1$$

Average Revenue, AR, is $AR = \frac{TR}{Q} = \alpha_0 Q^{\alpha_1 - 1}$ (3)

Marginal Revenue, MR, is the Demand Curve and is

$$MR = \frac{dTR}{dQ} = \alpha_0 \alpha_1 Q^{\alpha_1 - 1} \quad (4)$$

Average Cost, AC, is the Supply Curve and is

$$AC = \frac{C}{Q} = \gamma_0 Q^{\gamma_1 - 1} \quad (5)$$

Marginal Cost, MC, is $MC = \frac{dC}{dQ} = \gamma_0 \gamma_1 Q^{\gamma_1 - 1}$ (6)

Let $$\alpha_0 = \gamma_0 + \phi_0 \quad (7)$$

and $$\alpha_1 = \gamma_1 + \phi_1 \quad (8)$$

where $$\phi_0 > 0$$

and $$\phi_1 < 0$$

Then the cost functions relative to the revenue functions may be written

$$C = (\alpha_0 - \phi_0) Q^{(\alpha_1 - \phi_1)} \quad (9)$$

$$AC = \frac{C}{Q} = (\alpha_0 - \phi_0) Q^{(\alpha_1 - \phi_1 - 1)} \quad (10)$$

$$MC = \frac{dC}{dQ} = (\alpha_0 - \phi_0)(\alpha_1 - \phi_1)Q^{(\alpha_1 - \phi_1 - 1)} \tag{11}$$

From $$\Pi = TR - C \tag{12}$$

Profits, *Π*, are maximised where *MR=MC*. Thus

$$\frac{d\Pi}{dQ} = MR - MC = \alpha_0\alpha_1 Q^{\alpha_1 - 1} - (\alpha_0 - \phi_0)(\alpha_1 - \phi_1)Q^{(\alpha_1 - \phi_1 - 1)} = 0 \tag{13}$$

$$Q = q_1 = \left[\frac{(\alpha_0 - \phi_0)(\alpha_1 - \phi_1)}{\alpha_0\alpha_1}\right]^{\frac{1}{\phi_1}} \quad \text{at the turning point.} \tag{14}$$

For a maximum $$\frac{d^2\Pi}{dQ^2} = \alpha_0\alpha_1(\alpha_1 - 1)Q^{\alpha_1 - 2} - (\alpha_0 - \phi_0)(\alpha_1 - \phi_1)(\alpha_1 - \phi_1 - 1)Q^{(\alpha_1 - \phi_1 - 2)} \tag{15}$$

substituting (14) into (15)

$$\frac{d^2\Pi}{dQ^2} = \alpha_0\alpha_1(\alpha_1 - 1) - (\alpha_0 - \phi_0)(\alpha_1 - \phi_1)(\alpha_1 - \phi_1 - 1)\frac{\alpha_0\alpha_1}{(\alpha_0 - \phi_0)(\alpha_1 - \phi_1)} \tag{16}$$

$$= \alpha_0\alpha_1\phi_1 < 0 \quad \text{as required} \tag{17}$$

In equilibrium $$\Pi = TR - C = 0 \tag{18}$$

$$\alpha_0 Q^{\alpha_1} = (\alpha_0 - \phi_0)Q^{(\alpha_1 - \phi_1)} \tag{19}$$

$$Q = q_2 = \left[\frac{(\alpha_0 - \phi_0)}{\alpha_0}\right]^{\frac{1}{\phi_1}} \tag{20}$$

If $q_2 > q_1$ then let $x = q_2 - q_1 > 0$

$$\left[\frac{(\alpha_0 - \phi_0)}{\alpha_0}\right]^{\frac{1}{\phi_1}} > \left[\frac{(\alpha_0 - \phi_0)(\alpha_1 - \phi_1)}{\alpha_0\alpha_1}\right]^{\frac{1}{\phi_1}} \tag{21}$$

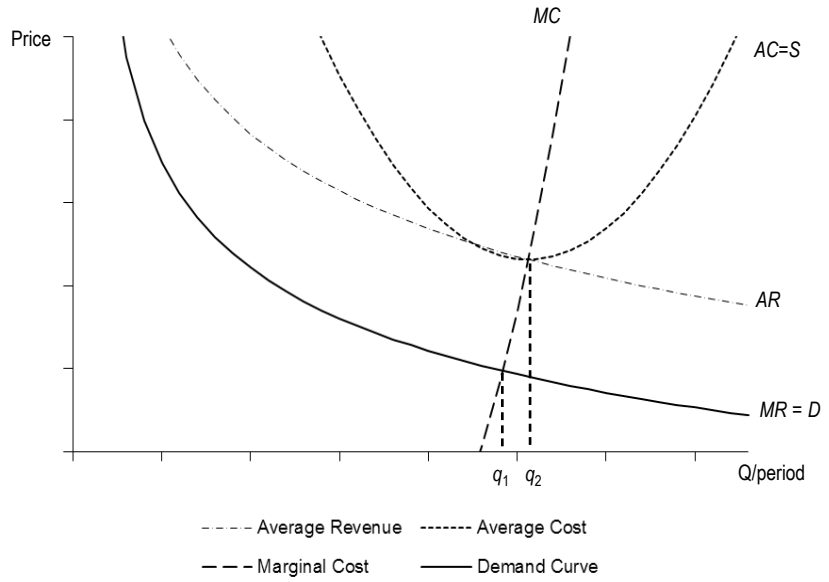
$$1 > \frac{\alpha_1 - \phi_1}{\alpha_1} \tag{22}$$

$$1 + x = 1 - \frac{\phi_1}{\alpha_1} \tag{23}$$

$$x = -\frac{\phi_1}{\alpha_1} > 0 \quad \text{as required.} \tag{24}$$

APPENDIX 2

Figure A2.1: A competitive market with perfect price discrimination and normal cost curves



With an upward-sloping marginal cost curve the same invitation to join the market or expand production exists at q_1 as was demonstrated in relation to Figure 2. Competition and the absence of entry barriers mean that the imperfectly competitive equilibrium, illustrated in Figure A2.1, occurs once again at output q_2 where average revenue equals average cost and where the profit, maximised at q_1, has been dissipated.

ENDNOTES

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2. A formal mathematical model (from which the Figures are drawn), using the same assumptions and reaching the same conclusions, is set out in Appendix 1.

3. The Figure for this situation has been consigned to Appendix 2 as it does not contribute substantively to the discussion.

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