May, 2002

Dynamic Pricing of Genetically Modified Crop Traits

by

Richard Perrin and Lilyan Fulginiti
Professors, Department of Agricultural Economics
University of Nebraska, Lincoln

Paper selected for presentation at the annual meeting of
the American Agricultural Economics Association
Long Beach, CA, July 28-31, 2002

May, 2002

Dynamic Pricing of Genetically Modified Crop Traits

by
Richard Perrin and Lilyan Fulginiti[a]

The issue considered here is the retail pricing of patented crop traits such as Roundup Ready herbicide resistance or Bt insect resistance. Our concern is not with the price of the seeds in which the traits are embodied, but rather with the implicit or explicit price for the traits themselves. Because such traits are now intellectual property that can be patented, monopoly pricing of them has received some limited consideration in the economics literature[1], but no one has yet examined the possible implications of the durability of these traits as a factor in determining such monopolists' pricing behavior.

Monopoly pricing of durable goods

The theory of monopoly pricing of durables traces to Coase (1972). He noted that when the seller of a new durable good sets a price in the first period, a fraction of potential customers will buy, but the remaining fraction still remain as potential customers in the next period. At a lower price in that next period, a fraction of the remainder will buy, and similarly for the period after that. The seller clearly has a strong incentive to exploit this kind of price discrimination through time, so as to realize greater revenues than from the usual single

[a] Professors, Department of Agricultural Economics, University of Nebraska, Lincoln. Paper selected for presentation at the annual meeting of the American Agricultural Economics Association, Long Beach, CA, July 28-31, 2002.

monopoly price for everyone. However, buyers can be expected to be aware of this possibility, and they therefore have an incentive to wait for next period's lower price before purchasing. The seller will probably try to convince buyers that he will not lower the price the next period, but it is difficult for him to make that a credible commitment, given the obviousness of his incentive to lower the price once the next period arrives with all its potential customers.

Thus Coase perceived a strategic game being played between the seller of the durable and his potential buyers. The seller's pricing strategy through time must be compatible with the buyers' incentives to wait for a lower price in the future. This incentive to wait can be weakened if the seller can make a credible commitment that he will not reduce the price later, despite the incentive he will have to do so. The outcome of the game, in terms of an equilibrium pricing strategy through time, is not obvious. Coase concluded that it is very likely that the equilibrium price will fall all the way to marginal cost (zero in the situations considered in this paper) in every period. The result would be that the monopolist is unable to earn any rents at all, let alone the "normal" monopoly rent obtainable by charging a single once-and-for-all monopoly price, or the even larger rent from intertemporal price discrimination. This conclusion has become known as the "Coase conjecture."

In this paper we first discuss the durablilty of crop traits and how it is determined by technological considerations and by intellectual property rights. We then consider the pricing issue in general, and then an equilibrium pricing strategy emerging from a specific formulation of the game that is dependent on the nature of intellectual property rights. Finally, we examine some empirical price paths for crop traits, to determine their consistency with the predictions of the analysis.

Technology, property rights, and the durability of crop traits

For purposes of this analysis, a durable good is an input that provides a flow of services for more than one production cycle. When seed is purchased, the producer acquires a bundle of traits, each of which can be thought of as providing a flow of services for the current crop year, and if the flow of services of a trait extends beyond that year, the trait may properly be considered a durable good. Crop traits are determined by the phenotypic expression of the crop's DNA, and while the DNA is durable because it duplicates itself, in general the trait will not be. For example, seeds from a cross of two plants with the trait of blue flowers may produce a Mendelian distribution of flower color in the first generation. However, if this and subsequent generations of plants are crossed and saved only if they have blue flowers, then the blue flower trait will ultimately become a durable (so long as no new DNA is admitted into the population) because there will be no heterogeneity of color remaining within the DNA of this selected population.

Varieties of crops such as soybeans and wheat are created by the recurrent selection process just described, and the traits exhibited by those crops are durables. If seeds from such a crop are saved and replanted, the flow of services from the trait continues into subsequent years. For crops such as corn, however, successful new cultivars are most often created by hybridization, which is the crossing of two or more distinctly different genotypes. While the first generation of this cross is designed to be a highly uniform phenotypic population for the commercial crop, the traits expressed by subsequent generations can be disastrously heterogeneous. A trait expressed by a hybrid is therefore not a durable. In some cases a particular trait may be exhibited by all subsequent generations, but the heterogeneity of other traits destroys the flow of services for which the hybrid was acquired.

There are at least two other technological phenomena that may affect the durability of crop traits. The first is the Technology Protection System (TPS), often referred to as the terminator technology, owned jointly by Delta and Pine Land Co. and USDA. While not yet commercialized, TPS seeds produce a crop of sterile seeds, thus insuring that none of the traits in the crop are durable. The second technology is apomyxis, currently being developed by Pioneer and CIMMYT, also not yet commercially viable. Apomyctic seeds produce a crop of viable seeds that are genetically identical to the maternal plant. Seeds saved from an apomyctic hybrid crop will replicate the commercial hybrid, thus insuring that all of the traits in the crop are durables.

However, even if a crop trait is technologically durable, the purchaser may not be legally entitled to enjoy the flow of benefits of the trait beyond the first year. If the seller can exclude a customer from future use of the trait, the seller is no longer faced with the vexing problems of durable good pricing. He would be in a position to either sell the seed anew to the producer each year, or to permit the producer to plant seed saved from the harvest in exchange for a rental or royalty payment or technology fee each year. This issue of legal durability is determined by the system of intellectual property rights and enforcement mechanisms to which a technologically durable crop trait is subject.

The two systems of intellectual property rights that are relevant to crop traits are utility patents and plant breeders' rights (Plant Variety Protection or PVP in the U.S. and Union for the Protection of Varieties or UPOV in much of the rest of the world.) If a crop trait is protected by a utility patent, the seller will have the right to exclude the buyer from using the trait in subsequent years if he wishes to do so, whereas if it is protected by plant breeders' rights, the seller does not have that right (he only has the right to exclude the buyer from giving or selling the trait to other producers.) Utility patents are clearly the stronger form of property rights, and they are most often used for crop traits even though they are much more expensive to establish. Within either system of property rights, however, the degree to which the seller is able to exclude future use of a durable trait depends on his enforcement effort and on the reliability and cost of the legal system through which enforcement takes place.

To summarize, if we have a trait that is technologically durable, the effect of patent protection is to allow the seller to exclude it as a durable for some fraction of customers, while under breeders' rights protection the trait is a legal durable for all customers. We turn now to a more explicit consideration of monopoly pricing issues to see how these alternatives might affect the sellers' choice of pricing strategy through time.

Property rights and the pricing of a non-durable crop trait

We first consider the pricing of a non-durable trait, which is similar to the pricing problem facing any seller with a downward-sloping demand curve. Consider Fig. 1, for example, in which we present a demand curve that is derived from a schedule of users' valuations, v, of the expected benefit of a particular trait for one crop year on, say, one hectare. We have scaled the function so that the valuation of the highest-valuation user is set at 1.0, and the total number of users (or hectares) deriving any benefit at all from the trait is also set at 1.0. The valuation curve $v = 1- q$ can reasonably be considered to be the demand curve facing the owner of the trait. We further believe it is reasonable to assume that the marginal cost of incorporating a trait in seed for additional crop area is essentially zero.

In this stylized case with linear demand, the trait owner maximizes profit by setting the standard monopoly price every year, p*= ½ , resulting in adoption (purchase) of the trait by q = ½ of the potential users every year. As a reference value that will be useful later, the stream of monopoly rents realized is then r*=¼ , with present value PV*=k/4, where k is the capitalization rate, presumed here to be the present value of a T-year annuity starting one year from the present, or $k= (1-(1+i)^{-T})/i$, where i is the discount rate.

Where property rights for the crop trait are not perfect and costless to enforce, the schedule of user valuations as shown in Figure 1 may not translate into the derived demand facing the patent owner. The patent owner may not be able to exclude all potential users from obtaining the trait from an unauthorized source (pirating), or he may find it too costly to do so. Just how the schedule of valuations is transformed into an effective demand curve is not evident, however. Deardorff (1992) and Perrin (1994) suggested that weakly-enforced property rights would result in payments only from some fraction q of potential customers, with that fraction common to all valuation levels. This proportional pirating model would imply that the quantity demanded is only fraction q of the quantity indicated by demand curve v, as shown by line $v^{pp} = 1-q/q$ in Figure 2. In this proportional pirating case, the optimal monopolist price remains at p*, but the optimal quantity to sell diminishes to q /2. The annual flow of rents falls to $r^{pp} = q/4 = q\, r^*$, and present value of rents falls to $PV^{pp} = q\, k/4 = q\, PV^*$.

Alternatively, Diwan and Rodrik (1991), followed by Perrin (1999), suggested that in the presence of weak property rights there is a limit royalty price, equal to some fraction f of the valuation for each customer, above which significant piracy would occur. This would result in a demand curve with height equal to fraction f of the demand curve v, as shown by line $v^{lp} = f - fq$ in Figure 2. In this limit pricing case, the optimal monopolist price falls to $f/2$, while the optimal quantity to sell remains at ½. The annual flow of rents is $PV^{pp} = f\ k/4 = f\ PV^*$, the same as for the proportional pirating case if the fractions f and q are equal. Giannakas (2000) suggests further that this limit pricing fraction f may be determined by the customer's expected cost of being caught pirating the trait, and that this expected cost is in turn determined by the enforcement expenditures of the patent owner as well as by the strength of the patent system. This allows him to explore the pricing of the trait within the framework of a regulatory game in which buyers, the monopolist, and the regulator are players.

The two theories above offer alternative explanations as to how a simple linear valuation schedule might be transformed into the monopolist's derived demand curve when property rights are less than perfect. Neither theory is particularly persuasive, since it seems likely that potential customers' willingness to pirate is distributed in a way that is neither strictly random without regard to payoff from pirating as implied by the first, nor strictly proportional to the expected benefit of pirating, as implied by the second. However, either approach is analytically convenient, and we will use the limit pricing approach in the analysis of durable pricing to follow.

Nash equilibrium pricing of durable traits

We now consider an explicit theoretical model of Coase's durable goods pricing situation to examine what intertemporal pricing strategies might emerge, and how they would be affected by property rights. Here we seek a Nash equilibrium solution to the game, which will insure the credibility of the resulting time path because by definition, none of the players in the game will have an incentive to behave otherwise. Suppose as before that the producers' capitalization rate is represented by $k = (1-(1+i)^{-T})/i$. Then the producers' valuations of the durable good will be uniformly distributed on the interval [0, k] rather than [0,1]. The Figure 1 annual payoff valuation curve $v = 1- q$ becomes the present valuation curve $V = kv = k - kq$ that we show in Figure 3. If this valuation curve is the effective demand curve, the monopolist could charge some arbitrary price P for the durable the first year (say $P^*=k/2$ which is equal to the present value of the normal monopolist price of $p^* = ½$ in Figure 1), then in the second year charge the monopolist price for the remaining portion of the demand curve, $k/4$, etc., and in this manner extract most of the consumers' surplus.

However, unless buyers are completely naïve, they will anticipate this reduction in price. A buyer with valuation kv and discount factor $d = 1/(1+i)$, will have an incentive to wait until next year to purchase if $(V-P_t) < d(V-P^e_{t+1})$, where P^e_{t+1} is the price he expects to be charged for the durable next year. If buyers' willingness to wait until next year constrains the price the seller can charge this year, then just how much will the seller decide to charge the first year and how fast will the price fall? A considerable number of papers have been published establishing conditions under which the Coase's zero-profit price would hold (see Tirole, 1988, Ch 1.) Here we adapt a relatively simple model that Tirole in turn adapted from Sobel and Takahashi.

Consider first the case in which it is costless to exclude non-buyers from using the trait in the future. This would correspond to the property rights established by the UPOV and PVPA systems of plant variety protection. If the monopolist could credibly establish that the trait would never be sold again, a one-time price $P^* = k/2 = kp^*$ could be charged, maximizing profits by selling only to the half of customers with the highest valuations. But because the monopolist will have an incentive to sell the trait again next year to half of the remaining potential users, it is difficult for him to assert credibly that he will never sell the trait again, and in this case his initial price must be compatible with the buyer's incentive to wait one year for the price he will charge next year.

Assume that the buyers' strategy is to identify an optimal limit price fraction l such that they will purchase if $V = kv > lP$. This implies that the effective demand curve is $P^d_t = V_t/l = k(1-q_t)/l$, shown in Figure 3 (similar to the limit-pricing demand curve of Figure 2.) At the price marked P_1, buyers would purchase quantity q_1, realizing a surplus equal to the shaded area above the line P_1, leaving the monopolist the rent below it. Assume further that the seller's strategy is to identify an optimal mark-down ratio m such that if the buyers with valuations above $V = kv = k(1-q)$ have already purchased the trait and the others have not, then he will set the price at $P = mV$. This implies that the seller follows a pricing curve such as $P^s_t = m V_{t-1} = m k(1-q_{t-1})$, also shown in Figure 3. This seller's behavior implies that the seller will charge an initial price $P_1 = m k$. The buyers' behavior implies that the initial quantity purchased will be $q_1 = 1 - ml$, which in turn from the seller's behavior implies that $P_2 = mlP_1 = k l m^2$ and $q_2 = 1 - lP_2/k = 1-(lm)^2$, or in general, $P_t = k l^{t-1} m^t$ and $q_t = 1 - m^t l^t$ (here note that q_t represents the total quantity sold since the first period, $t = 1$.)

The seller maximizes the present value of future sales,

$$PV= P_1q_1 + d\, P_2(q_2\text{-}q_1) + d^{\,2}P_3(q_3\text{-}q_2) + \ldots$$

$$= P_1 (1\text{-}l P_1/k) + d\, P_2(l P_1/k - l P_2/k) + \ldots\ .$$

Setting the derivative with respect to P_1 equal to zero yields $1 - 2 l P_1/k + dP_2 l/k = 0$, and since $P_1=mk$ and $P_2 = m l P_1$, then $1 - 2 l m + d\ (l m)^2 = 0$. Solving this for m we can obtain the seller's reaction curve as

(1) $m = [1\text{-}(1\text{-}d)^{1/2}\ ]/d\, l$.

For the marginal buyer at any point in time, $V = l P$, and because he is indifferent to waiting, $V - P_t = d\ (V - P_{t+1})$. Given that $P_{t+1} = m l P_t$, the marginal buyer's reaction curve can be expressed as

(2) $l = (1\text{-}\ d + dm)^{-1}$.

A Nash equilibrium under perfect information by both parties occurs when the reaction curves are mutually consistent, which occurs with

(3) $m =[(1\text{-}d)^{1/2} – (1\text{-}d)]/d$, and

(4) $l = (1\text{-}d)^{-1/2}$.

The time path of equilibrium prices under this solution, beginning with P_1 , is $(m\, k,\ l m^2\, k\ ,\ l^2 m^3\, k\ , \ldots)$. For a discount rate of .10, this time path of prices is (0.23k, 0.18k, 0.14k, 0.11 k, 0.08 k, …) or for T=5, a five-year life cycle of the trait, (0.88, 0.68, 0.52, 0.40, 0.31). For a discount rate of .20, the comparable numbers are (0.29k, 0.21k, 0.15k, 0.10 k, 0.07k, …) and (0.87, 0.62, 0.44, 0.31, 0.22). We show in Figure 3 the first four prices in the sequence of equilibrium prices and quantities corresponding to the 20% discount rate. Buyers capture surplus equal to the shaded area, while the seller captures rent equal to the area beneath. The latter area, total revenue received, equals 0.51 for a 10% discount rate or 0.52 for a 20% rate. This compares to the present value of returns from annual technology fees ($kp^* = k/2$) or the once and for all monopoly price ($P^*=k/2$) of 1.89 and 1.50, for these two discount rates.

This illustrates the "problem" (from the monopolist's point of view) of the pricing of durables: he earns only about a third of the normal monopoly rent, let alone any additional gains from intertemporal price discrimination. Because customers know the seller will have an incentive to lower the price next year, the seller's ability to charge a high price today is limited. In the case of this particular analysis, customers and seller are both fully aware of each other's circumstances, and the customers consider it credible that the price in the future will not be less than the Nash equilibrium price path indicated. Credibility, in this case, derives from customers' knowledge that the seller will have no incentive to set future prices in any other way.

Now relax the assumption of perfect and costless property rights. Suppose, first, that only fraction q of potential customers can be excluded from pirating the trait (*i.e.*, from acquiring it from a supplier other than the patent owner or his licensee.) Then the derived demand curve (analogous to v^{pp} in Figure 2) is represented by a clockwise pivoting of the valuation schedule V through the point ($V=k$, $q=0$) in Figure 3, which would result in no change at all in the time path of equilibrium prices. The seller's revenues would fall, however, to the fraction q of the level under perfect property rights. The seller's optimization problem would now include the amount to be spent on enforcement, if the fraction q is affected by enforcement effort, but that problem is not directly relevant to questions addressed in this paper.

Suppose, alternatively, that buyers had a limit price f V, above which they would choose to pirate the trait rather than purchase it from the seller. This would result in a counterclockwise rotation of the valuation schedule V through the point (V=0, q=1.0). The Nash equilibrium prices would fall to the fraction f of the level under perfect property rights.

Hence within the framework of a UPOV/PVP property rights regime in which purchasers are permitted to re-plant the crop with the trait, this game theoretic analysis results in an initial price considerably only one-fourth or so of the one-shot monopoly price, followed by prices that decline even further. Furthermore, any potential for piracy will reduce the seller's returns proportionately below even these levels, though the equilibrium price would only fall to zero (the extreme Coasian outcome) if the excludable portion of the potential customers falls to zero.

Will buyers of a durable crop trait pay for a durable?

To this point we have concluded that under a UPOV/PVPA breeder's rights regime, it is plausible that the seller of a technologically durable trait will charge a price that declines through time as suggested by Coase's conjecture. The height of this declining price path is clearly restricted by buyers' knowledge that the seller will in the future have an incentive to lower the price. However, in the case of a crop trait, today's customers are potential competitors of the monopolist – they will have the capability of selling the trait the next year. The entire crop of the first-year adopters could be used for seed the following year. Reproductive rates in small grains are on the order of 30 or more to one, so even a 3% adoption rate in year one would provide sufficient seed for the entire crop the following year. The price that the trait owner can charge the first marketing year therefore depends crucially on whether he can be credibly expected to exclude the future dissemination of the trait by those first-year buyers. Recall that as specified above, first-year buyers will only purchase if $P_1 < (1\text{-}d)kv + dP_2^e = d\ v + \delta\ (P_2^e - d^T v\ )$. In the extreme case that next year's price, P_2 , is expected to be zero, the buyer will pay no more for the trait than v, the value of its services for the coming year alone[2].

Thus if the IPR owner is unable to exclude potential customers from acquiring the trait for free the second year, he will only be able to extract rent during the first year of release of the trait. He could at best charge a purchase price equal to the optimal rent, $P=r^*$, and sales would cease with this first year. To the extent the monopolist is able to exclude future customers from black market acquisitions, he will be able to extract a higher price the year of release and will be able to make some sales in the future. If he can exclude all potential customers from this pirating activity, the price and sales pattern through time can rise to the level of that of a "normal" monopolist selling a durable. As we have seen, however, this "normal" level of prices and sales is limited by the credibility of his own commitment to a price path in the future.

Empirical intertemporal paths for prices of GMO traits

Crop traits that offer some empirical evidence on the issues raised here are the Bt trait in corn and the Roundup-Ready trait in soybeans. We have some preliminary comparisons of price paths in the U.S., which has relatively strong property rights, and Argentina, which has relatively weak ones. Price premiums for the traits in recent years are presented in Table 1.

Because corn seeds are hybrids, their traits are not technologically durable, we would expect the price to reflect the monopolists rent each year regardless of the IPR regime, comparable to p*=1/2 in Figure 1, unless users valuations shrink through time with the availability of better substitutes. The data of Table 1 are in generally in accord with this expectation. The lower Bt price in Argentina, as compared to the U.S., is apparently due to lower crop prices and lower yields there, since the property rights regime is irrelevant for hybrids. The reduction in Bt price in the U.S. has been attributed to the reduction in market price for the crop, but may also be due to a re-assessment of the potential demand curve.

Because soybeans are self-duplicating, the Roundup Ready trait in soybeans is a durable good. The trait is patented in the U.S. and buyers sign an agreement not to replant the seeds in the future, nor to offer them to others to plant. If these legal property rights are relatively cheap to enforce, we would then expect a constant rental rate through time. In the U.S., in fact, we see one upward adjustment in this price, perhaps due to a re-assessment of the demand curve, given the surge in adoption from two percent of soybean acres in 1996 to 36 percent in 1998.

In Argentina, however, property rights for the Roundup Ready trait differ in two ways. First, Monsanto has not yet been able to obtain a patent for the trait in Argentina, and second, property rights in seeds are difficult to enforce In the initial availability year of 1996, adoption in Argentina at 5% was slightly higher than than in the U.S., and in the following year at 23% it was double the U.S. rate of adoption, despite the higher charge for the trait ($15 in Argentina vs $5 in the U.S.) Clearly the Argentine user valuations of the value of the Roundup Ready trait were very strong. In 1998, however the premium fell to $5 and by 1999 it had fallen to a dollar per bag or less. The trait owners were unable or unwilling to exclude pirating, as reflected in the GAO (2000) report that Argentine soybean producers were planting 25-35% of the entire crop with their own saved seed, and another 25-50% of the crop with black market seed from seed multipliers. In the case of RR soybeans in Argentina, the Coase conjecture holds: the owner of the durable trait was unable to charge any monopoly rent at all on the durable after the first two years or so of sales.

Conclusions

Crop traits are technologically durable if they are embodied in the seed of a true-breeding variety as opposed to a hybrid seed. If the trait is protected by a utility patent, then whether the trait is durable or not the owner can be expected to charge the monopoly rental rate, or technology fee, each and every year for use of that trait. This rental rate should be in the vicinity of the median level of customers' valuations of the service of the trait for one year, with approximately half of the potential adopters choosing to adopt. However, if the trait is protected only by breeders' rights, the buyer retains the right to use the trait in the future, and the owner is selling a durable good to that buyer. Then in accord with Coase's conjecture about the pricing of durable goods, the price charged for the initial release of the trait can be expected to be much less than the monopoly rental rate and can be expected to fall after that, perhaps approaching zero. A similar result could occur under utility patent protection, if under the legal system it is impossible or prohibitively expensive to prohibit pirating of the trait.

We have so far examined the time paths of prices charged for the Bt trait in corn and the Roundup Ready trait in soybeans in the U.S. and Argentina from 1977 to 2000. We found fairly constant annual technology fees except for the case of RR soybeans in Argentina, where the trait owner was unable to exclude piracy, and rents fell to near zero in accord with Coase's conjecture. Because Bt corn is not a technologically durable trait, the technology fee for that trait remained constant even in Argentina. We intend to broaden the empirical study to consider additional traits that are observable across countries with differing property rights regimes.

References

Coase, R. H. 1972. Durability and Monopoly. *Jl. Law and Econ.* 15:143-149.

Deardorff, A.V. 1992. Welfare effects of global patent protection. *Economica* 59:35-51.

Diwan, I., and D. Rodrik. 1991. Patents, Appropriate Technology and North-South Trade. *J. Int. Econ.* 30:27-47.

GAO (U.S. General Accounting Office). 2000. *Information on Prices of Genetically Modified Seeds in the United States and Argentina*. GAO/RCED/NSIAD-00-55.

Giannakas, K. 2000. "Intellectual Property Rights under Costly and Imperfect Enforcement." Unpublished manuscript, University of Nebraska.

Perrin, R. K. 1994. Intellecutal Property Rights in Agricultural Development. In Anderson, J.R. (ed), *Agricultural Technology: Policy Issues for the International Community*. CAB International, Wallingford.

Perrin, Richard K. 1999. Intellectual Property Rights and Developing Country Agriculture. *Agricultural Economics* 21:221-229.

Sobel, Joel and Ichiro Takahashi. 1983. A Multistage Model of Bargaining. *Rev. of Econ. Stud.* 50:411-426.

Tirole, Jean. 1988. *The Theory of Industrial Organization*. MIT Press, Cambridge, MA.

Zilberman, David. undated manuscript. Value and Pricing of Agricultural Biotechnology Products under Alternative Regimes of Intellectual Property Rights.

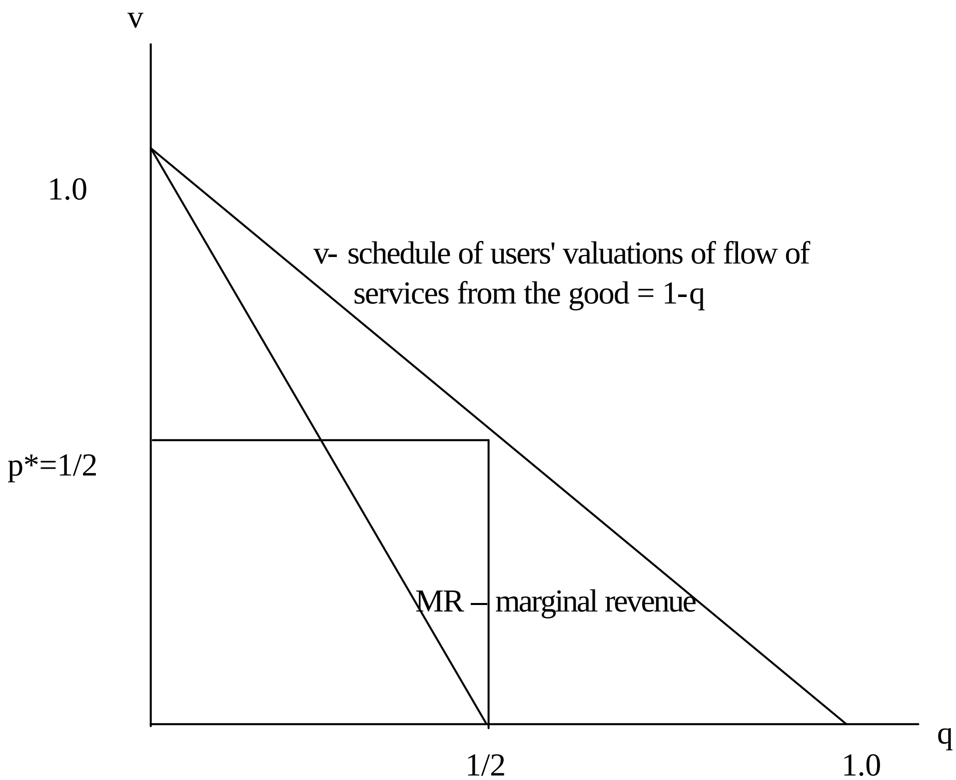

Figure 1. User evaluations of annual benefit of a trait

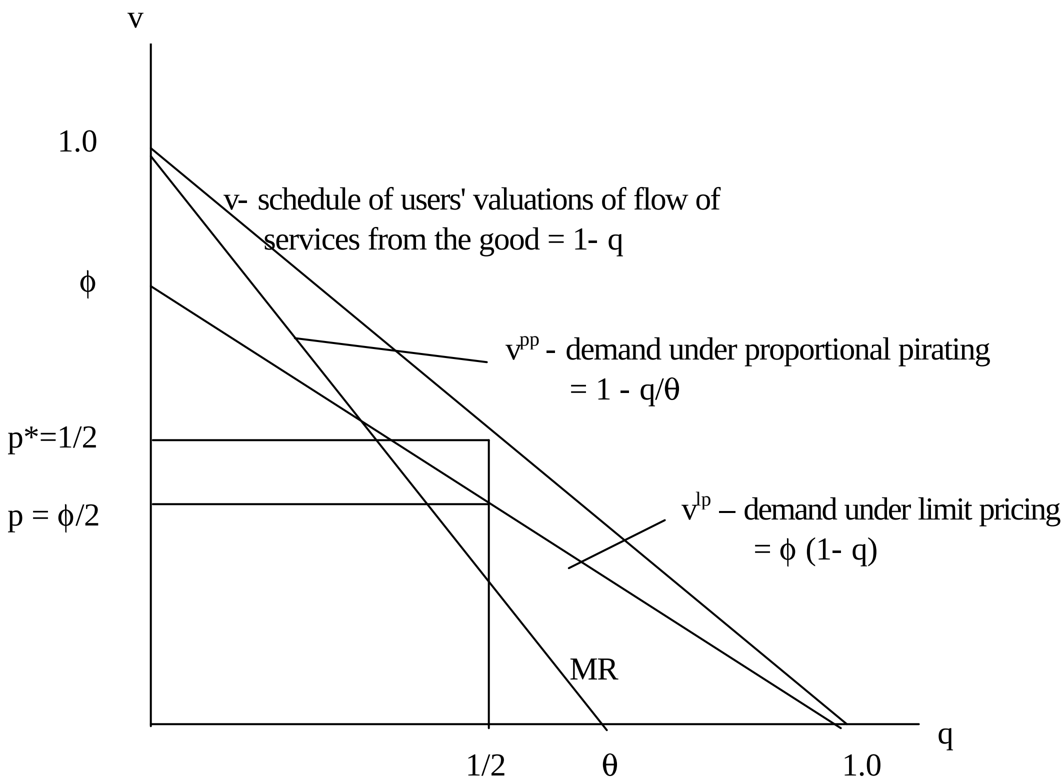

Figure 2. Effective demand with imperfect property rights.

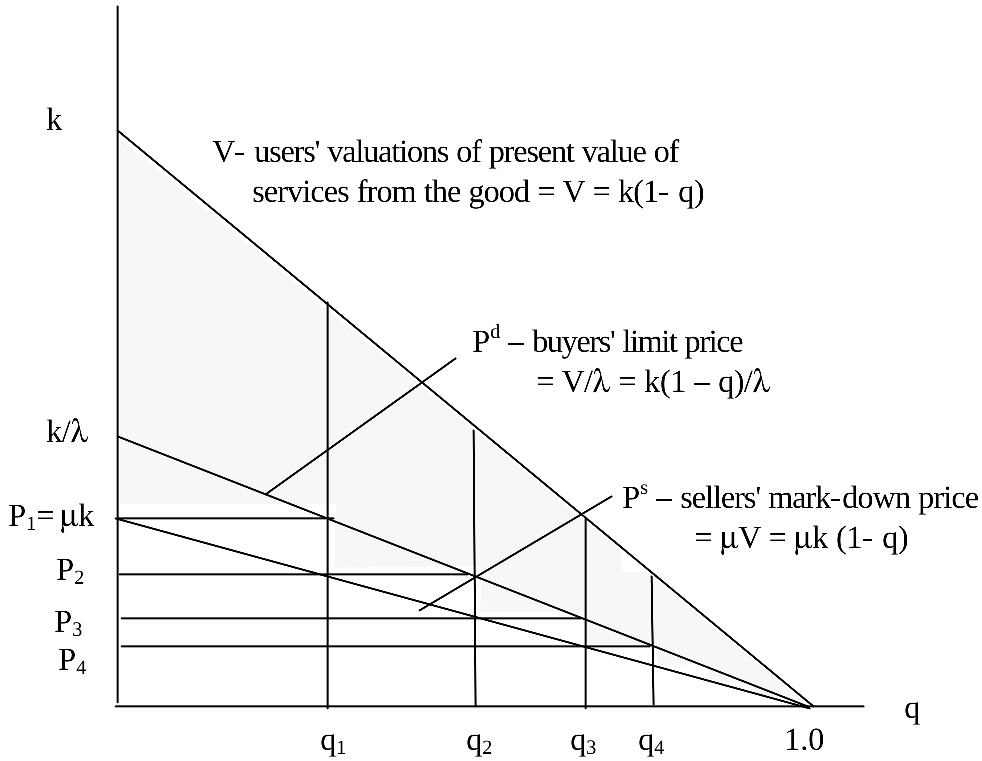

Figure 3. Nash equilibrium pricing of a durable trait.

Table 1. Prices for Bt corn trait and Roundup Ready soybean trait				
	1997	1998	1999	2000
Bt corn, US (bag of 80,000 seeds)	$35.00	$35.00	$24.00	$24.00
Bt corn, Arg (bag of 80,000 seeds)	none	none	$17.50	$17.50
RR beans, US (50-lb bag)	$5.00	$5.00	$6.50	$6.50
RR beans, Arg (50-lb bag)	$15.00	$5.00	$1.00	$1.00

Sources: GAO (2000), various websites

Endnotes

[1] See Perrin , Moschini and Lapan, Giannakas .

[2] This would be technically true only for an asset with infinite life, which is effectively the case if a new asset can be acquired for free any time in the future. Given a T-year asset life as in the inequality here, the buyer expecting a zero price next year would pay even less than the value of current services, by the bamount of the present value of services he would obtain in year T+1 if he postponed purchase.