The Optimal Supply of Public Goods[1]

Coase's lighthouse problem is an example of a public good (among the ships) that can and was provided by the private market.[2] Demsetz formalizes the problem of the private supply of public goods and discusses the issues in some detail.[3] The model can be applied to the lighthouse problem and some additional insight gained in the process.

Demsetz argues that the public good is analytically identical to the case of **joint products**. In the normal private market it often happens that two or more goods are produced simultaneously. The classic example is that in the slaughtering of steers both meat and hides are produced. In this case there is little tradeoff between the two products. From each steer comes a fixed amount of meat and a fixed size of the hide. In this way we can normalize the unit of measure to a standard steer. The demands of hide buyers and meat buyers can then be graphed in the same picture. We expect that meat buyers have larger demands. But for each steer the total demand is the *vertical* summation of the demand for hides and the demand for meat. The competitive equilibrium in the steer market derives from the intersection of the vertically summed demands and the supply of steers.

Public goods are no different in principle. Figure 1 shows the case of a public good in which all demanders are the same. Assume that there are n demanders. The vertical sum of their demands gives the aggregate demand. The supply side of the market is constructed to be identical to the competitive case. There are a perfectly elastic number of suppliers that all have cost conditions that resemble the average and marginal cost functions shown in Figure 1. Given this assumption, the industry supply is horizontal at the level of minimum average cost. The public good analog to the competitive joint products case occurs where the aggregate supply of the public good is q_s. The supply price of P^* is spread among the n demanders evenly. They all pay p^*. All demanders consume every unit of the public good that is produced. There are multiple suppliers each producing at minimum average cost and each providing q_f units.

As Demsetz says, an equilibrium is characterized by four conditions. (1) All firms are capitalizing on all potential profits given the price condition they face. (2) There is no incentive for more firms to enter the market. (3) No demander has the incentive to consume more or less. (4) The market clears, i.e., quantity supplied by the firms is exactly equal to quantity demanded by the buyers. The situation depicted in Figure 1 satisfies these conditions.

Consider what happens when the number of buyers increases. Figure 2 shows the shift in the aggregate demand when the number of buyers expands by k. The aggregate demand gets bigger. This causes the intersection of aggregate demand and supply to move to the right. The result is that more of the good is produced and each person pays less.

Demsetz's argument took a lot of flak. The most insightful (and most obtuse) was by Earl Thompson. Both Demsetz and Thompson were newly arrived at UCLA when their respective papers hit the streets. So they fought it out in Bunche Hall and finally presented their arguments in print. In my opinion Thompson's argument is correct but of the second order of importance. Demsetz is right except in the most peculiar circumstances which are not worth considering.

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[1] Layard and Walters (1978) Sec 6.3; Varian (1992) sections 23.1-23.5; Nicholson (1998) Ch 24, p 741-749; Silberberg (1990) Section 17.6; McClosky (1985) 324-128.

[2] Ronald Coase, "The Lighthouse in Economics," *Journal of Law & Economics*, October 1974, 357.

[3] Harold Demsetz, "The Private Production of Public Goods," *Journal of Law and Economics*, October 1970, 8(2), 293-306; "Joint Supply and Price Discrimination," pp. 389-406 and "Reply to Professor Thompson," pp. 413-416, *Journal of Law & Economics*, 16(2), October 1973.

Other critiques of Demsetz are wrong. Most founder because they fail to recognize that there is no uniquely efficient way to price a public good.

The common argument against Demsetz is that it is inefficient to charge for a public good because once produced, it has zero marginal cost in consumption. While true, this statement misses a crucial point in the Demsetz set up. In his model, all demanders consume all units of the public good. There is no unexploited consumer surplus. That consumers are forced to pay for the good is simply a method of collecting revenue to finance the good. The payment does not stop any demander from consuming any unit of the total amount of the public that is produced. The payment does, however, stop additional units from being produced. Any additional units would be inefficient because the aggregate marginal valuation by consumers is less than the marginal cost of production.

In the example that Demsetz uses, the public good can be privately produced because, while it is non-rivalrous in consumption, it is excludable. Movie theaters can bar entry to those who don't pay.

The second major flaw in the standard critique of Demsetz is best seen by applying the Demsetz model to Coase's lighthouse example. The simple model Demsetz has formulated needs some fine tuning to fit the lighthouse case. The problem is that with lighthouses there are different kinds of buyers. Fortunately Demsetz addresses this issue as well. Figure 3 shows the picture. Assume that there are two groups of buyers. Group 1 (D1) demanders are the least interested in the good. Group 2 (D2) has a larger demand. Again the aggregate demand is the vertical summation of the different individual demanders. In this case the aggregate demand has a kink at the point where group 1 falls out of the aggregate. Again assume that the supply curve is flat. The intersection of the supply and aggregate demand represents the efficient point.

This point occurs at an output level of L^* in Figure 3. The supply price of P^* is split between the two groups in unequal fashion. Group 1 pays P_1L^* while group 2 pays P_2L^*. There is nothing magic about the allocation of the prices. That is, the cost could be spread among the demanders in a different fashion. However, there is an efficiency characteristic associated with the production of L^* units. At that level of lighthouses, the marginal cost and marginal benefit of lighthouses is exactly equal.

While there is no efficiency characteristic of the pricing scheme, there is an equilibrium quality to it. Recall that an equilibrium condition is that each buyer should have no incentive to demand more given the price that each faces. Given that group 2 demanders pay P_2 for the last lighthouse built, they have no interest in demanding more lighthouses. Their marginal value is exactly equal to their marginal cost. The same is true for group 1 demanders paying P_1. As in Demsetz's movie example, if Figure 3 represented a competitive market for a joint product spread across two groups and competitively supplied, competition would result in the two prices indicated in Figure 3. Indeed this is an apt characterization of the movie business where movies are priced higher to early viewers compared to those who are willing to wait. The same is true in the book business.

Now let's consider what happens in the case of heterogeneous demands when the market expands. Figure 4 shows the effect of a new group of demanders entering the market. The demand curve shifts up. There are now two kinks in the aggregate demand, one where group 1 demanders place zero value on additional lighthouses and another where group 2 demanders place zero value on additional lighthouses. The intersection of the supply and aggregate demand moves to the right. The new efficient number of lighthouses is indicated by L^{**}.

Note that in this picture, the demand by the new group 3 consumers shifts aggregate

demand so that the equilibrium prices are unchanged. This is just a freak chance of the way the figure is drawn but it is interesting to consider the outcome in this case. The way the market is depicted in Figure 4, the equilibrium prices are unchanged. However, now group 3 demanders pay P_2 per lighthouse for a total of P_2 L**, and group 2 demanders pay P_1L**. In an equilibrium pricing scheme, group 1 demanders would pay nothing. If Figure 4 were applied to movies, group 1 would be the people who wait to see movies for free on broadcast TV. As applied to lighthouses, it turns out that group 1 demanders did not get off for free. Lighthouses in Great Britain were not priced in a competitive equilibrium fashion. This was true in part because they were supplied by a monopoly franchise of the crown.

It is important to distinguish an equilibrium pricing scheme from an efficient pricing scheme. Efficiency requires that (1) the vertically summed marginal valuations of all buyers equal the marginal cost of production, and (2) all buyers be allowed to consume all units of the good. These principles are satisfied in every case considered in Figures 1-4. However, this does not mean that in Figure 4 inframarginal demanders cannot be charged for the good. Let's say that the inframarginal demanders in Figure 4 are charged the same amount as they were in Figure 3. This charge does not necessarily impact on the efficiency of the supply of lighthouses. Even if group 1 consumers are charged P_1L*, it will not stop them from consuming all the lighthouses they desire. They will consume up to the point where their marginal valuation is zero. In lighthouses unlike movies, the consumers do not really pay per lighthouse. They pay a fixed fee and then get to consume all the lighthouses available. It turns out that group 1 demanders will stop short of consuming all the lighthouses because they have no demand to do so. However, their is no restriction placed on them. The only thing that results from the charge of P_1L* levied on group 1 is that the monopoly provider gets excess profit.

This is precisely the point that Coase made in the lighthouse example. The English crown had granted a benevolent society called the Trinity House the franchise on collecting tolls on lighthouses. Trinity House was a group that provided pensions for widows and orphans of lost seamen. It contracted for the construction of lighthouses and then administered the collection of tolls. In general what happened was that new lighthouses were constructed when the marginal tolls that could be collected equaled the cost of constructing new lighthouses. However, as new lighthouses were built, the marginal demand of inframarginal demanders went to zero. Even so, these consumers continued to pay the same tolls as they had in the past. This created a kind of profit for Trinity House.

However, it did not violate the efficiency conditions for the construction of new lighthouses (marginal benefits equaled marginal costs) and it did not violate the efficiency condition for the consumption of the public good. The inframarginal consumers had the right to consume the new lighthouses even though they did not have much interest in doing so.

Everything was fine, in Coase's opinion, until the government got involved. Parliament became annoyed for some reason that Trinity House was making a profit. In its "wisdom," Parliament decided that the money that Trinity House raised should not be spent on pensions for orphans and widows.[4] directed to the construction of even more lighthouses rather than given to widows and orphans. Eventually, the government took over the construction and maintenance of lighthouses. Of course, Parliament's view of Trinity House was wrong on efficiency grounds.

[4] "The use of the proceeds of the light dues for charitable purposes ceased in 1853. As a result, some reduction in the light dues was made possible, price moved closer to marginal cost and numerous ancient mariners and their families, unknown to the law and to us, were worse provided for." pp 371-372

Efficiency is not served by taking from the mouths of orphans and giving to the inframarginal lighthouse demanders by cutting their tolls. This is an equity issue. Moreover, efficiency was ill served by taking the rents collected from inframarginal lighthouse demanders and subsidizing the construction of more lighthouses where the marginal benefit was less than the marginal cost.

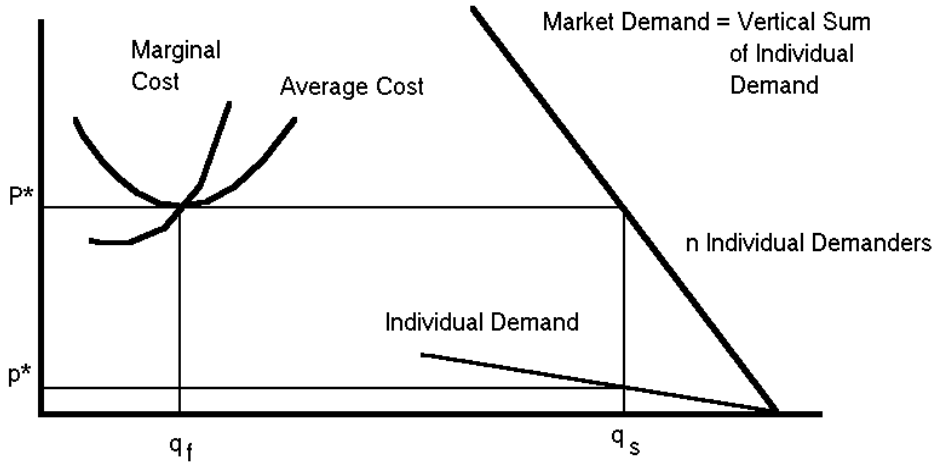

Figure 1

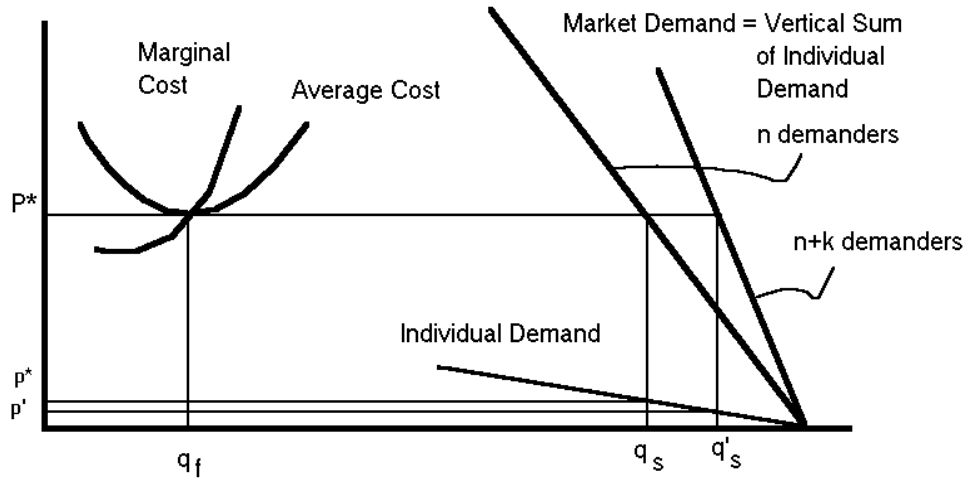

Figure 2

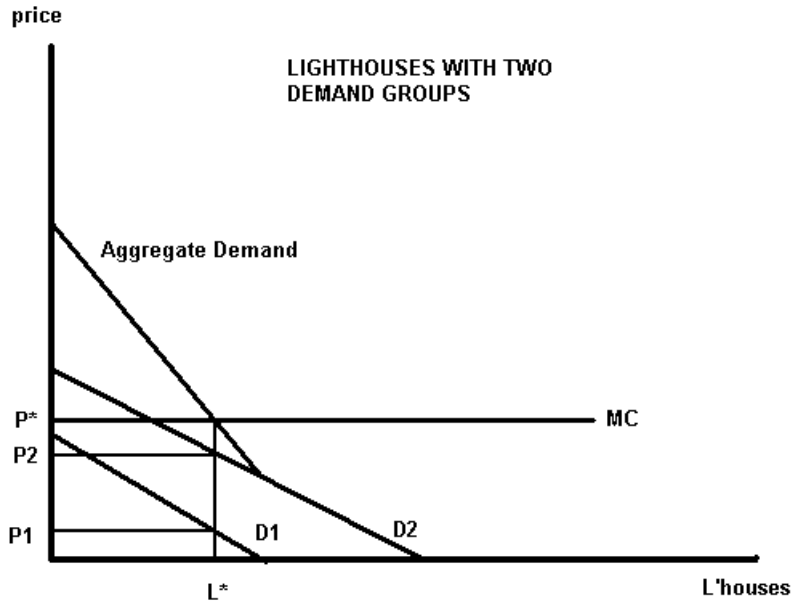

Figure 3

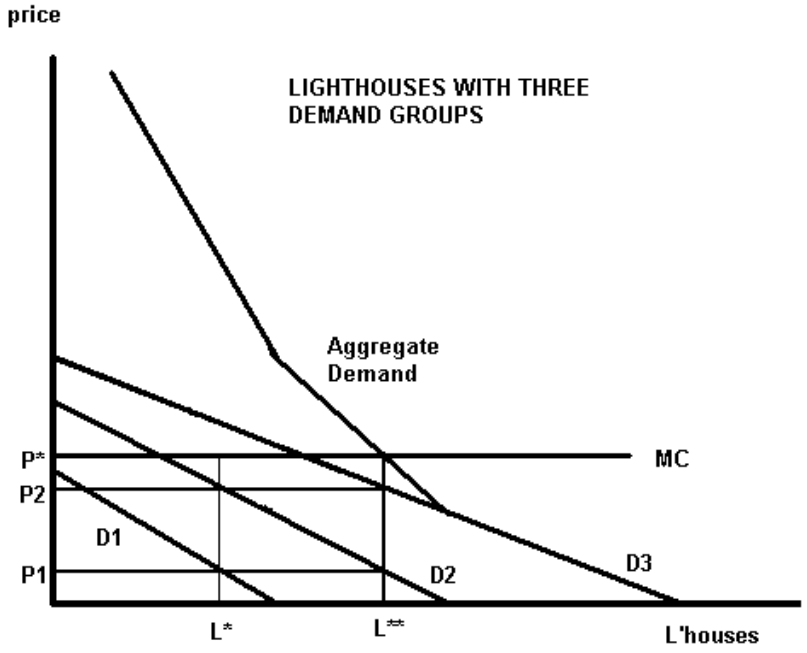

Figure 4

Addendum: Comparison of Public and Private Supply of Public Goods

Three principles were (more or less) elucidated above: 1) Public goods are like joint products because the market demand curve is the vertical sum of individuals' demands. 2) The demands for public goods are summed vertically because consumption of the good is non-rivalrous. Consumption by one individual does not diminish the enjoyment of any other individual. 3) The price paid by any one individual for the public good is arbitrary. Even so, the optimal supply is determined by the intersection of the vertically aggregated demand and the market supply of the good.

The median voter model is a theory of the public supply of public goods. The median voter model assumes that all individuals pay the same tax price for the public good. It also assumes that demand for the public good is normally distributed. When voters-citizens share the cost of the public good on a per capita basis, the median voter through the democratic process decides the amount of the public good by comparing the tax price of the public good with his/her marginal valuation. If the marginal valuation is below the per capita tax price, the vote goes against the spending. Only if the median voter's marginal valuation of the proposed amount of the public good is at least equal to the per capita tax price which is equal to the per capita average cost of the public good will the spending be approved at the polls. Because the distribution of demand for the public good is normal, the median voter is also the average demander. Hence, the per capita marginal cost of the public good is equal to the average marginal valuation, and the marginal valuation summed vertically across consumers is equal to the marginal cost of production.

Recognize the that tax price of the public good is not equal to the marginal valuation of the public good except for the median voter. Everyone else pays either too much or too little. However, the amount supplied is the optimal amount.

The public supply of public goods is one issue; the private supply of public goods is another. On the public supply front, we usually list national defense, the legal system, and charity as the major public goods supplied by the government. Of course, these are also supplied by private organizations as well, but the majority of the provision of these things comes from government.[5] On the private supply side, knowledge, technological innovation, and artistic creations are the main public goods. Such things as inventions, scientific formulae, literature, music, movies, and radio and TV programming are public goods privately produced.[6]

Even though these things are privately produced, there is a legal infrastructure in place to support their production. Inventions are supported by the patent system; artistic and literary inventions are protected by copyrights.

The economic efficiency of patents can simplistically be summarized as a tradeoff between short-run efficiency losses and long-run gains. The patent system allows an inventor to claim a monopoly on the innovation for 20 years.[7] This allows the patent right holder to use the legal system to stop other people from using the invention without paying for it. The ability to pursue tort claims against patent infringement does not always make the patent right

[5] Also, a lot of what government does is supply private goods. For whatever reason, government many times supplies utilities such as garbage collection, water, sewer, electricity, and gas.

[6] No doubt, these are privately produced because government bureaucrats could never be given the proper motivation.

[7] Source: http://www.uspto.gov/web/offices/pac/doc/general/whatis.htm. The length of the patent right has been variously reported. It may have changed marginally with amendments to the law.

economically viable. Some inventions are too simple, cheap, and easy to implement and, thus, cannot be protected.

Patent rights are inefficient in the short run. Consider drugs. Once the chemical compound that constitutes a drug is discovered, the cost of using the drug is only the manufacturing costs. Manufacturing costs of drugs are real low. Add in a little brand-naming and you still aren't into big money. The reduction of consumption that results from monopoly pricing during the patent life is a welfare loss.

On the other hand, it is the gain from this monopoly pricing that induces drug companies to work on inventing new drugs. The welfare gains from patent protection are the new drugs that are developed in anticipation of the monopoly money.

Copyrights are exactly the same. For instance, consider the effect of illegally copying computer software. The lost revenues to the software copyright owner has no effect at all on the efficacy of the current version of the software. However, it may affect the ability of the software company to update and enhance the performance of the computer program in future releases. From the consumers' perspective, paying full price for the software will discourage some individuals from using the product; this is a welfare loss because there is zero marginal cost for another user. However, the long-run gain is that computer program innovation will make the software more productive in the future.

The recent Napster copyright law suit frames the problem nicely. If all music currently available on cd was suddenly available over the internet free of charge and easily accessible, it would cause the price paid to the owners of these copyrights to fall precipitously. This would not change the availability of the current stock of music. However, it would potentially reduce the production of new music. Efficiency is served by increase consumption of existing music and is failed by the reduction of new musical performances.

The relevant question is, Which margin dominates? In the case of Napster, there is some argument that there are minimal lost revenues and that the advertising potential of the Napster medium actually encourages the production of new music. The fact is that these are tricky questions from an empirical perspective even though the theoretical tradeoff is fairly straightforward.

Government sanction of patent and copyrights is an attempt to create and enforce excludability in the private production of public goods. Without excludability, the free rider problem will cause the private market provision of public goods to fall short of the optimal level. Some public goods are more excludable than others.[8] However, even when the privately produced public good is perfectly excludable, the level that is produced in the market may fall short of the optimal. Consider the pricing problem of the privately produced public good compared to its publicly produced kin.

In the case of public production of public goods in the context of the median voter model, each citizen pays a tax price equal to the per capita share of the marginal cost of production. Some pay more than their marginal valuation for the quantity provided, some pay less, but they all pay because they are "coerced" by the police powers of government.

In the private production setting, if firms charge a single price that is equal to the per capita share of the marginal production costs, they will not raise enough money to cover costs. The reason is that people with valuations less than this price will not buy the good. Since the

[8] Based on both tort actions against patent and copyright infringement as well as purely private actions to limit access such as copy protection for DVDs and other electronic media.

private suppliers have no means by which to force consumers to pay, these revenues are lost in the per capita pricing. Consumers are priced out of the market even though the marginal cost of an additional consumer is zero. Indeed, the market equilibrium for a privately produced public good for which a single price is charged is zero production.

For this reason, private suppliers of public goods do not charge a single price. They price discriminate. Movie producers charge an array of prices that decline the longer the movie has been on the street. First run theaters charge the most, second run theaters charge less. Next the movie is shown on the premium cable movie channels. Then it is distributed in at movie rental stores. After a stay there it is sold in tape and digital formats. Finally, it ends up on broadcast TV.

Books are the same. Book originally come out in hard back. They are then discounted and sold through book clubs. Finally they come out in paper. If the book is really good, it will be made into a movie.

All of these methods and revenue sources are means by which the producers of these public goods can recoup the resources that they expend. Whether or not they are able to achieve the optimal level of production of these public goods is open to question. The issue cuts on two margins. First, we expect that the price discrimination schemes that they use to extract the differential marginal valuation across customers are not perfect. For instance, some movie aficionados are also patient. They value movies a lot but are willing to wait a long time before they see them. The movie producers are not able to capture this value and hence, the quantity of movies produced in a year may be less than optimal. On the other hand, movie producers are able to charge some people who have zero marginal value for the marginal movie produced in a year. Those of us who are at best indifferent to the medium are still forced to pay when we go to the movie rental store even though we are completely inframarginal to the process. Because of this, producers gain revenues that they wouldn't under a perfect 3rd degree price discriminating structure.

The efficiency of competitive price discrimination is defined by what is called Ramsey pricing. For any one unit of a privately produced public good, we can ask the question, What is the set of prices distributed across the heterogeneous consumers that maximizes consumer surplus while generating sufficient revenues to cover costs? This is the Ramsey pricing solution.

In the large across the many units of the public good that is produced, the welfare maximizing question is answered by zero profits. Firms will produce additional units of the public good up to the point where the profitability of the last unit produced has an expected value of zero. Additional units will drive the demand prices across all types of consumers down.