Tax policy – is it a better alternative to patent policy?

Aniruddha Bagchi

Kennesaw State University, USA

and

Arijit Mukherjee

Nottingham University Business School, UK, CESifo, Germany, INFER, Germany, and GRU, City University of Hong Kong, Hong Kong

Abstract: It is believed that if there is no informational asymmetry between the firms and the government, firms could be remunerated for innovation using optimal taxation rather than patents. We show that under reasonable conditions (such as the government's inability to customise the tax rate for each firm), patent protection is preferable than a tax/subsidy scheme if the marginal costs of the imitators are sufficiently higher than that of the innovator. Production inefficiency created by imitation is the reason for our result. If the marginal costs of the imitators are similar to that of the innovator, the authority can choose an appropriate patent breadth to replicate the outcome of the tax/subsidy scheme. Our result holds under both Cournot and Bertrand competition.

Key words: Patent; Tax; Welfare

JEL classifications: D43; H25; L13; O34

Correspondence to: Arijit Mukherjee, Nottingham University Business School, Jubilee Campus, Wollaton Road, Nottingham, NG8 1BB, UK.
Email: arijit.mukherjee@nottingham.ac.uk; Fax: +44 (0)115 84 66667

---

[*] We would like to thank Sugata Marjit, Matthew Mitchell and Peter Neary for helpful discussions. Aniruddha Bagchi gratefully acknowledges financial support from the Bagwell Center for the Study of Markets and Economic Opportunity at Kennesaw State University for this paper. The usual disclaimer applies.

Tax policy – is it a better alternative to patent policy?

1. Introduction

The common wisdom suggests that patent protection is not required if the patent authorities and the innovators have similar information. As nicely summarised by Scotchmer (1999), "Firms have better information on the costs and benefits of R&D than the government has and can thus make better decisions. If the patent authorities were as well informed as firms, a better system would be to commission R&D directly. Firms could then be remunerated using optimal taxation rather than patents, which would reduce deadweight loss to consumers." [1]

There are two important aspects in the above quote: information asymmetry and optimal taxation. If the innovators have better information than the government, there is a debate on the usefulness of the patent system. On one hand, patent system may create duplication of R&D costs and as Wright (1983) suggested, other reward systems may dominate the patent system. On the other hand, Loury (1979) suggested that patent system may benefit by increasing R&D expenditure, which, in turn, accelerates innovation. Even if the benefit from higher expenditure dominates the cost of duplication, a patent system may not use the private information efficiently. See Gandal and Scotchmer (1993) and Minehart and Scotchmer (1999) for the implications of private information.

We focus on the other aspect, i.e., optimal taxation. We show that even if there is no informational problem but optimal taxation is not possible due to the reasons discussed later, a patent system will be preferable than a tax/subsidy scheme depending on production efficiency created by the patent system by eliminating imperfect imitation, which is the reason for higher

[1] It is generally believed that patent protection encourages innovation and increases social welfare, thus creating "dynamic efficiency". However, it also creates a "static inefficiency" problem by increasing product market concentration. The optimal patent protection must take into consideration the issue of static inefficiency vs. dynamic efficiency (Leffler and Leffler 2004, Ordover 1991, O'Donoghue and Zweimiuller 2004, etc.).

marginal costs of the imitators compared to the innovator. Patent system is preferable than a tax/subsidy scheme with no patent protection if the marginal costs of the imitators are sufficiently higher than that of the innovator. Our result holds under both Cournot and Bertrand competition. The consideration of a single innovator in our analysis eliminates the effects of the patent race mentioned above, and the production inefficiency created by imitation is the reason for our result.

We considered that patent protection eliminates imitation while the tax/subsidy scheme generates imperfect imitation. Hence, it is implicit that the patent breadth is large enough to eliminate imitation. On the other hand, the complexity of the technology and/or the efficiency of the imitators in imitating the technology of the innovator may determine the extent of imperfect imitation under the tax/subsidy scheme. If the technology is complex and/or the imitators are not very efficient in imitating, our result suggests that patent protection with maximum patent breadth (which eliminates imitation) is better than the tax/subsidy scheme. However, if the technology is not complex and the imitators are efficient in imitating, a patent protection with maximum patent breadth is not better than the tax/subsidy. In this situation, the authority can choose an appropriate patent breadth to replicate the outcome of the tax/subsidy scheme, implying that the tax/subsidy scheme and the patent system with an appropriate patent breadth will create the same welfare. Thus, our paper also contributes to the literature on patent design (see, e.g., Arrow, 1962, Nordhaus, 1969, Scherer, 1972, Gilbert and Shapiro, 1990, Klemperer, 1990 and Gallini, 1992; see, Langinier and Moschini, 2002, for a nice overview of this literature).

There are some other papers (O'Donoghue et al., 1998, Scotchmer, 1999 and Cornelli and Schankerman, 1999) looking at the optimal patent system in the presence of a single innovator. However, the focus of those papers is on the informational problems, while our argument is based on production inefficiency.

There is an existing literature showing the effects of tax/subsidy policies on innovation and on investment in general. See Leahy and Neary (2009) for a nice survey of this literature. However, that literature did not consider how a tax/subsidy scheme performs in relation to a patent policy, which is the focus of our paper.

We assume that the government cannot choose optimal taxation. If a government can choose optimal taxation, it can impose discriminatory per-unit output tax on the imitators to induce them to exit the market, thus eliminating production inefficiency. However, as mentioned in Coşgel (2006, p. 333), "The cost of administering a system with discriminatory rates can be very high when the characteristics of tax payers do not differ systematically or when these differences cannot be easily observed. It is generally easier to identify differences between the sectors of the economy than within each sector, making it harder to implement discriminatory rates within a sector." Heady (1993) also discusses the limitations of optimal taxation due to administrative and compliance costs. Hence, if the government needs to use uniform tax, it is better for the government to use non-distortionary lump-sum profit tax, which we consider in our analysis.

The remainder of the paper is organised as follows. Section 2 describes the model and shows the results under Cournot competition. Section 3 considers the case of Bertrand competition. Section 4 concludes.

2. The model and the results under Cournot competition

2.1. Patent protection to induce innovation

Assume that there is an innovator, called firm 1, which invests an amount R to invent a new product. We normalise the marginal cost of producing the product by firm 1 to *0*. If there is patent protection, firm 1 produces the good as a monopolist, implying that the patent breadth is large enough to eliminate imitation. We will discuss below the implications of a smaller patent breadth. However, if there is no patent protection, we assume that $(n - 1)$ number of firms imitate the technology of firm 1, and each imitator produces the good with the marginal cost $c \geq 0$, implying that imitation can be imperfect, and as mentioned in the introduction, the complexity of the technology and/or the efficiency of the imitators in imitating the innovator's technology may be the reason for imperfect imitation. All firms compete like Cournot oligopolists. We will consider Bertrand competition in Section 3.

To show our results in the simplest way, we assume in this section that the products are homogeneous and the inverse market demand function for the product is $P = 1 - q$, where P is price and q is the total output. We also assume that $R \in (\frac{(1+(n-1)c)^2}{(n+1)^2}, \frac{1}{4})$. It will be immediate from our analysis that if $R < \frac{(1+(n-1)c)^2}{(n+1)^2}$, there will be no need for patent protection or a tax/subsidy scheme to induce innovation, since the innovator has the incentive to innovate the technology even if $(n - 1)$ firms imitate the technology and compete with the innovator.

If there is patent protection, straightforward calculation shows that the equilibrium net profit of firm 1 is $\pi_1^P = \frac{1}{4} - R$, which is positive since $R < \frac{1}{4}$ by assumption. Welfare under patent protection is $W^P = \frac{3}{8} - R$.

If there is no patent protection, the equilibrium net profit of firm 1 under innovation can be found as $\pi_1^{NP} = \frac{(1+(n-1)c)^2}{(n+1)^2} - R$. We have assumed $R > \frac{(1+(n-1)c)^2}{(n+1)^2}$, implying that firm 1 will not invent the technology in the absence of patent protection, and the corresponding welfare will be zero.

Hence, patent protection can generate welfare $W^P = \frac{3}{8} - R$ by inducing innovation.

2.2. Tax/subsidy scheme to induce innovation

Now consider a situation with no patent protection, but the government imposes tax on profits and lump-sum tax on the consumers and uses the tax revenue to cover any loss of the innovator due to imitation. This can happen provided the sum of total gross industry profit and consumer surplus is higher than the cost of R&D, i.e., if welfare is positive.

If n firms (i.e., the innovator and $(n-1)$ imitators) produce like Cournot oligopolists, straightforward calculation gives the equilibrium output of the innovator and the ith imitator as $q_1^{NP,t} = \frac{1+(n-1)c}{n+1}$ and $q_i^{NP,t} = \frac{1-2c}{n+1}$, $i = 2, \ldots, n$, respectively. We assume that $c < \frac{1}{2}$. The gross equilibrium profit of the innovator and the ith imitator are respectively $\pi_1^{NP,t} = \frac{(1+(n-1)c)^2}{(n+1)^2}$ and $\pi_i^{NP,t} = \frac{(1-2c)^2}{(n+1)^2}$, $i = 2, \ldots, n$.[2] The government can raise a tax revenue and can use the tax revenue to subsidise the innovator for any loss due to imitation if the sum of total gross industry profit and consumer surplus is higher than the cost of R&D, i.e.,

$$\frac{(1+(n-1)c)^2}{(n+1)^2} + \frac{(n-1)(1-2c)^2}{(n+1)^2} + \frac{(n-c(n-1))^2}{2(n+1)^2} > R \text{ or } \frac{n(2+n)+c^2(-1+n)(5+3n)-2c(-2+n+n^2)}{2(1+n)^2} > \mathrm{R},$$

which is satisfied since $R < \frac{1}{4}$ by assumption.

Welfare under the tax/subsidy scheme is

$$W^{NP,t} = \frac{(1+(n-1)c)^2}{(n+1)^2} + \frac{(n-1)(1-2c)^2}{(n+1)^2} + \frac{(n-c(n-1))^2}{2(n+1)^2} - R .$$

2.3. Comparing welfare

[2] For simplicity, we impose tax on the gross profit of the innovator, i.e., excluding the R&D cost. The result will not be affected even if we impose tax on the net profit of the innovator, i.e., including the R&D cost.

Now compare welfare under "patent protection" and "no patent protection with tax/subsidy". We find that $W^{NP,t} \underset{<}{\geq} W^{P}$ if $\frac{(1+(n-1)c)^2}{(n+1)^2}+\frac{(n-1)(1-2c)^2}{(n+1)^2}+\frac{(n-c(n-1))^2}{2(n+1)^2}-\frac{3}{8}\underset{<}{\geq}0$ or $c \underset{>}{\leq} \frac{3+n}{10+6n} \equiv c^*$, where $c^* \in (0,\frac{1}{2})$.

Both the patent system and the tax/subsidy scheme induce innovation for $R \in (\frac{(1+(n-1)c)^2}{(n+1)^2},\frac{1}{4})$, and the patent system generates higher welfare and therefore, is preferable compared to the tax/subsidy scheme for $c \in (c^*,\frac{1}{2})$.

The reason for the above result is as follows. The tax/subsidy scheme increases competition but also creates production inefficiency in the industry if the marginal costs of the imitators are higher than that of the innovator. On one hand, higher competition under the tax/subsidy scheme increases the total output compared to patent protection and tends to increase welfare. On the other hand, production inefficiency under the tax/subsidy scheme tends to reduce welfare by increasing the cost of production in the industry. This happens since the imitators steal business from the innovator, implying that some of the outputs produced by the innovator under the patent system will be produced by the relatively high-cost imitators under the tax subsidy/scheme. If the marginal costs of the imitators are sufficiently higher than that of the innovator, the production inefficiency effect dominates the competition effect and the tax/subsidy scheme reduces welfare compared to patent protection.[3] In this situation, patent protection with a maximum patent breadth that eliminated imitation is preferable than the tax/subsidy scheme even if there is no informational problem between the firms and the government.

[3] In different contexts, Klemperer (1988) and Lahiri and Ono (1988) discussed similar effects of competition and production inefficiency under Cournot competition.

The tax/subsidy scheme creates higher welfare and therefore, is preferable compared to patent protection for $c \in (0, c^*)$. As discussed in the introduction, this result holds if the patent breadth is large enough to eliminate imitation. However, the authority can choose an appropriate patent breadth to replicate the outcome of the tax/subsidy scheme. Hence, for $c \in (0, c^*)$, the tax/subsidy scheme and the patent system with an appropriate patent breadth will create the same welfare.

The above discussion is summarised in the following proposition.

Proposition 1: *Consider* $R \in (\frac{(1+(n-1)c)^2}{(n+1)^2}, \frac{1}{4})$. *The patent system preventing imitation is preferable than the tax/subsidy scheme for* $c \in (c^*, \frac{1}{2})$. *If* $c \in (0, c^*)$, *the tax/subsidy scheme and the patent system with an appropriate patent breadth will generate the same welfare.*

3. The case of Bertrand competition

The purpose of this section is to show that the result shown in the previous section under Cournot competition also holds under Bertrand competition.

We assume in this section that the inverse demand function faced by the ith firm, *i = 1, 2, ..., n*, is given by $P_i = 1 - kx_i - \gamma \sum_{j=1}^{n} x_j$, $i \neq j$, where $k = \left[1 + (n-1)(1-\gamma)\right]$. The corresponding demand function is given by $\mathrm{x}_i = \frac{[k - \gamma - P_i\left(k + \gamma(n-2)\right) + \gamma \sum_{j=1}^{n} P_j]}{(k-\gamma)\left[k + \gamma(n-1)\right]}$, $i \neq j$. This demand function is similar to Shubik and Levitan (1980), and follows from the utility function $U=\sum_{i=1}^{n}x_i-\frac{1}{2}[k\sum_{i=1}^{n}x_i^2-2\gamma\sum_{i\neq j}x_ix_j]$. Under this utility function and the demand structure, the market size is not affected by the number of products.

3.1. Patent protection to induce innovation

If there is patent protection and only firm 1, the innovator, produces the product, like subsection 2.1, we get the equilibrium net profit of firm 1 as $\pi_1^P=\frac{1}{4}-R$, and the corresponding welfare as $W^P=\frac{3}{8}-R$.

We assume that $R\in(\Omega,\frac{1}{4})$, where $\Omega=\frac{[k+\gamma(n-2)][2k^2+\gamma^2(3+c(n-2)(n-1)-2n)+k\gamma(-5+c(n-1)+2n)]^2}{(k-\gamma)[2k+\gamma(n-3)]^2[k+\gamma(n-1)][2k+\gamma(2n-3)]^2}$ implying that firm 1 will not innovate in the absence of patent protection and tax/subsidy scheme, since, in the absence of patent protection and the tax/subsidy scheme, the net profit of firm 1 will be $\pi_1^{NP}=\Omega-R<0$.

3.2. Tax/subsidy scheme to induce innovation

Now consider the tax/subsidy scheme, which will induce the innovator to innovate if the tax revenue can at least cover the cost of R&D, and this can happen if the welfare is positive.

If *n* firms (i.e., the innovator and *(n – 1)* imitators) produce like Bertrand oligopolists, given the demand and cost functions, we get the equilibrium prices charged by the innovator and the *i*th imitator as $P_1^{NP,t}=\frac{[2k^2+\gamma^2(3+c(n-2)(n-1)-2n)+k\gamma(-5+c(n-1)+2n)]}{[2k+\gamma(n-3)][2\text{k}+\gamma(2\text{n}-3)]}$ and $P_i^{NP,t}=\frac{[2(1+c)k^2+\gamma^2(3+2c(n-2)^2-2n)+k\gamma(-5+4c(n-2)+2n)]}{[2k+\gamma(n-3)][2\text{k}+\gamma(2\text{n}-3)]}$, *i = 2, ..., n*, respectively. The corresponding outputs are $q_1^{NP,t} = \frac{[(k+\gamma(n-2))(2k^2+\gamma^2(3+c(n-2)(n-1)-2n)+k\gamma(-5+c(n-1)+2n))]}{(k-\gamma)[2k+\gamma(n-3)][k+\gamma(\mathrm{n}-1)][2k+\gamma(2\mathrm{n}-3)]}$ and

$q_i^{NP,t} = \frac{[(k+\gamma(n-2))(2(1-c)k^2+\gamma^2(3+c(n-1)-2n)+k\gamma(-5-2c(n-2)+2n)]}{(k-\gamma)[2k+\gamma(n-3)][k+\gamma(n-1)][2k+\gamma(2\mathrm{n}-3)]}$, *i = 2, ..., n.*

We assume that $c < \frac{(k-\gamma)[2k+\gamma(2n-3)]}{2k^2+2k\gamma(n-2)-\gamma^2(n-1)}$.

The gross equilibrium profit of the innovator and the *i*th imitator are respectively $\pi_1^{NP,t} = \frac{(k+\gamma(n-2))[2k^2+\gamma^2(3+c(n-2)(n-1)-2n)+k\gamma(-5+c(n-1)+2n)]^2}{(k-\gamma)[2k+\gamma(n-3)]^2[k+\gamma(\mathrm{n}-1)][2k+\gamma(2\mathrm{n}-3)]^2}$ and

$\pi_i^{NP,t} = \frac{(k+\gamma(n-2))[2(1-c)k^2+\gamma^2(3+c(n-1)-2n)+k\gamma(-5-2c(n-2)+2n)]^2}{(k-\gamma)[2k+\gamma(n-3)]^2[k+\gamma(n-1)][2k+\gamma(2\mathrm{n}-3)]^2}$, *i = 2, ..., n.*[4]

The government can raise a tax revenue equal to the cost of R&D and can use this tax revenue to subsidise the innovator for the cost of R&D provided the sum of total gross industry profit and consumer surplus is higher than the cost of R&D, i.e.,

$$\frac{\begin{array}{l}(k+\gamma(n-2))[2c(k-\gamma)(3k+\gamma(n-4))(n-1)(2k+\gamma(2n-3))^2 \\ -(k-\gamma)(3k+\gamma(n-4))n(2k+\gamma(2n-3))^2 \\ +c^2(n-1)(-12k^4-28k^3\gamma(n-2)+k^2\gamma^2(-89+(89-20n)n) \\ +\gamma^4(n-1)(6+(n-6)n)-2k\gamma^3(n-2)(13+n(2n-13)))]\end{array}}{2(\gamma-k)[2k+\gamma(n-3)]^2[k+\gamma(n-1)][2k+\gamma(2n-3)]^2} > R,$$

and this will happen since $R < \frac{1}{4}$ by assumption.

[4] For simplicity, we impose tax on the gross profit of the innovator, i.e., excluding the R&D cost. The result will not be affected even if we impose tax on the net profit of the innovator, i.e., including the R&D cost.

Welfare under the tax/subsidy scheme is

$$W^{NP,t} = \frac{\begin{array}{l}(k+\gamma(n-2))[2c(k-\gamma)(3k+\gamma(n-4))(n-1)(2k+\gamma(2n-3))^2 \\ -(k-\gamma)(3k+\gamma(n-4))n(2k+\gamma(2n-3))^2 \\ +c^2(n-1)(-12k^4-28k^3\gamma(n-2)+k^2\gamma^2(-89+(89-20n)n) \\ +\gamma^4(n-1)(6+(n-6)n)-2k\gamma^3(n-2)(13+n(2n-13)))]\end{array}}{2(\gamma-k)[2k+\gamma(n-3)]^2[k+\gamma(n-1)][2k+\gamma(2n-3)]^2} > R.$$

3.3. Comparing welfare

Now compare welfare under "patent protection" and "no patent protection with tax/subsidy". It can be shown that $W^{NP,t}$ is higher (lower) than W^P if *c* is lower (higher) than a critical value, say, c^{**}. Since the expression for c^{**} is complicated, we use an example here to show that a result similar to Proposition 1 holds.

We plot $(W^{NP,t} - W^P)$ in Figure 1 for *n = 2* and $\gamma = .5$. It is immediate from the figure that the tax/subsidy scheme creates higher (lower) welfare compared to patent protection for smaller (larger) values of *c*, implying that the tax/subsidy scheme is preferable (not preferable) to the patent system for smaller (larger) values of *c*. However, if *c* is small, an appropriate patent breadth will create the same welfare under the patent system and the tax/subsidy system.

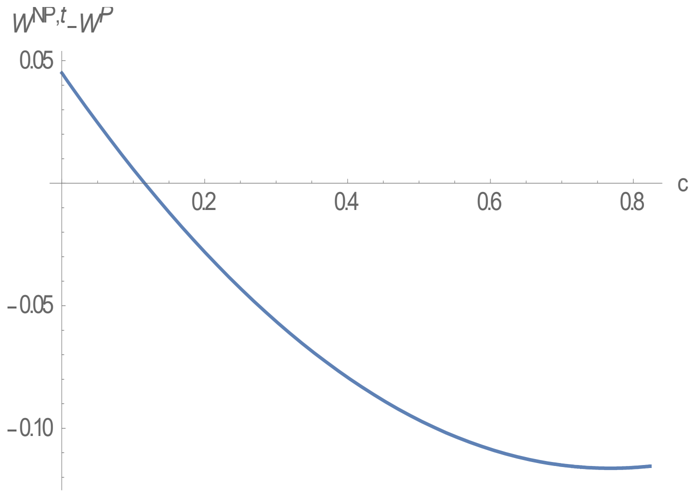

Figure 1: $(W^{NP,t} - W^{P})$ for $n = 2$ and $\gamma = .5$

The above analysis shows that the results under Bertrand competition are similar to that of Cournot competition. The reasons for the results under Bertrand competition are similar to that of under Cournot competition.

The following proposition summarises the result under Bertrand competition.

Proposition 2: *Consider* $R \in (\Omega, \frac{1}{4})$. *The patent system preventing imitation is preferable than the tax/subsidy scheme for sufficiently higher values of c. If c is not sufficiently high, the tax/subsidy scheme and the patent system with an appropriate patent breadth will generate the same welfare.*

4. Conclusion

The patent system is used quite commonly to encourage innovative activity. However, there is also an undesirable effect of the patent system known as the "static inefficiency" problem. This arises because the patent system grants monopoly rights to the patent holder, which, in turn, restricts output to increase profit. It is generally believed that patent protection is not required if the patent authorities and the innovators have similar information (Scotchmer, 1999).

We show that even if there is no informational asymmetry between the firms and the government, there is still a case for patent protection. Patent protection is preferable to a tax/subsidy scheme with no patent protection if the marginal costs of the imitators are sufficiently higher than that of the innovator, which may happen if the technologies are complex and/or the imitators are inefficient in imitating the innovator's technology. Otherwise, the authority can choose an appropriate patent breadth to replicate the outcome of the tax/subsidy scheme. Our result holds under both Cournot and Bertrand competition.

References

Arrow, K.J., 1962, 'Economic welfare and the allocation of resources for inventions', In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Ed. by R.R. Nelson, Princeton, NJ: Princeton University Press.

Clarke, R. and D. Collie, 2003, 'Product differentiation and the gains from trade under Bertrand duopoly', *Canadian Journal of Economics*, 36: 658-73.

Cornelli, F. and M. Schankerman, 1999, 'Optimal patent renewals', *Rand Journal of Economics,* 30: 197–213.

Coşgel, M. M., 2006, 'Taxes, efficiency, and redistribution: discriminatory taxation of villages in Ottoman Palestine, Southern Syria, and Transjordan in the sixteenth century', *Explorations in Economic History*, 43: 332–356.

Gallini, N., 1992, 'Patent policy and costly imitation, *Rand Journal of Economics*, 23: 52-63.

Gandal, N. and S. Scotchmer, 1993, 'Coordinating research through research joint ventures', *Journal of Public Economics*, 51: 173–193.

Gilbert, R., and C. Shapiro, 1990, 'Optimal patent length and breadth', *Rand Journal of Economics*, 21: 106-112.

Heady, C., 1993, 'Optimal taxation as a guide to tax policy: a survey', *Fiscal Studies*, 14: 15-41.

Klemperer, P., 1988, 'Welfare effects of entry into markets with switching costs', *Journal of Industrial Economics*, 37: 159-65.

Klemperer, P., 1990, 'How broad should the scope of patent protection be?', *Rand Journal of Economics*, 21: 113-30.

Lahiri, S. and Y. Ono, 1988, 'Helping minor firms reduces welfare', *Economic Journal*, 98: 1199-1202.

Langinier, C. and G, Moschini, 2002, 'The Economics of Patents', in *Intellectual Property Rights and Patenting in Animal Breeding and Genetics*, Ed. by S. Newman and M. Rothschild, CAB International, 31-50.

Leffler, K. and C. Leffler. 2004. Efficiency trade-offs in patent litigation settlements: Analysis gone astray. *USFL Rev.*, 39, p.33.

Leahy, D. and P. Neary. 2009. Multilateral subsidy games. *Economic Theory*, 41, 41-66.

Loury, G.C., 1979, 'Market structure and innovation', *Quarterly Journal of Economics*, 93: 395–410.

Minehart, D. and S. Scotchmer, 1999, 'Ex Post regret and the decentralized sharing of information', *Games and Economic Behavior*, 17: 114–131.

Nordhaus, W.D., 1969, *Inventions, growth and welfare: a theoretical treatment of technological change.* Cambridge, MA: MIT Press.

O'Donoghue, T., S. Scotchmer and J.-F. Thisse, 1998, 'Patent breadth, patent life, and the pace of technological progress', *Journal of Economics and Management Strategy*, 7: 1–32.

O'Donoghue, T. and J. Zweimuller. 2004. Patents in a model of endogenous growth. *Journal of Economic Growth*, 9: 81-123.

Ordover, J. A. 1991. A patent system for both diffusion and exclusion. *Journal of Economic Perspectives*, 5: 43-60.

Scherer, F.M., 1972, 'Nordhaus' theory of optimal patent life: a geometric reinterpretation', *American Economic Review*, 62: 422-427.

Scotchmer, S. 1991. On the optimality of the patent renewal system. *Rand Journal of Economics*, 30: 181-196.

Shubik, M. and R. Levitan, 1980, '*Market Structure and Behaviour*', Harvard University Press, Cambridge, MA.