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The Real Price of Patents

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Summary

In this thesis we seek to determine whether there exists a potential alteration or supplementation to the patent system of today. We propose the establishment of an International Organization with the sole purpose of buying and distributing patents. The method backing the thesis' arguments is a mix of theoretical and applied microeconomics. This thesis sets out to describe (almost) all linear combinations of competitive and monopolistic market structures, where a drastic innovation with positive externalities occurs. Modelling the relevant market outcomes, we create a model focusing on the effects of a patent buyout, where the innovation creates positive externalities, and would if not bought and distributed, create a monopoly situation.

Using microeconomic patent theory proposed by Kremer (1998) and Guell & Fischbaum (1995) (among others), we prove that establishing said International Organization, in theory, can lead to favorable results, by mathematically proving that the increase in social surplus can exceed the funds used to pay for the patents, for some patents with positive externalities.

Abbreviations

CL = Compulsory Licensing

DWL = Deadweight Loss

E = Externalities

EU = European Union

G&F = Guell & Fischbaum

IPR = Intellectual Property Rights

IB = International Body

MSB = Marginal Social Benefit (private value and external benefit)

R&D = Research & Development

SSM = Social Surplus Maximizers

TRIPS = Trade Related aspects of Intellectual Property rights

WTO = World Trade Organization

List of Symbols

α = *unknown positive externalities*

a = *demand curve*

β = *the slope of externalities*

b = *the slope of the demand curve*

C = *competitive situation*

CS = *consumer surplus*

D = *demand*

ε = *elasticity of demand*

ω = *markup going towards zero*

M = *monopoly situation*

MC = *c* = *marginal cost*

MR = *marginal revenue*

P = *price*

PS = *producer surplus*

Q = *quantity*

S = *social surplus*

T = *time periods*

x = *a decrease in MC followed by an innovation*

κ = *fee*

SECTION 1. INTRODUCTION TO THE RESEARCH TOPIC

In 1839, the French government purchased the Daguerreotype patent from the Parisian individual Louis Daguerre, making it a public domain and free to use by any of the worlds inventors (except England). This master thesis will research and question the economic effects of Intellectual Property Rights (IPR), and if it is economically optimal to designate a global patent buyout organization (denoted IB: “International Body”). These kinds of buyouts may help eliminate the negative consequences of monopolies, mainly by removing deadweight losses and price jumps. We chose to focus on an international organization rather than national, because nations may not have incentives for distributing patents. National exports of intellectual properties can generate value as demonstrated by the case of Danish patent exports, where the Danish GDP is substantially affected by patent exports (Megaw and Milne, 2018). However, in the case of patent buyouts by a national organization, the practice of subsidies is more relevant for this particular thesis.

The idea of the topic came from one of the economics courses offered at BI Norwegian Business School: GRA 1305 Industrial Organization. After having participated in this course, where patents and research & development (R&D) were touched upon, we decided to use the master thesis to explore this subject further.

1.1. PURPOSE OF THE THESIS

The main goal of this thesis is to examine if it is possible to create a more economically optimal patent scheme than what currently exists. *Is it possible to improve on today's patent practice without decreasing innovation incentives, and at the same time increase the total social surplus generated?* This question is affected by several factors, e.g. *How long should a patent last? What are the consequences if authorities waive a patent outside the innovator's expectations? How do we value a patent? What is the value of said patent? At what price should* *an innovator be willing to sell a patent?* We will answer these questions by mainly introducing a third party with purchasing power: Authorities or other International Body (IB).

1.2. RESEARCH PROBLEM

One of the major questions we want to answer is: *How much should an IB be willing to pay for a patent?* A parallel to this research question is the paper by Professor Michael Kremer (1998), Patent Buyouts: A Mechanism for Encouraging Innovation, which discusses which patents should be bought and what selling process should be applied; and Professor Robert C. Guell & Marvin Fischbaums (1995), Toward Allocative Efficiency in the Prescription Drug Industry, which challenges efficient patent practices. We want to look at the difference between the competitive market company profits and the social surplus, which none of the aforementioned papers have done. Further, by comparing the private value of an innovation to the Social Surplus Maximizers (SSM) value, and then introducing valuation factors, we suggest that an IB may be a positive supplement to today's patent scheme.

Kremer (1998) proves that a second price sealed auction will reveal the true value of a patent, but that this only proves how much a patent is worth to a potential buyer, and not to the society as a whole. More specifically, there exists three different price ranges of patents; 1. what it is worth for a private actor (both monopolistic and competitive), 2. what it is worth for the SSM without externalities, and 3. what it is worth for the SSM with externalities.

This leads us to our research question:

Is it economically optimal to appoint a global patent body that buys and distributes patents that can exploit positive externalities, and thereby increase total social surplus?

1.3. FRAMEWORK

The thesis is organized as follow: section 2 presents an analysis of the existing literature, focusing on what we consider to be most relevant for further discussions. In section 3 we will give a brief introduction to what patents are, its requirements and an exception rule. Section 4 includes formal theoretical models, like monopoly with deadweight loss and patent breadth. In section 5 we will prove that current patent practice may have room for improvement by applying a SSM perspective. In further sections we seek to define the optimal patent price through an applied theoretical framework, and then finally introducing externalities as a new variable, illustrating that the true value of a patent for a social perspective may be even higher than first estimated. In section 9 we will draw a conclusion on our findings.

SECTION 2. REVIEW OF LITERATURE

This section reviews the literature we consider relevant for our discussion. Kremer's paper (1998) and Guell & Fishbaum's paper (1995) share the common goal of addressing how the government decides patent prices based on size and form.

Kremer, M. (1998).

As the social value of an invention is often worth more than the private value of a temporary monopoly (which generally last up to 20 years) (Scotchmer, 2004, p. 69), the patent system is an inefficient compromise that under-incentivizes innovation. Some argues that inventors should hold legally sanctioned monopolies, while other argues that inventions should be shared as public goods.

In a well-known paper by Professor Michael Kremer (1998), he proposes that the government should purchase patents and then place them in the public domain. Figure 2.0.1. shows how an auction could be used to determine the price at which the government would offer to buy out patents. Under this mechanism, the market value of patents would be determined through a second degree sealed auction, where any private party is permitted to bid. The government would then offer to pay for the patent private value times a fixed markup (between 2,5 and 3,33 of the private value) that compensates for the inequality between the private- and social surplus (Kremer, 1998, p. 1142). Most of the patents that the government bought would be placed in the public domain. However, in order to avoid distortions and to induce accurate valuations, a fraction of patents would be sold to the highest bidder according to randomization by the government. Patent holders would have the right to accept or reject the government's offer.

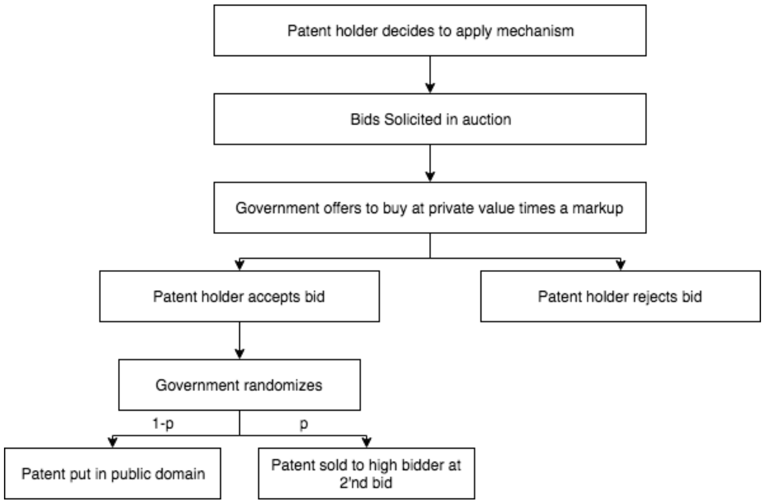


Figure 2.0.1: Auction mechanism for patent buyouts.

As in any sealed auction, auction participants will consider their own interest in bidding. That means that if a private party bids too low, then he will not win the auction; and if a private party bids too high, then he may end up paying too much for the patent. Hence, it is a weakly dominant strategy to bid one's true valuation (Watson, 2013, p. 364). This will be very valuable for the government, as they can estimate the private value using the information from the entire distribution of bids. Also, competitors of the patent holder may have better information than the government about the patent's value.

An example of how the patent buyout works occurred when Louis Daguerre and Isidore Niépce sold their rights in a negotiation in 1839. In exchange for revealing the secrets of the process, the French inventors of photography received pensions totalling 10.000 francs per annum (Scotchmer, 2004, p. 42). Afterward, the process was put in the public domain and was free to use by any of the worlds inventors (except England) (Wood, 1980, p. 12). One can only assume that Daguerre and Nièpce received value commensurate with their invention, as they would not have accepted a price less than the patent value.

Despite the dignity of Kremer's proposal, there are theoretical challenges to his system. First, the system relies upon that auction participants reveal their true valuation of the innovation. Second, it remains potential collusion among patent holders and bidders, as a seller of a patent would have an incentive to bribe bidders to enter high bids. Additional concerns are finding the capital to implement the purchases and the possibility of preventing a patent holder from using his invention.

Guell, R.C. & Fischbaum, M. (1995).

In this paper, Professor Robert C. Guell and Marvin Fischbaum (G&F) proposes an alternative to price controls, focusing specifically in the prescription drug industry. Their proposal is useful for describing the problem that all suggestions regarding patent prices seek to resolve: the inefficiency associated with a limited monopoly. As G&F state: "The problem is that, in order to garner those profits, monopolist set price above marginal cost and produce less than the socially desirable output". More precisely, producers exercise monopoly power by setting price above the competitive level, which a patent entitles the producer to do. For instance, medicine that cost little to produce might sell for a lot more. Some consumers may not have enough resources to make the purchase, and will therefore fail to do so at the monopoly price, even though they value the medicine more than the price to manufacture it. When this occurs, the consumers lose more from higher prices than the producers gain, which causes a deadweight loss (Guell & Fischbaum, 1995, p. 217). See figure 2.0.2 for an illustration.

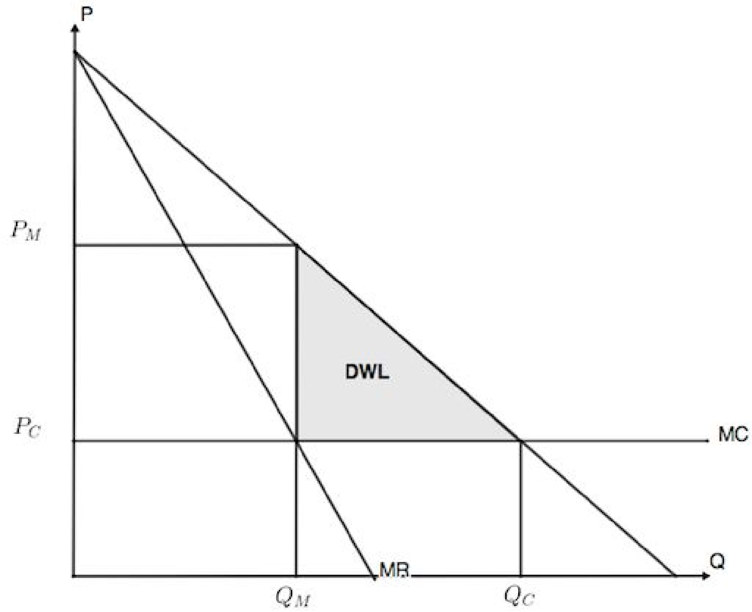


Figure 2.0.2: Deadweight loss (grey area) from monopoly pricing.

To solve the deadweight loss problem, G&F suggest that the government should provide funds for R&D, in exchange for placing the research in the public domain. Further, the government should allow the "invisible hand"[1] to work, inventors to obtain patents, and then pay the inventors for their patent. They suggest directly "that the government buy prescription drug patents at a price equaling the net present value of the profit they would have generated and distribute the patents to U.S. drug manufacturers" (Guell & Fischbaum, 1995, p. 221). Assuming that this can be done in practice, it is easy to see how this would solve the inefficiency problem. By putting the patent in the public domain, the government would invoke competition, leading to production at a level that normally would be higher than the monopoly level at a lower price. As the government pays the inventors the difference between the profits that they would have earned and the profits that they might still earn from being the sole producer, the inventors would be indifferent.

However, this specific proposal is not the main point in G&F's paper. They deliberate the US government's ability to confiscate patents for public use and pay

[1] Phrase originally coined by Adam Smith to describe unobservable market, forces in the book 'The Wealth of Nations'.

“just compensation”, under the Fifth Amendment to the Constitution of the U.S. mandates (Guell & Fischbaum, 1995, p. 225). G&F argue strongly against this, as the valuation of the patent differs between the seller and buyer, and that paying “just compensation” will lead to a decrease in incentives to conduct R&D in the future, as they may risk having the patent confiscated anyway. We discuss the mechanisms which makes this possible in section 3.2.

Further, Guell & Fischbaum discuss that if a patent is to be bought, an isolated market could be set up, run for a set period and time, and then the data can be used and scaled up to set a fairly accurate estimate for the real value of the patent (lost monopoly profits). Nevertheless, this does not answer the question of how to create an administrative agency that would determine which patents to take.

SECTION 3. BACKGROUND

For the purpose of this thesis, we will give a brief introduction to patents.

3.1. PATENTS AND ITS REQUIREMENTS

A patent is a government issued document that gives the inventor or the owner of the patented invention exclusive rights to a specific new device, apparatus or a process for a limited period of time, generally 20 years (Scotchmer, 2004, p. 69). To get a patent, one have to file for an application that explains the invention, and how it differs from what others have done before. Then, the government reviews the application and grants the inventor the patent if the requirements for patentability are fulfilled. There are four requirements for patentability:

1. Statutory:

   The invention must fall within the scope of patentable subject matter, meaning that it must either be a machine, a manufactured product, a composition made from two or more substances, or a process for manufacturing objects (Scotchmer, 2004, p. 66).

2. Usefulness:

   The invention must be useful. Traditionally, this mean three things: practical utility, operability and beneficial utility. An example is that a machine must work according to its intended purpose and a chemical must exhibit an activity or have some use.

3. Novelty:

   The invention must be new. It can not have been described in earlier publications, and it can not have been used or sold in the past.

4. Non-obviousness:

   The innovation must be different from previous innovations "in ways that would have been obvious to somebody who had ordinary skill in the technology" (Scotchmer, 2004, p. 68).

3.2. TRIPS AGREEMENT

The World Trade Organization's (WTO's) agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) was implemented on January 1st, 1995 and is the most comprehensive international instrument on intellectual property rights (Nguyen, 2010, p. 1). The agreement was negotiated in the Uruguay Round (1986 - 1994) as an addition to the former GATT agreement, which today forms the basis for WTO activities (Nguyen, 2010, p. 1).

The TRIPS agreement contributes to a worldwide strengthening of protection of intellectual property by establishing minimum standards of different related regulations (Nguyen, 2010, p. 1). It can be considered as a "multilateral rule of law" to the degree to which WTO members must now protect the intellectual property of other members'. However, the TRIPS agreement also contains provisions that allows flexibility for countries to accommodate their own patent and intellectual property systems and developmental needs. This is specified in article 31 of the TRIPS agreement, and is called compulsory licensing.

3.2.1. COMPULSORY LICENSING

Compulsory licensing is when a government allows a third party other than the patent holder to produce the patented product or process without the consent of the patent holder (WTO, 2018). The policy can apply to patents in any field, but it is most used in association with pharmaceuticals. However, for national emergencies or other circumstances of national urgency, there is no need to attempt voluntary licensing (WTO, 2018).

Compulsory licensing allows pharmaceutical drug companies to manufacture patented drugs and sell them at a fraction of the price that the patent holders would. They can do so, as it is only the cost of producing the medication that need to be recovered, and not also the cost of R&D (WHO, 2005). Table 1.1 in the attachment show some examples of compulsory licensing applied for pharmaceuticals worldwide from year 2001 to 2010 (Beall and Kuhn, 2012).

SECTION 4. THEORETICAL FRAMEWORK

In this section we introduce the theory that will lay foundation for our thesis, which we consider to have an importance for further analyses. Creating monopolies of ideas and directly subsidizing research both lead to serious consequences, as inventors cannot fully capture the social value of their invention. Spillovers of their ideas to other researchers exists, and hence, patents may provide insufficient incentives to develop socially valuable inventions. Patents also create static distortions from monopoly pricing and stimulates socially wasteful expenditures when “inventing around patents” (Kremer, 1998, p. 1137). However, patent may prohib industrial secrets, ensuring that research on the patented areas are possible even when the patent is active. This makes the research in the relevant field faster than it would be if the knowledge was not made public.

4.1. CONSTRAINED VS. UNCONSTRAINED MONOPOLIST

It is common to separate between process innovations and product innovations when considering the output of R&D. Process innovations is the implementation of a new or significantly improved production or delivery method, while product innovations are the creation of new goods (Pepall, 2014, p. 552). In this thesis, we are going to focus on process innovations.

When considering process innovation, one can further separate between drastic and non-drastic innovations (Pepall, 2014, p. 552). Roughly speaking, drastic innovations are innovations with such great cost savings that they allow the innovator to price as an unconstrained monopolist; at least for some time. By contrast, non-drastic innovations give the innovator a cost advantage over its rivals, but not unconstrained monopoly power.

The formal distinction between drastic and non-drastic innovations is illustrated in figure 4.1 below, where:

$$P = price$$

$$Q = quantity$$

$$MC = marginal\ cost$$

$$MC' = reduced\ marginal\ cost\ followed\ by\ an\ innovation$$

$$MR = marginal\ revenue$$

$$p^M = monopoly\ price$$

$$q^M = monopoly\ quantity$$

$$q^C = competitive\ quantity$$

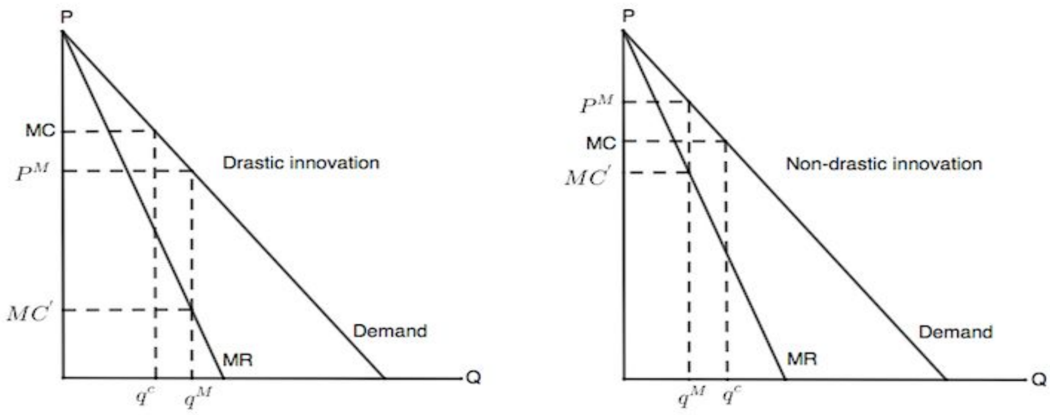


Figure 4.1: Drastic (left) and non-drastic (right) innovation.

Mathematically expressed, under drastic innovation $q^M > q^C$ or $P^M < MC$: the innovator can charge monopoly price P^M without constraint, and under non-drastic innovation $q^M < q^C$ *or* $P^M > MC$: the innovator cannot charge monopoly price P^M , because rivals can undercut that price.

4.2. MONOPOLY

A monopoly is a market with only one supplier of a good where there are no close substitutes for the product or the process that the supplier is providing (Mankiw, 2008, p. 312). The monopolist is the only source of the particular product or process, and therefore they have in theory the ability to charge whatever price they want. Practically, however, the monopolist is constrained by the consumer's willingness to pay (Mankiw, 2008, p. 316). We elaborate on this constraint in section 4.3.

Patents can create a monopoly situation because the patent holder can legally exclude other potential competitors from using the product or process for a number of years. Because the monopolist charge a price above marginal cost (MC), not all consumers who value the good at more than its cost buy it. Thus, the quantity produced and sold by the monopolist is inefficiently low from a social point of view (Scotchmer, 2004, p. 36). As a consequence, a deadweight loss (DWL) occurs. Scotchmer (2004) defines a deadweight loss as follows: “Deadweight loss occurs when people are excluded from using the good even though their willingness to pay are higher than the marginal cost“. The monopoly situation with a DWL is illustrated in figure 4.2, where the DWL is represented by the area of the triangle between the demand curve (which reflects the value to consumers) and the MC curve (which reflects the cost to the monopolist).

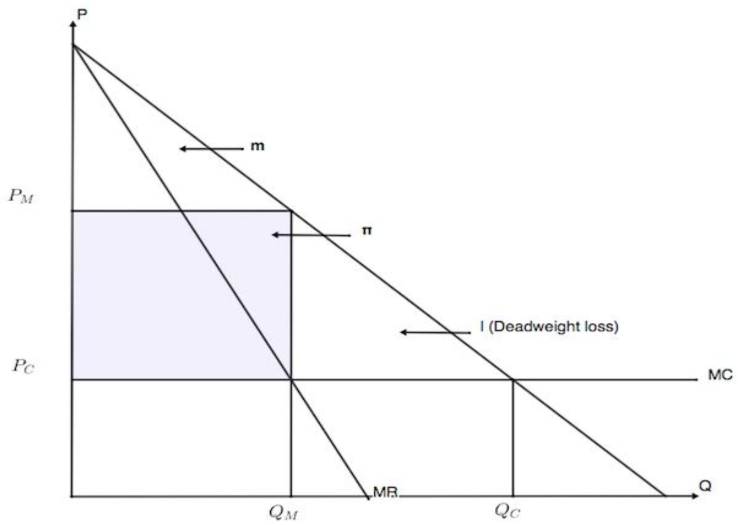


Figure 4.2: The inefficiency of monopoly.

The figure shows a product that is produced at a marginal cost, $P_c = MC$. Without any patent protection, meaning if competitively supplied, the produced quantity is equal to the efficient level Q_c. Thus, the socially efficient quantity is found where the demand curve and the MC curve intersect. The parameters $m + \pi + l$ illustrates the total surplus, which in this case is the consumer surplus. In this particular situation, there is no producer surplus.

However, when a patent is granted, a monopoly situation occurs, and the innovator can profit by pricing the product optimally at P_m, where $P_m > P_c = MC$. The innovator's per period profits are represented by π in figure 4.2. The total surplus is reduced to the area $m + \pi$, which in turn gives a deadweight loss equal to l. The loss occurs because the product is produced below the socially efficient level, i.e. $Q_C > Q_M$. After the duration of the patent, the total surplus increases to the area $m + \pi + l$.

This demonstrates the trade-off of the patent system; balancing between the benefits of encouraging additional innovative activities and the costs of forgoing the competitive provision of some goods and services.

4.3. PRICE ELASTICITY OF DEMAND

An important concept in relation to patents is the price elasticity of demand. Price elasticity of demand is a term used when discussing price sensitivity, or more precisely, the percentage change in quantity demanded in response to a one percent change in price (Mankiw, 2008, p. 91). Measuring increases and/or decreases in percentage terms keeps the definition of elasticity unit-free. The formula for calculating price elasticity of demand is:

$$Price\ elasticity\ of\ demand\ (\varepsilon) = \frac{percentage\ change\ in\ quantity\ demanded}{percentage\ change\ in\ price} = \frac{dQ}{dP} \times \frac{P}{Q}$$

As the changes in price and quantity usually will move in opposite directions, we do not bother to put in the minus sign as it is tedious to keep referring to an elasticity of a negative value (Mankiw, 2008, p. 91). It is quite common in verbal discussion to refer to elasticities of 1 or 2, rather than -1 or -2.

When the price elasticity of demand is equal to zero, we say that the demand is perfectly inelastic. When the price elasticity of demand is between zero and one, we say that the demand is inelastic. When the price elasticity of demand is equal to one, we say that the demand is unit elastic. Finally, when the price elasticity of demand is greater than one, we say that the demand is elastic.

In monopoly, the marginal revenue (MR) is positive when the demand curve is elastic, it is zero when it is unit elastic, and it is negative when the demand curve is inelastic. This means that a monopolist is only able to maximize his profit by producing a quantity of output that falls within the elastic range of the demand curve (Mankiw, 2008, p. 316). Since no sensible monopolist will produce on the portion of the demand curve which gives him negative MR, the elasticity of demand must be greater than one (Vali, 2013, p. 166). See figure 4.3 below as an illustration.

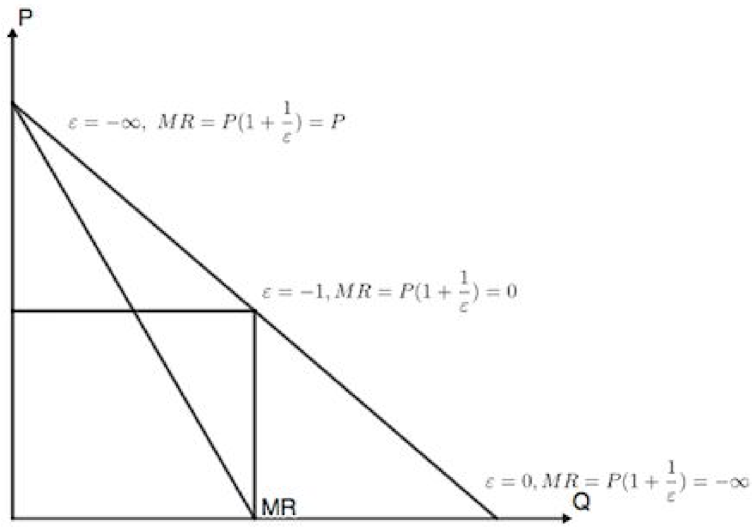


Figure 4.3: The relationship between MR and ε.

One can also link the relationship between MR and ε mathematically:

$$MR = P + \tfrac{dP}{dQ}Q$$

$$MR = P\left[1 + \tfrac{Q}{P} \times \tfrac{dP}{dQ}\right]$$

Since $\tfrac{dP}{dQ} \times \tfrac{Q}{P}$ is the reciprocal of price elasticity of demand, ε, we have that:

$$MR = P\left[1 + \tfrac{1}{\varepsilon}\right]$$

4.4. OPTIMAL PATENT LENGTH

In our thesis, we assume that the normal patent length is the optimal patent length, and that the normal patent length, is as defined by Scotchmer (2004) and WTO, 20 years (WTO, 2006). Nevertheless, we still want to include the theory of optimal patent length by Nordhaus (1969) and Scherer (1972), as we believe it is an important part in general patent theory.

The theory of optimal patent length is originally based on a model of Nordhaus (1969), which was later extended and criticised by Scherer (1972). Generally, the model is based on the idea that inventions and innovations are not free goods. This indicates that there cannot be an invention or innovation that reduces unit production costs without R&D costs. For any given production task, there exists an "invention possibility function", which relates the percentage unit production cost reduction B (which is the output of an inventive effort), to the expenditure of R&D. Hence, the more input in research, the greater your cost savings will be. In contrast to Nordhaus (1969), Scherer (1972) believes that the invention possibility function, $B(RD)$, is inflected. This means that at first there are increasing returns in lower levels of R&D expenditure, and later diminishing returns in higher degrees of investments. See figure 4.4.1 as an illustration.

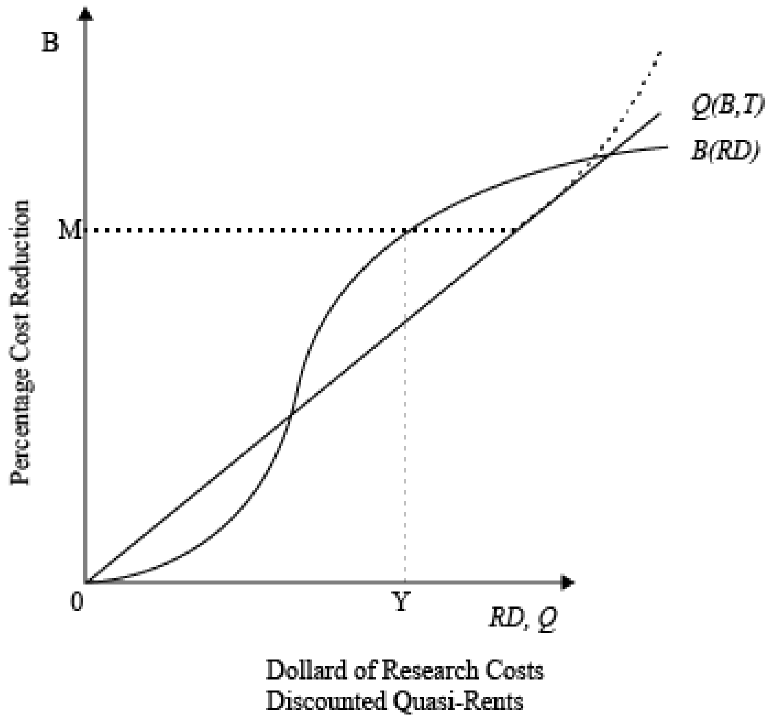


Figure 4.4.1: The "invention possibility function".

Scherer (1972) assumes that the benefits to the firm depend in a more advanced manner. Initially, production takes place under competitive conditions at a constant unit cost and price, C_o. Once a patent is granted, the unit cost is reduced to C_1, which means that the firm with the patent can either drive other firms out of business, produce the former output X_0 and command a monopoly rent of C_0EAC_1 per year, or it can license the patent. Note that the patent holder is not permitted to charge a price above the cost C_o associated with the competitive process. Based on this, and the fact that demand in not very elastic, the optimal post-invention price and quantity under monopoly will be similar to the price and quantity in the pre-invention equilibrium. However, if the cost reduction associated with the invention is drastic (i.e. the cost reduces to C_2), the new long-run cost curve cuts the monopolist's MR curve to the right of the old competitive output, X_0. This implies that the patent holder gets both a price reduction and an output expansion. See figure 4.4.2 as an illustration.

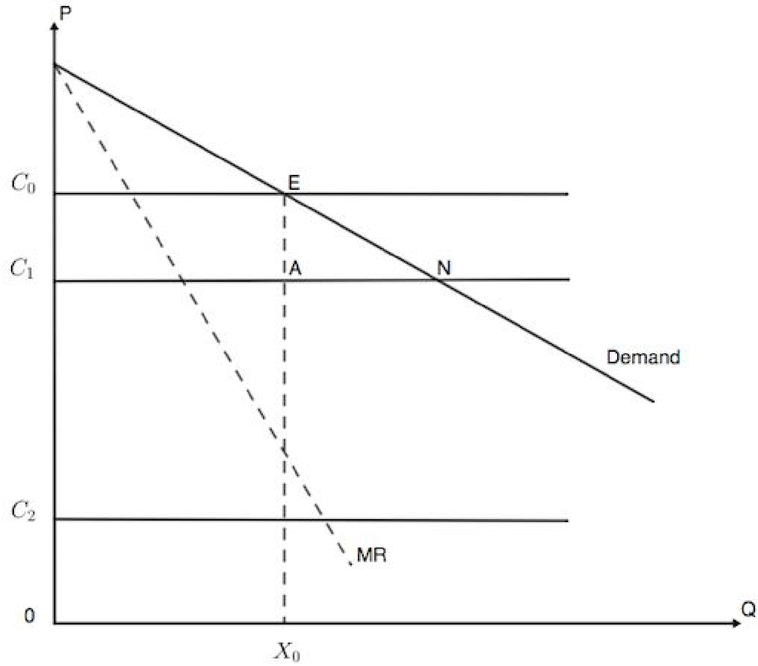


Figure 4.4.2: Benefits to the firm.

For a given patent life $T = T^*$, the monopolist's total discounted quasi-rent function, $Q(B, T^*)$, can be shown as a straight line. However, with a drastic cost reduction, the quasi-rent function begins to curve upwards. This can be seen as a dotted line-extension in figure 4.4.1.

Once the patent has expired, competition drives the price down to C_1, output is increased, the producer's surplus ceases, and the society gains a new consumers' surplus of C_0ENC_1. Assuming equal marginal utility of income between the patent holder and the society, the price society pays to induce a reduction from C_0 to C_1 is the offering of the welfare triangle E-A-N, for the entire patent duration, plus the inventor's R&D costs. The socially optimal patent life can be found by balancing the marginal deferrals of this welfare triangle surplus and the R&D cost.

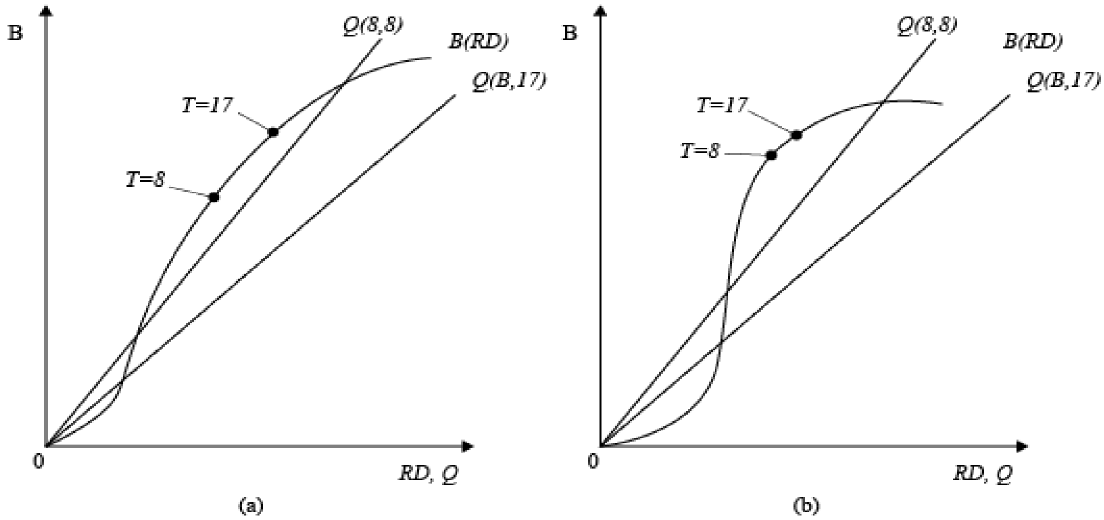


Figure 4.4.3: Optimal patent life and curvature of Invention Possibility Function.

Scherer (1972) use patent lenghts of 8- and 17 years to illustrate that the optimal patent life is shorter. The sharper the curvature of the invention possibility function, the smaller is the difference in cost reduction (induced by a given increase in patent life), and hence the optimal patent life is shorter. The longer the patent life, the more R&D is needed, and the cost reduction effect attenuates. See figure 4.4.3 as an illustration.

Scherer (1972) concludes that there exists a finite patent length due to the following reasons:

1. There are diminishing returns to R&D.
2. The extra profit you gain by increasing R&D are discounted. Meaning, the longer the patent duration, the more profit is discounted.
3. Society must wait longer for welfare maximization, as the amount of induced cost reduction, B , rises due to a longer patent life.

4.5. PATENT BREADTH

One variable that Scherer (1972) did not consider in his paper is patent breadth. Patent breadth is more complicated than patent length, as there is no universally accepted measure of breadth comparable to time as a measure of duration. Patent breadth has to do with how easy it is for competitors to imitate the product or process, and that only minor changes are needed to exploit the patented idea (Scotchmer, 2004, p. 69). Hence, the larger the changes, the more difficult it will be for competitors to invent around the patent and cut into the innovator’s profit.

There are disagreements in what effect this has on the society. Clearly, a reduction in patent breadth would induce more competition, which will benefit the consumers. But too narrow a patent reduces the incentive to innovate. Considering these factors, what exactly is the optimal patent breadth? Gilbert and Shapiro (1990) demonstrate that the optimal patent is very narrow but infinitely long. Broad patents are costly for the society, because they give excessive monopoly power to the patent holder. Klemperer (1990) on the other hand, model patent breadth both narrow and long, or broad and short, depending on the structure of demand. Depending on one’s view on the change in social welfare, the optimal patent breadth will be different.

In our thesis, patent breadth is assumed as a part of the private value, and unnecessary broad patents will not significantly increase private value. However, it can increase the potential deadweight loss, and alternative models where we include patent breadth and its effect on social surplus, is not accounted for.

4.6. STRUCTURING THE PROFIT: LENGTH AND BREADTH

In subsection 4.4. we considered optimal patent length and in subsection 4.5. we discussed optimal patent breadth. In this subsection, we assume that the correct value of the patent right has been determined, and ask how the value should be structured as a policy matter. Should patents be broad and short, or narrow and long? The ratio test (Scotchmer, 2004, p. 107) can determine answers to these questions, and the purpose with the test is to maximize the ratio profit to deadweight loss.

The ratio test

One looks at two different policies: $(T*,\ K*)$ and $\left(\widehat{T},\ \widehat{K}\right)$ which result in $(T*,\ p*)$ and $\left(\widehat{T},\ \widehat{p}\right)$, where:

$T\ =\ patent\ life$

$K\ =\ cost\ of\ an\ incumbent\ to\ enter$

$p\ =\ price\ charged\ by\ the\ monopolist$

$T*\ <\ \widehat{T}\ and\ p*\ >\ \widehat{p}$

$q\,(p)\ =\ quantity\ demanded\ at\ price\ p$

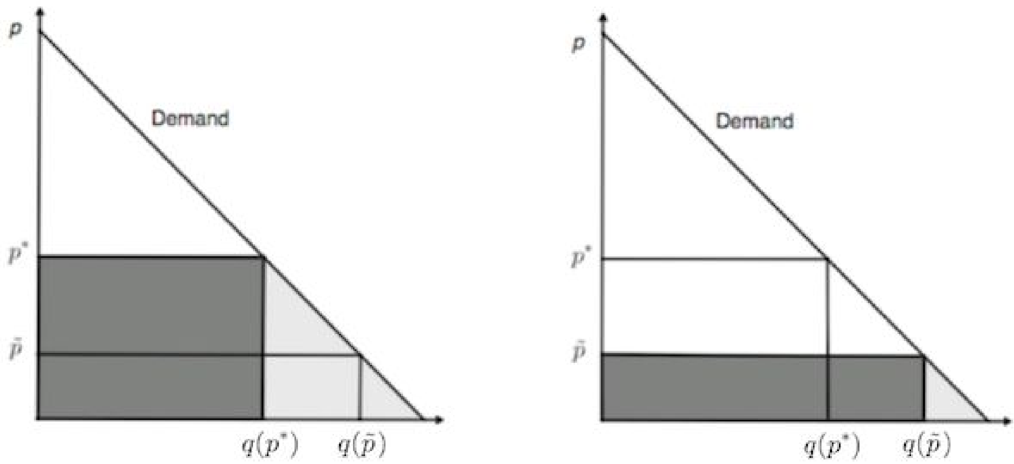


Figure 4.6: The ratio test. Dark grey represents the profit while light grey represents the deadweight loss.

If the ratio of per-period profit to per-period deadweight loss is lower with the monopoly price $p*$ than with the lower price $\widehat{p}$, then $\widehat{p}$ is the better policy (Scotchmer, 2004, p. 109). Both policies are equally profitable if $p*q\,(p*)\,T*\ =\ \widehat{p}q\,(\widehat{p})\,T$. For each price, $s\,(p)$ is the consumer surplus, and the consumers are better off with the policy $(T,\ p)$, if:

$$\widehat{T}s\,(\widehat{p})\ +\ \left(\tfrac{1}{r}-\ \widehat{T}\right)s\,(0)\ >\ T*s\,(p*)+\ \left(\tfrac{1}{r}-\ T*\right)s\,(0)\quad ,$$

where $s\,(0)$ is the consumer surplus at price zero.

The first part of the two equations illustrates the consumer surplus during the period of patent protection, while the second part of the two equations illustrates the consumer surplus in the period after the patent expires. Further, the inequality can be written as:

$$T\,[s\,(0)\;-\;s\,(\widehat{p})] < \;T*[s\,(0)\;-\;s\,(p*)]$$

The loss in the consumer surplus by charging a higher price than the competitive one, can be written as the profit $\widehat{p}q\,(\widehat{p})$ plus the deadweight loss $d\,(\widehat{p})$, i.e.:

$$s\,(0) - \;s\,(\widehat{p}) \;=\; \widehat{p}q\,(\widehat{p}) \;+\; d\,(\widehat{p})$$

The profits are equal to:

$$\widehat{T}\widehat{p}q\,(\widehat{p}) = \;T*p*q\,(p*)$$

$$\rightarrow \frac{\widehat{T}(\widehat{p}q(\widehat{p}) + d(\widehat{p}))}{\widehat{T}\widehat{p}q(\widehat{p})} \;<\; \frac{T*(p*q(p*) + d(p*))}{T*p*q(p*)}$$

$$\rightarrow\; 1 \;+\; \frac{\widehat{T}d(\widehat{p})}{\widehat{T}\widehat{p}q(\widehat{p})} < 1 \;+\; \frac{T*d(p*)}{T*p*q(p*)}$$

$$\rightarrow \frac{\widehat{p}q(\widehat{p})}{d(\widehat{p})} \;>\; \frac{p*q(p*)}{d(p*)}$$ = The ratio of per period profit to per period DWL

The best policy is the one that in each period of protection has the highest ratio of profit to deadweight loss. With linear demand, the ratio test supports the longer patent life with lower price. This can also be seen when looking at figure 4.6 above.

SECTION 5. ESTABLISHING ROOM FOR IMPROVEMENT

5.1. THE SOCIAL SURPLUS MAXIMIZERS (SSM) PERSPECTIVE

Applying the basic model of patent length by Nordhaus (1969), and assuming that there is a competitive industry, a non-drastic innovation, the costs of R&D is increasing ($dr(x)/dx > 0$ and $d^2 r(x)/dx^2 > 0$), where:

$$c \ = \ operating\ cost$$

$$x \ = \ intensity\ of\ R\&D\ investments$$

$$c - x \ = \ expected\ operating\ cost\ after\ innovation$$

$$r(x) \ = \ cost\ of\ undertaking\ R\&D\ at\ intensity\ x$$

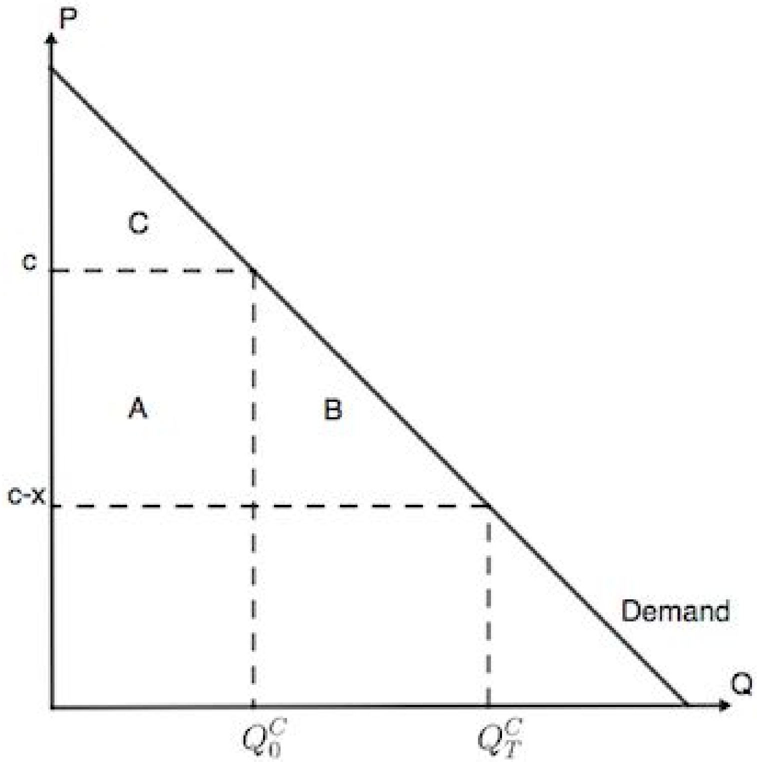


Figure 5.1: Innovation gains during period of patent protection (T years) and after patent protection.

As seen in figure 5.1, following the cost decrease from c to $c-x$, the innovator receives a profit of A for T years (active patent time). When the patent expires, the total quantity produced increases from Q_0^C to Q_T^C, as the price reduces to $c-x$ $(P = MC)$. The new consumer surplus becomes $A+B+C$, where B has formerly been a deadweight loss (DWL) for T years. Since the overall costs are decreased, the innovator can either licence the innovation to its competitors for a fee of $c-x$, or sell its product at a slightly lower cost, capturing the entire market. Either way, the current market price and the overall output should remain unchanged.

Solving this problem as a Social Surplus Maximizers problem (by maximizing social surplus), we see that when converting the area B, from a DWL to a consumer surplus for an additional T years, may benefit all. The DWL constitutes the potential imperfections of the patent scheme, because the market will be underperforming for T years. There exists people with a willingness to pay for the product greater than the marginal costs, however, the active patent excludes them from participating in the trade.

For the innovator:

The per period profit the innovator receives for a patent can be written as $\pi^m(x;T)$, and hence, the present value of an innovation is:

$$V_i(x;T) = \sum_{t=0}^{T-1} R^t \pi^m(x;T) \ = \ \frac{1-R^t}{1-R}\pi^m(x;T)$$

Therefore the net value for the innovator is:

$$V_i(x;T) \ - \ r(x),$$

where R is the discount factor (Pepall, Richards and Norman, 2014, p. 580).

By introducing values to the model we present a traditional demand curve $P = a - bq$, where q is quantity of production.

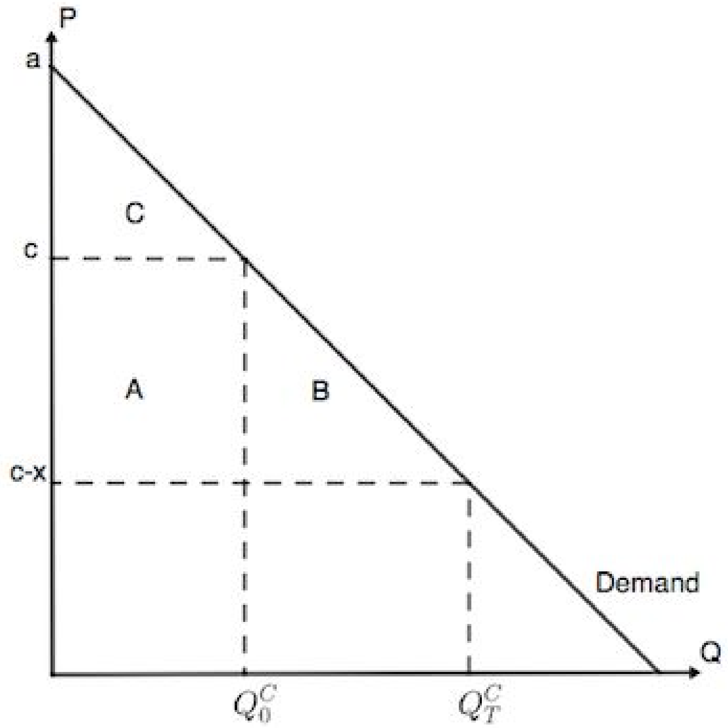


Figure 5.2: Modification of Figure 5.1. Innovation gains during period of patent protection (T years) and after patent protection.

We then have three different situations regarding social surplus: 1. before an innovation (S_0), 2. during an active patent (S_t), and 3. after said patent expires (S_N). As usual, the social surplus is defined as the sum of consumer surplus, producer surplus and taxes. For simplicity, we exclude taxes. Thus, we have:

$$S_0 = CS_0 = (a-c)Q_0^C \times \tfrac{1}{2} \text{, since } CS_0 = (a-c)Q_0^C \times \tfrac{1}{2}\text{, } PS_0 = 0\text{,}$$

$$S_t = (a-c)Q_0^C \times \tfrac{1}{2} + xQ_0^C \text{, since } CS_t = (a-c)Q_0^C \times \tfrac{1}{2}\text{, } PS_t = xQ_c^0\text{,}$$

$$S_N = CS_0 = (a-(c-x)Q_T^C \times \tfrac{1}{2} \text{, since } CS_N = (a-c)Q_0^C \times \tfrac{1}{2}\text{, } PS_N = 0\text{.}$$

We see that $S_N > S_t > S_0$, since we get rid of the DWL of B. The most socially optimal situation occurs when the patent expires, and all surplus gets shifted over to the consumers. However, this implies that the patent must have existed in the first place, and the problem of patent/R&D incentives arises.

Thus, potential area of improvement in classical patent policies is to get rid of the DWL in a competitive market where a firm invents a non-drastic innovation.

SECTION 6. EXTERNALITIES

Externalities or spillover effects arises "when a person engages in an activity that influences the well-being of a bystander and yet neither pays nor receives any compensation for that effect" (Mankiw, 2008, p. 202). For instance, pollution emitted by a factory affect more than its suppliers and employees. Its emissions into the air may annoy people who live nearby and it may make nearby resort areas less attractive, which consistently causes reduced tourist revenues.

Externalities can either be positive or negative, and it is especially interesting in connection with analyses of economic welfare. When externalities exist, benefits or costs seen by private persons differ from the true social cost consequences of their actions. That is, the market equilibrium fails to maximize the total benefit to the society as a whole (Mankiw, 2008, p. 202). For example, producers may not consider the full cost of the pollution their factories create. In addition, consumers of those products may not consider the full cost of the pollution their purchase is contributing to. To solve the problem, the government can internalize the externality by subsidizing goods that have positive externalities and taxing goods that have negative externalities. As for our thesis, we are going to focus on positive externalities.

6.1. POSITIVE EXTERNALITIES

In the presence of a positive externality, the social value of a good is greater than the private value. The social value, which we denote marginal social benefit (MSB), is calculated by adding the marginal private benefit and the marginal external benefit at every level of output, Q. Further, the socially optimal quantity, $q*$, is greater than the equilibrium quantity, q_1 (which are determined by the private market). That means the market produces less than the optimal amount of the good - also called underproduction. This in turn, means the market outcome is not the optimal outcome; the optimal outcome occurs where the supply curve crosses the MSB curve.

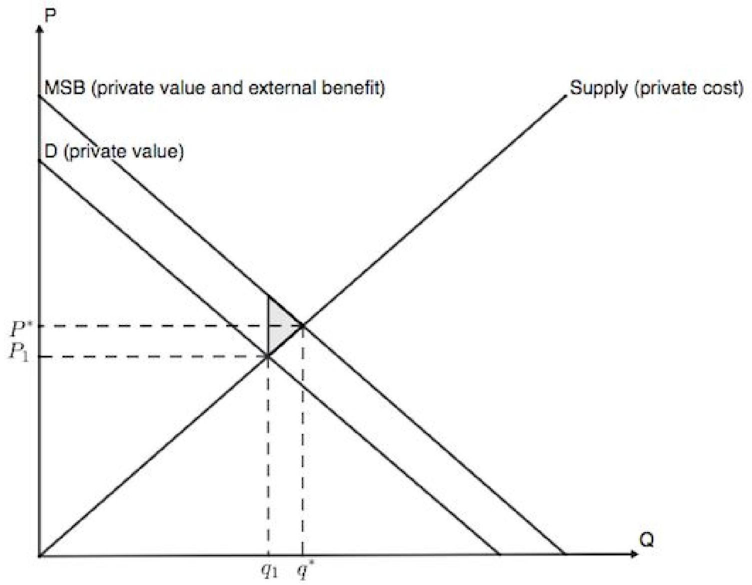


Figure 6.1: Illustration of market failure (grey triangle) when there is a positive externality.

The underproduction of goods occurs because the producers do not capture the social value the goods create for bystanders. As a consequence, an allocative inefficiency arises, which is illustrated as a grey triangle in figure 6.1.

If the producers received a government subsidy equal to the external benefits associated with the goods, the producers would be compensated, and would therefore supply an optimal quantity of the goods, cf. figure 6.2. This is assuming, that the size of the subsidy is set correctly. If demand is inelastic, a subsidy will lead to a small rise in consumption, and if it is elastic it will lead to a big rise in consumption. However, even when subsidies are absent, the consumer surplus is significantly higher than the pre-externality conditions.

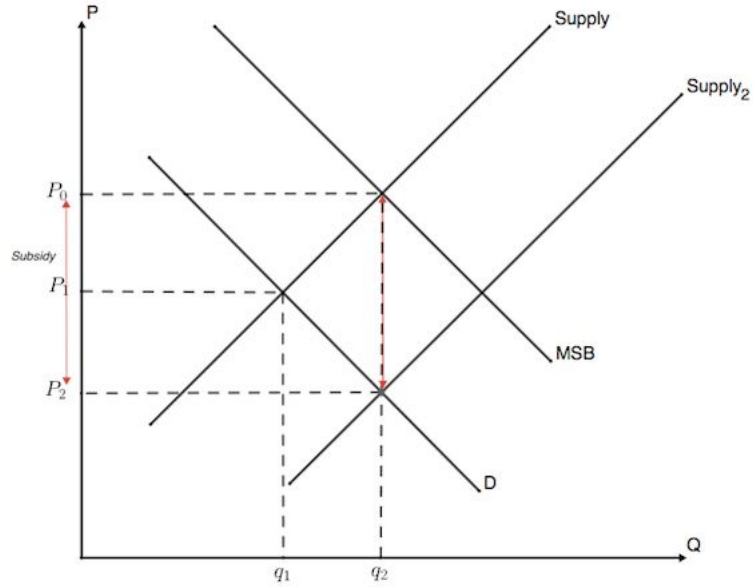


Figure 6.2: Illustration of subsidy with positive externality.

As we are modelling our figures in a more simplified way (with linear production cost, and hence, a flat marginal cost), the figures above will instead be looking like figure 6.3 below. As a result, P_0 will now equal P_1 in figure 6.2. This is illustrated in figure 6.3.

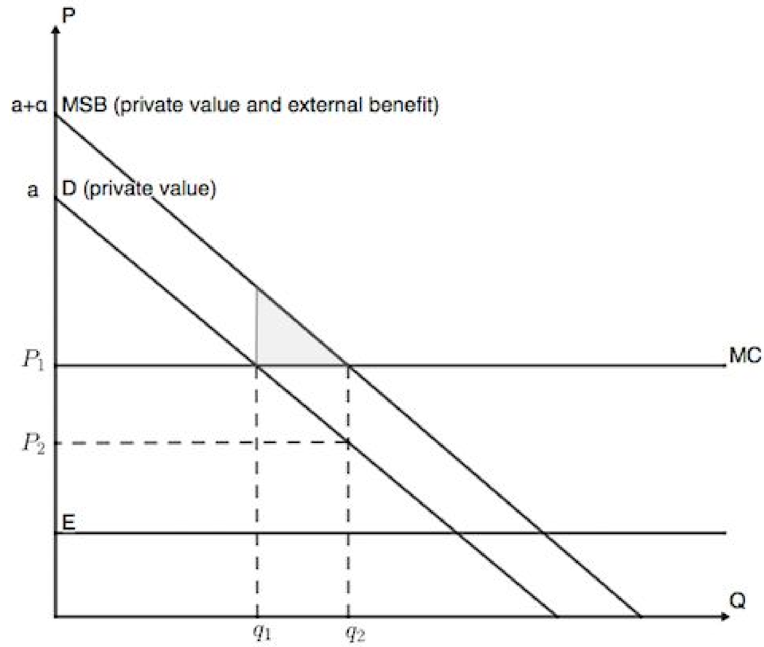


Figure 6.3: Diagram with linear marginal cost.

There are many common examples of positive externalities. Biking to job every day can lead to a healthier lifestyle which again can lead to less absence from work. Keeping your garden well maintained increases the value of your property and also those of your neighbors. Research into new technologies creates knowledge that other people can use, and so on.

In the following section, two conditions for optimal externality taxes will be stated. Then, we will develop and give a graphical interpretation of an externality tax-subsidy algorithm for a competitive economy of numerous firms and numerous interdependent externalities.

SECTION 7. MODELING THE COMBINED THEORIES

Our aim is to show that there can exists unknown positive effects from innovations and that there may exists room for improvement seen from a Social Surplus Maximizers (SSM) perspective. However, the external effects are only present when an innovation takes place, and are not existing until there is an innovation. In this section, we combine the pre-defined theories to fit one single model, explaining that current patent practise could be altered (in theory), and create room for a new International Body (IB), which maximizes the total social surplus. We will also concentrate on process innovation with drastic or major innovations. This is to limit the scope of this thesis.

We start with re-establishing what we already know.
A competitive market:

$$Demand\ (D):\ P_D = a - bq\ ,$$

$$Externalities\ (E):\ P_E = \alpha - \beta q\ \text{, thus}$$

$$Marginal\ Social\ Benefit\ (MSB) \equiv D + E = (a + \alpha)\ - q(b + \beta)$$

In most of this thesis, as illustrated by the figures, we operate with $\beta = 0$, since the positive externalities are not determined by the produced output. However, as there may exist cases where the positive externalities are determined by output, we choose to include β in the equations, to later specify that $\beta = 0$.

First, when an innovation takes place, the marginal cost reduces from c *to* $c - x$, which consistently reduces the price from p_1 *to* p_2, assuming competitive markets where $mc = p$.

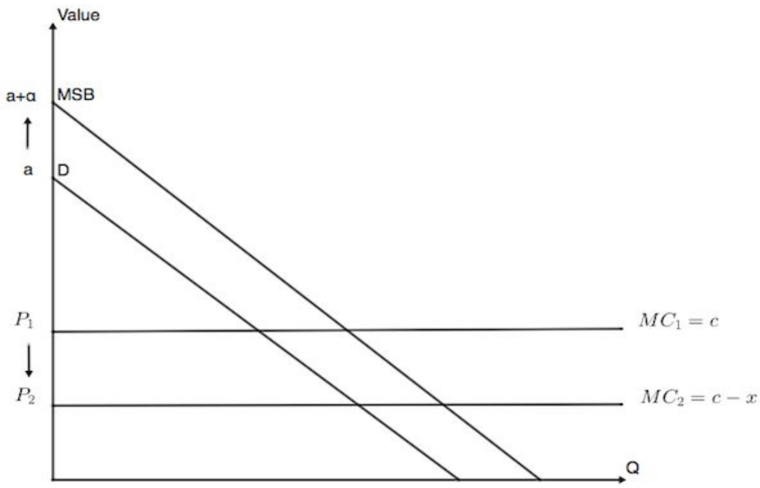


Figure 7.0.1: Modelling demand with decreased real price.

Second, the innovation creates positive externalities as a result of the reduced marginal cost and price. As illustrated, the MSB is linearly placed to the right of the demand curve (on the y-axis, a to $a + \alpha$).

Third, the overall quantity produced increases from q_1 *to* q_2, and from q_2 *to* q_3^*. Firstly because of the innovation, and secondly because of the positive externality (with optimal subsidies). q_3^* is not market determined, but rather determined by the subsidies. In this case, q_3^* is determined by the optimal level of subsidies given the positive externalities. A monopolist will not account for externalities since it is not internalized. This is an assumption we keep through the thesis.

q_i can be written as:

$$q_{1,i,c} = \frac{a-c}{b}, \; q_{1,i,m} = \frac{a-c}{2b},$$

$$q_{2,i,c} = \frac{a-(c-x)}{b}, \; q_{2,i,m} = \frac{a-(c-x)}{2b}, \text{ and}$$

$$q^*_{3,i,c} = \frac{a+\alpha-(c-x)}{(b+\beta)}$$

We get the following figure (with $\beta = 0$):

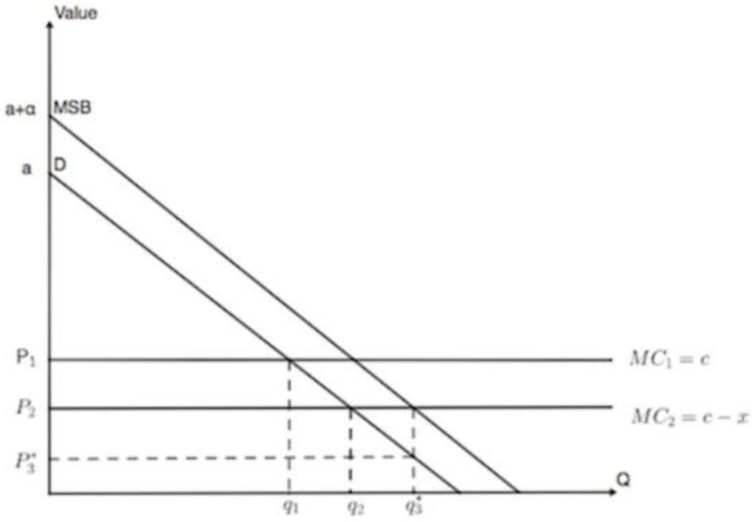


Figure 7.0.2: Modelling demand with decreased real price and subsidies.

We now have a couple of splitting scenarios. The two we chose to separate is 7.1) *without a patent buyout* and 7.3) *with a patent buyout*. We further separate the scenario with buyout into two different scenarios: 7.3.1) *without subsidies* and 7.3.2) *with subsidies*. We will be focusing on selected scenarios in section 8, but for clarity we will show how an innovation with positive externalities affect (almost) all the chosen market conditions.

7.1. WITHOUT PATENT BUYOUT

In the case without patent buyout we assume a drastic innovation, as it will become too many independent cases if we account for both monopolistic and competitive competition, before and after the innovation, with and without patent buyout, *and* drastic and non-drastic innovation.

In this section, we repeat what has been determined earlier in the thesis; the total value of the innovation is time dependent, as it consists of three periods (before the innovation, during the patented period, and after the patent expires).

Hence, the periods can be explained by: period one ($S_{0,c}$) no innovation has occurred and there is perfect competition; period two ($S_{t,m}$) a drastic innovation has occurred and has been patented for t years and is therefore creating a monopoly; and period three: t years has gone by and the patent has expired, leading to a perfect competitive market for $N \to \infty$ years, where all actors have access to the innovation.

Before an innovation, $S_{0,c}$

$$S_{0,c} = CS_{0,c} = (a-c)q_{1,c} \times \tfrac{1}{2}\text{, since } CS_0 = (a-c)q_{1,c} \times \tfrac{1}{2}\text{,}$$

$$PS_{0,c} = 0\text{, } \sum_{i=1}^{N} S_{0,c} = \sum_{i=1}^{N} \left[\frac{1}{(1+r)^i}\frac{(a-c)^2}{2b}\right]\text{, } \pi_{0,c} = 0 \text{ since } p_{1,c} = c\text{, and } N \to \infty\text{.}$$

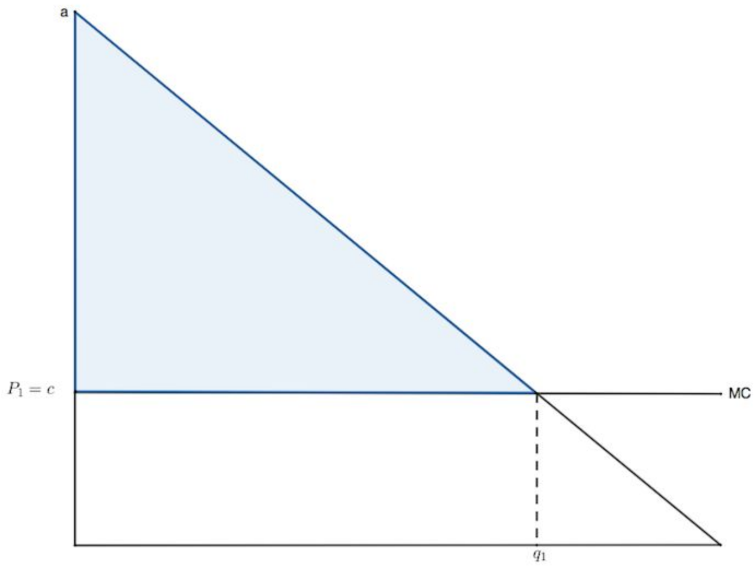


Figure 7.1.1: Without patent buyout, before an innovation.

During an active patent, $S_{t,m}$

During this period, the producer operates as a monopolist; profit maximizing without including the social benefits. The figure below illustrates how the price and quantum changes when going from a competitive market without the cost reduction, $(p_{1,c}, q_{1,c})$, to a monopolistic market with the cost reduction, $(p_{2,m}, q_{2,m})$.

$$S_{t,m} = \frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b}) \text{, since}$$

$$CS_{t,m} = \frac{(a-(c-x))^2}{8b} \text{ , } \pi_{t,m} = \frac{[a-(c-x)]^2}{4b} \text{, and } e = \alpha(\frac{a-(c-x)}{2b}).$$

$$\sum_{i=1}^{t} S_{t,m} = \sum_{i=1}^{t} \left[\frac{1}{(1+r)^i} \frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b})\right].$$

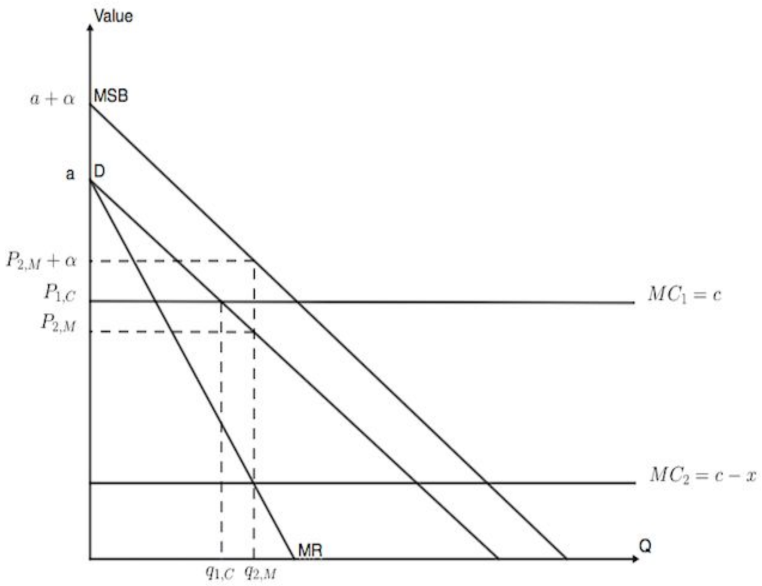


Figure 7.1.2: Without patent buyout, during an active patent.

<u>*After the patent expires,*</u> $S_{N,c}$

After the patent expires, the market transforms back to a competitive market. In the figure below, you can see the market transformation from the pre-innovation competitive market to the post-innovation competitive market.

$$p_{2,N,c} = c - x \text{, and } q_{2,N,c} = \frac{a-(c-x)}{b}.$$

$$S_{N,c} = CS_{N,c} + e = \left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right),$$

$$\text{since } CS_{N,c} = \frac{(a-(c-x))^2}{2b} \text{ , } e = \alpha\frac{a-(c-x)}{b} \text{, and } \pi_{N,c} = 0.$$

The time discounted sum becomes: $\sum_{i=t}^{N} S_{N,c} = \sum_{i=t}^{N} \left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)\right].$

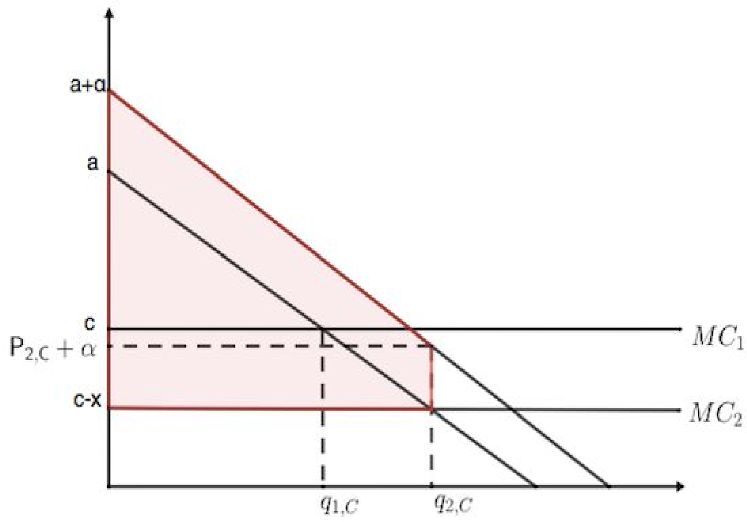


Figure 7.1.3: Without patent buyout, after the patent expires.

The overall social surplus becomes the perpetuity sum of the two latter stages, where the second stage, S_t, has a period of $T = t$. The increase in social surplus can be found by comparing the surplus before the innovation, S_0, and after the innovation, S_t and S_N.

If an innovation does not occur, the overall continued social surplus is:

$$\sum_{i=o}^{N} S_0 \equiv \sum_{i=o}^{N} \left[\frac{1}{(1+r)^i}\frac{(a-c)}{2}q_1\right] \text{ where } N \to \infty .$$

If an innovation occurs, the overall continued social surplus is:

$$\sum_{i=o}^{t} S_{t,m} + \sum_{i=t}^{N} S_{N,c} = \sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\frac{3(a-(c-x))^2}{8b} + \alpha\left(\frac{a-(c-x)}{2b}\right)\right] + \sum_{i=t}^{N}\left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)\right],$$

as the patent is valid for n years, effectively rendering the market a monopoly. Then, after n years surpasses, the market convert back to competitive, increasing the overall social surplus. Since all cases accounts for the market before an innovation occurs, the social values as well as the producer profits, are not accounted for as the alternatives are the same in all cases (within the market cases, i.e. monopolistic or competitive).

In addition to the innovation effect, there is also established positive external effects, as a result of the innovation. For instance, the decrease in mortality rate results in more labour, and vaccination decreases overall health costs.

7.2. DISCOUNTING

We use Scotchmer (2004), when discounting present values. In section 7 and 8, we denote the time discount factor, $\widehat{t_N}$, where:

$$\widehat{t_N} = \int_o^N e^{-rt}dt \text{ is geometrically congruent to } \sum_{i=1}^{N} \frac{1}{(1+r)^i} .$$

Since we mainly apply linear values in this thesis, we define:

$$\widehat{t_N} \equiv \sum_{i=1}^{N} \frac{1}{(1+r)^i} \text{, where } N \to \infty .$$

7.3. PATENT BUYOUT (GENERAL) (RED OR GREEN AREA)

To understand what happens if there is a patent buyout, and if a government decides to subsidies the innovated product, we must consider two market cases: competitive- and monopolistic markets. Since no market is at perfect competition, nor is it very usual to have a perfect monopoly, the real world will be somewhere in between. The cases illustrated are just extreme scenarios which lets us draw a minimum and maximum.

The two different scenarios can be illustrated by the following figure, where blue represents the case before the innovation, red represent the case after the innovation without subsidies, and green represent the case after the innovation with subsidies. The price/quantity denotations becomes:

$$p_1 \& \, q_1 = \textit{Before innovation}, \; S_0 .$$

$$p_2 \& \, q_2 = \textit{After innovation}, \; \textit{without subsidies}, \; S_t \; .$$

$$p_3 \& \, q_3 = \textit{After innovation}, \; \textit{with subsidies}, \; S_N .$$

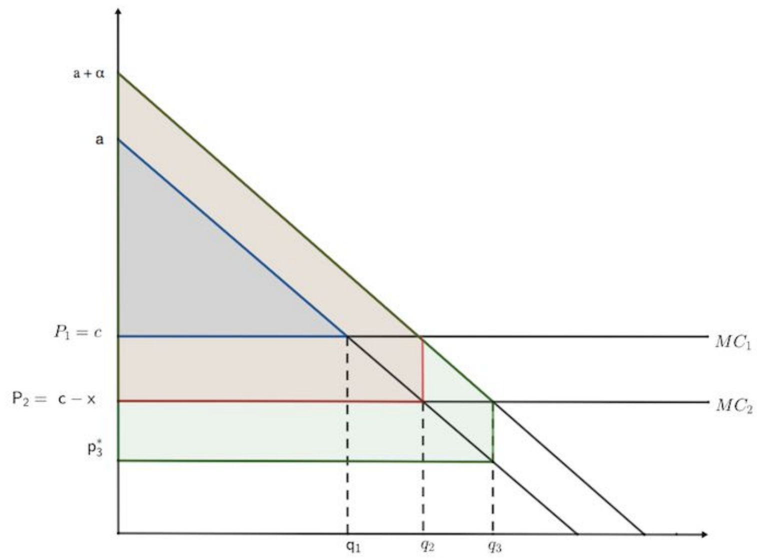


Figure 7.3: *Before and after innovation with positive externalities, and with and without subsidies.*

Colour	**Explanation**	**Denotion**
Blue	Without innovation and externalities	$S_0 : p_1 \& q_1$
Red	With innovation and externalities, without subsidies	$S_T : p_2 \& q_2$
Green	With innovation, externalities and subsidies	$S_N : p_3 \& q_3$

Below we separate the different scenarios with and without subsidies.

7.3.1. PATENT BUYOUT WITHOUT SUBSIDIES (RED AREA, COMBINED FIGURE)

7.3.1.1. COMPETITIVE MARKET

The first thing that happens is that the producer's cost function decreases from c to $c-x$, which causes q_1 to increase to q_2. The equilibrium point to the consumer surplus (CS) is based upon finding the point where q_2 equals the marginal social benefit (MSB). The CS is therefore a long and extensive equation. This can be illustrated with the following figure:

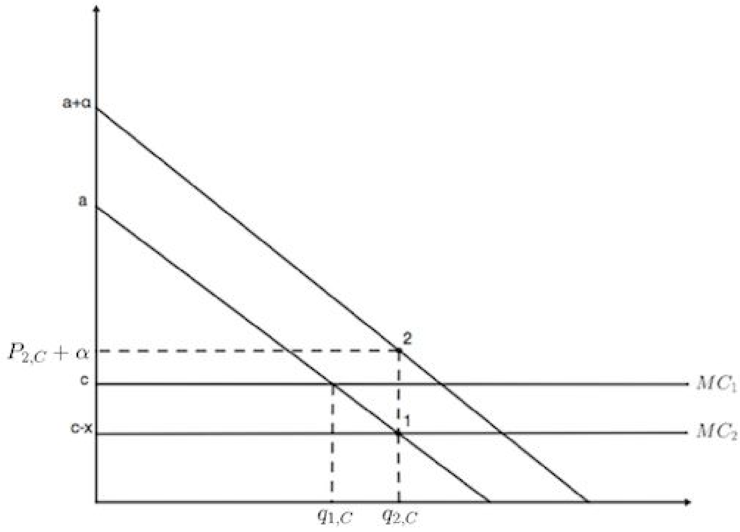


Figure 7.3.1.1: Red area with a competitive market.

The easiest way to find the CS is by finding the parameter to the post innovation price and quantity. Since price equals marginal cost in a competitive market, we have that $p = c - x$ and $q = \frac{a-(c-x)}{b}$ (which we usually denote q_2). $MSB = a + \alpha - q_2(b + \beta)$. The CS therefore becomes: $CS_{b,c} = \frac{(a-(c-x))^2}{2b}$, and the external benefit is $e = \alpha q_2$.

Further, the social surplus equals the consumer surplus plus the external benefit. This can be written as: $S_{b,c} = \left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)$.

The time consistent social surplus then becomes:

$$\sum_{i=1}^{N} S_{b,c} = \sum_{i=1}^{N} \left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)\right].$$

The price equals the marginal cost (as we are in a competitive market), which means that when the marginal cost decreases, so do the consumer price. As a result, the quantum increases. There is nothing to gain for the firms, and hence their profits are zero. And as we can see from the figure and the mathematical representation, the true consumer surplus increases.

7.3.1.2. MONOPOLISTIC MARKET

In this scenario the marginal revenue (MR) is originating from the firm's demand curve, D. The reason we choose to connect the MR from the firm's demand curve and not the marginal social benefit (MSB) curve, is that the MSB curve is determined by externalities. Hence, the MSB curve is not a part of the firm's production function. This means that the firms are not fully aware of the externalities they create and the increasing demand from the consumers. For an illustration, see figure 7.3.1.2 below.

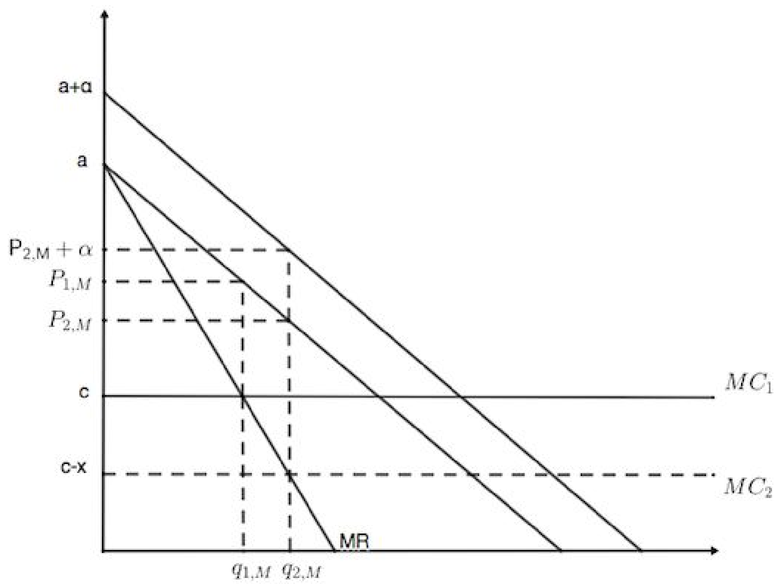


Figure 7.3.1.2: Monopolistic market without subsidies.

The consumer and producer surplus becomes a product of the new equilibrium: $CS_{b,m} = \frac{(a-(c-x))^2}{8b}$ and $\pi_{b,m} = \frac{[a-(c-x)]^2}{4b}$. The social surplus, however, is the sum of the aforementioned: $S_{b,m} = \frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b})$, where $q_2 = \frac{a-(c-x)}{2b}$ and $p_2 = \left(\frac{a+(c-x)}{2}\right)$.

The time continued social surplus then becomes:

$$\sum_{i=1}^{N} S_{b,m} = \sum_{i=1}^{N} \left[\frac{1}{(1+r)^i} \frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b})\right].$$

The first thing that happens is that the firm's marginal cost decreases from c to $c - x$, which causes the monopoly price to decrease from p_1 to p_2. The quantity produced therefore increases from q_1 to q_2. Even though the firm is not aware of the positive externalities it creates, the consumers will still benefit from this externality. Thus, the reference point for the consumer surplus, which was a, increases to $a + \alpha$.

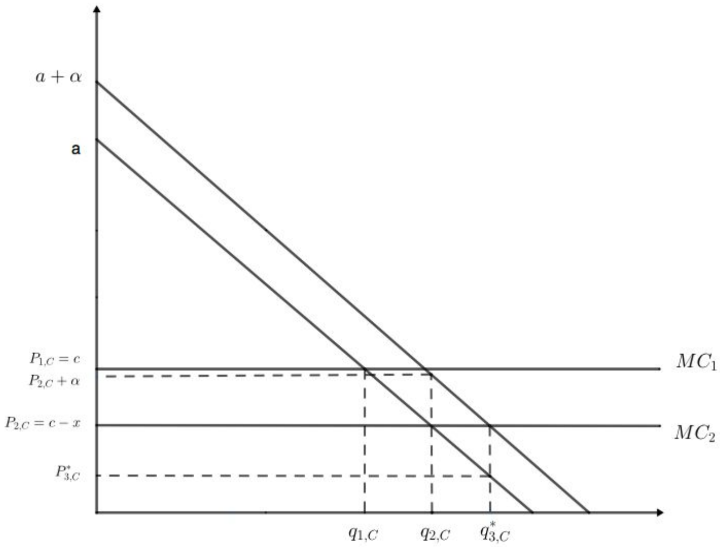
7.3.2. PATENT BUYOUT WITH SUBSIDIES (GREEN AREA, COMBINED FIGURE)

If a national or local government was to subsidies a product after a patent buyout, we would normally have to consider both potential market structures: competitive and monopolistic. However, a case where a monopoly receives subsidies after selling its own invention is highly unlikely, thus we only consider a competitive market structure. A competitive market gets rid off the deadweight loss (DWL) associated with an externality, whereas a monopoly has a natural occuring DWL in all cases. In the next subsection, we seek to find the social surplus associated with a patent buyout with subsidies.

7.3.2.1. COMPETITIVE MARKET

The first thing that happens is that the producer's cost function is reduced from c to $c - x$. Further, since it is a competitive market, where $p = mc$, the price is reduced from $p_1 = c$ to $p_2 = c - x$. The demand function has increased from D to MSB, and is therefore creating the new quantity equilibrium from q_1 to q_2.

Since the Social Surplus Maximizers (SSM) knows that the social demand comes from the MSB, whereas the company still operates with the D (as the market is not integrated), the SSM government now offers subsidies to the producer equalling the cost of decreasing the product price from p_2 to p_3^*. This is boosting production from q_2 to q_3^*. The equilibrium is now between the new marginal cost, $c - x$, and the MSB. This results in the earlier DWL being erased. With a competitive market, the figure becomes:



Figur 7.3.2.1. With subsidies, competitive market.

As the market is competitive, the pre-subsidisation price is determined by the marginal cost, hence: $p_{2,c} = MC_2 = c - x$ and $q^*_{3,c} = \frac{(a+\alpha)-(c-x)}{2(b+\beta)}$. Further, the post-subsidisation price becomes: $p^*_{3,c} = a - b(\frac{(a+\alpha)-(c-x)}{2(b+\beta)})$. The consumer surplus can then be written as: $CS_{s,c} + e = \frac{(a+\alpha)-(c-x)}{2} q^*_{3,c} + ((c-x) - p^*_{3,c}) q^*_{3,c}$ (not respectively), which can be re-written to: $CS_{s,c} = (\frac{(a+\alpha)+(c-x)}{2}) q^*_{3,c}$. The now gone DWL is the area between $p_{2,c} + \alpha$ and $p_{2,c}$, and $q_{2,c}$ and $q^*_{3,c}$. We know that $\pi = 0,$ since the difference between the price and the marginal cost equals the subsidies. Further, the social surplus equals the consumer surplus, $S_{s,c} = CS_{s,c}$. The subsidies cancels out, as they result in a decreased price and increased production volume in an assumed perfect scale (no arbitrage).

Therefore, the time continued social surplus becomes:

$$\sum_{i=1}^{N} S_{s,c} = \sum_{i=1}^{N} \left[\frac{1}{(1+r)^i} \left(\frac{(a+\alpha-(c-x))^2}{4(b+\beta)} \right) \right] .$$

7.4. CONCLUSION

The different social surpluses can be divided into the following which is going to be used in Section 8:

	Competitive Market		Monopolistic Market	
Before the drastic innovation occurs	$CS_{0,c}$	$(a-c)q_1 \times \frac{1}{2}$	$CS_{0,m}$	$\frac{(a-c)^2}{8b}$
	$PS_{0,c}$	0	$PS_{0,m}$	$\frac{(a-c)^2}{4b}$
	$S_{0,c}$	$CS_{0,c}$	$S_{0,m}$	$\frac{3(a-c)^2}{8b}$
	$\Sigma S_{0,c}$	$\sum_{i=1}^{N}\left[\frac{1}{(1+r)^i}\frac{(a-c)^2}{2b}\right]$	$\Sigma S_{0,m}$	$\sum_{i=1}^{N}\left[\frac{3(a-c)^2}{8b(1+r)^i}\right]$
	$q_{1,0,c}$	$\frac{a-c}{b}$	$q_{1,0,m}$	$\frac{a-c}{2b}$
	$p_{1,0,c}$	c	$p_{1,0,m}$	$\frac{a-c}{2}$
	$C_{0,c}$	c	$C_{0,m}$	c
	$\pi_{o,c}$	$= 0$	$\pi_{o,c}$	$> 0 \quad \forall \frac{a-c}{2} > c$
No patent buy out	$CS_{N,c}$	$\frac{(a-(c-x))^2}{2b}$	$CS_{t,m}$	$\frac{(a-(c-x))^2}{8b}$
	$PS_{N,c}$	0	$PS_{t,m}$	$(p_{1,t,m}-(c-x))q_2$
	$S_{N,c}$	$\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)$	$S_{t,m}$	$\frac{3(a-(c-x))^2}{8b}+\alpha(\frac{a-(c-x)}{2b})$
	$\Sigma S_{N,c}$	$\sum_{i=t}^{N}\left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)\right]$	$\Sigma S_{t,m}$	$\sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\frac{3(a-(c-x))^2}{8b}+\alpha(\frac{a-(c-x)}{2b})\right]$
The sum of the respective social surpluses are the total social surplus if a patent buyout does not occur	$q_{1,N,c}$	$\frac{a-(c-x)}{b}$	$q_{1,t,m}$	$\frac{a-(c-x)}{2b}$
	$p_{1,N,c}$	$c-x$	$p_{1,t,m}$	$\frac{a+(c-x)}{2}$
	$C_{N,c}$	$c-x$	$C_{t,,m}$	$c-x$
	$\pi_{N,c}$	$= 0$	$\pi_{t,,m}$	$= \frac{(a-(c-x))^2}{4b} > 0$

Patent buyout without subsidies	$CS_{b,c}$	$\frac{(a-(c-x))^2}{2b}$	$CS_{b,m}$	$\frac{(a-(c-x))^2}{8b}$
	$PS_{b,c}$	0	$PS_{b,m}$	$(p_{2,b,m} - (c-x)q_{2,b,m}$
	$S_{b,c}$	$\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)$	$S_{b,m}$	$\frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b})$
	$\Sigma S_{b,c}$	$\sum_{i=t}^{t}\left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2} + \alpha\right)\right]$	$\Sigma S_{b,m}$	$\sum_{i=1}^{N}\left[\frac{1}{(1+r)^i}\frac{3(a-(c-x))^2}{8b} + \alpha(\frac{a-(c-x)}{2b})\right]$
	$q_{2,b,c}$	$\frac{a-(c-x)}{b}$	$q_{2,b,m}$	$(\frac{a-(c-x)}{2b})$
	$p_{2,b,c}$	$c-x$	$p_{2,b,m}$	$\frac{a+(c-x)}{2}$
	$C_{b,c}$	$c-x$	$C_{b,m}$	$c-x$
	$\pi_{b,c}$	$= 0$	$\pi_{b,m}$	$> 0 \quad \forall \frac{a-(c-x)}{2b} > c-x$
Patent buyout with subsidies	$CS_{s,c}$	$\frac{(a+\alpha)-(c-x)}{2}q_{3,s,c}$		
	$PS_{s,c}$	0		
	$S_{s,c}$	$CS_{s,c}$		
	$\Sigma S_{s,c}$	$\sum_{i=1}^{N}\left[\frac{1}{(1+r)^i}(\frac{(a+\alpha-(c-x))^2}{4(b+\beta)})\right]$		
	$q_{3,s,c}$	$\frac{(a+\alpha)-(c-x)}{2(b+\beta)}$		
	$p_{3,s,c}$	$a - b(\frac{(a+\alpha)-(c-x)}{2(b+\beta)})$		
	$C_{s,c}$	$c-x$		
	$\pi_{s,c}$	$= 0$		

Further, we discuss whether the social surplus difference between an innovation with- and without subsidization is greater than the private valuation of the innovation for the innovator. If this is the case, the theoretical establishment of an International Body is economically optimal.

SECTION 8. TO ESTABLISH OR NOT ESTABLISH AN IB?

In this section we set out to explain the process of a patent buyout and the potential change in social surplus affected by it, using the Guell & Fishbaum (G&F) method of valuation. Then we will conclude the present value of the entire transaction applying the social surplus maximizers (SSM) perspective. This section focuses on patent buyouts *without* subsidised production, as it has already been widely established that subsidising productions with positive externalities will increase social surplus.

The section will be divided into the following subsections: 1) Before the innovation, 2) If an innovation occurs, 3) The method of patent valuation,
4) Difference between private and public value, 5) The transaction, and 6) Further considerations.

ASSUMPTIONS:

We assume no time delays (meaning that the time for an innovation to take effect occurs instantly), rational actors, drastic innovation, a bid equal or greater than the private value will always result in a trade, and no establishment cost or administrative costs for an International Body (meaning that the only costs for the organisation is the direct buy-out price).

8.1. BEFORE THE INNOVATION

The market is described as competitive, with the inverse demand function: $P = a - bq$ and $MC = c$. This gives us a consumer- and social surplus of $CS_{0,c} = S_{0,c} = \frac{(a-c)^2}{2b}$, and a profit of $\pi_{o,c} = 0$, since $P = MC$. We assume the market is in perfect equilibrium, as no innovation and cost reduction has occurred yet. We further assume no positive nor negative externalities exists before the innovation.

8.2. IF A DRASTIC INNOVATION OCCURS

The difference between private and public value:

The private value is determined by the profit the innovator would make in the time period the patent is active:

$$\sum_{i=1}^{t}[\pi_t] = \sum_{i=1}^{t}\left[\frac{[p_{t,m}-(c-x)]q_{t,m}}{(1+r)^i}\right].$$

Further, the social value surplus is the overall difference between the social surplus if a buyout occurs or not. This value is created if a buyout occurs, i.e.:

$$\sum_{i=1}^{N} S_{b,c} - \left(\sum_{i=1}^{t} S_{t,m} + \sum_{i=t}^{N} S_{N,c}\right),$$

where $S_{b,c}$ is the social surplus if a an innovation is bought and distributed, $S_{t,m}$ is the social value if the patent is not bought and a monopoly situation occurs, and $S_{N,c}$ is the social surplus that occurs after the patent has expired and the market is back to a competitive market. If there exists a positive difference between the public valuation and the private valuation (meaning overall profit (κ)), the market will be more efficient with a patent buyout. The reason for why we set the requirement of the overall social surplus difference must be greater than the total buyout price, is because the market (which operates both as social surplus receivers and as a fundraiser for the International Body) should expect direct social surplus gain greater or equal to that of the private innovator receives, as the capital they invest in the IB should generate a positive surplus.

We are aware of that both Kremer and G&F follows traditional microeconomic theory, which says that as long as monopolies exist, where $S_{b,c} \geq S_{t,m}$, then the patent should be bought and distributed. On account of the funds paid to the innovator, this is just a matter of the funds changing hands, thus cancelling out on a social surplus level. However, this does not account for the fundraising problem. If the IB could ensure the capitalist (which in this case is the member countries of the IB) that the money they raise would benefit the capitalist substantially more than the the innovator, then fundraising may seem more appealing.

8.3. METHOD OF PATENT VALUATION

When determining which valuation method to value one respective patent, both G&F (establish a test market and scale up the data to determine the private value) and Kremer (second bid sealed auction and randomized public buyout) have proposed applicable theories. However, G&F (1995) may be a better fit for estimating the private value of one single patent, as Kremer (1998) assumes that the patent holder applies the mechanism of trade. Kremer's process also has an element of chance to it, as which patent falls into the public domain. The G&F valuation process can be seen as impractical, but is in theory the most applicable process to value one specific patent. Further, the patent buyout will not be very efficient if there is clear time limitations (i.e. patents for medications against a fast spreading health implication), as the process depends on setting up test areas to estimate demand. Assuming there are no time delays and that the valuation process leads to an accurate private value, κ, then:

$$\kappa = \sum_{i=1}^{t} \{\pi_i + u_i\} = \sum_{i=1}^{t} \left\{ \left[\frac{[p_{t,m} - (c-x)]q_{t,m}}{(1+r)^i} \right] + u_i \right\} = \sum_{i=1}^{t} \left\{ \frac{1}{(1+r)^i} \frac{(a-(c-x))^2}{4b} + u_i \right\},$$

where u_i is the error term (deviation from the real value in period i), and κ is the sum off all profits the innovator would generate in the period the patent is valid.

8.4. DIFFERENCE BETWEEN PRIVATE AND PUBLIC VALUE

If the social surplus of an innovation with a buyout without subsidies, minus the social surplus without a buyout is greater than the fee, κ, and a markup, ω, the International Body should buy and distribute the patent. Hence, if the net social value gained from the buyout is greater than the buyout price, i.e:

$$\sum_{i=1}^{N} S_{b,c} - \left(\sum_{i=1}^{t} S_{t,m} + \sum_{i=t}^{N} S_{N,c} \right) \geq \kappa + \omega ,$$

(where ε is the markup) which can be written as:

$$\sum_{i=1}^{N}\left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)\right]-$$

$$\left[\sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\frac{3(a-(c-x))^2}{8b}+\alpha(\frac{a-(c-x)}{2b})\right]+\sum_{i=t}^{N}\left[\frac{1}{(1+r)^i}\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)\right]\right],$$

then the IB should buy the patent. The main findings of our thesis can be further simplified to:

$$\sum_{i=1}^{t}\left[S_{b,c}-S_{t,m}\right]\geq\kappa+\omega\,,$$

by applying the fact that $S_{b,c}=S_{N,c}$, thus $\sum_{i=1}^{N}S_{b,c}-\sum_{i=t}^{N}S_{N,c}=\sum_{i=1}^{t}S_{b,c}$.

Writing out the whole equation, putting κ on the left hand side:

$$\sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\left(\left\{\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)-\left(\frac{3(a-(c-x))^2}{8b}+\alpha(\frac{a-(c-x)}{2b})\right)\right\}-\left\{(\frac{(a-(c-x))^2}{4b})+u_t\right\}\right)\right]\geq\omega,$$

where we further assume a perfect valuation, meaning $u_t=0$.

We can then rewrite the function to:

$$\sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\left(\left\{\left(\frac{a-(c-x)}{b}\right)\left(\frac{a-(c-x)}{2}+\alpha\right)-\left(\frac{3(a-(c-x))^2}{8b}+\alpha(\frac{a-(c-x)}{2b})\right)\right\}-\left\{(\frac{(a-(c-x))^2}{4b})\right\}\right)\right]\geq\omega\,.$$

Now we see a pattern in the denominator which let us rewrite the equation to:

$$\sum_{i=1}^{t}\left[\frac{1}{(1+r)^i}\left(\frac{(a-(c-x)(4\alpha-(a-(c-x))}{8b}\right)\right]\geq\omega\,,$$

which yields the following results:

$$\widehat{t}_t(q_{2,c})(\frac{4\alpha-(a-(c-x))}{8})\geq\omega \text{ , with } \widehat{t}_t=\sum_{i=1}^{t}\frac{1}{(1+r)^i}\text{ , where } \widehat{t}_t<t\;\;\forall\;r>0\,.$$

Because we know that $q_{2,c}$ is strictly positive, then we also know that $\frac{4\alpha-(a-(c-x))}{8}$ ≥ 0 for ω to be greater than or equal to 0. We see that ε is positively affected by both α and $c-x$, and negatively affected by a. This means that a high a will decrease the likelihood of a patent purchase being SSM optimal. A high marginal cost, as well as a high positive externality value, will increase the likelihood. Another interesting result is that we can find out if a patent buyout will grant an increase in social surplus, just by knowing α, a, c and x. If $\frac{4\alpha-(a-(c-x))}{8}\geq 0$, then the present value of the increase in social surplus is equal to or greater than the private value. This allows us to “cheat”, as it shows us instantly if a patent buyout will yield a positive or negative change in social surplus. If $\frac{4\alpha-(a-(c-x))}{8} \geq 0$, the full equation then becomes:

$$\widehat{t_t}(q_{2,c})(\frac{4\alpha-(a-(c-x))}{8}) \geq \omega \ .$$

In other words, if $4\alpha + (c-x) \geq a$, then the patent should be bought. The International Body (IB) can further find the value of the patent, κ, and the change in social surplus, $\sum_{i=1}^{N} S_{b,c} - \left(\sum_{i=1}^{t} S_{t,m} + \sum_{i=t}^{N} S_{N,c} \right)$. The difference between these are the markup price ε, and a potential surplus made by the IB.

Thus, if this holds true, an IB should be established and buy the patent. The result shows us that the IB should not pay more than the expected exceeding social surplus, and any value of $\frac{4\alpha-(a-(c-x))}{8} \geq \omega \geq 0$, will result in a surplus where society receives more than it pays. However, this raises a new concern. If the market is at, or close to *common knowledge*[2], where the producer is aware of the positive externalities, he will try to get ω as close to maximum as possible, while the IB will try to minimize it. This would create a game not accounted for in this thesis.

8.5. APPLIED EXAMPLE

Consider a firm with the following inverse demand function: $P = 120 - q$ and marginal cost $MC_1 = c = 80$. Now, assume an innovation has occurred. This decreases the marginal costs from 80 to 20 ($MC_2 = c - x = 20$) and the social demand for the product is $MSB = 150 - q$ (i.e. $\alpha = 30$). The new competitive

[2] Common knowledge defined by Watson (2013): “A particular fact F is said to be common knowledge between the play-ers if each player knows F, each player knows that the others know F, each player knows that every other player knows that each player knows F, and so on.”

equilibrium price become $p_{c,2} = 20$, and output $q_{c,2} = 100$. If the innovation is non-drastic, the best innovator can do is to set price as an constrained monopolist, meaning $P_{c,2} = 80 - \varepsilon$. Since the innovator can charge a profit maximizing price $p_{m,2} = 70$, and $q_{m,2} = 50$, he can price as an unconstrained monopolist. Since normal patent length is $N = 20$ (Scotchmer, 2004, p. 69), and we assume that normal length is the optimal length, the equation can be solved as: $\widehat{t_t}(q_{2,c})(\frac{4\alpha-(a-(c-x))}{8}) = 20(100)(\frac{4\times30-(120-(80-60))}{8}) \geq \varepsilon \Rightarrow 5'000 \geq \omega$, with $r = 0$ for simplicity.

This tells us the maximum price the International Body (IB) can pay in addition to the private value for the patent, while still insuring an increase in overall social surplus. Any value over 200.000 would constitute a loss for the IB, as they would pay more than the increase in social value. This value of κ is determined by applying the equation presented in section 8.3., which is $\kappa = \sum_{i=1}^{t} \left\{ \frac{(a-(c-x))^2}{4b} + u_t \right\}$, assuming $u_t = 0$. When applying the same values used to find ε, the private value becomes: $\kappa = 20 \left[\frac{(120-(80-60))^2}{4} \right] = 50.000$. This means that the IB's willingness to pay for the patent cannot exceed $\kappa + \varepsilon = 55.000$, while the least amount of money the innovator is willing to sell it for is $\kappa = 50.000$. The room for bargaining is thus 5000. We can prove that ω has to take on this value or less, by showing that the expected difference in social surplus is equal to the private valuation.

The total surplus society would gain from this transaction is: $\sum_{i=1}^{N} S_{b,c} - \left(\sum_{i=1}^{t} S_{t,m} + \sum_{i=t}^{N} S_{N,c} \right)$, which can be written as: $\sum_{i=1}^{t} \left[q_{2,c} \right] \left[\frac{a-(c-x)+4\alpha}{8} \right]$ (see Section 7). We can calculate this using the applied values: $20\,[100]\,[27,5] = 55.000$, which is the same as $\kappa + \omega$.

Since both social surplus and the private value are discounted by the same timeframe, we decided to keep the applied example simple by keeping $r = 0$.

However, if the discount rate is greater than zero, all values (social surplus, private value, and markup) are affected proportionally the same.

As mentioned above, there exist cases where we see a present value equalling zero. Assuming $c-x$ stays constant, a slight decrease in α from 30 til 25 will lead to $\frac{4\alpha-a+(c-x)}{8}=0$, which constitutes that the IB cannot pay anything over the private valuation (no markup). Any value of α under 25 in this example, would lead to a loss seen from a Social Surplus Maximizers (SSM) perspective. In this case, the patent should not be bought and distributed.

8.6. FURTHER CONSIDERATIONS

As this thesis highlights, there may exists clear motivations to establish an International Body (IB) from a Social Surplus Maximizers (SSM) perspective. However, the real world is somewhat different from a constructed theoretical one. It would cost money to establish and run an organisation of this size and purpose. Further, there would be large time delays when a potential buyout occurs, as we follow the G&F method. Any buyout has to wait until an isolated experiment has been conducted. Time delays would also occur in the market transformations (both when a competitive market is transformed to a monopoly, and when a monopoly is transformed into a competitive market), as the change following an innovation is not immediate. This will impact the valuation as the social surplus and the private profits are determined by the time of the market transformation (i.e. changing from a competitive to a monopolistic market, and vice versa).

In addition to the previously mentioned, the question of funding also arises. In the long run, the IB can charge a fee from the member states, enough to cover the valuation plus the markup. Using a form of internalized fee structure, the tax income from products with negative externalities could be reallocated to pay for the IB fee.

Also, the one time fundraising would be a relevant question, as they need to have funds to purchase any patent. Having the hosting state (the country where the patent is registered) pay for a patent would be counterproductive, as it will only serve as an incentive to not participate in the scheme. Nations with a large number of patents would both have to pay for the buyout of several patents, as well as the income from patent exports would disappear. A one time fundraising from all participating states, where developed economies could use budgeted foreign development funds to cover the fee, could be a sufficient fundraising to let the fund become operational.

SECTION 9. CONCLUSION

We agree with Kremer on the following: monopolies are bad, and a potential problem of this thesis is the fundraising. However, we believe the markup is not set at a rate between 2,5 and 3,33, but rather as the difference between the overall social surplus and the private valuation, which is then determined by negotiation between the buyer and seller with a classic game theory approach. If the International Body promise the capitalist (as in all market participants) at least the same in added social surplus (i.e. over that it would already receive) as it offers the private innovator in exchange for the patent, it could be perceived as a more favorable investment. Each member state could in addition to receiving the patent rights, choose by themself to subsidies the innovated field, further decreasing the price from the innovation price.

Kremer focused primarily on getting rid of monopolies ascending by patents, however, as we have illustrated throughout this thesis, there exists many different market conditions where a patent buyout would be more favourable than others. An IB could in theory buy all patent rights to ensure that no unnecessary monopolies is to be created, however, we are comfortable in saying that there are some patents which should be prioritized over others.

If an IB is the optimal organisation to buy and distribute patents, is yet to be determined. However, in theory, it could be a great way to distribute wealth by letting more countries participate and compete in production, as well as decrease the product price, which would let more consumers participate in the market. These values may also exist in patent buyouts which leads to reducing negative externalities, however, that is not researched in this thesis.

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Attachment

Year(s)	Country	National Income Group	Drug Area	Total Products	Outcome
2001 (2007)	Brazil	UMIC	HIV/AIDS	2	CL/discount
2001	Brazil	UMIC	HIV/AIDS	1	Discount
2001	Canada	HIC	Anthrax	1	Discount
2001-2003	South Africa	UMIC	HIV/AIDS	8	VL/discount/none
2001	United States	HIC	Anthrax	1	Discount
2002	Egypt	LIC	Erectile dysfunction	1	CL
2003-2004	Malaysia	UMIC	HIV/AIDS	3	CL
2003, 2007	Brazil	UMIC	HIV/AIDS	1	Discount
2003	Zimbabwe	LIC	HIV/AIDS	All	CL
2004	Mozambique	LDC	HIV/AIDS	3	CL
2004	Zambia	LDC	HIV/AIDS	3	CL
2005-2006	Argentina	UMIC	Pandemic flu	1	VL
2005-2007	Brazil	UMIC	HIV/AIDS	1	Discount
2005-2009	Brazil	UMIC	HIV/AIDS	1	Discount
2005	Ghana	LIC	HIV/AIDS	All	CL
2005	Indonesia	LIC	HIV/AIDS	2	CL
2005	Taiwan	HIC	Pandemic flu	1	VL
2006-2007	India	LIC	Cancer	1	None
2006 (2010)	Thailand	UMIC	HIV/AIDS	1	CL
2007	Rwanda	LDC	HIV/AIDS	1	CL
2007 (2010)	Thailand	UMIC	HIV/AIDS, CVD	2	CL
2007-2008	Thailand	UMIC	Cancer	1	Discount

2007-2008	Thailand	UMIC	Cancer	3	CL
2010	Ecuador	UMIC	HIV/AIDS	1	CL

*Table 1.1.: CL episodes by year and country. * UMIC = upper-middle-income countries, HIC = high income countries, LIC = low-income countries, LDC = least developed countries.*

BI Norwegian Business School - campus Oslo

GRA 19502

Master Thesis

Component of continuous assessment: Forprosjekt, Thesis MSc

Is it economically optimal to appoint a global patent body that buys and distributes patents that can reduce negative externalities, and thereby reduce future social costs?

Navn: Line Irina Kaknes, Andreas Fredriksen

Start: 01.01.2018 09.00

Finish: 15.01.2018 12.00

BI Norwegian Business School
Preliminary Thesis Report

Is it economically optimal to appoint a global patent body that buys and distributes patents that can reduce negative externalities, and thereby reduce future social costs?

Date of submission:
15.01.2018

Study programme:
Master of Science in Business
Major in Economics

Supervisor:
Per Botolf Maurseth

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1. INTRODUCTION TO THE RESEARCH TOPIC

In 1839, the French government purchased the Daguerreotype patent from the Parisian individual Louis Daguerre, making it a public domain and free to use by any of the worlds inventors (except England). This master thesis will research and question the economic effects of Intellectual Property Rights (IPR), and if it is economically optimal to designate a global patent buyout organization (denoted IO: "International Body"). These kind of buyouts may help eliminate the negative consequences of monopolies by mainly removing dead weight losses and price jumps.

The idea of the topic came from one of the economics courses offered at BI Norwegian Business School: GRA1305; Industrial Organization. After having participated in this course, where patents and R&D were touched upon, we wanted to use the master thesis to explore the subject further.

1.1. PURPOSE OF THE THESIS

The main goal behind our thesis is to see if it is possible to create a more sustainable patent scheme than that of now. As of today, the world patent regime has changed little from that it was when it was first introduced, leading to a balance between innovator incentives and market competition.

How much should a patent embrace? How long should a patent last? What is the consequences if authorities waives a patent outside the innovator's expectations? What we would like to find out is whether there is a better solution than that we have of today, mainly by introducing a third party with purchasing power: Authorities or other IOs.

1.2. RESEARCH PROBLEM

One of the major questions we want to answer is: *How much should an IO be willing to pay for a patent?* A parallel to this research question is the paper by Michael Kremer (1998), *Patent Buyouts: A Mechanism for Encouraging Innovation,* which discusses which patents should be bought and what selling process should be applied; and Robert C. Guell & Marvin Fischbaums (1995), *Toward Allocative Efficiency in the Prescription Drug Industry*, which challenges efficient patent praxises. We want to look at the difference between the competitive market company profits and the social surplus, which none of the above stated papers have done. Further, by comparing the private value of an innovation to the Social Surplus Maximizers (SSM) value, and then introducing valuation factors, we suggest that an IO may be more sustainable than that of today´s patent scheme.

Michael Kremer (1998) proves that a second price sealed auction will reveal the true value of a patent, but that this only proves how much a patent is worth to a potential buyer, and not to the society as a whole. More precisely, there exists three different price ranges of patents: What it is worth for a private actor (both monopolistic and competitive), what it is worth for the SSM without externalities, and what it is worth for a SSM with externalities.

This leads us to our research question:
Is it economically optimal to appoint a global patent body that buys and distributes patents that can reduce negative externalities, and thereby reduce future social costs?

We will investigate this question by using theories from classic patent and R&D theories, as well as selected papers.

1.3. FRAMEWORK

The framework of the thesis is a combination of industrial-, micro- and climate economics. The main idea is to see if it can be profitable for the society to buy patents from private organizations, both by volunteering to sell and expropriation. We also want to see if this can reduce negative externalities in terms of emissions and resource use, as well as maintaining incentives that patents have traditionally been protectors of. We will try to do this while keeping the R&D incentives constant.

In chapter 4, *Establishing Room for Improvement*, we will prove that current patent praxis may have room for improvement by applying a SSM perspective. Further we seek to define the optimal patent price through todays applied theoretical framework, and then finally introducing externalities as a new variable, illustrating that the true value of a patent for a social perspective may be even higher than first estimated.

It will be a theoretical thesis, which hopefully combines existing economic models within the above-mentioned economic areas.

2. BACKGROUND

For the purpose of the thesis, we will first give an introduction to patents; its definition, and its requirements. We will also present our review of literature.

2.1 PATENTS AND ITS REQUIREMENTS

A patent is a government issued document that gives the inventor or the owner of the patented invention exclusive rights to a specific new device, apparatus or a process for a limited period of time, generally 20 years. To get a patent, one have to file for an application that explains the invention, and how it differs from what others have done before. Then, the government reviews the application and grants the inventor the patent, if the requirements for patentability are fulfilled. There are four requirements for patentability, and these are:

1. *Statutory:*
   The invention must fall within the scope of patentable subject matter, meaning that it must either be a machine, a manufactured product, a composition made from two or more substances, or a process for manufacturing objects (Scotchmer, 2004, 66).
2. *Usefulness:*
   The invention must be "useful". Traditionally, this mean three things: practical utility, operability and beneficial utility. An example is that a machine must work according to its intended purpose and a chemical must exhibit an activity or have some use.
3. *Novelty:*
   The invention must be new. It can not have been described in earlier publications, and it can not have been used or sold in the past.
4. *Non-obviousness:*
   The innovation must be different from previous innovations "in ways that would have been obvious to somebody who had ordinary skill in the technology"

(Scotchmer, 2004, 68).

A patent does not give a right to produce, use or sell an invention. It rather gives the inventor the "right to sue for infringement if anyone tries to make, use, sell, offer, import, or offer to import the invention into the country of issuing the patent" (Scotchmer, 2004, 66). The process of patenting involves a lot of work, and can take several years to complete.

Little has changed from the patent system today, and the patent system as it was before 1982. What has changed, is the odd that the various parties will succeed at different points in the process (Jaffe, A.B & J. Lerner, 2004, 12).

2.2. REVIEW OF LITERATURE

Kremer, M. (1998). Patent Buyouts: A Mechanism for Encouraging Innovation. Quarterly Journal of Economics 113(4): 1137-1167.

Michael Kremer proposes patent buyouts in his article, where he argues that the government should buy patents and turn over the rights to the public for free. Patent buyouts would reduce consumer prices, instead of having to wait T years for the patent to expire. In addition, Kremer proposes a Second Degree Sealed Auction to reveal real valuations of patents.

Guell, R.C. & Fischbaum, M. (1995). Toward Allocative Efficiency in the Prescription Drug Industry. The Milbank Quarterly: 213-230.

The price system for innovation has been criticised as inefficient for the society. In this paper by Robert C. Guell & Marvin Fischbaum, an alternative method estimates the deadweight loss of the consumer surplus associated with the exercise of monopoly power. Guell & Fischbaum proposes an alternative to price controls, where the government purchase pharmaceutical patents, and distribute them freely within the country of origin (US). They are also licensing it to foreign states for a set fee, to remove double marginalization.

Scotchmer, S. (2004). Innovation and Incentives. The MIT Press.

This book by Suzanne Scotchmer presents the historical, legal and institutional contexts in which innovation takes place. The book discusses knowledge as a public good, the economic design of intellectual property, several models of cumulative innovation, the relation of competition to licensing and joint ventures, patent and copyright enforcement and litigation, private & public funding relationships, patent values and the return on R&D investment, intellectual property issues arising from direct and indirect network externalities, and globalization (Scotchmer, 2004, 366).

3. THEORETICAL FRAMEWORK

In this section, we will introduce the theory that will lay foundation for our thesis, which will believe will be important for further analysis. Creating monopolies in ideas and directly subsidizing research both lead to serious consequences, as inventors cannot fully capture the social value of their invention. Spillovers of their ideas to other researchers exists, and hence, patents may provide insufficient incentives to develop socially valuable inventions. Patents also create static distortions from monopoly pricing and stimulates socially wasteful expenditures when "inventing around patents" (Kremer, 1998, 1137).

3.1 MONOPOLY

Patents creates a monopoly situation because the inventor or the owner of the patented invention is the only one that is allowed to produce the product or the process, and offer it to the market. The problem with monopoly is that it is not Pareto optimal for a society, as it creates a deadweight loss. Scotchmer (2004) defines deadweight loss as follows:
"Dead-weight loss occurs when people are excluded from using the good even though their willingness to pay are higher than the marginal cost". The monopoly situation with the deadweight loss is illustrated below.

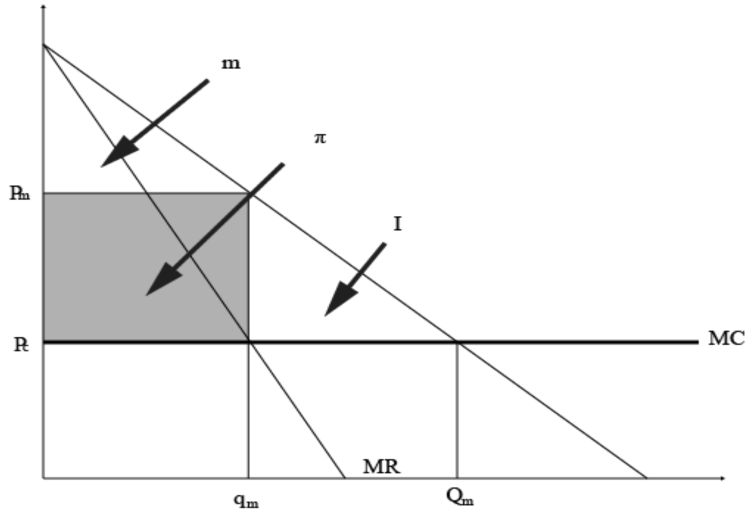

Figure 1: *Monopoly situation with deadweight loss.*

In a competitive situation, the figure shows a product that is produced at a marginal cost, $P_c = MC$. Without any patent protection, i.e. if competitively supplied, the produced quantity is equal to Q_c. The parameters $m + \pi + I$, illustrates the total surplus, which in this case is the consumer surplus. In this situation, there is no producer surplus. However, when a patent is granted, a monopoly situation occurs, and the innovator can profit by pricing the product optimally at P_m, where $P_m > P_c = MC$. The innovator's per period profits are then represented by π. The total surplus is reduced to the area $m + \pi$, which in turn gives a deadweight loss equal to I. The loss arises because the product is produced at an inefficiently low level from a social point of view, i.e. $Q_c > q_m$. This demonstrates the trade-off of the patent system; balancing between the benefits of encouraging additional innovative activities and the costs of forgoing the competitive provision of some goods and services.

3.2 PRICE ELASTICITY OF DEMAND

An important concept in relation to patents is the price elasticity of demand. Price elasticity of demand is a term used when discussing price sensitivity, or more precisely, the percentage change in quantity demanded in response to a one percent change in price. The formula for calculating price elasticity of demand is:

$$Price\ Elasticity\ of\ Demand\ =\ \frac{\%\ Change\ in\ Quantity\ Demanded}{\%\ Change\ in\ Price}$$

As the changes in price and quantity usually will move in opposite directions, we do not bother to put in the minus sign as we are more concerned with the co-efficient. When the price elasticity of demand is equal to zero, we say that the demand is perfectly inelastic. When the price elasticity of demand equals one, we say that the demand is unit elastic. Finally, when the price elasticity is greater than one, we say that the demand is perfectly elastic.

3.3. OPTIMAL PATENT LENGTH

The theory is originally based on a model of Nordhaus (1969), which was later extended and criticised by Scherer (1972). Generally, the model is based on that inventions and innovations are not free goods, which means that there cannot be an invention or innovation that reduces unit production costs without research and development (R&D) costs. For any given production task, there exists an “invention possibility function” that relates the percentage unit production cost reduction, B, to the expenditure of R&D. This means that the more input you put in research, the greater your cost savings will be. Scherer (1972) argues that the invention possibility function is inflected, which is illustrated as an S curve in the figure below (i.e. $B(RD)$). This means that there at first is increasing returns in lower levels of R&D expenditure, and later diminishing returns in higher degrees of investments.

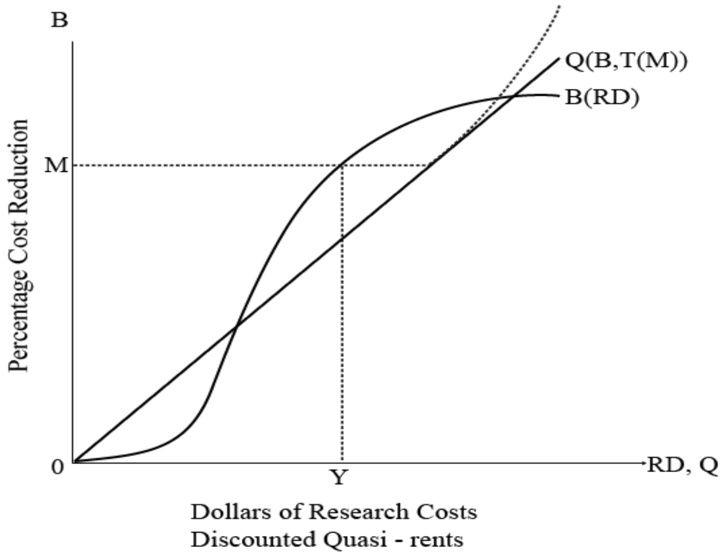

Figure 2: *The "invention possibility function"*.

Source: Scherer, F.M. (1972). Nordhaus´ Theory of Optimal Patent Life: A Geometric Reinterpretation.

Scherer (1972) assumes that the benefits to the firm depend in a more advanced manner. Initially, production takes place under competitive conditions at a constant unit cost and price, C_o. But when a patent is granted, the unit cost is reduced to C_1, which means that the firm with the patent can either drive other firms out of business or it can license the patent. Note that the inventor or the owner of the patented invention is not permitted to charge a price above the cost C_o associated with the competitive process. Because of this, and if demand is not very elastic, the optimal post-invention price and quantity under monopoly will be similar to the price and quantity in the pre-invention equilibrium. As an illustration, see the model below.

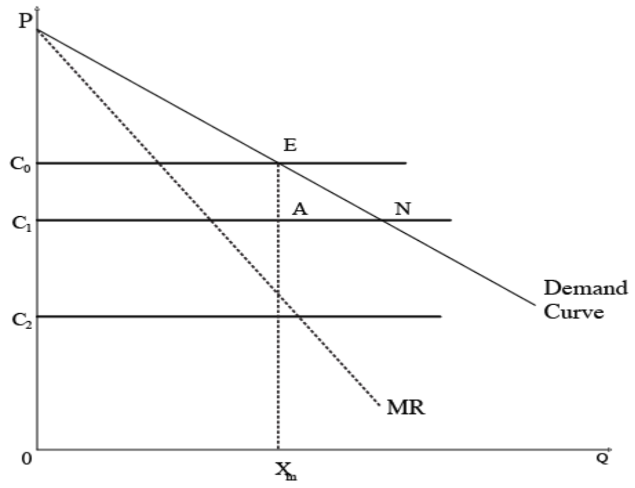

Figure 3: "Benefits to the firm"

Source: Scherer, F.M. (1972). Nordhaus´ Theory of Optimal Patent Life: A Geometric Reinterpretation.

Patent lenghts of 8- and 17 years are used in Scherer´s (1972) paper to illustrate that the optimal patent life is shorter. The sharper the curvature, the smaller the distance between the two spots, and hence the optimal patent life is shorter. The longer the patent life, the more R&D is needed, and the cost reduction effect attenuates.

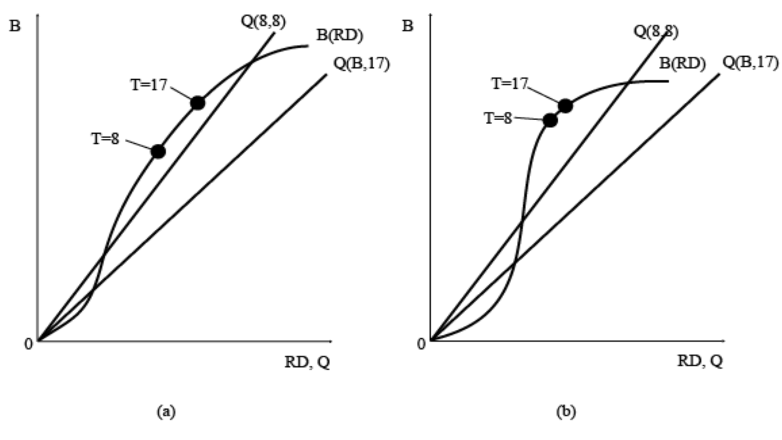

Figure 4: "*Optimal Patent Life and Curvature of Invention Possibility Function"*

Source: Scherer, F.M. (1972). Nordhaus´ Theory of Optimal Patent Life: A Geometric Reinterpretation.

Scherer (1972) concludes that there exists a finite patent length due to the following reasons:

1. There are diminishing returns to R&D.
2. The extra profit you gain by increasing R&D are discounted. Hence, the longer the patent duration, the more profit is discounted.
3. Society must wait longer for welfare maximization.

3.4 PATENT BREADTH

One variable that Scherer (1972) did not consider in his paper is patent breadth. Patent breadth is more complicated than that of patent length, as there is no universally accepted measure of breadth comparable to time as a measure of duration. Patent breadth has to do with how easy it is for competitors to imitate the product or process, and that only minor changes are needed to exploit the patented idea (Scotchmer, 2004, 69). Hence, the larger the changes, the more difficult it will be for competitors to "invent around the patent" and cut into the innovators profit.

There are disagreements in what effect this has on the society. Clearly, a reduction in patent breadth would induce more competition, which will benefit the consumers. But too narrow a patent reduces the incentive to innovate. So what exactly is the optimal patent breadth? Gilbert and Shapiro (1990) demonstrate that the optimal patent is to have very narrow but infinitely long patents, as broad patents are costly for the society, because they give excessive monopoly power to the patent holder. Klemperer (1990) on the other hand, model patent breadth both narrow and long, or broad and short, depending on the structure of demand.

4. ESTABLISHING ROOM FOR IMPROVEMENT

4.1 THE SSM PERSPECTIVE

Applying the basic model of patent length by Nordhaus (1969), and assuming that there is a competitive industry, a non-drastic innovation, the costs of R&D is increasing ($dr(x)/dx > 0$ and $d^2r(x)/dx^2 > 0$), where:

c = *operating cost*

x = *intensity of R&D investments*

$c - x$ = *expected operating cost after innovation*

$r(x)$ = *cost of undertaking R&D at intensity x*

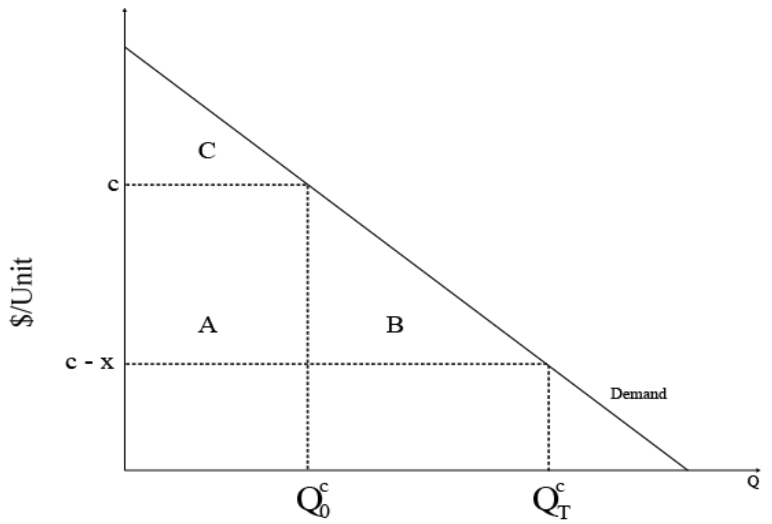

Figure 5: "*Innovation gains during period of patent protection (T Years) and after patent protection*"
Source: Pepall, Richards, Norman (2014). Wiley, Industrial Organization: Contemporary Theory and Empirical Applications.

As can be seen in figure 5, following the cost decrease from c to $c - x$, the innovator receives a profit of A for T years (active patent time), and when the patent expires, the total quantity produced goes from Q_0^C to Q_T^C as price reduces to $c - x$, $(P = MC)$. The new consumer surplus is $A + B + C$, where B has formerly been a deadweight loss (DWL) for T years.

Since the overall costs are decreased, the innovator can either licence this innovation to its competitors for a fee of $c - x$, or sell its product at a slightly lower cost, capturing the entire market. Either way, the current market price and overall output should remain unchanged. Hence, solving this as a SSM problem (by maximizing Social Surplus), we see that converting the area B from a DWL to a consumer surplus for an additional T years, may benefit all.

For the innovator:
The per period profit the innovator receives for a patent can be written as: $\pi^m(x; T)$, and hence, the present value of an innovation is:

$V_i(x; T) = \sum_{t=0}^{T-1} R^t \pi^m(x; T) = \frac{1-R^t}{1-R}\pi^m(x; T)$, therefore the net value for the innovator is:

$V_i(x; T) - r(x)$ (Pepall, Richards, Norman, 2014) Where R is the discount factor.

By introducing values to the model we present a traditional demand curve $P = a - bz$ where z is quantity of production.

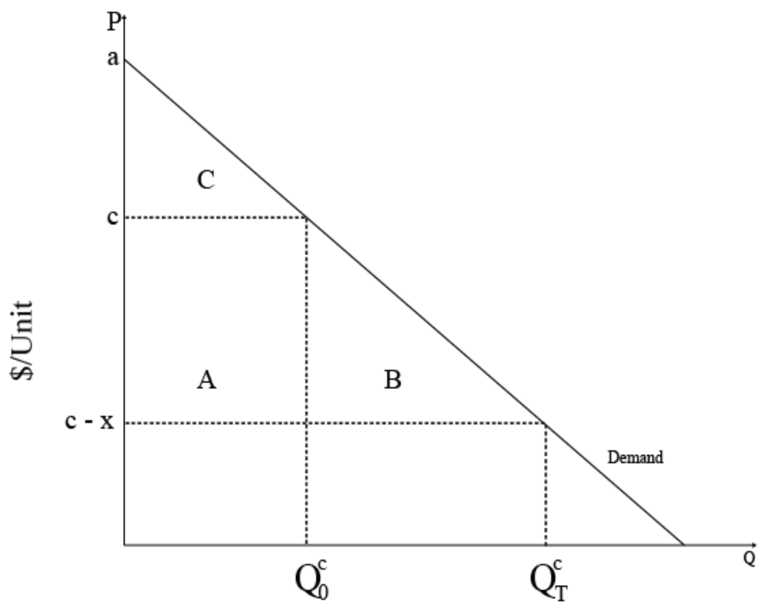

Figure 6: Modification of Figure 5: "*Innovation gains during period of patent protection (T Years) and after patent protection*"

We then have three different situations regarding social surplus: 1. before an innovation (S_0), 2. during an active patent (S_t), and 3. after said patent expires (S_{T+1}). As usual, the social surplus is defined as the sum of Consumer surplus, Producer Surplus and Taxes. For simplicity, we exclude taxes. Thus:

$S_0 = CS_0 = (a-c)Q_0^C \times \frac{1}{2}$, since $CS_0 = (a-c)Q_0^C \times \frac{1}{2}$, $PS_0 = 0$,

$S_t = (a-c)Q_0^C \times \frac{1}{2} + xQ_0^C$, since $CS_t = (a-c)Q_0^C \times \frac{1}{2}$, $PS_t = xQ_c^0$,

$S_{T+1} = CS_0 = (a-(c-x)Q_T^C \times \frac{1}{2}$, since $CS_{T+1} = (a-c)Q_0^C \times \frac{1}{2}$, $PS_{T+1} = 0$,

Here we see that $S_{T+1} > S_t > S_0$, since we get rid of the DWL of B. The most socially optimal situation occurs when the patent expires, and all surplus gets shifted over to the consumer. However, this means that the patent has to have existed in the first place, and the problem of patent/R&D incentives arises.

Thus, potential area of improvement in classical patent policies is to get rid of the DWL in a competitive market where a firm invents a non-drastic innovation.

5. EXTERNALITIES

In the master thesis we aim to define and introduce a variable for externalities, which impacts the overall value of an innovation, afflicting the real value of the patent from the perspective of the SSM. If we can prove that the $PV(S_0) \neq PV(S_1)$ where S_0 is the traditional present value of social surplus, and S_1 is the present value of social surplus including externalities, we can determine that for an IO with a mission of buying and distributing patents at the sellers private valuation, there may exist an even higher surplus than initially estimated.

6. METHODOLOGY

This part is about the choice of research methodology; the reason for our design and method.

6.1 RESEARCH DESIGN

When selecting a research design it is critical for the development of the thesis that it provides a framework for how data should be collected and processed. Which type of research design to use depends on how much knowledge you have about the research question in advance. The aim of the research design that it should connect the methodology with the theory and the research question (Gripsrud, G., et al., 2010). There are five main types of research design: Experimental, Cross-sectional, Longitudinal, Case Study and Comparative Design (Bryman, 2016).

Since this will be a theoretical thesis, we have not chosen an empirical application yet, hence, the research design is not currently decided. This will be decided when all mathematical calculations are done, and we seek to prove the theories presented in the paper.

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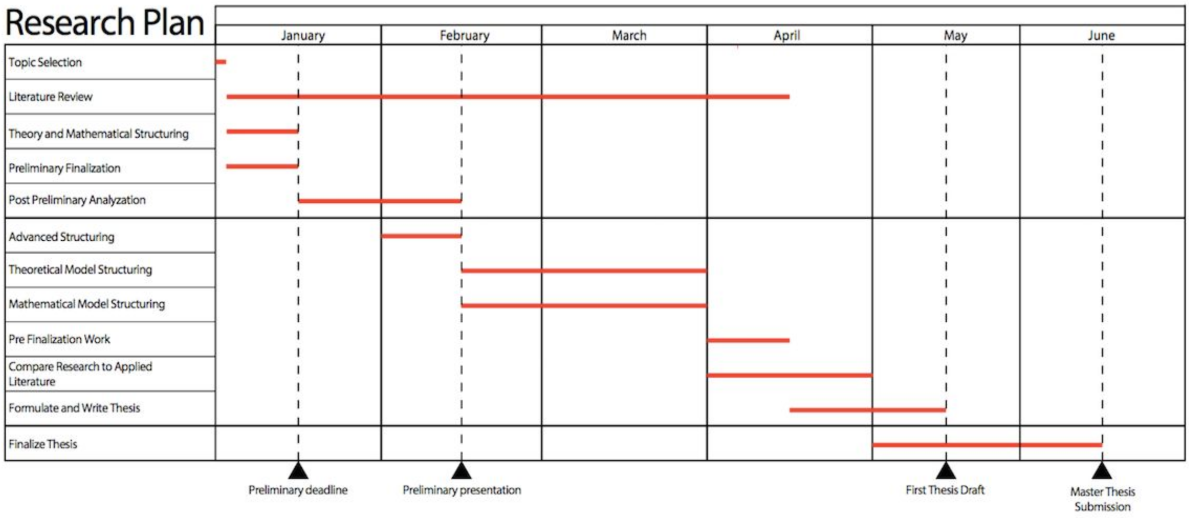
APPENDIX


Research Plan
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