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Evergreening and patent cliff hangers[1]

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1. PROBLEM BACKGROUND

1.1 A tragic windfall

The tragic 9/11 events in 2001 implied a delay in the court proceedings in Boston that dealt with a case involving AstraZeneca and its blockbuster drug Losec (Prilosec in the US). The key basic patent for this drug had been received by the Swedish company Astra in the US in 1981 (US patent # 4.255.431, issued March 10, 1981). Astra later merged with Zeneca in 1998-99, forming AstraZeneca ("AZ"). The delay in court proceedings in 2001, due to the unexpected and time-consuming involvement of the court in the 9/11 events, implied in turn that competitive entry of generica into the Losec market was also delayed. At this time media circulated an undemented estimate of 200 MUSD as the monthly profits reaped by AZ from this drug. These profits were to be heavily reduced by competitive entry which was sure to take place as soon as possible after the key patent expired, as generic drug manufacturers had prepared their "springboards" for entry into this lucrative market.

1.2 The patent cliff challenge

Right or wrong, the sales, profits and profit margin of a blockbuster drug are towards the end of its effective patent protection usually very large, which incentivizes pharma firms to employ a myriad of means/tactics/strategies to delay entries by competitors, i.e. means to maintain a competitive position and sustain any temporary competitive advantages, such as patent protection. The consequences of the expiration of a key patent in form of risks of a substantial drop in sales, profits and profit margins due to competitive entry, are particularly pronounced in the pharma industry in which non-intellectual property ("IP") based entry barriers are relatively difficult to erect during the effective patent protection. These drastic consequences of patent expiration are often referred to as "the patent cliff". In the case of AZ and its pre-merger constituent Astra, expiration of its key Losec patent, together with Astra's anticipated over-dependence upon Losec had early on been perceived as having such drastic consequences on its financial performance that it became an argument in favor of Astra's merger with Zeneca in 1998-99. Astra had since the 1980s tried to generate more radical innovations in its research and development ("R&D") pipeline but essentially without enough successes to be perceived as providing a business portfolio sufficiently diversified to pick up the company's expected financial drop from the patent cliff, perceived by some as suicidal while disputed by others.

1.3 The evergreening approach

Thus, all in all, extending the effective patent protection of Losec and its successor Nexium in a second product generation, i.e. what is referred to as evergreening, bridging the patent cliff had become a strategic issue for AZ with powerful incentives to invent various strategies to that effect.

AZ is not a unique case in this respect and many firms engage in various forms of evergreening. This is troublesome for competitors, not the least manufacturers of generic drugs in the pharmaceutical industry, who try to invent counterstrategies. Evergreening is also troublesome at an IP policy level since the statutory duration of intellectual property rights ("IPRs"), being a key policy variable for fostering dynamic competition, is in effect circumvented or invented around strategically by IPR users. Evergreening is finally troublesome for all agents on the purchasing and using side along with price regulating and anti-competitive agencies and since evergreening typically sustains high price levels. Pricing of pharmaceuticals is as complex as it is controversial and evergreening plays an important role in that context at the same time as it arguably plays an important role for managing patent expirations and financing continued R&D on the innovator side. How to trade-off the interests of innovative and imitative producers, users and society via the IPR-system is without doubt a problem, enlarged by the large values involved for all stakeholders as will be shown below.[2]

1.4 The Losec case

The paper presents in some detail the empirical case of the pharmaceutical blockbuster drug Losec, which was succeeded by the drug Nexium as a second product generation.[3] This case is particularly rich in many aspects of evergreening based on a dynamically extended portfolio of IPRs, patents and follow up patenting in particular, but also trademarks and trade dress, within and across two product generations, complemented by a successful global patent litigation strategy. The case, moreover, illustrates how a couple of IP policy developments substantially aided evergreening. In addition, it contains some unexpected drama, which is useful in getting attention to the evergreening phenomenon. The paper ends with a discussion of implications of evergreening strategies for managerial counter-strategies as well as for innovation and IP policies.

2. EVERGREENING DEFINED AND DESCRIBED

2.1 Evergreening defined

Evergreening in a general sense refers to the extension of the duration of an existing temporary monopolistic or market dominant position by various means or strategies. We can then talk more specifically about evergreening of sales or profits from products, technologies, services and equity. Evergreening can be accomplished by erecting entry barriers of all sorts and employing entry deterrence strategies for delaying entries or weakening competition and/or strengthening own competitive advantages when the dominant position is threatened. It is moreover a standard result in industrial organization theory that a monopolist has more to lose by the entry of a second company than the latter has to gain, something that incentivizes the monopolist to pay the prospective entrant for not entering, i.e. to engage in a so called reverse settlement or "pay for delay" scheme.[4] Typically evergreening has been practiced in the pharmaceutical industry when an IP-based temporary monopoly is about to expire, and then IP strategies for evergreening of IP as well as other means have been used to evergreen product sales.

2.2 How evergreening is used

This paper aims to explore the phenomenon of evergreening by means of IP strategies in general, and patent strategies in particular. If, e.g., an innovation through widespread adoption and diffusion has led to a high growth rate in a market with a low rate of technological substitutions, high switching costs and steep learning curves, then any prolongation of a dominant market position pays off handsomely. Traditionally evergreening involves follow-up patenting of product and process improvements and new and non-obvious applications or medical indications of the basic invention as illustrated in Figure 1.[5]

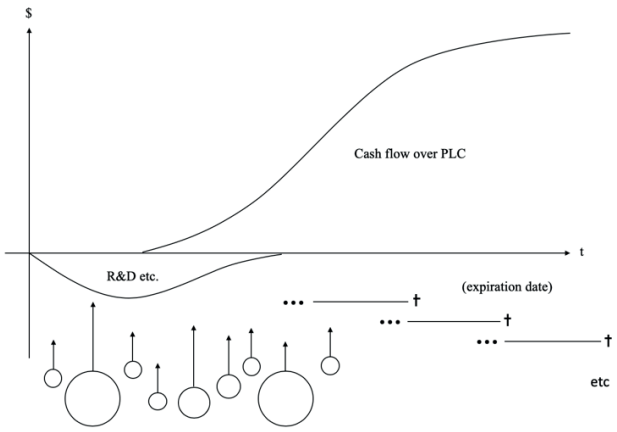


Figure 1 Continuous patenting and build-up of patent portfolio over time
Source: Granstrand (1999)

[1] Helpful comments on the paper and the topic have been received from Marcus Holgersson, Ivan Hjertman, Mike Scherer and Frank Tietze. The financial support from Vinnova under grant 2017-04469 for the project "Intellectual assets, innovation, growth and value creation and the role of new digital technologies and digital property" and the assistance of Andreas Opedal is gratefully acknowledged.

[2] See e.g. Feldman, R. (2019). Drugs, Money, and Secret Handshakes: The Unstoppable Growth of Prescription Drug Prices. Cambridge University Press, UK, for a recent study of pharmaceutical pricing in the US, and Scherer, F.M. (2004). The Pharmaceutical Industry – Prices and Progress. New England Journal of Medicine, 351(9), 927-32, for an international study.

[3] For further readings on the case, see Östholm, I. (1995). Drug Discovery – a pharmacists story. Swedish Pharmaceutical Press, Stockholm, Sweden; Sundling, S. (2003). Per aspera ad astra. Ekerlids; Granstrand, O., and Tietze, F. (2016). IP Strategies for Evergreening Inventions (CIM Working Paper 2016:1). Chalmers University of Technology, and Granstrand, O. (2018a). Evolving Properties of Intellectual Capitalism: Patents and Innovations for Growth and Welfare. Edward Elgar Publ., Cheltenham, UK.

[4] See a standard textbook like Scherer, F.M. (1980). Industrial Market Structure and Economic Performance (2nd rev. ed.). Chicago, IL: Rand McNally, or Tirole, J. (1988). The Theory of Industrial Organization. Cambridge, MA: The MIT Press.

[5] For a thorough study of legal aspects of pharmaceutical patents, see Domeij, B. (2000). Pharmaceutical Patents in Europe. Kluwer Law International. See also Domeij, B. (2003). Initial and follow-up pharmaceutical inventions in Europe. Published as Ch. 8 in Granstrand (2003), pp. 177-197, for some legal aspects of initial and follow-on pharmaceutical inventions.

Evergreening could also be accomplished by launching a series of product generations with overlapping technology or resource bases, where a strong patent position in the technological overlap is leveraged to a strong market position for the subsequent product generation as illustrated in Figure 2.

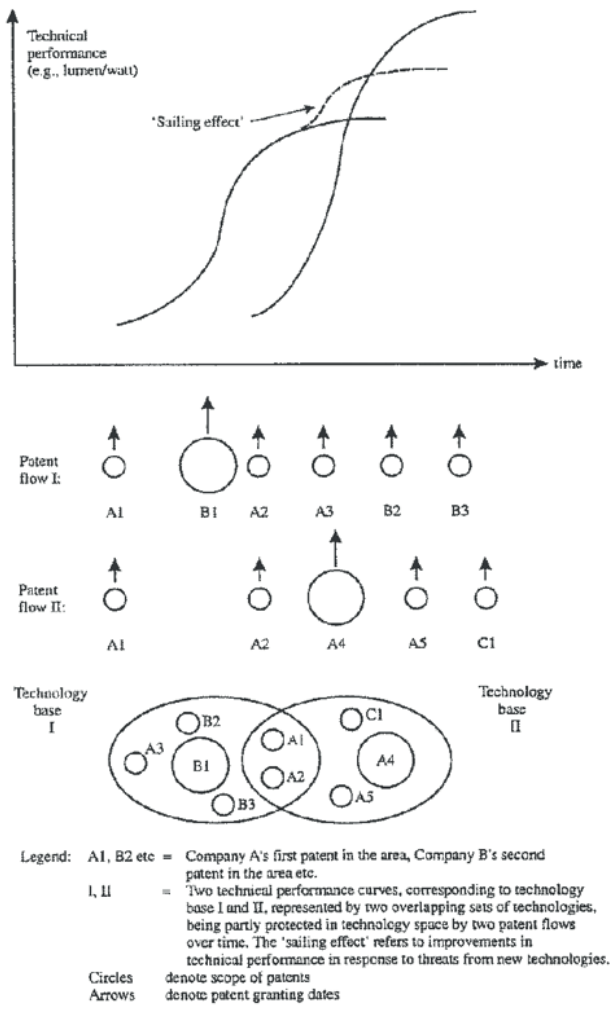


Figure 2 Patenting strategies in the case of two sequential product innovations (adapted from Granstrand, 1999)

Evergreening is well recognized in industry, especially in the pharmaceutical industry, and in some policy circles but it is not well researched by academia.[6] Firms are clearly incentivized to engage in evergreening, while the patent system is designed to encourage dynamic competition and the provision of innovations by granting innovators legal rights for achieving a temporary or time limited monopolistic position just long enough for innovators to recover their investments. In return for these rights innovators have to provide sufficient disclosure of their invention secrets to enable competitors to enter the market after patent expiration. However, such an institutional design carries the seeds to counter its purpose when the time limits are not set right or could be strategically surpassed by its users, incentivizing them to become abusers. Policy responses are then called for, but as the paper will show such a call and response is difficult to get in tune.

3. EMPIRICAL CASE[7]

3.1 Point of departure

The medical drug Losec (with generic name omeprazole) for stomach ulcers was developed at Astra-Hässle in Mölndal, Sweden, and launched with its first year of sales in 1988. It quickly became a commercial success and for several years was the world's annually best-selling drug. The basic patent on the active substance was applied for in 1978 in Sweden and in 1979 in Europe and the US, among other countries, and was granted in 1981 in the US – which meant that its validity in the US would expire in 1999 (although subsequently prolonged for 3 years). The basic patent can be regarded as a very strong one with a substantial inventive step and strategic blocking effect in terms of restricting possibilities for inventing around. Losec represented a whole new biological mechanism based on proton pump inhibitors and was thus a technologically radical innovation that also became economically very large since it attained huge growth and profitability. (The patent's past and future value was estimated by Astra-Hässle management in 2000 to lie between 15–30 billion US dollars (BUSD).)

This innovation contributed more than any other of Astra's radical innovations to making Astra one of the 15 largest global pharmaceutical companies, from having been among the 40 largest before Losec. As mentioned, in 1999 Astra merged with Zeneca to become AstraZeneca (AZ). A major motivation behind this merger was to create economies of scale and diversify the risks and vulnerability to the "patent cliff" impact upon profits and growth, i.e. the reduction in profits and sales due to patent expiration. Thus, major patents may have dual impact upon growth over time, possibly even leading to M&As. In 2004, AZ was the sixth largest pharmaceutical company and had sales of prescription drugs amounting to 21.4 BUSD, ranked after Merck and before Novartis.

Losec was further developed after its initial launch to include, for instance, an improved form of encapsulation for the active substance, which yielded a so-called formulation patent. This type of patent, although essential, did not have the same high inventiveness as the original substance patent but nevertheless required substantial R&D efforts and ingenuity. An essential step in the commercialization of Losec was precisely the development of a well-functioning pharmaceutical preparation. Astra sought and was granted a patent on the preparation, which proved to be very valuable in the competition with generic drug companies, i.e. companies that sell generic drug copies of an original drug, which typically then has lost its patent protection. An extra month without competition from generic drugs was said in the media to be worth at least 200 million US dollars for Astra.

Astra and later AZ was also forced to defend its patents in numerous court disputes in various countries. In the US, Astra very likely benefited from the greater propensity of US courts since the 1980s not to invalidate a patent under attack.

The case of Losec thus illustrates how strongly complementary patents with both large and small inventive steps altogether contributed to an enormous growth in value but also to risks of falling profits and growth after patent expiration. The drug Nexium, a descendant of Losec forming a second product generation, further illustrates the economic importance of more – in technical and scientific terms – modest progress and incremental improvement work along a science and technology trajectory. These cases demonstrate the important interplay and synergies between radical and more incremental product as well as process innovations. Figure 3 shows the sales pattern of the two product generations.

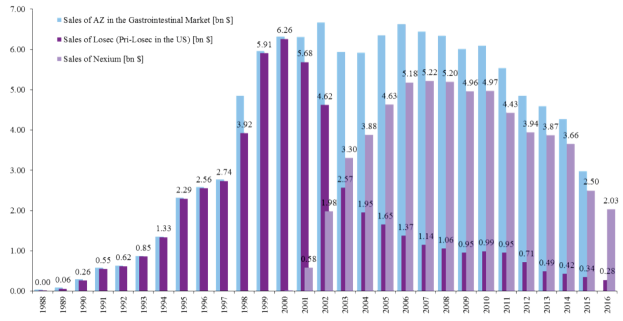


Figure 3 Evergreening of Losec by Nexium[8] (Source: Granstrand and Tietze (2016) and AZ annual reports)

3.2 IP value distribution

Table 1 shows how the value derived from IP is shared between the innovative producer, thought of as AZ, and consumers in different appropriation regimes. The underlying model is linear as a first approximation, and static as reflecting a year at the mature end of patent protected phase of the Losec product cycle, before the onset of generica and before the cannibalization of the second generation Nexium.[9] The assumptions of the model are of course disputable as well as the data, but still offer a ballpark estimate and some interesting interpretations.[10] First the value transfer from the innovator to consumers (without regard for equity) from competitive entry, or alternatively from hypothetical non-profit regulation, is indeed considerable and a good illustration of the patent cliff, a transfer that easily motivates extreme adversarial responses from all sides, and especially for the single "patent cliff hanger". Second, a hypothetical price regulation based on a fairness principle stipulating equal value sharing between innovator and users (intermediaries apart), actually reduces the monopolistic innovator's annual value capture only by 12.5%, while increasing the consumer value with 75%. This is quite surprising and constitutes food for thought about how to smooth a patent cliff through licensing on some fair terms, i.e. fair, reasonable and non-discriminatory terms ("FRAND") based licensing, which could be compulsory or even voluntary towards the approach of the patent cliff, rather than, say, a patent term restoration. Third, the absolute figures are large and uncertain but in line with the total value of the Losec strategic (=unavoidable) patent as estimated to be in the range of 25-50 BUSD.

Table 1 IP value distribution under different pricing regimes in BUSD per year[1)]

Pricing	Consumer value	Producer value	Societal value
Monopolistic[2)]	1.2	2.4	3.6
Competitive[3)]	4.8	0	4.8
Regulated[4)] for non-profit	4.8	0	4.8
Fair[5)]	2.1	2.1 (=8/9 * 2.4)	4.2

Notes:
1) Case of radical product innovation with approximate linear demand and supply curves with constant marginal cost, constant dollars, and no discounting (since impact is per year). Fixed costs are partly sunk, partly variable costs. Value = surplus and societal value = welfare = consumer value + producer value (i.e. with no equity).
2) As a result of IP-based evergreening.
3) As a result of IPR expiration, and competitive market entry of generica.
4) As a result of non-profit regulation ("No profits in the welfare sector").
5) As a result of compulsory FRAND-based licensing, equalizing consumer value (surplus) and producer-value (surplus).

6 See Granstrand, O., and Tietze, F. (2016). IP Strategies for Evergreening Inventions (CIM Working Paper 2016:1). Chalmers University of Technology, for a survey of literature on evergreening.

7 This section draws on Granstrand, O. (2018a). Evolving Properties of Intellectual Capitalism: Patents and Innovations for Growth and Welfare. Edward Elgar Publ., Cheltenham, UK.

8 Note: AZ does not report cumulative figures for sales in gastrointestinal market for 2016.

9 The underlying model is outlined in Granstrand, O. (2018a). Evolving Properties of Intellectual Capitalism: Patents and Innovations for Growth and Welfare. Edward Elgar Publ., Cheltenham, UK, pp. 186-7.

10 A similar analysis with a linear demand curve is presented in Romer, P.M. (2002). When should we use intellectual property rights? American Economic Review, 92(2), 213-216, in the case of value sharing of copyrighted material through file sharing of music. Romer's analysis challenges the traditional design of copyright from an economic welfare analysis point of view, demonstrating the considerable net welfare gains from filesharing, despite its presumed negative effects upon value creation from production of new music.

4. DISCUSSION

4.1. Typologizing evergreening

From the case study we can distinguish between the following types of evergreening.

First, evergreening of a dominant market position on the product/technology/service/equity market can be accomplished by IP-based as well as non-IP-based strategies (e.g. reverse settlements, which was also used by AZ).

Second, IP-based evergreening strategies may in turn be based on single or multiple IPRs of a single IPR type or of multiple types of IPRs, i.e. through multi-protection. IPRs, and patents in particular, may then cover different features of products, processes, components (hard and soft), complementary products or devices, and applications. As for patents, they could be complementary as well as substitutes, e.g. for building patent fences or surrounding basic patents with application patents.

Third, although the case illustrates evergreening from the point of view of a single firm, multiple firms or organizational entities could engage jointly in evergreening.[11]

Figure 4 illustrates the duration of various major types of IPRs. Here it is interesting to note the conceivable impact of new technologies like artificial intelligence ("AI") and blockchain. AI based generation of patents, designs, copyrighted material and trademarks, passing a kind of Turing test (meaning that a patent and trademark office examiner cannot discover that the creation and rights application is computer generated) is likely to enhance the possibilities of evergreening, especially if the inventive step, originality or distinctive feature type of requirements are set low. As for database rights, granted on the basis of substantial and non-trivial investment in the database as has been the case in the EU, sensors and AI in Internet of Things systems certainly will facilitate evergreening.[12] In regards to trade secrecy, it will be enhanced by blockchain and encryption technologies. Thus enhanced technology based protection of IP will increase, which calls into question whether the IP protection by legal means has to be modified and rebalanced.

Third, evergreening may be intragenerational and intergenerational as illustrated by Losec and Nexium. The case of inter-generational evergreening or multi-generational evergreening with three product generations may be illustrated as in Figure 5 below.[13]

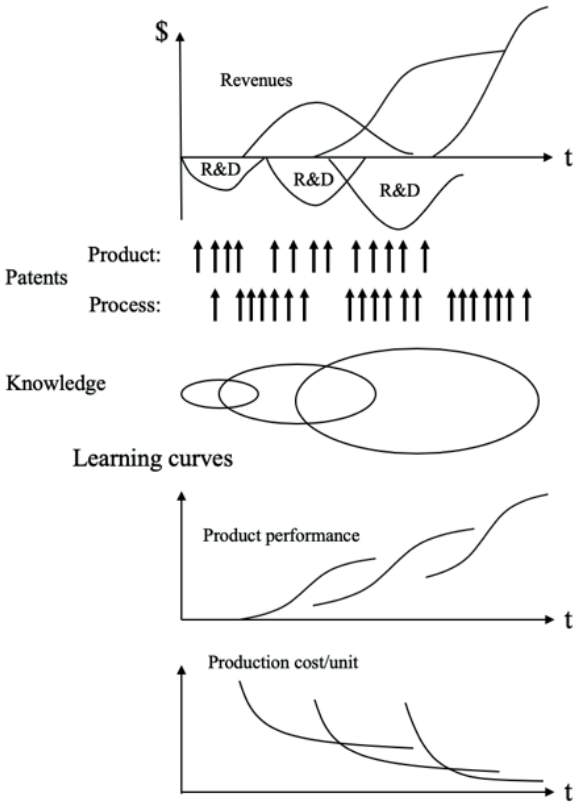


Figure 5 Patent based multi-generational evergreening with three generations

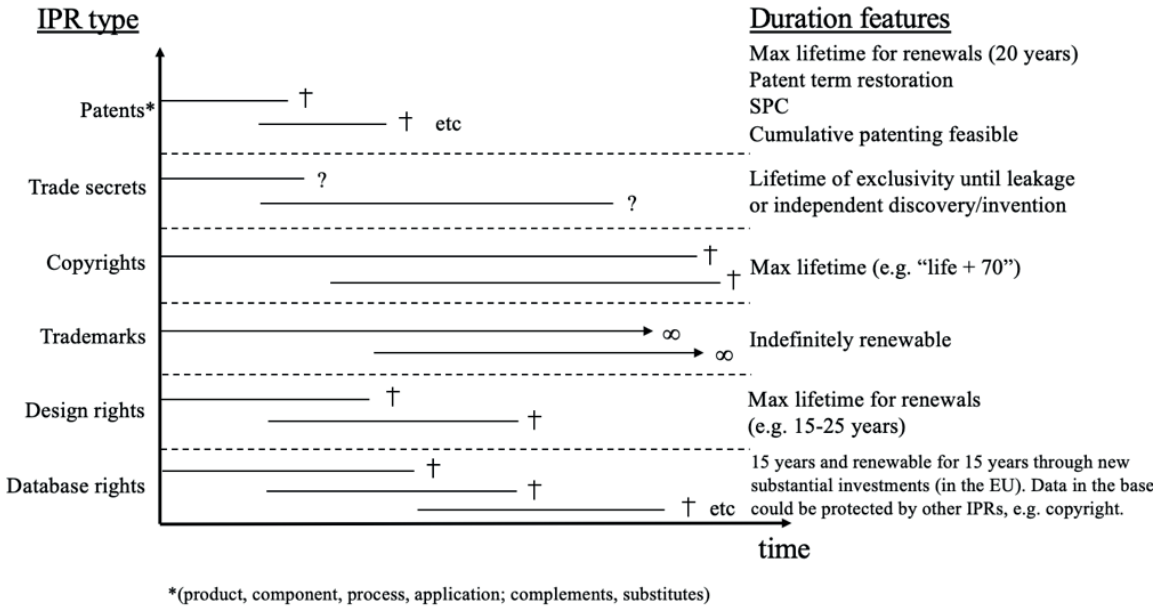


Figure 4 Evergreening features in multi-protection

4.2. The strategy-policy game

Many of the problems with the patent system derive from the fact that the system can be strategically gamed by its users in ways that are difficult to counter by policy makers, including law makers. This leads to a meta-game between strategists at industry level, who are involved in a competitive game with each other, and policy makers at the government level, who needless to say might be involved in games with each other as well. We will refer to this meta-game as the strategy-policy game.[14]

This kind of meta-game is more or less omnipresent in any decentralized governance system and it should come as no surprise that it is present in the patent system in general. Evergreening by exploiting the rules in the patent system then provides a good illustration of the strategy-policy game as strategists want to increase the duration of effective patent protection in order to increase monopolistic rents while policy makers want to limit it in order to increase competition. At the same time, viewing evergreening as a strategy-policy game provides useful analytical tools for coping with evergreening. One such tool is a strategy-policy matrix as shown in Table 1, considering the categories of policy-makers (without a competing category), evergreeners and their competitors.

As seen from Table 1 there are many elaborate strategy options for evergreening and a fair amount of response strategies, while the standard patent policy variables are relatively few, i.e. duration, inventive step (non-obviousness), scope of protection, patentable subject matter and patenting fees. It is outside the scope of this exploratory paper to make an economic policy analysis of evergreening and suggest policies to cope with it, but a few observations and reflections are in order. First, it is a daunting task to assess the economic consequences of evergreening that operates in increasingly complex technologies with significant prospects as well as costs for improvements with unclear counterfactuals. Evergreening defendants may argue somewhat in line with Kitch's prospect theory and the standard critique of that theory is difficult to empirically verify.[15] Nevertheless, evergreening is widespread and probably increasingly so and it runs counter to the basic idea of limiting the duration of IPRs, patents in particular. This clearly calls for policy analysis and research, which in turn requires clear definitions, operationalizations and typologies, to which end this paper hopefully has made some contributions. Second, even if evergreening is found to be detrimental to innovativeness, growth and welfare, at least certain types of it, it is difficult to find effective policy remedies that can add to the countering effects of strategies against it, i.e. add to the market forces.[16] This is so much due to the compounded effects of changes in terms of the parameters or policy variables in the patent system with its one-size-fits-all features and the industry specific nature of evergreening. More restrictions on the use of patent term restorations upon application are possible.

[11] An example is the Microsoft-Intel alliance with the so called Wintel combination of software and hardware platforms.

[12] For a good review of the legal protection of databases in the EU, see Axhamn, J. (2016). Databasskydd. Stockholm University.

[13] A good case of multigenerational evergreening is the Gillette sequence of razors with 1-2-3-4-5 razor blades, each number of blades defining a product generation covered by numerous patents of which some read on more than one generation. The use of backward and forward compatibility of razors and razor blades and standards further contributes to evergreening.

[14] This type of game can be looked upon as being played in simple cases at two levels with two competing categories of collaborating players at each level – a rule-making level and a subordinate rule-playing level.

[15] See Kitch, E.W. (1977). The Nature and Function of the Patent System. Journal of Law and Economics, 20(2), 265-290, for the theory and Kaufer, E. (1989). The economics of the patent system. Chur: Harwood Academic Publishers, for the critique of it.

[16] The Federal Trade Commission (FTC) in the US has voiced concerns, emanating in a legal brief in a special case in 2012, that reformulations of a pharmaceutical, dubbed a "product hopping" strategy by the FTC, in effect can be detrimental to competition by helping to keep generics out of the market rather than providing useful medical innovations (The Economist, June 21st 2014, p.72).

Table 2 The strategy-policy matrix for patent based evergreening[17]

EVERGREENING STRATEGIES

For	Against[18]
• Search and research for strategic patents and patent fences • Fragmentation and patenting of complementary resources and elements in the business innovation system, typically by • Follow-on/continuous sequential patenting of product/process improvements, features and applications for the innovation and its related complements • Aggregation and patenting of substitute resources and products/ technologies, typically by blocking patents and patent fencing outside the own product area (cf "offensive patenting"[19]) • Sequential patent blanketing and patent flooding • Multi protection, combining patents with other IPRs • Grant-back licensing • Deterring litigation and litigation threats, possibly using NPEs (non-practicing entity) and privateering[20] • Lobbying	• Invalidation[21] • Invent around • Patent or license acquisition • Patent pooling and cross-licensing • Partnering • Use of general bargaining power, e g purchasing or procurement power • Ignore and/or infringe • Delay entry until patent expiration • Abandon entry and related commercial operations and R&D • Patent racing to foreclose evergreening patents, e g by surrounding a strategic patent with application patents or invent around or racing for strategic improvement patents.

EVERGREENING POLICIES

For[22]	Against
• Patent term restoration • Injunctions • Delaying licenses, concessions, approvals, litigation etc.	• Reduction of statutory duration • Reducing the scope of protection • Reducing patentable subject matter • Increasing the inventive step requirement • Increasing patenting fees for sequential and/or substitute patents • Market power abuse intervention • Compulsory licensing • Abandoning the patent system

Raising the inventive step requirement is also possible but with mixed effects upon evergreening since possibilities to patent minor sequential improvements are reduced but so are invent around possibilities.[23] Third, policy remedies are perhaps more called for and also more easy to find for some other forms of evergreening, not being based on patents, as practiced in the pharmaceutical industry (including AZ in the Nexium case), reverse settlements and branding post-patent drugs. The latter form of evergreening is based on IPRs, trade marks in particular, and could be surprisingly effective and profitable, not the least in countries with generics of poor quality, a fair amount of corruption, weak government price controls and a foreign-is-better syndrome among buyers, prescribers and users, promoted by various means by foreign producers.

[17] The table gives important and common examples of patent-based evergreening but is not exhaustive. Non-patent based means for evergreening of product sales also exist such as marketing of branded products after patent protection has expired ("off-patent" products) and reverse settlements ("pay-for-delay" of entry).
Moreover, policies as well as strategies for and against evergreening could be regarded as opposites and included in the matrix as such. Similarly policies aimed at strengthening or weakening the propensity to employ a certain strategy could be included. Such examples that are easy to derive logically are excluded here, however.

[18] Response strategies to blocking patents in general apply here, see Granstrand, O. (1999). The Economics and Management of Intellectual Property: Towards Intellectual Capitalism. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, pp.232-234 in addition to patent strategies to foreclose evergreening patents.

[19] The dichotomy defensive/offensive patenting is avoided here since it is both unclear and value-laden.

[20] See especially Ewing, T.L. (2011). Indirect Exploitation of Intellectual Property Rights by Corporations and Investors: IP Privateering & Modern Letters of Marque & Reprisal. Gothenburg: Chalmers University of Technology, on privateering. The use of privateering specifically for evergreening is likely although unclear, however.

[21] Invalidation of patents, especially by digging up prior art, is more common than generally recognized and could possibly affect a major share of all patents, see in particular Henkel, J., Schöberl, S., and Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. Research Policy, 43, 879-890.

[22] Policies are taken in a broad sense here and includes laws, regulations, agency decisions and interventions. Policies in a narrow sense explicitly designed to promote evergreening in general are fairly rare in practice as to be expected. In theory they are conceivable, however, e g in line with the arguments in Kitch's prospect theory, claiming that a broad and durable protective scope in emerging technologies allows for more coordinated subsequent improvement processes by the rights holder.

[23] Raising the inventive step requirement could be justified on other grounds such as the need to reduce transaction costs, see Granstrand, O. (ed.) (2003). Economics, Law and Intellectual Property. Boston, MA: Springer, Ch 10 for an empirical and theoretical study with this conclusion.

[24] For derivation details, see Granstrand, O. (2018b). Industrial Innovation Economics and Intellectual Property (7th ed.). Gothenburg, Sweden: Svenska Kulturkompaniet, pp. 185-6.

APPENDIX

Some simple pricing models for radical product innovations

Assuming the radical product innovation has created a new market which in a given period in a mature stage has a linear demand curve with price p and quantity q, constant marginal cost c and fixed investment cost FC, elementary micro-economic theory tells us that the optimal profit maximizing price p_m for a monopolistic innovation is the average of the maximal willingness to pay among customers b and the marginal cost c, i.e.

$$p_m=(b+c)/2$$

which gives the innovator the maximal profits

$$\bar{\pi}_m=(b-c)^2/4a-FC$$

Competitive entry and perfect competition on the other hand as the opposite extreme (and thus idealized case) gives the competitive market price

$$p_c=c$$

and zero surplus profits (above variable costs, including cost of capital) for competitors and thus no contribution to any fixed costs. A price regulator that wants to set a price p_r that eliminates the innovator's surplus profits, taking fixed costs into account, and maximizes welfare (as the sum of consumer surplus value and producer surplus profits):

$$p_r=p_m-\sqrt{a\bar{\pi}_m}$$

A price p_f, regulated or negotiated, which is fair in the sense that it equalizes aggregate consumer value created by the innovation and the innovator's profits, then is:

$$p_f=(b+2c)/3$$

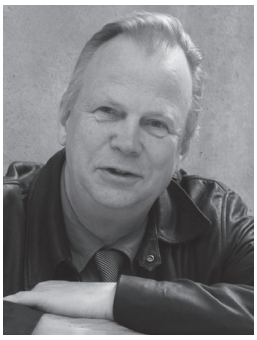
which gives the innovator profits

$$\pi_f(p_f)=2(b-c)^2/9a-FC$$

Thus, a monopolistic innovator would lose

$$\pi(p_m)-\pi(p_f)=(b-c)^2/36a$$

by fair pricing.[24] Whether this fair pricing is reasonable in some sense is left as an open question.



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