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Unproductive entrepreneurship and patents

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The aim of this article is to define and discuss the significant phenomenon of unproductive entrepreneurship in patent use. First, the fundamental (incentivising productive entrepreneurial behaviour) and non-fundamental (possibly serving rent-seeking purposes) functions of patents are distinguished. Next, the non-fundamental patenting motives are classified into (i) driven by the environment and (ii) driven by the internal organisation. Further, the behavioural foundations for unproductive entrepreneurship in patents are investigated with the use of institutional analysis and game theory methods. Based on this novel analysis, it is finally suggested that economic theory and patent law have gone apart, warranting a call for a change in the current intellectual property system.

Keywords: economic theory, patent law, institutions, innovation

JEL: K11, O34, P14

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1. Introduction

Tabarrok (2002) observes that a widely used argument for patent protection is the conviction that without patents there would be fewer inventions. However, there are at least two drawbacks to such reasoning. First, it is not clear why a society would need more inventions than the number of inventions created in an economy without patent protection (Tabarrok 2002). Second, many studies (see e.g. Mansfield, Schwartz, Wagner 1981; Mansfield 1986; Levin et al. 1987; Boldrin, Levine 2013; Förster 2017) suggest that most of the known inventions would have been created without a patent system.

Boldrin and Levine (2013) note that patent protection does not contribute to increased productivity of enterprises, unless productivity is measured by the number of patents. But such an approach would be unsubstantiated, since the correlation between the number of patents obtained by enterprises and their productivity is, to say the least, doubtful. The above observations lie at the core of the so-called 'patent puzzle' (Tawney 2013), according to which, despite a definite rise in the number of patents obtained by enterprises and a significant improvement in the legal protection of inventions, we do not observe an adequate acceleration in technological progress or an increase in the level of enterprise R&D.

According to Boldrin and Levine (2013), comparative studies suggest that systems with relatively weak patent protection may mildly stimulate innovation, whereas systems of strong patent protection hinder innovation and usually lead to numerous socially undesirable effects (loss of consumer surplus and total welfare, high costs of legal disputes over patents, enterprises resigning from the development of patents due to holdup). Strandburg et al. (2006) notice that many researchers and policy-makers have alleged that patenting is getting out of hand, i.e. patents are increasingly of low quality and they provide the transaction costs of a protected knowledge without the benefit of spurred innovation.

Historically, the long list of the negative effects of patent protection is discussed by Vaughan (1925), Clark (1927), Burns (1936), Hayek (1944), Edwards (1949), and Robinson (1956) (see also, Karbowski, Prokop 2013).

Interestingly enough, Schumpeter never discussed in detail intellectual property rights, despite the fact that patent protection was a prominent topic in the economic debate during Schumpeter's lifetime (Blaug 2005). As Guichardaz and Penin (2019) notice, Schumpeter did not see patents as playing a key role for fostering innovation. 'Early Schumpeter' (prior to 1932, i.e. before moving to the USA) saw the source of an economic innovation in the entrepreneurs who played a key role in the evolution of the capitalist system (Acs, Audretsch 1988; see also Karbowski 2020). The social role of an entrepreneur was to change the routinised system of production via innovation. Over the years, Schumpeter's ideas evolved and his attention turned to large monopoly firms. In *Capitalism, Socialism and Democracy* (1942), Schumpeter moved away from his earlier concept of the key role of entrepreneurs and replaced them with large monopoly firms. According to 'late Schumpeter', large firms with the monopoly power are the source of economic innovation (Acs, Audretsch 1988).

The Schumpeterian view of the economic system made patents redundant in Schumpeter's thought due to three reasons (Guichardaz, Penin 2019). First, for Schumpeter, innovators are sufficiently incentivised by non-monetary elements. Second, innovators are sufficiently rewarded with the market first-mover advantages. Third, firms are doomed to innovate in order to avoid disappearing.

Though patents were redundant in Schumpeter's thought, they constitute a central concept in the modern innovation economics (Blaug 2005; Guichardaz, Penin 2019). So what makes patents so popular, both in the current economic thought and business practice?

Are these the arguments that we would call fundamental, according to which patents (understood as rewards for the inventors, sufficient incentives to undertake a creative activity, or a compensation for the disclosure of a technological secret) benefit society as a whole by promoting inventions and disseminating knowledge (cf. e.g. Machlup 1958; Arrow 1962; Bessen, Maskin 2009; Becker 2015; Leibowicz 2018; Vonortas 2018)? Or perhaps, as Blaug (2005) suggests, the popularity of patents is determined more by the fact that they have become specific products of intellectual work, products that may be bought or sold and, in the end, having detached themselves from their fundamental tasks, have turned into an object of large-scale trade, and a strategic tool? The above research questions will serve as leading motive of the present review article.

The recognised review papers on patent use (cf. e.g. Penin 2005, 2012; Somaya 2012) very often follow Blaug's (2005) perspective, and perceive patents as strategic instruments of firms. The integrative review published by Somaya (2012) distinguishes generic patent strategies (proprietary strategy, defensive strategy, leveraging strategy) from the strategic management of patents (real options, signalling and information disclosure, nonmarket strategies in patents, patent management capabilities), leaving the patent functions (here referred to as fundamental) that constitute the economic theory justification of patents aside. The similar focus on patents as strategic instruments of firms is present in Penin's (2005, 2012) studies.

To the best of author's knowledge, the recognised review papers on patent use do not explicitly distinguish between patent functions which motivate productive entrepreneurial behaviour and promote public welfare and patent functions which largely motivate the unproductive entrepreneurship and rent-seeking (Baumol 1996). The present article takes the institutional perspective, and explores the productive and unproductive entrepreneurship functions of patents, patent regulations and the resulting economic incentives and, more importantly, the behavioural foundations for entrepreneurship in patent use. The analysis of the underlying social forces in patent entrepreneurship is the novelty and the contribution to the relevant literature on patents. As regards the scientific method, the present paper complements the standard institutional analysis with game--theoretic tools.

The aim of this article is twofold. First, we would like to draw reader's attention to the significant phenomenon of unproductive entrepreneurship in patent use. Following Baumol's (1996) view on entrepreneurship, we define unproductive entrepreneurship in patents as finding creative ways of patent use that add to the patentees' own wealth, power or prestige and little to the social product. In this vein, we further define fundamental and non-fundamental functions of patents, classify non--fundamental patenting motives, and investigate the behavioural foundations for the unproductive entrepreneurship in patent use. Second, we set out to show that the economic theory and the patent law have gone apart, vindicating a call for an institutional change in the current intellectual property system.

The article proceeds as follows. In the next section, we focus on the non-fundamental functions of patents and classify non-fundamental patenting motives. The subsequent section deals with the patents' rationale and patent 'substitutes' or rival solutions. The following section investigates the behavioural foundations for unproductive entrepreneurship in patents, and also shows prospects of institutional change in the current intellectual property system. Conclusions follow and close the article.

2. Non-fundamental functions of patents and unproductive entrepreneurship – literature review and conceptualization

Fundamental functions of patents boil down to the following (cf. Mazzoleni, Nelson 1998; Nordhaus 1969): patents can promote inventions (including cumulative inventions, cf. Scotchmer 1991), patents can help knowledge dissemination, patents can limit wasteful invention efforts (early patents prevent wasteful technological races), and patents can help technology transfer.

Observe that fundamental functions of patents incentivise productive entrepreneurial behaviour (Baumol 1996) of economic agents. These functions direct entrepreneurial activity toward productive goals and promote public welfare. Note, however, that fundamental functions of patents derive from relatively old socio-economic ideas. For example, patents as rewards for the inventors were endorsed by English economists. Adam Smith (1776), Jeremy Bentham (1843) or John Stuart Mill (1848) acknowledged that the awarding of a patent is a fair reward for the inventor's efforts. Austrian economists (cf. e.g. von Wieser 1927) adopted the perspective that a patent constitutes a sufficient incentive to take on pioneering research (see also, Machlup 1958).

Note that the above ideas and arguments do not have to be still valid in today's business environment. Nowadays, legal rules of the game, public policies, and strategic behaviour of competing firms generated various non-fundamental patent functions which hardly facilitate productive entrepreneurship (this point will be elaborated upon further in the present section). Clearly, the following list of non-fundamental functions of patents does not have an ambition to be always valid. In some cases, these functions can be truly productive. However, in general, it seems fair to label them as non-fundamental.

2.1. Non-fundamental functions of patents

A patent system offers these days diverse possibilities for making non-fundamental use of patents (Blind, Cremers, Mueller 2009). Firms may use patents, for example, to block competitors (1) (Grossmann, Filipović, Lazina 2016), or as an argument in negotiations with potential business partners (2) (Ernst 2003; Bekkers, Iversen, Blind 2011). The other identified motives of non-fundamental use of patents include (cf. e.g. Langinier 2005; Penin 2005; 2012; Blind et al. 2006; Blind, Cremers, Mueller 2009; Chien 2008; Freitas, Nuvolari 2012; Noel, Schankerman 2013; Cohen, Gurun, Kominers 2019): enhancing the reputation of an enterprise, often associated with increased value of the enterprise and attracting external financing (3), increasing motivation and effectiveness of the R&D personnel (4), increasing ability of the firm to establish business cooperation, including the licensing of patents to new suppliers or customers (5), establishing a standard in a given industry (6), trading in patented technologies (7), gaining competitive advantage over rivals (8), protection of the enterprise's share in the domestic or international market (9), increasing the operating costs of the enterprise's rivals (10), raising the entry barriers to the market (11), strategically misleading the enterprise's rivals in the patent race (12), forcing (by bringing a case to court) other enterprises to bear the expenses of a legal dispute over patent violation – patent predation strategy (13). At least some of the above non-fundamental uses of patents (e.g. strategic deception or patent predation) serve predominantly rent-seeking behaviour (cf. Table 1, and the following discussion).

Blocking competitors may be defensive or offensive. In the defensive strategy, an enterprise patents an invention to prevent other enterprises from using a given invention, even if it does not intend to use that invention. In the literature, this practice is called 'patent shelving' or 'patent parking', and such a patent is called a 'submarine patent' (Gallini 2002). In the offensive strategy, an enterprise patents an invention to prevent other enterprises from patenting inventions similar to the one it intends to use (Blind, Cremers, Mueller 2009). Both forms of blocking serve the purpose of protecting the share of the enterprise in the domestic or international market.

According to Noel and Schankerman (2013), extensive patent portfolios increase the bargaining power of an enterprise in negotiations with potential business partners in the area of mergers, license agreements or R&D cooperation agreements. As Farrell and Shapiro (2008) notice, even weak patents (questionable patents which might be found invalid if litigated) can increase the bargaining power of the patent holder or decrease the bargaining power of the downstream licensees making them accept surprisingly high patent royalties. The latter has a detrimental effect on the social welfare, and examining patent validity can bring social benefits.

Penin (2003, 2005) and Mazzoleni and Nelson (1998) claim that patents may serve purely as a (true or false) signal of the competences of an enterprise in advanced technologies, which may help improve the market reputation of the enterprise and increase its value (cf. Hall, Jaffe, Trajtenberg 2005). This motive for patenting is closely associated with increasing the ability of firms to launch cooperation with external partners. Obtaining a patent may significantly shorten and streamline the process of searching for contractors, new employees, or new sources of funding (Hall, Ziedonis 2001; Penin 2005). The patent system encourages high-tech firms to enter into innovation networks to make up the appropriability deficit and capture a greater portion of R&D spillovers (Barnett 2000). Innovation networks are especially appealing to private R&D investment, since they reduce the risk to which a firm is exposed, but maintain the organizational independence of network members. Patents attract private R&D investment by fostering the formation of cooperative networks that spread the risks inherent in innovation (Barnett 2000).

Patents may also serve the purpose of measuring the effectiveness of R&D teams in an enterprise (Blind et al. 2006; Blind, Cremers, Mueller 2009). Patent-based indicators may constitute a component of motivational and remuneration policies in an enterprise that is active in the area of technology development.

The patenting of inventions and establishment of industry standards are not performed simultaneously (Blind, Thumm 2004). In the standardisation process, decisions on patenting are usually preceded by a strategic decision on the degree of disclosure of the results of scientific research performed by enterprises (Grossmann et al. 2016). Also, it is particularly important (Lerner, Tirole 2014) to decide strategically on possible ex-post licensing of patents essential to establish a standard (Iversen, Oversjoen, Lie 2004) in an industry. Some authors (cf. e.g. Schankerman 1998; Reitzig 2004; Sandner, Block 2011; Harrigan, DiGuardo 2017) believe that patents determine long-term competitive advantage of firms. Patents, being time-specific market entry barriers, may secure a privileged market position for an enterprise, especially in industries characterised by a relatively slow technological progress (cf. Tushman, Anderson 1986; Henderson 1993). Harrigan and DiGuardo (2017) note that in markets with a fast rate of technological progress and significant ratio of radical innovations (Tirole 1988) to total innovations, competitive advantages obtained by enterprises as a result of having their inventions patented are usually only short-term.

However, even then patents may be traded and may generate additional revenue from licensing fees (Griliches 1981; Lanjouw 1998; Bosworth, Rogers 2001; Bessen 2008). Raising the operating costs of the rivals is a competition strategy that, unlike predatory pricing, does not force an enterprise to commit short-term economic profit so as to achieve the long-term goal of limited market competition. Raising the competitors' operating costs most often involves forcing them (by threatening to sue them) to license the patents comprising the portfolio of a given firm. Licensing fees paid by the competitors increase their operating costs. In special cases, the strategy of increasing the operating costs of competitors may be associated with a predatory strategy, i.e. by increasing the operating costs of competitors sufficiently high, a predator may reduce the unit price of a product to the level where the other market players will not be able to cover the average variable cost and, consequently, cease production and, over a longer perspective, leave the market. Clearly, such a strategy of patent use may serve the purpose of expanding the enterprise by increasing its share in a given domestic or international market.

Salop and Scheffman (1983) suggest that patents may be used by enterprises as strategic market entry barriers. A new firm may enter a market where a technology patented by the existing monopolist is used if it reduces production costs below a threshold determined in the patent. If a market for a certain product is sufficiently profitable (and the demand for that product is sufficiently high), a new firm may enter the industry by introducing process innovation, and consequently the monopoly market may transform into a market of fierce duopolistic competition. If a market for a certain product is not sufficiently profitable (and the demand for that product is not sufficiently high), a new enterprise will most probably not emerge on the market. Interestingly enough, the Anglo-Saxon patent system provides for patent renewal a certain period of time after the submission of a patent application. Patent renewal is subject to a payment made by the patent owner. Patent renewal mechanism may be used as a strategic instrument (Langinier 2004). If the market of the existing monopolist is sufficiently profitable, this may be such an attractive incentive that a new firm will enter the market regardless of whether the patent of the existing monopolist has or has not been renewed. The monopolist, foreseeing such behaviour from a new competitor, may save some costs and choose not to renew the patent, so as to collect more resources for the resulting fierce duopolistic competition. If, however, the market of the existing monopolist is not sufficiently profitable, patent renewal will most probably stop a new enterprise from entering the industry. But what if a market is profitable and the monopolist renews a patent? This could be a strategy of misleading the competitor by sending a signal suggesting low profitability of the market, whereas in reality, the market is sufficiently profitable. Thus, a patent may act like a strategic barrier to entering the industry (Langinier 2004).

Another 'non-fundamental motive' for the use of patents is to mislead competitors in a patent race (see, e.g. Horstmann, MacDonald, Slivinski 1985; Crampes, Langinier 1998; Langinier 2005). An enterprise competing for a patent, having completed an invention, must choose the right date for patenting that invention. If there is no competition, an enterprise should only compare (i) the discounted payoff from owning a patent if the invention is patented promptly upon completion, with (ii) the discounted payoff from owning a patent if the invention is patented at a later date. However, if competition exists, strategic considerations should also be analysed. The leader in a patent race frequently decides to keep an invention secret so as to maintain competitive advantage over rivals, and at the same time to be able to improve the invention. If, following subsequent work, marginal increase in the quality of the invention strongly decreases, the leader may decide to patent the invention and use it in production processes. Thus, submitting a patent application may mean

that the invention cannot be improved any further. However, enterprises sometimes treat patents as a decoy, namely they randomly patent various technologies (regardless of whether or not it is possible to further improve them with the available know-how and technical resources), so as to make it impossible for other firms to interpret the decision to patent the invention as an indicator of the degree of invention advancement. Consequently, other enterprises, despite the patenting of a given technology by the leader, may continue their R&D works on that technology in subsequent periods, because they do not know whether or not it may be further improved. At the same time, the leader may work on a completely different technology with major commercial potential, hoping that at least some of competitors pursue their R&D work in another, and unpromising, direction.

Patent predation means that an enterprise makes use of a court dispute over patent infringement in order to financially 'weaken' its market rival and cause reduction in its rating or loss of reputation among investors or customers (Chien 2008). In patent predation strategy, the outcome of a court dispute is not particularly important and instead, the strategy consists of starting a dispute and continuing it for a long time (Chien 2008) to cause as much loss to the rival as possible, and ideally to force it to leave a given industry. Patent predation strategies are used frequently in the ICT markets (Chien 2008). Another kind of patent predation is patent trolling by opportunistic business entities (Cohen, Gurun, Kominers 2019). Such entities collect patents not for the sake of innovating, but to litigate against intellectual property infringements. Based on empirical evidence, Cohen, Gurun and Kominers (2019) show that such litigation exerts a negative impact on innovation efforts at targeted enterprises (they cease or reduce innovation activities when they are sued by opportunistic patent trolls). Practical application of patent predation strategies is often possible thanks to the existence of patent thickets. In order to create patent thickets enterprises submit numerous patent applications over a relatively short period of time. These applications present various modifications of a rival's commercialised market invention, so as to 'surround' a technology important for the competitor with the enterprise's own patents. The tighter the competitor's technology is 'entangled' by the enterprise's own patents, the more effectively (faster and on more solid grounds) will it be possible to apply the patent predation strategy.

2.2. Conceptualization

Bearing in mind all the above motives (1)–(13) for the non-fundamental use of patents, the following classification is possible (see Table 1). First of all, it should be noted that a majority of the above motives are driven by the competitive environment of an enterprise, and few of them are directly associated with the firm's internal organisation. Secondly, motives are driven by the environment focus on either (i) competition with other enterprises, or (ii) cooperation with external partners through negotiations, commercial exchanges or licensing of technologies.

It is worth observing that enterprises which manage their patents usually remain in coopetitive relationships with external innovation partners. What makes coopetitive relationships special is the coexistence of two different logics of maintaining interactions (Bengtsson, Kock 2000; Gnyawali, Charleton 2018). On the one hand, the parties to this specific relationship tend to compete with each other due to existing conflict of interests, but on the other hand, they also cooperate with each other because of some common interests. Bengtsson and Kock (2000) note that the parties to a coopetitive

relationship must competently separate the two logics of interaction to make coopetition possible. Such separation usually makes one type of logic dominant over the other, and accordingly, Bengtsson and Kock (2000) identify the following types of coopetition: (i) cooperation-dominated, (ii) competition--dominated, and (iii) balanced.

Table 1
Classification of the non-fundamental motives for patent use

Driven by the environment	**Driven by the internal organisation**
Competitive (1), (8), (9), (10), (11), (12), (13)	(4)
Collaborative (2), (3), (5), (6), (7)	

Note – numbers correspond with motives listed in section 2.1.
Source: own elaboration.

Following this line of thinking, we may claim that the non-fundamental use of patents may have the form of coopetition, which can be cooperation-dominated relationship (if led by the cooperative motives listed in Table 1), competition-dominated (if led by the competitive motives with some share of cooperative ones), or balanced coopetition. As a dynamic phenomenon, the nature of firm's 'patent use coopetition' may change and evolve as the market develops.

If competitive motives (1), (10)–(13) (see Table 1) initiate and steer the firm's behaviour, a serious risk of unproductive entrepreneurship (Baumol 1996) in patent use is posed. Observe that behaviour generated by the competitive motives (1), (10)–(13) meets Baumol's unproductive entrepreneurship criteria. Following competitive motives (1), (10)–(13) firms act as actors who are creative in finding ways that add to their own wealth, power (here, market power) or prestige and add little to the social product. The current patent system, and specifically the legal rules of the game determining firms' incentives and payoffs, gives rise to patent rent-seeking behaviour initiated by the competitive motives (1), (10)–(13). Also, some cooperative motives listed in Table 1 may lead to unproductive entrepreneurship. Specifically, the cooperative motives (2), (5) pose a significant risk of market collusion and subsequent social welfare reduction (cf. e.g. Martin 2006; Miyagiwa 2009; Belleflamme, Peitz 2015; Leibowicz 2018).

The pioneering empirical study by Holgersson and Granstrand (2017) shows the importance of various patenting motives to both large firms and SMEs. It turns out that the 'fundamental patenting motives' are assessed as follows (1–5 scale; 1 means 'not at all important', 5 means 'very important'): 4.17 for product technology (large firms), 3.97 for product technology (SMEs), 2.51 for process technology (large firms), and 2.56 for process technology (SMEs). In turn, the 'non-fundamental patenting motives' are assessed by enterprises as follows: blocking competitors (3.57 for large firms, 3.40 for SMEs), improving the corporate image towards investors (2.96 for large firms, 3.77 for SMEs), facilitating R&D collaboration with others (2.32 for large firms, 2.75 for SMEs), gaining a better position in standard

setting (2.26 for large firms, 2.81 for SMEs), providing motivation for employees (3.30 for large firms, 3.00 for SMEs), and providing measures of R&D productivity (2.72 for large firms, 2.30 for SMEs).

The above empirical results show that nowadays non-fundamental functions of patents are certainly not a marginal phenomenon. The last claim applies also to motives leading to unproductive entrepreneurship in patent use.

In the next sections, we focus on the incentives and payoffs in the current patent system, discuss its 'substitutes' and prospects of change, and we also analyse behavioural foundations for unproductive entrepreneurship in patent use.

3. Patent system and competitive solutions – institutional analysis

3.1. Alternatives to patents

Having in mind the rent-seeking behaviour in patent use, it is worth considering solutions competitive to the current patent regulations, i.e. ex-post rewards and public patent buyouts (Polanyi 1944; Wright 1983; Tirole 1988; Kremer 1998; Shavell, van Ypersele 2001; Penin 2005; Becker 2015; Leibowicz 2018).

Ex-post rewards consist of the money paid to inventors by competent government agencies. An invention is not protected by a patent and once the reward is paid, the invention is transferred to the public domain (Penin 2005). The evaluation of the extent of the reward by the public agency is a major challenge. The reward is supposed to be equivalent to social welfare benefits associated with the invention. Public patent buyouts imply buying patents from their owners by competent government agencies, and placing those patents in the public domain (Barton 1998; Penin 2005). Both ex-post rewards and patent buyouts help reduce welfare loss caused by the temporary monopoly of the patent owner (David, Foray 2002).

The key difference between patent protection and competitive solutions is the fact that in the case of the former the value of the reward for the inventor is determined by the market (total economic profits associated with the monopolist position, made in the period of patent validity), and for the latter, the value of the reward is calculated by the government. The problems associated with the rewards or public buyouts are as follows: (i) the fact that the government (or social planner) needs to have full information, (ii) the problem of coordinating the work of various government agencies which cooperate in the evaluation process, (iii) a collusion between the inventor and the government body awarding the reward or evaluating the patent, and (iv) low credibility of the representatives of the government who may reduce the amount of the reward below reliable calculations or initial declarations (Penin 2005).

Comparing the socio-economic effects of patent protection and rival solutions, it may be hypothesised that, provided full information is available, the solutions competitive to patent protection are more beneficial to the society, because they preserve the social advantages of the patent system (ensure sufficient incentives to innovate), while at the same time limit the social costs of regulation (no economic distortions associated with monopoly occur). It is, however, fair to say that adverse effects related to patent protection can be to some extent mitigated by patent holders if they share the patent with interested parties (I owe here to the anonymous Reviewer).

In addition, the patent buyout system can deprive patents of their numerous nonfundamental uses. The latter is particularly promising from the welfare viewpoint if the unproductive entrepreneurship

functions of patents can be effectively limited. Public patent buyouts would make it impossible for private patent aggregators (patent trolls) to amass patent portfolios and sue cash-rich companies irrespective of actual patent infringement (Cohen, Gurun, Kominers 2016). As Cohen, Gurun and Kominers (2019) show, the above patent trolling practices exert a negative impact on the innovation activities of both targeted companies and whole markets. It is due to the fact that patent trolls via their unproductive entrepreneurship actions extract rents from productive companies by exploiting imperfections of the patent system, i.e. a threat of legal action makes targeted companies settle because of costly litigation (Cohen, Gurun, Kominers 2016). The latter suggests a need to change the patent system, and screen out or significantly limit unproductive entrepreneurship in patent use.

The reward system may be superior to patents in terms of transaction costs associated with the commercialisation of technologies. In many industries, enterprises intending to launch a new technology are forced to buy licences for the components of that technology from numerous patent owners (cf. patent tragedy of the anticommons or patent holdup cases; Heller, Eisenberg 1998; Lemley, Shapiro 2007). Often, the transaction costs of such a procedure are so high that the enterprise resigns from launching a new technology, which in turn means a loss for consumers. The patent holdup problem increases with royalty stacking, i.e. when multiple patents read on a single product or technology (Lemley, Shapiro 2007). In such a case, royalty fees that have to be paid to all patent holders can add up to an amount which is large enough to hinder innovation. The risk of patent holdup and royalty stacking has also a detrimental effect on the standard setting efforts. It is due to the fact that downstream firms face multiple upstream gatekeepers, each of whom must grant a licence to their essential patents, before the downstream firms commercialise the industrial standard (Rey, Salant 2012). This is not a case with the ex-post reward system.

If, however, full information is not provided (and this is a realistic expectation), ex-post rewards or patent valuations may be understated, i.e. their value may be lower than the value of the social surplus due to the invention. As a result, some socially desirable inventions may never be commercialised. It should be also noted that, judging realistically, inventors have much more extensive information on their patents and the resulting benefits for the society compared with the social planner. It is to the detriment of the ex-post reward system, as the social planner's evaluations of inventions may be mismatched (Wright 1983; Penin 2005). Based on the above arguments, the solutions competitive to the patent protection can hardly replace patents. However, it does not mean that the current patent system does not exhibit a space for improvement. According to some authors (Tabarrok 2002; Boldrin, Levine 2013; Asay 2015; Spulber 2018), the economic theory and patent regulations have gone apart, i.e. the latter no longer reflects the findings derived from the economic theory of patents (Tabarrok 2002). This argument is briefly recapitulated below.

3.2. Tabarrok's analysis and beyond

Let B mean the social benefits of an invention, if it becomes commercialised. The social benefits of a commercialised product invention are direct to both consumers (new products) and producers (demand enhancing effect). The social benefits of a commercialised process invention are direct to producers (cost reducing effect) and only indirect to consumers (possibly lower prices of the goods). Then, let C mean the private R&D costs associated with developing a given invention. As Tabarrok

(2002) stresses, if imitators have the same production costs as the inventor, the competition can move the market price down, so that the inventor recovers only production costs, but not the R&D costs. The economic rationale for patent is to give the inventor the incentive to incur the R&D costs, so that the inventor can recoup his (or her) sunk costs of creating the intellectual property. Inventors acquire only a part (θ) of the social benefits of an invention if it becomes commercialised, but they cover the full R&D costs. An invention gets developed, if $\theta B - C > 0 \Rightarrow \theta > C/B$. In practice, the value θ may be increased by granting the inventor with more monopolistic power as a result of owning a patent. Note that for $\theta < C/B$, an invention will not be developed, even if the social benefits of the invention are higher than the private costs of its development ($B > C$). If $\theta > C/B$, the monopolistic power on account of owning a patent should be limited to $\theta = C/B$. This simple theory of patents makes it possible to formulate the following implications. The value θ should grow together with the rise of the inventor's private R&D costs and drop with the rise of the social benefits of a commercialised invention. Although it is difficult to evaluate the social benefits of an invention due to incomplete information, the private R&D costs ought to be presented in the inventor's financial statements. Thus, a patent system should reward inventors with monopolistic profit on account of a patent proportionally to the costs of developing the patented item (more costly inventions should entitle inventors to better possibilities of generating monopolistic profit). Meanwhile, the world's three most prominent patent protection systems, the American, European, and Japanese, do not account for the private costs of creating inventions. Consequently, patent law is detached from its economic grounds, which results in the mass granting of patents for inventions that cost little or even nothing to develop.

According to Tabarrok (2002), the industry where this practice is particularly visible is the computer software market, and today, another such industry has become the mobile applications market. Significant sunk costs of R&D usually apply to object-like goods, e.g. devices or medicines. Codes for computer software or mobile applications are idea-like goods. Their costs of development are relatively small and comparable to the development costs covered by the imitators (cf. Burk, Lemley 2009). The latter is not the case for object-like inventions, where imitators can largely spare costs of laboratory research or experimentation. When we analyse markets for computer software or mobile applications from the public economics perspective, it is worth observing that codes for computer software or mobile applications constitute non-rival goods which are difficult to control (or exclude others from using them). As Romer (1992, 2002) notices, for rival goods, strong property rights lead to socially efficient outcomes and do not produce market distortions. This is, however, not the case with non-rival goods where we encounter a trade-off, i.e. weak property rights lead to under--provision, but strong property rights produce market distortions (Nordhaus 1969). The reason for the market distortions is that for a non-rival good (e.g. code for computer software or mobile application) a patent implies a market price higher than the opportunity cost which is close to zero. As a result, the difference between the market price and the marginal cost of production creates a distortion and decreases social welfare (Romer 1992, 2002). Note that rival goods are object-like goods (in contrast to ideas), i.e. they have an opportunity cost. Thus, for rival goods, the difference between the market price and the marginal cost of production does not have to exist in the case of patent protection, so that market distortions do not have to occur. However, for non-rival goods, distortions are unavoidable when patents are present. Therefore, Romer (1992, 2002, see also Nelson, Romer 1996; Boldrin, Levine 2005) suggests a redesign of the institutional architecture and insists on the development of public R&D centres as knowledge production machines which play an essential, spillover-propagating role in

the economics of ideas. Though the public economic theory proves the patent protection of software doubtful, computer and mobile software patents are not sufficiently restricted by patent law (Lemley 2013; Sampat 2018). In fact, only in the USA, over 150 000 software patents are granted every year, and this constitutes a larger number than all other patents granted annually (see uspto.gov, for the latest data). Not only have software patents a dubious justification from the economic theory perspective, but also, at least to some authors (see Thomas 2008; Comino, Manenti, Thumm 2019 and the literature therein), they do not promote innovation due to pervasive patent holdup and patent thicket effects.

Another industry where the divergence of patent law from economic theory is apparent is biotechnology. Bio-tech firms patent stem cells. This contradicts the fundamental principle of the economic justification of patent protection stating that a patent cannot be granted for a discovery (Machlup 1958). Stem cells are created by nature, they are naturally unique, and subjecting them to routine biotechnological harvesting does not make them inventions. Taking advantage of the inadequacies of the patent law in order to gain exclusive rights to stem cells is simply another example of industrial rent-seeking. Copyright protection of cell harvesting recipes constitutes an adequate protection of the expression of ideas applicable to natural cells. Replacing copyright protection of natural cell harvesting recipes with patent protection of natural cells themselves is simply a confusion.

Lastly, it is fair to observe that the above analysis does not cover all possible hybrid forms of intellectual property which often allow patent holders to manage risks of opportunistic use of patents by other parties (I owe here to the anonymous Reviewer, and refer to relevant literature – Alchian, Demsetz 1973; Williamson 1998).

4. Behavioural foundations for unproductive entrepreneurship in patent use, and prospects of institutional change – discussion

4.1. Behavioural foundations

In this section, we investigate the behavioural foundations for unproductive entrepreneurship in patent use. Consider a multiplayer game between patentees. They can choose strategy P (productive entrepreneurship strategy in patent use) to promote public welfare, or strategy U (unproductive entrepreneurship strategy in patent use), say blocking competitors or patent predation, to pursue self-interest at the expense of public welfare. $P_p(n)$ denotes the individual payoff for playing strategy P, $P_u(n)$ for playing strategy U, where n stands for the number of players who choose P. The payoff matrix of the game is given in Table 2.

Observe that unproductive entrepreneurial behaviour in patent use is incentivised so long as $P_p(N) < P_u(N-1)$, i.e. if in the group of N patentees selecting strategy P, a player selecting P would be better off playing instead strategy U. Following Płatkowski's (2017) typology of social dilemmas and their properties, the latter property of the game between patentees can be defined as 'greed in patent use'. Observe further that greed is not a feature of players, but refers to the system of incentives present in the game. Note also that the above game does not necessarily exhibit the multiplayer prisoner's dilemma. Greed (Ahn et al. 2001), though present in the prisoner's dilemma, is also the characteristic of the volunteer's dilemma (cf. e.g. Diekmann, Przepiorka 2015), which constitutes a closer representation

of the game between patentees compared with the prisoner's dilemma (needless to say, the volunteer's dilemma would lead to a different set of Nash equilibria compared with the multiperson prisoner's dilemma). Observe that in the game between patentees if at least one player chooses (or better, volunteers to play) strategy P which promotes public welfare, the other players are tempted to play strategy U to pursue self-interest at the expense of public welfare.

Table 2
Payoffs in a game with multiple patentees

	P…P	**P…PU**	**…**	**PU…U**	**U…U**
P	$P_p(N)$	$P_p(N-1)$	…	$P_p(2)$	$P_p(1)$
U	$P_u(N-1)$	$P_u(N-2)$	…	$P_u(1)$	$P_u(0)$

Note: N stands for the set of all patentees, and, e.g. P…PU denotes the set of $N-2$ players selecting P and one player selecting U.
Source: own elaboration based on Płatkowski (2017).

As Baumol (1996) notices, the productive contribution of the society's entrepreneurial activities varies because of their allocation between productive and unproductive activities. This allocation is heavily influenced by the relative payoffs society offers to such activities. We claim that as long as greed, defined as above, is present in the patent system and policy, the unproductive entrepreneurship in patent use should be expected as a rational and self-interested behaviour of economic agents (Coase 1976). Of course, public policy can influence the allocation of productive and unproductive entrepreneurship in patent use by setting the payoff scheme.

4.2. Prospects of change

In this vein, a few prospects of change in the patent system are now briefly presented. The former sections show, among other things, major imperfections in the patent system and also identify some drawbacks of the rival solutions. What then are the possibilities for improving the current regulations? An institutional change of the patent protection may be considered. It should involve bringing patent law closer to economic theory. Technically speaking, this means that public policy and patent law should set the θB value at close to the private costs of developing an invention (C). The public policy can affect the θ value by determining the items that can be patented, and determining the duration of the patent.

Patentable items can be determined on the basis of expert evaluation of the costs of developing inventions relative to the imitation costs in the given product/technological category (if the R&D costs

are relatively minor, an item cannot be covered by patent protection). Many software patents would fail such an R&D cost evaluation (Tabarrok 2002; Burk, Lemley 2009). Furthermore, for items which passed an R&D cost test, inventions associated with high costs of development should be protected by relatively 'long' patents, whereas relatively 'short' patents should protect inventions associated with low private costs of development. The exact, category-like, patent length can be dependent on the R&D costs reported in the financial statements. Prior to assigning an invention to a patent length category, the patent office in cooperation with the ministry of finance or the revenue agencies can verify the reported R&D costs and check if they are not largely exaggerated.

The existing patent system is in fact a 'zero-one' system, i.e. a patent is granted for 0 or x (e.g. 20) years. By making it more flexible, lawmakers would bring it closer to economic theory (Nordhaus 1969; Tabarrok 2002; Asay 2015; Spulber 2018). Awarding patents for minor inventions (granted for 6 to 10 years, depending on the country) practiced, e.g. in China, Japan or the largest European economies (excluding Great Britain) constitutes a step towards reconciling law with economic theory. The above economies allow some flexibility in the system and provide for x-year (e.g. 20-year) patents granted for fully-fledged inventions and y-year (e.g. 10-year) patents granted for minor inventions.

A change of the patent system can also limit or control certain forms of socially unproductive use of patents by enterprises. From the public perspective, the practice of using patents in order to limit competition is undesirable. A good example is the already mentioned patent shelving. Not only does it block competition, but it also hinders innovation. Thus, it seems that the regulator should pay particular attention to this type of practice. Interestingly, some countries try to limit the patent shelving practice (Shavell 2004). These states have introduced legal regulations forcing entrepreneurs to use the contents of their patents.

As Boldrin and Levine (2013) observed, the historical evidence shows that innovations leading to the creation of new markets or industries (cf. chemicals, cars, radio, TV, personal computers, investment banking) are seldom born out of patent protection, but often of coopetitive environments without patent protection. Historical evidence shows further that the turn of industries towards patent protection occurs once they mature. The initial patent-free coopetitive relationships between firms in the given industry are gradually replaced by the patent-mediated forms of coopetition (see Table 1). Patent licensing, trading in patented technologies, standard setting, market share protection and expansion along with unproductive uses of patents usually intensify with market age. In mature industries, the regulator's (in particular, competition authority's) attention should primarily focus on the environment-driven non-fundamental uses of patents (see Table 1). Competitive non-fundamental behaviour in patents can limit market rivalry or, in particular cases, lead to formation of a monopoly in a given industry along with monopoly-related social losses. Cooperative non-fundamental behaviour in patents can, in turn, lead to the formation of a cartel (since R&D cooperation between enterprises is a step towards cartelisation of the market, cf. e.g. Martin 2006; Miyagiwa 2009; Belleflamme, Peitz 2015; Leibowicz 2018; Medda 2018). Martin (2006) or Miyagiwa (2009), among others, show that R&D cooperation between firms can serve a collusive function. The latter result sheds unfavourable light on the cooperation of enterprises in R&D. Many industrial economists (cf. Belleflamme, Peitz 2015) suggest that R&D cooperation promotes innovation and increases social welfare in the industry. But, they do not take the account of the effects of cooperation in R&D on product market competition. Following Martin (2006) or Miyagiwa (2009) if R&D cooperation between firms enhances the incentives to collude in the final product market, the innovation policy oriented at promoting interfirm cooperation in R&D

can be counterproductive, i.e. it can work in favour of market collusion and ultimately to the detriment of social welfare. As a result, both competitive and cooperative non-fundamental behaviour in patents can act to the detriment of social welfare. An important reservation has to be, however, expressed. The R&D cooperation can involve the coordination of R&D investments between firms or knowledge sharing (Kamien, Muller, Zang 1992). The detrimental effects of R&D cooperation suggested by Martin (2006), Miyagiwa (2009) or others follow the cooperation understood as the coordination of firms' R&D investments. Welfare reducing effects of R&D cooperation in the form of knowledge sharing have not been reported.

Replacing the patent system with ex-post rewards or public buyout does not seem a solution due to the information asymmetry between the inventor and the regulator. Moreover, patents perform the function of a coordination mechanism in the economy (Penin 2005) that helps enterprises start welfare enhancing cooperation with other firms (competitors, suppliers or purchasers) or universities (Becker, Dietz 2004; Belderbos et al. 2004; Medda 2018; Capuano, Grassi 2019) more efficiently. In this sense, patents act as costly signals sent to business or academic communities that the patent owner holds sufficient research and commercial competences (Penin 2005). This signalling function enables a more efficient matching between various innovation actors.

5. Conclusions

Starting from the research goals – (1) to draw attention to unproductive entrepreneurship in patents, and (2) to confront economic theory with the legal system of patent protection, we arrived at the following findings. First, the patent system promotes both productive (e.g. inventions, knowledge transfer) and unproductive entrepreneurship (e.g. limiting market competition, predatory behaviour), and the proportion of the former type of entrepreneurship to the latter depends on the public policy and law-based payoffs related to productive and unproductive patent strategies of economic agents. Unproductive entrepreneurship in patents can be driven by greed and not directed at the public good. Having in mind the leading motive of this paper, we can conclude that unproductive entrepreneurship in patents is not a marginal phenomenon in today's business. The creativity of economic agents gave birth to various functions of patents and patenting motives not considered when patent regulations were originally formulated.

Second, the economic theory of patents and the patent law have gone apart, leaving a space for institutional change in the intellectual property system. Patent law could set the value of inventor's benefits at much closer to the private costs of developing an invention. A change of the patent system could also limit or control certain forms of socially unproductive use of patents by enterprises. In the author's opinion, the regulator's attention should primarily focus on the environment-driven non-fundamental uses of patents that can effectively reduce market competition.

In general, this article raises the need for a broader discussion on the organisation of the patent system, its goals and institutional setup. Such a discussion may contribute to the comprehensive evaluation of the consequences (benefits and costs) of the system of legal protection of inventions, as well as to the development of possible and socially acceptable institutional changes in this matter. Some prospects of change (determining patentable items and patent length on the basis of the R&D costs, monitoring for patent uses reducing public welfare carried out by competition authorities) have been

sketched out in this article. However, the author deliberately does not close the catalogue of possible and socially acceptable institutional changes in the matter under consideration. The author does not have the ambition to exhaust such a catalogue on his own, and prefers to keep this paper as an open invitation to a discussion within the larger audience with interest in intellectual property and related institutions.

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Nieproduktywna przedsiębiorczość a patenty

Streszczenie

Celem niniejszego artykułu jest zdefiniowanie oraz omówienie istotnego gospodarczo zjawiska tzw. nieproduktywnej przedsiębiorczości (zob. źródła w tekście głównym) w korzystaniu z patentów. W artykule posłużono się następującymi metodami badawczymi – studiami literatury oraz formalną analizą opartą na teorii gier.

Aby osiągnąć postawiony cel artykułu, autor na podstawie studiów literatury zaproponował podział funkcji patentów na dwie grupy. Pierwsze to funkcje podstawowe. Ich zadaniem jest dostarczanie odpowiednich bodźców do podejmowania pracy twórczej/wynalazczej, upowszechnianie wiedzy, stymulowanie transferu technologii oraz eliminowanie powielania prac badawczo-rozwojowych (zob. źródła w tekście głównym). Drugą grupę tworzą funkcje niepodstawowe. Ich katalog jest otwarty i mogą w dużym stopniu służyć do tzw. poszukiwania renty (zob. źródła w tekście głównym). Autor na podstawie badań literatury wyróżnił wśród niepodstawowych funkcji patentów następujące funkcje: (1) blokowanie rywali rynkowych, (2) argument w negocjacjach z potencjalnymi partnerami biznesowymi, (3) podniesienie reputacji przedsiębiorstwa (powiązane zazwyczaj z podniesieniem wyceny przedsiębiorstwa), (4) zwiększenie motywacji i efektywności pracowników działu badawczo-rozwojowego przedsiębiorstwa, (5) zwiększenie zdolności przedsiębiorstwa do nawiązywania współpracy w obszarze technologii, (6) chęć ustanowienia standardu przemysłowego, (7) handel opatentowanymi technologiami, (8) uzyskanie przewagi konkurencyjnej nad rynkowymi rywalami, (9) ochrona udziału przedsiębiorstwa w lokalnym lub zagranicznym rynku, (10) zwiększenie kosztów operacyjnych rywali przedsiębiorstwa, (11) podniesienie barier wejścia na rynek, (12) zmylenie rywali przedsiębiorstwa w wyścigu o patent, (13) zmuszenie innych przedsiębiorstw do ponoszenia dodatkowych kosztów prawnych.

Następnie na podstawie przeglądu literatury zaproponowano klasyfikację niepodstawowych funkcji patentów, w której dokonano podziału tych funkcji na (i) motywowane przez środowisko przedsiębiorstwa oraz (ii) motywowane przez wewnętrzną organizację przedsiębiorstwa.

W dalszej części opracowania analizie poddano behawioralne mechanizmy nieproduktywnej przedsiębiorczości w korzystaniu z patentów, posługując się metodami teorii gier oraz ekonomii instytucjonalnej. Na podstawie powyższej analizy zwrócono uwagę na możliwe kierunki zmian w systemie ochrony własności intelektualnej. Szczególnie warto tu podkreślić ideę zróżnicowania długości czasu obowiązywania patentów w zależności od wartości utopionych kosztów prac badawczo-rozwojowych (zob. źródła w tekście głównym).

Słowa kluczowe: teoria ekonomii, prawo patentowe, instytucje, innowacje