Quaderni di AIDA

Collana fondata da Luigi Carlo Ubertazzi

Diretta da Michele Bertani - Marco Ricolfi - Davide Sarti

Nuova serie – n. 33

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To my family

CHAPTER I
THE COLLAPSE OF THE ONE-INNOVATION ONE-PATENT MODEL AND THE RAISE OF PATENT PORTFOLIOS

SUMMARY: 1. Introduction. Patentability trends in the new millennium. – 2. A first tentative explanation: The signalling function of patents. – 3. The rejection of the "one-innovation one-patent" model. – 3.1. From sequential innovation to the emergence of complex-technology products. – 3.2. Patent propensity in "complex" and "discrete" industries. – 4. The era of patent portfolios. – 4.1. Motivation to build a patent portfolio in complex vis-à-vis discrete technology industries. – 4.2. Strategic advantages stemming from patent portfolios. – 5. Patent portfolios and the pharmaceutical sector. – 6. Conceptual roadmap of the book.

1. It is very well known that the patent system has chronically attracted waves of criticism, almost from its very inception. [1] Many prominent scholars have called for its outright abolition. [2] Others

[1] See, in this regard, the seminal contribution by MACHLUP and PENROSE, *The Patent Controversy in the Nineteenth Century,* in *The Journal of Economic History*, 10, 1950, 1. These authors, however, as well known, although acknowledging the negative aspects and downsides of the system, concluded against it abolition.

[2] See, with regard to the North American patent system, JAFFE and LERNER, *Innovation and Its Discontents,* Princeton University Press, USA, 2004, *passim*. In broader terms, see BOLDRIN and LEVINE, *Against Intellectual Monopoly,* Cambridge University Press, UK, 2008, *passim.* More recently: MOSER, *Evidence from Economic History*, in *The Journal of Economic Perspectives*, 27, 2013, I, 23, at 23-44, showing that several countries who did not have patent protection had an innovation rate identical to those who benefitted from the patent system, just relying on trade secret and lead time. Some other authors have moved one step further proposing alternative

have shifted the criticisms from the system as a whole towards its constituent parts, proposing constructive amendments aimed at fixing some of its supposed loopholes.[3] And yet, despite the criticisms, the patent system seems to be in great shape. Patenting trends all over the world have dramatically increased, reaching 3.276.700 patent filings worldwide in 2020.[4] The number of European patent applications filed at the EPO in 2021 totaled 188 600 (comprehending titled filed both from European firms and international firms via PCT procedure), being 160.022 in 2015,[5] while the North American patent trend shows an increase from 503.582 in 2011 to 597.172 in 2020.[6]

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systems to reward innovators. See GALLINI and SCOTCHMER, *Intellectual Property: When is it the Best Incentive System?* in JAFFE, LERNER and STERN (eds.), *Innovation Policy and the Economy,* Vol. 2, MIT Press, Cambridge, 2002, 51, at 53-55. More recently, W.W. FISHER and SYED, *Infection: The Health Crisis in the Developing World and What We Should Do About It,* Stanford University Press, USA, 2017, available at https://cyber.harvard.edu/people/tfisher/Infection.htm (last accessed 20th January 2023).

[3] See DI CATALDO, *La questione brevettuale all'inizio del XXI secolo*, in *Riv. dir. comm.*, 2017, I, 37, at 38-46, where the author highlights however how the so called *patent controversy* has now reached a more mature stage where scholars – besides the most extremist attacks – tend today not to question the exhistence of the system as a whole but rather strive to tailor its rules, often adapting them to the technological features of different sectores, in order to maximize social utility.

[4] See WIPO, World Intellectual Property Organization, *World Intellectual Property Indicators 2021,* available at https://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2021.pdf (last accessed 20th January 2023). For past data see also FINK, KHAN and ZHOU, *Exploring the worldwide patent surge,* in *Economics of Innovation and New Technology,* 25*,* 2016, II, 114, reporting that between 1982 and 1995 worldwide patent filings score a number between 800.000 and 1 million per year and in 2011 the overall number has more than doubled.

[5] Confront the date made available by the EPO at https://www.epo.org/news-events/news/2022/20220405.html with previous statistics at https://www.epo.org/about-us/annual-reports-statistics/annual-report/2015/statistics/review.html (last accessed 20th January 2023), and https://www.epo.org/about-us/annual-reports-statistics/annual-report/2015/statistics/patent-applications.html (last accessed 20th January 2023).

[6] See Cfr. WIPO, World Intellectual Property Organization, statistics database, available at https://www3.wipo.int/ipstats/keysearch.htm?keyId=221 (last accessed 20th January 2023). See GIRARD, *Does "strategic patenting" threatens innovation?*

The above data should be positively read as a confirmation of the usefulness of the patent system and patents' perceived effectiveness as instrument to secure innovations and maximize their values.[7] Moreover, one might reasonably read such "patent inflation"[8] as a positive sign that innovation is growing, if one assumes that more patent filings are synonym of greater inventive activity within a certain field.

Such statistics, however, must be read together with another set of interesting data which seem to head towards an opposite direction. And indeed it seems that of all these titles of protection yearly released by the patent offices worldwide only a small percentage is actually put to use and practiced.[9] Experiential figures show that often titles of protection are abandoned well before their estab-

And what could happen if it did, in MUKHOPADHYAY, AKHILESH, SRINIVASAN, GURTOO, RAMACHANDRAN, IYER, MATHIRAJAN and SUBRAHMANYA (eds.), *Driving the Economy through Innovation and Entrepreneurship. Emerging Agenda for Technology Management*, Springer, India, 2013, at 329, showing that more than 350.000 patent applications are filed before the USPTO every year and that nearly 200.000 are granted. The author addressed globalization of markets as one of the causes of the recent surge in the total number of patent filings worldwide, since international firms extend patent protections in all major markets.

[7] See in this regard STRAUS and KLUNKER, *Harmonization of International Patent Law*, in *I.I.C.*, 38, 2007, 907, at 908 and ff., explaining that the strengthening and expansion of the patent system reflect the economic changes in today's society, characterized by innovation and "a growing dependency on knowledge capital as a source of economic power and competitive advantage".

[8] The terminology has been used by J. Masur who, however, talking about the North-American patent system, tributes the recent surge in patent applications to dysfunctions inherent both the USPTO, liable of granting too many invalid patents, and the CAFC, liable of loosening patentability standards which are then implemented by the former. See MASUR, *Patent Inflation*, in 121 *Y.L.J.*, 2011, 470.

[9] See TORRISI, GAMBARDELLA, GIURI, HARHOFF, HOISL and MARIANI, *Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey*, in *Research policy*, 45, 2016, 1374, at 1374–1385. Such phenomenon was called, already in 1981, of "sleeping patents". See GILBERT, *Patents, Sleeping Patents, and Entry Deterrence*, in SALOP (ed.), *Strategy, Predation and Antitrust Analysis*, Federal Trade Commission, Bureau of Economics and Bureau of Competition, Washington, 1981, 205, at 223 and ff., discussing the anticompetitive potential of patents accumulation as an exclusionary pre-emptive strategy.

lished expiry dates [10] – sometimes even before the actual grant of the patent [11] – and that only a minor part of granted patents are ever litigated or licensed. [12]

A joint reading of the two sets of data seems to lead to puzzling conclusions. On the one side, the circumstance that so many firms worldwide invest in patenting their innovations seems to provide strong confirmation of the usefulness of the system. On the other side, however, the fact that several undertakings do not look fully interested in practising or defending their patented inventions seem to suggest the opposite inference: namely, that many – if not most – of the patents filed and obtained turn out to be of negligible or no value at all to the firm. [13] An assumption which seems to find con-

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[10] See LANDES and POSNER, *The Economic Structure of Intellectual Property Law,* The Belknap Press of Harvard University Press, Cambridge Massachusetts – London, UK, 2003, at 311, arguing that the average economic life for a patent (including maintenance fees) is about 16.6 years. In the same sense: LEMLEY and SHAPIRO, *Probabilistic Patents,* in *J. of Econ. Perspectives*, 19, 2005, 75, at 79, arguing that between 55 and 67% of issued U.S. patents would lapse for failure to pay maintenance fees before their expiration date, clearly demonstrating that the titles were of little value to their owners.

[11] See LAZARIDIS and VAN POTTELSBERGHE DE LA POTTERIE, *The rigour of EPO's patentability criteria: an insight into the "induced withdrawals"*, in *World Patent Information*, 29, 2007, IV, 317, analyzing EPO patent applications between 1985 and 2004 and finding that a significant percentage (between 6 and 14 percent) of the applications were withdrawn well before completion of the granting process. Similarly, focusing on the practice of German inventors, see JELL, *Patent Filing Strategies and Patent Management: An Empirical Study*, Gabler Verlag, Munich, 2012, 16, noting that it is a common practice in Germany to withdraw patent filings before the actual grant or refusal of the patent.

[12] See LEMLEY, *Rational Ignorance at the Patent Office*, 95 *NW. U. L. Rev.*, 1495, 1507 (2001), arguing that sometimes patents are not put to use because the firm is not able to attract the necessary financial capitals to actually bring the related invention to the market or some other times, once again despite their technical merit, they do not meet consumers' demand. Similarly see PHILLIPS, *A spanner in the works – or the spanner that works? Patents and the intellectual property system*, in TAKENAKA (ed.), *Patent Law and Theory A Handbook of Contemporary Research*, Edward Elgar Publishing, Cheltenham (UK) – Northampton (USA), 2009, 132, at 142.

[13] There seems to be empirical evidence showing that most patents do not provide any significant economic returns to their owners. See GAMBARDELLA, HARHOFF

firmation in two recent phenomena which are worth recalling: on the one side, the recent propensity of some undertakings, mainly in the United States, to issue so called "*patent pledges*",[14] whereby they spontaneously agree not to enforce their exclusive rights against competitors.[15] On the other side, the tendency of some undertakings, specifically in some countries,[16] to get rid of worthless patents, by selling them to specific entities (so called *Patent Assertion Entities* – also called *non practising entities (NPEs)* or, with a negative implication, *patent trolls*) who do not innovate nor produce any goods or items.[17]

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and VERSPAGEN, *The value of European patents*, in *Eur. Manage. Rev*. 5, 2008, II, 69; HARHOFF, SCHERER and VOPEL, *Citations, family size, opposition and the value of patent rights,* in *Research Policy* 32, 2003, VIII, 1343.

[14] Patent pledges have been defined as "commitments made voluntarily by patent holders to limit the enforcement or other exploitation of their patents". See CONTRERAS, *Patent Pledges,* in 47 *Ariz. St. L.J.* 2015, 543, at 545, observing that such voluntary commitments represent a middle ground between full commercial exploitation of the exclusive rights and their abandonment to the public domain. Generally, patent pledges are directed to wide segments of a certain market and often they do not ask for any monetary compensation. While the most well known example of patent pledge comes from a very specific context, namely the so called FRAND commitments regarding standard essential patents, examples of patent pledges seem to abound today in a wide range of sectors, from the electric vehicle industry to information technologies in general to biotech. See CONTRERAS, *A patent pledge taxonomy,* in CONTRERAS and JACOB (eds.), *Patent Pledges, Global Perspectives on Patent Law's Private Ordering Frontier*, Edward Elgar Publishing, Cheltenham (UK) – Northampton (USA), 2017, 7.

[15] Patent pledges seem at odds with the traditional incentive theory rationale permeating patent law theories, as firms file for protection, keep protection alive, but at the same time choose to curtail the most valuable right coming with the patent: the right to exclude. In this sense: ASAY, *The informational effects of patent pledges,* in *Patent Pledges,* in CONTRERAS and JACOB (eds.), *Patent Pledges, Global Perspectives on Patent Law's Private Ordering Frontier*, Edward Elgar Publishing, Cheltenham (UK) – Northampton (USA), 2017, 227, at 231 and ff.

[16] On the reasons why patent assertion entities prefer to file suit mostly outside Europe see: LOVE, HELMERS, GAESSLER and ERNICKE, *Patent Assertion Entities in Europe,* in SOKOL (ed.), *Patent Assertion Entities and Competition Policy*, Cambridge University Press, UK, 2017, 104.

[17] *PAEs* gather unused titles of protection from different actors and gather them into big portfolios. Their peculiarity, however, arises from the circumstance that they

The massive recourse to patent protection for inventions which are never reduced to practice – and worse: are ceased to PAEs – seems at odd with the utilitarian incentive-based theory which explain the granting of exclusive rights precisely with the aim of rewarding, through the exploitation of the invention on the market, the inventor. [18]

Given the circumstance that patents are extremely costly to obtain, one may reasonably ask why rational firms invest so many capitals in – apparently – worthless titles of protection. In other words, why do firms recur to patents, investing huge amounts of money, if a significant portion of such costly exclusive rights are

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do not work the inventions, but profit from asserting patent counterfeiting against any imprudent/inexperienced entrepreneurs who happens to stumble in their protected technology. For a thoughtful analysis of the issue see CONTROPIA, KESAN and SCHWARTS, *Unpacking Patent Assertion Entities,* in 99 *Minn. L. Rev*., 2014, 649.

[18] See, SCHERER, *The Economics of the Patent System,* in F.M. SCHERER*, Industrial Market Structure and Economic Performance*, II ed., 1980, 439-458, reprinted in F.M. SCHERER, *Patents, Economics, Policy and Measurement*, Edward Elgar Publishing, Cheltenham (UK) – Northampton (USA), 2005, 3, at 4, arguing that Government has chosen to grant patent rights for three reasons: namely, to promote inventions, to encourage the development and commercial utilization of inventions, and to encourage disclosure of inventive concepts to the public at large. More recently: SCOTCHMER, *Innovation and its incentives*, MIT Press, Cambridge (MA) – London (UK), 2004, at 31 and ff. The incentive theory and the public good nature of intellectual property is brilliantly illustrated by E.C. JOHNSON, *Intellectual Property and the Incentive Fallacy*, in *39 Fla. St. U. L. Rev.*, 2012, 624, at 628. See in this regard also GUELLEC, *Patents as incentive to innovate*, in GUELLEC and VAN POTTELSBERGHE DE LA POTTERIE (eds.), *The Economics of the European Patent System, IP Policy for Innovation and Competition*, Oxford University Press, Oxford, 2007, 45, at 49 and ff.; and LANDES and POSNER, *The Economic Structure of Intellectual Property Law*, *supra* footnote n. 10, at 13, 18 and ff., and especially at 20 where they explain that unless there is power to exclude, the incentive to create IPRs in the first place would be at risk, with the consequence that socially desirable investments would not be undertaken were the IP owners not capable to recoup their sunk costs. There is then what they describe as an "access versus incentives" tradeoff, meaning that the creation of an IP right creates a social cost, reducing access to that good, but at the same time by making it artificially scarse, it creates incentives to invent it in the first place, which should hopefully be an offsetting social benefit.

rarely worked by their inventors nor used in any – apparent – meaningful way. [19]

2. Some authors have explained the recent surge in patents underlying their financial value and the role they have come to play within the firm's internal organization and structure. IPRs in general, and patents in particular, indeed are intangible assets whose economic value is not simply relevant to the firm, as we have assumed so far, but also *measurable* in monetary terms and regularly taken into account in the firm's financial internal prospects and statements. [20] Furthermore, it seems that in many industries the ratio of tangible to intangible assets within the firm has dramatically changed, with scenarios where intangible assets may even come to account for nearly the 80% of the firm corporate value. [21] This is mainly due to the fact that the structure of today's firm is profoundly changed. [22] Enterprises today can easily outsource large parts of the manufacturing processes of the end products to other firms located elsewhere. [23] Therefore, while outsourcing makes it no longer

[19] A paradox of this kind was registered with specific regard to the semiconductor industry where despite the industry features (rapid pace of technological change and short product life cycles) seemed to imply a stronger favor towards trade secret and natural lead time, empirical evidence suggested a sharp and constant increase in patent filings from 1980's onwards. See HALL and ZIEDONIS, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, in *Rand J. Econ.*, 32, 2001, 101, 125.

[20] See, *ex multis*, HOWELL and BAINBRIDGE, *Intellectual Property Asset Management*, Routledge, NY, USA, 2014, at 148 and ff.

[21] See GIRARD, *Does "strategic patenting" threatens innovation? And what could happen if it did*, *supra* footnote n. 6, at 335.

[22] More extensively on the subject see PETRUSSON, *Patents as Structural Capital – Towards Legal Constructionism*, in GRANSTRAND (ed.), *Economics, Law and Intellectual Property, Seeking Strategies for Research and Teaching in a Developing Field*, Kluwer Academic Publishers, The Netherlands, 2004, 363, at 365 and ff.

[23] See GIRARD, *Does "strategic patenting" threatens innovation? And what could happen if it did*, *supra* footnote n. 6, at 333 and ff., pointing at examples from the high tech industries – Apple, for example – where big firms invest in IPRs and then have their final products assembled in countries where manufacturing is a lot

vital to invest in manufacturing and assembling facilities, intangible goods and reputation are essential assets to the firm.[24] This even more so for start-ups and in general all firms collecting financial capitals to invest in innovation from the venture market.[25] In this latter scenario, intangible assets and patents in particular work as a signalling tool,[26] conveying information on the market about the firm.[27] This on the assumption that the high costs associated to patenting will deter low-innovating firms from investing in this type of signalling activity.[28]

In a similar way, patents can also be used as instrument to signal good performances of individuals (i.e. inventors). Often, patent records are used as indicators by the companies' management department to evaluate employees' performances and are used to model reward schemes.[29] By the same token, university researchers

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cheaper. Similarly see CASS, *Lessons from the Smartphone Wars: Patent Litigants, Patent Quality, and Software,* in 16 *Minn. J.L. Sci. & Tech.*, 1, 2015, at 14.

[24] See DREYFUSS and FRANKEL, *From Incentive to Commodity to Asset: How International Law is Reconceptualizing Intellectual Property,* in 36 *Mich. J. Int'l L.,* 2015, 557, at 562, explaining that the liberalization of trade also brought as a consequence the re location of manufacturing and the development of new global value chain which are spread geographically into different venues for research development, production, distribution and servicing.

[25] Cfr. LERMAN, *Patent Strategies of Technology Start-ups: An Empirical Study*, in *Intellectual Property, Patent Law eJournal*, 2015, 1, available at SSRN: https://ssrn.com/abstract=2610433 (last accessed 20th January 2023).

[26] See LONG, *Patent Signals,* in 69 *U. Chi. L. Rev*., 2002, 625 arguing that the exclusivity features of patent rights, and the related incentive function, is not the only rationale behind patent law, as firms find increasingly valuable recurring to patents for other reasons such as to signal information to the market thereby reducing information asymmetries between patentees and third parties.

[27] See HÄUSSLER, HARHOFF, and MUELLER, *To Be Financed or Not… – The Role of Patents for Venture Capital-Financing,* in *Discussion Paper Series of SFB/TR 15 Governance and the Efficiency of Economic Systems,* 9, 2012, 3, available at SSRN: http://ssrn.com/abstract=1393725 (last accessed 20th January 2023), arguing that start-up especially file patent applications mainly to attract shareholders.

[28] Cfr. LONG, *Patent Signals, supra* footnote n. 26, at 657.

[29] See BLIND, CREMERS and MUELLER, *The influence of strategic patenting on companies' patent portfolios*, in *Research policy*, 38, 2009, 428. See also LEVIN, *A*

and professors are often evaluated, *inter alia,* in light of the number of patented inventions. [30]

While the signalling theory of patents has appeal and probably had some impact on the recent patent surge, the most compelling explanations for this phenomenon must be found somewhere else and in particular within two sets of circumstances that happen to be somewhat interrelated. In particular, on the one side, there has been a profound change in the very same structure of innovation, which has taken a more articulated and multifaceted feature, naturally demanding more patents in order to be efficiently protected. This has gradually led firms to file for multiple patents over a certain innovative trail: hence, to the formation of patent clusters or portfolios. On the other side, firms have then come to acknowledge the strategic value of the bundle of rights over a single or few patents: the latter circumstance being responsible to ignite a vicious circle leading towards more and more patenting.

3. Patent statutes and laws of the industrial revolution were clearly conceived for pioneer inventions, this term referring to break-through innovations which would generally bring about a new category of products, unknown before, or a new type of industrial machinery or process. An indirect proof of this can be found in that many national patent laws in Europe only contemplated novelty and industrial applicability as patentability requirement, whereas

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New Look at the Patent System, in *76 Am. Econ. Rev.,* 1986, II, 199, at 199-201, suggesting that patents can be used to measure R&D employees' performances and productivity.

[30] On patents conceived by academic researchers and professors see: PILA, *Sewing the Fly Buttons on the Statute': Employee Inventions and the Employment Context,* in *Oxford Journal of Legal Studies*, 32, 2012, 265; MOWERY and SAMPAT, *Patenting and Licensing University Inventions: Lessons from the History of the Research Corporation,* in *Industrial and Corporate Change,* 10, 2001, II, 317; VAN DONGEN, WINNINKA and TIJSSEN, *Academic inventions and patents in the Netherlands: A case study on business sector exploitation,* in *World Patent Information*, 38, 2014, 27. See RANTANEN and JACK, *Patens as credentials,* in *Washington and Lee L. Rev.,* 76, 2019, 311.

the requirement of originality was introduced at the end of the seventies, thanks to the ratification of the European Patent Convention. [31]

The first patent laws were designed with the idea that the innovative concept generally converged into a single inventive contribution and the working of the inventive teaching gave birth to a final end product or apparatus, or conceived an industrial process. Consequently, one title of protection was generally enough to protect the patented invention against risks of counterfeiting or free riding. While this assumption has remained true in some instances and for some industries, in some other sectors the very same physiognomy of innovation and the way it develops have profoundly changed, although such profound changes have been recognized relatively recently.

3.1. The changes in the features of technological development and innovation were acknowledged by the academia roughly at the end of the eighties, when a few eminent scholars started drawing a distinction between somewhat "traditional" industrial sectors and sectors where innovation would embrace a "sequential" feature. [32] In the former ones innovation was "discrete and well-defined", the related inventions consisting in teachings leading to the making of a stand-alone product, with no room for subsequent technical advances. In the latter sectors, by contrast, scholars rightly emphasized a distinguishing new feature of innovation, pointing out how innovation would no longer come in waves of isolated break-

[31] On the codification of the originality requirement see DI CATALDO, *L'originalità dell'invenzione*, Giuffrè, Milan, 1983, at 107-108, arguing that the level of inventiveness should be tailored differently across industries, as each sector has its own pace and method of conducting research.

[32] See SCOTCHMER, *Innovation and Incentives*, *supra* footnote n. 18. SCOTCHMER, *Protecting Early Innovators: Should Second-Generation Products Be Patentable?,* in *Rand J. Econ*, 117, 1996; GALLINI and SCOTCHMER, *Intellectual Property*: *When is it the Best Incentive System?, supra* footnote n. 2; KOBAK, *Intellectual Property, Competition Law and Hidden Choices Between Original and Sequential Innovation*, in *3 Va. J.L. & Tech*., 6, 1998, 1522.

through discoveries,[33] like it used to happen during the eighteenth century, but it looked more like a continuous line where new inventions would flourish on top of previous ones, whose findings they would embed, thereby bringing about new ameliorated products.[34]

Sequentiality, however, was not the only distinguishing feature. R. Merges and R. Nelson, in particular, were among the few to underline that in certain industries – like those producing automobiles, aircrafts, electric light systems, semiconductors and computers – not only technology would advance *in time* by improving on existing innovations, but it would often exhibit a *cumulative* character, meaning that final end products were made throughout the assembling of many inventive subcomponents and parts.[35]

While *sequentiality* and *cumulativeness* were often addressed interchangeably by the literature of that time,[36] Merges and Nelson's seminal contribution laid the basis for a different conceptualization of innovation, still in use today, distinguishing between "discrete" vis-à-vis so called "complex"[37] technolo-

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[33] This is the model of innovation that Josef Schumpeter had in mind, where so called "perennial gales of creative destruction" would periodically erode strong market positions by introducing new products which would swipe the old ones away. See SCHUMPETER, *Capitalism, Socialism and Democracy,* Harper & Row Publishers Inc., London, NY, 1942, at 84.

[34] See GILBERT and SHAPIRO, *Optimal Patent Length and Breadth*, in *21 R.a.n.d. J. Econ*., 1990, 106; KLEMPERER, *How Broad Should the Scope of Patent Protection Be?*, in *21 R.a.n.d. J. Econ.*, 1990, 113; DAM, *The Economic Underpinnings of Patent Law*, in *23 J. of Legal Stud*., 1994, 247.

[35] See MERGES and NELSON, *On the Complex Economics of Patent Scope,* in *90 Colum. L. Rev*., 1990, 839, at 881 and ff. Note that the authors emphasize the "complex" nature of such innovations, but still label it "cumulative".

[36] SCOTCHMER, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, in *The Journal of Economic Perspectives*, 5, 1991, I, 29, discussing the implication of cumulative and sequential innovation with regard to issue of optimal patent breath between first and second inventors.

[37] See *ex multis* HARHOFF, HALL, GRAEVENITZ, HOISL and WAGNER, *The Strategic use of patents and its implications for enterprise and competition policies,* final report, European Commission, Bruxelles, 2007, at 9 and ff. COHEN, NELSON and WALSH, *Protecting their intellectual assets: appropriability conditions and why U.S.*

gies.[38] And indeed scholars nowadays tend to agree that while sequentiality is a feature shared by most industrial sectors,[39] the distinguishing element between the two technologies hinges upon the fragmented vis-à-vis unitary nature of innovation, and its implication from the patent law perspective, mainly in terms of numbers of titles necessary to protect the overall inventive concept and ownership.[40]

Accordingly, scholars emphasize that in complex technologies industries, where the innovation which makes the final product is the result of the assembly of a multiple set of intertwined sub-innovations,[41] fragmentation of technologies results in a likely

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manufacturing firms patent (or not), in *National Bureau of Economic Research*, 7552, 2002, 1, at 19-23 and ff.; COHEN, GOTO, NAGATA, NELSON and WALSH, *R&D Spillovers, patents and the incentives to innovate in Japan and the United States,* in *Research policy*, 2002, 1349, at 1356 and ff.; TORRISI, GAMBARDELLA, GIURI, HARHOFF, HOISL and MARIANI, *Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey, supra* footnote n. 9, at 1375; L. MARENGO, PASQUALI, VALENTE, and DOSI, *Appropriability, patents, and rates of innovation in complex products industries,* in *Economics of Innovation and New Technologies,* 21, 2009, 8, 753, at 754-755. Note, however, that the sectors have slightly changed. Today *information technologies, telecommunications* and *electrical engineering industries* are regarded as "complex" technologies, while under the heading of "discrete" industries scholars intend *Macromolecular Chemistry and Polimers, Organic Fine Chemistry, Pharmaceuticals and Cosmetics* or *Agriculture and Food industries.*

[38] As noted by Justine Pila, the word "technology" in the current patent debate seems to have largely displaced the role previously played by the concept of "industry". See PILA, *The Requirement for an Invention in Patent Law,* Oxford University Press, UK, 2010, at 9.

[39] And indeed already in the nineties S. Scotchmer attributed the cumulative feature of innovation to most of the industrial sectors, from to pharmaceuticals to computer software. See SCOTCHMER, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, supra* foonote n. 36, at 29.

[40] See REITZIG, *The private values of 'thickets' and 'fences': towards an updated picture of the use of patents across industries*, in *Economics of Innovation and New Technology*, 13, 2004, V, 457, at 459.

[41] See GUELLEC, MARTINEZ and ZUNIGA, *Pre-emptive patenting: securing market exclusion and freedom of operation*, in *Economics of Innovation and New Technology*, 21, 2012, 1, at 4. Similarly, see GRANSTRAND, *Are we on our Way in the New Economy with Optimal Inventive Steps?*, in GRANSTRAND (ed.), *Economics, Law and Intellectual Property, Seeking Strategies for Research and Teaching in a Developing*

fragmentations – hence in a *natural proliferation* – of patent rights, as each sliver of sub-technology which makes the whole can well represent a severable patentable subject matter.[42] Furthermore, the existence of separate-but-related technologies, which come to merge into a single final product, implies a *modular* structure of innovation, where technical advances may proceed on a number of different fronts at the same time,[43] with the only limit of interoperability.[44] Consequently, complex technology sectors are often characterized also by fragmentation of *ownership* on the overall innovation, as many firms can autonomously pursue sub-innovation paths and will obtain patent rights on their components or technologies.[45]

Field, Kluwer Academic Publishers, UK, 2004, 223, at 233-234, addressing with the term "the IP assembly problem" a new scenario where new products and services are not simply high-tech, meaning that they make use of highly-sophisticated technologies, but they have become "mul-tech", in the sense that technologies require the implementation of multiple products, with the consequence that patents become "[…] more cross-linked and interdependent, with each new business becoming reliant on an increasing number of inventions and patents".

[42] A. Galasso and M. Schankeman describe ''complex technology'' industries as sectors where innovation is highly cumulative and requires the input of a large number of patented components held by distinct firms. See GALASSO and SCHANKEMAN, *Patents and Cumulative Innovation: Causal Evidence from the Courts*, in *Q. Jour. of Econ.*, 2015, 1, at 2.

[43] Merges and Nelson described as complex the industries relying on "complex products" whereby the technology advances comprehend a "complex system where many components, subcomponents and parts, and technical advance may proceed on a number of different fronts at once". MERGES and NELSON, *On the Complex Economics of Patent Scope, supra* footnote n. 35, at 881. Similarly, LANGLOIS, *Technological standards, innovation and essential facility. Towards a Schumpeterian Post-Chicago Approach*, SSRN Electronic Journal, 1999, 25, available at http://digitalcommons.uconn.edu/econ_wpapers (last accessed 20th January 2023), explaining that most cumulative technologies are "system products", meaning products that permit or require the simultaneous functioning of a number of complementary components.

[44] See HARHOFF, HALL, GRAEVENITZ, HOISL and WAGNER, *The Strategic use of patents and its implications for enterprise and competition policies, supra* footnote n. 37, at 9 and ff., explaining that in complex technology industries each single component is related to the others through a set of design rules or interfaces and that innovation within a single component can proceeds at her own speed, regardless of what the others are doing.

[45] COHEN, GOTO, NAGATA, NELSON and WALSH, *R&D Spillovers, patents and*

By contrast, discrete technologies sectors, such as the chemical and pharmaceutical ones, are described as those sectors where, despite being sequential, the innovation process maintains a more *unitary* feature.[46] In these sectors, the innovation process develops along a unitary research trail traced by the inventor and progresses through improvements and small technical advances. Think for example to the discovery of new coding functions of a certain protein, which will lead to a first patent on the protein structure, claiming expressly the new coding function, and then it will later attract further patents aimed at covering new methods to extract the protein, new methods to produce the proteins on a large scale, products – such as a diagnosis test which measures the probability of developing a certain disease associating certain values about the percentage of proteins present in the human blood – etc.

While there surely is plenty room for follow-on inventions to be patented, Merges and Nelson stressed that in "discrete industries" inventions are not made of intertwined subparts, nor do their inventions normally make part of a complex system, with a modular structure, as it happens for "complex technologies".[47] Moreover, although it is both technically and legally possible for a competitor that pursues the same research path to file for patent protec-

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the incentives to innovate in Japan and the United States, supra footnote n. 37, at 1356, explaining that in complex product industries firms often do not have proprietary control over all the essential complementary components necessary to make the final product. Firms hold rights over technologies that other parties need: a circumstance that creates mutual dependence and fosters cross-licensing.

[46] Note that Merges and Nelson did not include the chemical sector among the ones producing discrete technologies, believing it deserved to constitute a third autonomous group. The authors indeed attributed to it a somewhat mixed character explaining that that even if a chemical product is in most cases a discrete entity — meaning that it rarely represents the basis of follow-on innovation — given the peculiar relation between chemical structure and function, especially in bio-chemicals, it might also happen that a new chemical entity turns out to hold a wide set of applications: hence, it would exert cumulative features of innovation. MERGES and NELSON, *On the Complex Economics of Patent Scope, supra* footnote n. 35, at 883.

[47] See MERGES and NELSON, *On the Complex Economics of Patent Scope, supra* footnote n. 35, at 882 and ff.

tion on a derivative invention (as it happens, for example, in the case of second use patents), it often happens that ownership of the patents – main and derivative ones – covering the overall inventive concept tends to stay in the hands of a single owner.

3.2. The differences between complex and discrete technologies described above (namely: fragmentation of innovation and related interdependence of patent rights in industries featuring complex technologies vis-à-vis unitary character of innovation and tendency towards single ownership of patent rights featuring discrete technologies) have led many scholars to think that firms active in the former sectors would patent more heavily than those active in the latter. [48]

This assumption was further corroborated by the belief that the expected value of a single patent, independently considered, in complex technologies is assumed to be negligible. [49] By contrast, in discrete technology sectors, most scholars contend that since innovation is not fragmented and exhibit a unitary feature, with exclusive rights likely to be concentrated in the hands of a few leading firms, the value of independent patents should be sensibly higher, and (few) patents should allow to fully appropriate the value of the invention embedded in the final product. [50]

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[48] In this sense see COHEN, NELSON and WALSH, *Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing firms patent (or not), supra* footnote n. 37, at 19, arguing that the key distinction between firms active in the production of discrete and complex technologies lies in the circumstance that a new product or process is comprised of numerous separately patentable elements versus relatively few. Similarly see TORRISI, GAMBARDELLA, GIURI, HARHOFF, HOISL, and MARIANI, *Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey, supra* footnote n. 9, at 1375.

[49] According to some scholars, in sectors featured by complex technologies the expected average value of an individual patent tends to be very low, as it is generally linked to the value of other related patented or unpatented technologies, which might well belong to rivals. In this sense: HALL and ZIEDONIS, *The patent paradox revisited: an empirical study or patenting in the U.S. semiconductor industry, 1979-1995, supra* footnote n. 19, at 107.

[50] See HARHOFF, HALL, GRAEVENITZ, HOISL, and WAGNER, *The Strategic use of*