Coming to Grips with Patents in High Technology Investments: A Case Study Analysis Using the Example of Ambature

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This paper discusses the practical application of established financial economic methods in evaluating the economic relevance of the patents of an early-stage firm operating in a nascent technology field. It does so using the example of Ambature, an Arizona-based high technology startup whose business model consists of licensing high temperature superconductivity. The patent analysis is performed from the perspective of this startup going into its first institutional round of funding. This study aims to facilitate the task of investing in early-stage technology firms while at the same time helping patent owners get a better grasp of how to put their intellectual property to work. In doing so, the paper aims to promote active markets for patented technology.

I. Scoping Investment Opportunities in Emerging Technologies

In a post-credit crunch era, investors face low interest rates and are eagerly looking for alternative ways to put their money to work. Can new inventions and patents offer such an alternative? Adequately valuing potential returns on an investment and weighing them against the risk profile of the investment is crucial to any type of financial decision. Patents are no exception to that. The adequate valuation of patents thus plays a crucial role in vital markets for technology while at the same time allowing investors to make educated investment decisions. In spite of this, investors lack adequate information and knowledge about the valuation of patents as well the importance of patent valuation in an investment decision.

The major challenge does not seem to be that patents cannot be valued for financial purposes, nor disposed of any intrinsic features that would prevent the establishment of secondary markets for innovation. The challenge is that investors are rather ignorant about patents and are not well informed on their risk and reward structures. Moreover, technology entrepreneurs seeking funding usually do not possess the necessary skill sets to communicate the value of patents. Current accounting standards, which reflect the value of patents only partially, do not make things easier.[1] This leads to market inefficiencies as valuable technology sits gathering dust while investors are not able to scope out potentially attractive financial opportunities.[2] A recent report issued by the European Commission calls for greater accountability in IP valuation, alongside a range of IP awareness raising mechanisms, to counteract this phenomenon.[3] A similar position is being taken by the British Government, which has identified the lack of accredited valuation systems for patents as a major barrier to the promotion of intellectual property in

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1 *See* Roya Ghafele, *Accounting for IP?*, 5 J. INTELL. PROP. L. & PRAC. 521, 527 (2010) (discussing the problems with fair-value IP accounting).

2 *See id.* at 527–28 (discussing problems with current IP markets).

3 *See Final Report from the Expert Group on Intellectual Property Valuation*, European Comm'n, at 7, 22–23, 57, 91 (Nov. 29, 2013), *available at* http://ec.europa.eu/research/innovation-union/pdf/KI-01-14-460-EN-N-IP_valuation_Expert_Group.pdf (detailing common problems with IP valuation and providing recommendations for improved IP valuation).

financial markets.[4] Certainly, the United States can offer a range of laudable exceptions such as Silicon Valley Bank, which has a decades-long track record of valuing patents.[5] Yet institutions like these are the worthy exceptions, rather than the norm.

Against this background, this paper's unique contribution is in showing how established financial economic methods can be applied to value the patents of an early-stage firm operating in a nascent technology field. It does so using the example of Ambature, an Arizona-based startup seeking to license high-temperature superconductivity (HTS).[6] The patent valuation is performed from the perspective of this startup going through its first institutional round of funding. In doing so, this article enhances the transparency of IP valuation and thus promotes access to funding of early-stage technology enterprises. Patents are often the most tangible assets that these firms dispose of.[7] Illustrating the potential use and value of their patents facilitates investment in early-stage technology by capturing the potential future revenue streams associated with their main business asset.[8]

This paper is privileged to have access to otherwise confidential information. Ambature agreed to reveal to the public all information necessary for the patent valuation. By limiting the scope of the IP valuation to a very specific context, namely that of patents filed by a startup in the area of HTS for investment purposes only, this paper strongly reduces the complexity of the question of patent valuation and avoids the pitfall of trying to explain a multitude of patent valuation scenarios in varying contexts. It merely shows how patents can be valued within the narrow parameters of a company in this startup's situation and identifies the driving factors for the value of such patents. Thus, this paper does not claim to offer a one-size-fits-all approach to patent valuation.

The paper is structured as follows. First, the need for patent valuation is established in light of an evolving patent paradigm, which views patents through an intangible-assets lens. Then the valuation methods of this paper are discussed in light of well-known financial valuation methods. The empirical part of the paper presents the specific context of HTS, the technology field this startup is active in. The article concludes by offering the estimated value of the patents of this specific

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4 *See Banking on IP? The Role of Intellectual Property and Intangible Assets in Facilitating Business Finance*, Intellectual Property Office, at 210, 214, 216–17 (Nov. 6, 2013) (by Martin Brassel & Kelvin King), *available at* http://www.ipo.gov.uk/ipresearch-bankingip.pdf [hereinafter *Banking on IP?*] (discussing barriers to IP markets in the U.K. and providing recommendations for overcoming these barriers).

5 *See About Silicon Valley Bank*, SILICON VALLEY BANK, http://www.svb.com/about-silicon-valley-bank/ (last visited Jan. 9, 2015) (disclosing that Silicon Valley Bank's clients include 50% "of all venture capital-backed tech and life science companies in the US"); *History & Timeline*, SILICON VALLEY BANK, http://www.svb.com/Company/History—Timeline/ (last visited Jan. 9, 2015) (cataloging opening of first office in 1983).

6 *Corporate Info*, AMBATURE, http://ambature.com/corporate-info/ (last visited Jan. 9, 2015).

7 *Banking on IP?*, *supra* note 4, at 20.

8 *See id.* at 209–10, 216–17 (discussing IP investor concerns and recommending ways to ease these concerns).

startup and by underlining the preliminary role of patent valuation in making an investment decision in hopes of promoting IP financial markets.

II. The Need for Patent Valuation

The valuation of the portfolio of pending and granted patents of a startup often remains the best guess of the firm's value.[9] Because the value of an early stage business cannot be assessed directly, the valuation must be determined by the conditional probability that a patent will contribute to firm performance given the firm's intrinsic features.[10] Patent filing has thus been repeatedly cited as a means for startups to accelerate the receipt of funding.[11] As a consequence, startups have come to use patents to signal quality and to preserve their right to exclude others from a market.[12] Ambature, the startup analysed here, illustrates that patent filing also serves as a means to form strategic alliances, access markets, and promote open innovation.

To successfully invest in a firm that owns early-stage technology patents, one must first understand the nature of patents and their economic features. Patents are temporary monopoly rights granted by the state to overcome market failures associated with the provision of knowledge.[13] The patent system provides inventors with an opportunity (but by no means a guarantee) to recover research and development (R&D) costs and eventually make a profit on an invention.[14] In this sense, patents institutionalize a commercial paradigm over knowledge relations and allow knowledge and inventions to be placed into a market system.[15] In the absence of a functioning patent system as a market for knowledge, ideas and creativity

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9 *See id.* at 21 ("Many [small and medium sized enterprises] are asset rich and cash poor, but crucially their 'assets' are typically in intangibles rather than physical tangible assets . . . .").

10 *See* Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 1995–97 (2007) (detailing a basic economic model for negotiated patent royalty rates).

11 *See, e.g.*, David H. Hsu & Rosemarie H. Ziedonis, *Resources as Dual Sources of Advantage: Implications for Valuing Entrepreneurial-Firm Patents*, 34 STRATEGIC MGMT. J. 761, 772 (2013) ("[W]hile patents are generally important across founding teams, teams without IPO experience benefit *more* from patents in attracting prominent VCs in the initial round of funding.").

12 *See* Uschi Backes-Gellner & Arndt Werner, *Entrepreneurial Signaling via Education: A Success Factor in Innovative Start-Ups*, 29 SMALL BUS. ECON. 173, 187 (2007) (discussing the use of patents as a signal for quality); Stuart J.H. Graham & Ted Sichelman, *Why Do Start-Ups Patent?*, 23 BERKELEY TECH. L.J. 1063, 1081 (2008) (discussing the use of patents in market exclusion).

13 *See* Ian David McClure, *Commoditizing Intellectual Property Rights: The Practicability of a Commercialized and Transparent International IPR Market and the Need for International Standards*, 6 BUFF. INTELL. PROP. L.J. 13, 16 (2008) ("In essence, a government-granted monopoly is endowed to the rights owner for all prospective opportunities to manage that idea."). *See generally* U.S. CONST. art. I, § 8, cl. 8 (stating that patents promote scientific progress "by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries"); 35 U.S.C. § 154(a)(2) (2013) (defining a patent term as 20 years).

14 *See* John E. Dubiansky, *An Analysis for the Valuation of Venture Capital-Funded Startup Firm Patents*, 12 B.U. J. SCI. & TECH. L. 170, 173–74 (2006) (discussing the income-generating opportunities available to a patent owner).

15 *See id.* at 171–72 (discussing the emergence of a market for intellectual assets).

would not be activated because there would be no system through which to realize their tradable worth.

The introduction of a functioning patent system "renders embedded and tacit knowledge codifiable, functional and manageable."[16] Furthermore, it "enables the generation of surplus value."[17] By disaggregating an invention from its owner, patents are legally packaged for the transfer of ownership through a transaction and have value in themselves.[18] Patents are thus resources of multiple advantages as they relate to commercial transactions. Patents, viewed through an intangible assets perspective, have the potential to become a "versatile article of trade" which bears intrinsic value uncoupled from the underlying business model.[19]

A series of recent patent transactions underlines the argument. Nokia sold its mobile-phone business units to Microsoft in the fourth quarter of 2013 but kept its patent portfolio.[20] Similarly, Google sold Motorola to Lenovo in early 2014 but retained its patents.[21] In 2011, 6,000 patents of the bankrupt Nortel Networks Corporation, worth $4.5 billion USD, were sold to Rockstar Consortium, a group of buyers composed of technology giants such as Apple, Microsoft, and Sony.[22] In 2014, speculators predicted that Blackberry could make a similar move and sell its patents to increase its cash reserves.[23] At the time, analysts estimated that Blackberry could expect some $2 billion USD for its patents.[24] But which patents have the potential to generate billions of dollars and which don't?

Patents are probabilistic property rights.[25] High degrees of uncertainty are explained by legal, technological, and market risks. Essentially, they provide the patent owner with an option—but by no means a guarantee—to generate income.[26]

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[16] Roya Ghafele & Benjamin Gibert, *Promoting Intellectual Property Monetization in Developing Countries*, 13 (World Bank, Policy Research Working Paper No. 6143, 2012), *available at* http://dx.doi.org/10.1596/1813-9450-6143.

[17] *Id.*

[18] *See* Anne Kelley, *Practicing in the Patent Marketplace*, 78 U. CHI. L. REV. 115, 123 (2011) (describing various patent transfer transactions and associated challenges).

[19] McClure, *supra* note 13, at 14; *see id*. at 127–28 (providing an example of a conceptual valuation model).

[20] Press Release, Nokia Corporation, Nokia to Sell Devices & Services Business to Microsoft in EUR 5.44 Billion All-cash Transaction (Sept. 3, 2013), *available at* http://company.nokia.com/en/news/press-releases/2013/09/03/nokia-to-sell-devices-services-business-to-microsoft-in-eur-544-billion-all-cash-transaction.

[21] Press Release, Google, Lenovo to Acquire Motorola Mobility from Google (Jan. 29, 2014), *available at* http://investor.google.com/releases/2014/0129.html.

[22] Peg Brickley, *Nortel $4.5-Billion Patent Sale to Apple, Microsoft, Others Approved*, WALL ST. J., July 11, 2013, *available at* http://online.wsj.com/news/articles/SB10001424052702303812104576440161959082234; Pedro Hernandez, *Apple and Microsoft's Rockstar Patent Group May Sell IP*, EWEEK (Dec. 27, 2013), http://www.eweek.com/mobile/apple-and-microsofts-rockstar-patent-group-may-sell-ip.html.

[23] Sarah Cohen, *Potential Buyers Wait for BlackBerry's Patents*, FORBES (Feb. 5, 2014, 11:00 AM), http://www.forbes.com/sites/sarahcohen/2014/02/05/potential-buyers-wait-for-blackberrys-patents.

[24] *Id.*

[25] Lemley & Shapiro, *supra* note 10, at 2004, 2019.

[26] *See supra* notes 14–15 and accompanying text.

While legal risks depend on the validity of the patent, technological and market risks are explained by the fact that technologies are subject to cycles and may become obsolete at some point or not be viable altogether. The value of a patent is thus based on the conditional probability that a firm will actually succeed in profiting from its patents given a range of heterogeneous risk factors.

III. Drivers of Patent Value

Since the early 1990s, there has been burgeoning academic literature that seeks to capture the value of patents through the analysis of publicly available indicators such as forward citations and the number of patent families.[27] A good example of this school of thought is the work of Tomo Fischer and Jan Leidinger, who studied Ocean Tomo's patent auction data and found that patent value is driven by both forward citations and the number of patent families.[28] While the study of easily compared patent matrixes comes in handy, it is seriously limited as a sole method for assessing patent value because it provides no insight into how a firm manages its patents or intends to put its patents to work. Also, it does not lend itself to the valuation of patents owned by startups in a nascent technology field. Such firms tend to own forward-looking portfolios, often characterized by patents for "nascent technologies that do not yet have any 'dominant designs', or . . . [whose] ecosystems are rapidly changing."[29]

In nascent technology fields, a firm should be sure to build a patent fortress around an emerging technology space to make it very expensive or even impossible for competitors to invent around a firm's patented technology space.[30] Patents of startups are, by their very nature, future-oriented because startups need to make sure they are not left out of future markets.[31] Looking at the capabilities that a firm has to unlock an emerging market is the only way to capture this key indicator.[32]

Patents in such specific contexts can thus be understood as internal resources that have the potential to provide their owner with a competitive advantage. This study conceptualizes patents as a bundle of productive resources whose purpose,

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27 *See, e.g.*, Dietmar Harhoff, Francis Narin, F. M. Scherer & Katrin Vopel, *Citation Frequency and the Value of Patented Inventions*, 81 REV. ECON. & STATISTICS 511, 511 (1999) ("[P]atents of relatively high economic value are cited more frequently than are low-value patents."). *See generally* Adam B. Jaffe, Manuel Trajtenberg & Rebecca Henderson, *Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations*, 108 Q.J. ECON. 577, 580, 583 (1993) (discussing the use of patent citations and related issues).

28 Timo Fischer & Jan Leidinger, *Testing Patent Value Indicators on Directly Observed Patent Value—An Empirical Analysis of Ocean Tomo Patent Auctions*, 43 RES. POL'Y 519, 520, 526–27 (2014) ("We find that forward citations and family size are significant indicators for patent value . . . .").

29 Mikael Collan & Kalevi Kyläheiko, *Forward-Looking Valuation of Strategic Patent Portfolios Under Structural Uncertainty*, 18 J. INTELL. PROP. RTS. 230, 230 (2013).

30 *See* Graham & Sichelman, *supra* note 12, at 1068–69, 1081 (discussing the benefits of "blocking" and "preemptive" patenting).

31 *See* Collan & Kyläheiko, *supra* note 29, at 230–31 (discussing the nature of future-oriented patents).

32 *See supra* Part I.

along with external resources, is to foster the production and sale of goods and services at a profit.[33] In doing so, it takes advantage of management research conducted on the resource-based theory of the firm.[34] Patents may therefore be understood as a source of economic rent for a firm since patents are costly to invent around and provide a temporary protection from imitation by other firms.[35]

The value of patents is intertwined with the value of the underlying goods and services that they protect. According to Barney, "[Patent] resources are valuable when they enable a firm to develop and implement strategies that have the effect of lowering a firm's net costs and/or increasing a firm's net revenues beyond what would have been the case."[36] Thus, it is not the resources themselves that are valuable, but only the strategic opportunities they offer that are valuable. This is commensurate with Dubiansky's observation that patents have no intrinsic value.[37] The drivers of the commercial value of patents can be understood by looking at the peculiar features of the patent resources and investigating how they help a firm deliver goods and services more effectively than its rivals.[38] Only then can one assess the rent-generating potential of the resources and understand how the firm could best exploit its patent resources.

IV. Patent Valuation Techniques

An early-stage firm can use its patents to bring a technology to market itself, or it can license its patents to third parties so that others can bring the technology to market.[39] An early-stage firm can also use its patents to manage competition by either seeking to prevent competitors from accessing a given technology space or by using them as a bargaining chip to form strategic alliances with firms operating in the same technology space.[40] So, the value of the patents can be grasped by assessing the potential future royalty revenues or by evaluating the costs competitors would incur if they tried to invent around the patents.[41] The paragraphs below explain how such business opportunities can be reflected in financial models.

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33 *See* EDITH PENROSE, THE THEORY OF THE GROWTH OF THE FIRM 28 (4th ed. 2009) (providing an analogous description of business firms).

34 See Yasemin Y. Kor & Joseph T. Mahoney, *Edith Penrose's (1959) Contributions to the Resource-Based View of Strategic Management*, 41 J. MGMT. STUD. 183, 188–89 (2004), for a discussion on Penrose's contribution to the resource-based theory of the firm.

35 *See* Richard P. Rumelt, *Theory, Strategy, and Entrepreneurship*, *in* 2 INTERNATIONAL HANDBOOK SERIES ON ENTREPRENEURSHIP 11, 18–19 (Sharon A. Alvarez et al. eds., 2005) (discussing the factors that contribute to increased economic rent).

36 Jay B. Barney & Asli M. Arikan, *The Resource-based View: Origins and Implications*, *in* THE BLACKWELL HANDBOOK OF STRATEGIC MANAGEMENT 124, 138 (Michael A. Hitt, et al. eds., 2001).

37 *See* Dubiansky, *supra* note 14, at 173 ("A patent is worth nothing on its own. It is nothing more than a property interest in a right to make or sell an invention.").

38 *See* PENROSE, *supra* note 33, at 21–22 (discussing the characteristics and usage of productive resources retained by firms).

39 Dubiansky, *supra* note 14, at 173.

40 *See* Graham & Sichelman, *supra* note 12, at 1066, 1068–69 (discussing potential incentives for startup companies to file patents).

41 *See* Roya Ghafele, Benjamin Gibert & James Malackowski, *Emerging IP Monetisation Solutions: The Institutionalisation of an IP Exchange*, 5 INT'L J. INTELL. PROP. MGMT. 115, 128 (2012).

In the same manner that startups are valued, patents can be valued using cost-, market-, and income-based approaches.[42] The income-based approach assesses the value of a patent based on the net present value of the future income streams that the patent can generate.[43] Accordingly, the income-based approach assumes that the value of a patent is based on these future returns.[44] The future income streams are calculated using either a discounted-cash-flow or a real-options approach.[45] The discounted-cash-flow approach takes the cash flow forecasts for the useful life of the patent and adjusts them to account for the risks involved in income generation.[46] The real-options approach treats the patent as if it were an option that the owner can exercise if and when the benefits of patent use outweigh the costs of implementation.[47] This approach has found its application in Monte Carlo simulations, which have found relatively little use among patent valuation professionals.[48] This is so because it is a dynamic approach that reflects the consequences of duration and risks of licensing transactions. It is probably the most widely applied approach in practice. It is cautioned, however, that the real-options method does not allow one to grasp that proprietary technology is subject to technology life cycles. This is because technological relevance varies over the useful life of a patent asset, while the real-options method uses a constant discount rate throughout the life span.[49]

The relief-from-royalty approach looks at patent value as the price that a company aiming to commercialize the technology would be willing to pay for a license.[50] It can also express the amount of profit the startup may expect by making and selling the patent itself. This is done by means of comparison and identification of benchmark profits.[51] From an investor's point of view, this method is helpful because it provides insight into the resale value of a patent.[52] This method helps the investor understand the value a patent license could have in the market rather than

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[42] Dubiansky, *supra* note 14, at 174.

[43] Mohan Rao, *Valuing Intellectual Property in Licensing Transactions*, LICENSING J., June–July 2008, at 20, 24.

[44] *Id.*

[45] Dubiansky, *supra* note 14, at 175.

[46] *Id.*

[47] *Id.*

[48] Monte Carlo simulations are algorithms that use repeated random sampling to generate numerical results; they are not widely appropriate for patent valuation procedures. For an explanation of Monte Carlo simulations and how they can be used to distort the value of IP, see Patrina Ozurumba, *Information* Under-*Load: Rethinking IP Valuation in the Context of U.S. Securities Regulation*, 19 J. L. BUS. & ETHICS 89, 95–96 (2013).

[49] *See, e.g.*, Paul Flignor & David Orozco, *Intangible Asset & Intellectual Property Valuation: A Multidisciplinary Perspective*, WORLD INTELL. PROP. ORG. 14 (June 2006), http://www.wipo.int /export/sites/www/sme/en/documents/pdf/IP_Valuation.pdf (cautioning use of real option options approach).

[50] Dubiansky, *supra* note 14, at 173–74.

[51] *See* GORDON V. SMITH & RUSSELL L. PARR, VALUATION OF INTELLECTUAL PROPERTY AND INTANGIBLE ASSETS 243–44 (3rd ed. 2000) (defining benchmark profits between an enhanced product and a commodity product).

[52] Dubiansky, *supra* note 14, at 174.

what the underlying technology's potential future cash flows could be.[53] In doing so, the relief-from-royalty approach looks at a patent asset as if it were a piece of machinery or other service equipment being put on the market.[54] This approach has its shortcomings because it is usually hard to find comparable royalty rates for similar patented technology.[55]

The market approach determines patent value using a benchmark method. By identifying comparable licensing transactions in a given technology field, this approach allows for the estimation of royalty rates that can be used to determine the commercial value of patents.[56] This method involves an understanding of evolving technology trends and a grasp of the transaction value of patents in this field.[57] In theory, the market approach is very appealing; however, in practice, opaque and non-transparent licensing markets seriously hamper it.[58] Identifying comparable licensing transactions requires substantial knowledge of licensing markets in a given technology field.[59] Several databases have been established in this regard.[60] However, the very nature of bilateral licensing transactions makes it difficult to get an in-depth understanding of the features and volume of current deals.[61] Another shortcoming of this method is that it assumes that the market is best to determine value.

The cost method gives insights into how difficult it could be for competitors to invent around the startup's patents.[62] This approach tends to be relatively conservative in nature.[63] By looking at historic costs associated with creating the underlying invention, the cost method captures the sunk costs associated with patent creation.[64] This method factors in opportunity costs associated with potential delays and risks associated with the failure of replication.[65] In doing so, the cost method looks at historic costs and therefore avoids speculation.[66] This approach is most commonly used for accounting purposes. The cost approach has a couple of shortcomings as well. The value of a patent is more than the sum of its parts. In the

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53 *Id.*

54 *Id.*

55 *See* Ozurumba, *supra* note 48, at 94 (criticizing the market-based approach due to the inaccuracy of IP valuations based on rumors or distinct pieces of IP).

56 Dubiansky, *supra* note 14, at 174; Kelley, *supra* note 18, at 124 n.56.

57 Dubiansky, *supra* note 14, at 174–75.

58 *Id.*

59 *Id.*

60 *See generally* THOMSON REUTERS, 2012 STATE OF INNOVATION 3–4 (2013) (utilizing the Derwent World Patents Index database), *available at* http://img.en25.com/Web/ThomsonReutersScience/1002126.pdf.

61 Dubiansky, *supra* note 14, at 174–75.

62 *See* Rao, *supra* note 43, at 21 (discussing the cost approach in the context of patent licensing).

63 *See generally* Ghafele, Gibert & Malackowski, *supra* note 41, at 128 (discussing the cost approach in reference to unit license right (ULR) contracts).

64 Dubiansky, *supra* note 14, at 174.

65 Weston Anson, David Noble & Jemma Samala, *IP Valuation: What Methods Are Used to Value Intellectual Property and Intangible Assets?*, LICENSING J., Feb. 2014, at 1, 3.

66 *See id.* at 2 (noting that the cost method can utilize hard, soft, and market historical costs).

absence of adequate ways to invent around a patent and of determining opportunity costs, the backward-looking nature of the historic-cost approach may not allow one to capture the dynamic opportunities and risks associated with patent ownership.[67]

V. Case Study of Ambature

A. The Technology Sector: High-Temperature Superconductivity

Ambature, which engages in the R&D of HTS and extremely low resistance (ELR) materials, filed the pending patents valued in this study. Ambature seeks to modify existing high-temperature superconducting materials such that zero to low electrical resistance is achieved at a temperature close to room temperature.[68] This is groundbreaking research that has the potential to substantially transform the current functioning of a range of markets. Ambature focuses most of its research efforts on A-axis thin films because it believes this is essential to creating the effect of HTS and ELR on materials. These films are characterized by growing vertically along the A-axis, which leads to the ability to execute certain additional important applications. The synthetic material that Ambature seeks to develop could be used as a substitute for a range of materials in existing commercial applications and could bring products and services to market that currently do not exist.

The firm describes itself as "an advanced materials, technology development, and intellectual property licensing company."[69] Ambature's technical implementations include extremely low resistance nanowires, inductors, capacitors, transistors, rotating machines, bearing assemblies, transformers, power transmission components, fault current limiters, magnetic resonance imaging (MRI) components, Josephson junctions, quantum interference devices, antennas, filters, sensors, actuators, interconnects for system in package (SIP) applications, interconnects for micro-electromechanical systems (MEMS), interconnects for radio frequency (RF) circuits, integrated circuit devices, and energy storage devices.[70]

As of August 31, 2014, Ambature has received $15,759,722 in funding, mainly from high net worth individuals.[71] Ambature's technology development is done within the facilities of Arizona State University (ASU), which is one of the few universities that possess the necessary physical infrastructure to undertake such research. A short overview of the technology field in which the firm operates helps to understand the transformative value of this type of R&D and thus contributes to determining the value of this firm, whose business model is primarily patent driven.

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67 *See* Rao, *supra* note 43, at 22 (discussing the drawbacks of the cost approach).
68 Ambature, Inc., Ambature Business Plan 4 (Apr. 2011) (confidential and proprietary) (on file with author).
69 *Id.*
70 U.S. Patent Application No. PCT/US2012/031554, at 1–2 (filed Mar. 30, 2012) (published as WO 2012/135683 A1).
71 Balance Sheet for Ambature, Inc. (Aug. 31, 2014) (confidential) (on file with author).

B. Superconductivity: Potentially a Game Changer

Superconductivity is a quantum mechanical phenomenon characterized by zero electrical resistance as a current flows through a material at certain temperatures.[72] Superconductive materials also expulse magnetic fields when cooled below a characteristic temperature.[73] Over one hundred years ago, Dutch physicist Heike Kamerlingh Onnes discovered that the electrical resistivity of metallic conductors decreases as the temperature is lowered, and, that at the same time, the conductivity of the conductors becomes infinite.[74] Onnes received the Nobel Prize in Physics in 1913 for his work in this area.[75] Since then, major scientific progress has been made, and, in 2009, a superconducting material operating at -2°F was put forward for the first time.[76]

In spite of these important scientific advances, there is still some way to go before superconductivity can be commercially applied on a large scale. This is because existing commercial applications of superconductivity depend to a large extent on expensive cooling systems, which are neither environmentally friendly nor commercially attractive in the long run.[77] Thus, the major challenge remaining is to identify and modify superconducting materials such that zero to low resistance is achieved at close to room temperature.[78] Should this major breakthrough be achieved on a large-scale commercial basis, this technology has the potential to fundamentally transform energy markets, as well as a range of other markets such as cell networks, quantum computing, sensor technology, and medical imaging.[79] Superconductors offer a series of advantages over ordinary conductors. Because of minimal energy losses, superconductors are energy and cost efficient.[80] This technology also helps reduce the size and weight of motors, generators, and supporting equipment.[81] Because of their superior electrical performance and lower power consumption, superconductors can also overcome shortcomings of silicon-based electronics.[82] In addition, they operate as sensors with close to zero noise.[83]

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[72] J. C. GALLOP, SQUIDS, THE JOSEPHSON EFFECTS AND SUPERCONDUCTING ELECTRONICS 3, 8 (1991).

[73] *Id.* at 3.

[74] Dirk van Delft & Peter Kes, *The Discovery of Superconductivity*, PHYSICS TODAY, Sept. 2010, at 38, 38.

[75] *The Nobel Prize in Physics 1913*, NOBELPRIZE.ORG (last visited Oct. 26, 2014), http://www.nobelprize.org/nobel_prizes/physics/laureates/1913/.

[76] *See* ANDREW MCWILLIAMS, BCC RESEARCH, SUPERCONDUCTORS: TECHNOLOGIES AND GLOBAL MARKETS 12–14 (2014) (discussing the history of superconductivity) [hereinafter MCWILLIAMS (2014)].

[77] *See* ANDREW MCWILLIAMS, BCC RESEARCH, SUPERCONDUCTORS: TECHNOLOGIES AND GLOBAL MARKETS 7 (2008) (explaining the impracticality of superconductor cooling requirements) [hereinafter MCWILLIAMS (2008)].

[78] *See* MCWILLIAMS (2014), *supra* note 76, at 15–16 (discussing the limitations of superconductors).

[79] *See id.* at 18–19 tbl.1 (listing the major applications and end uses of superconductors).

[80] *Id.* at 14.

[81] *Id.* at 15.

[82] *Id.*

Despite their advantages, superconductors also suffer from a range of limitations. These include their existing low temperature requirements, brittleness, and sensitivity to changing magnetic fields.[84]

VI. Ambature's Patent Strategy

While Ambature plans to produce commercial materials that exhibit low resistance at close to room temperature, it does not seek to bring products to market by itself.[85] Instead, it seeks to license its portfolio of issued and currently pending patents to corporations that have the necessary means to bring the technology to market.[86] By initially identifying one single strategic partner who can bring the technology to market per technology field, Ambature can tap into the advantages that big corporations bring to the table and thus realize many of the management tactics proposed by "open innovation."[87] Large firms can exploit innovative technology on a greater scale and thus derive considerable value from it due to their access to complementary assets necessary for the distribution, marketing, and manufacturing of products.[88]

Ambature need not have all these complementary assets itself. By entering into strategic partnerships, it can significantly reduce its cost structure and rely on its patents as a medium of exchange.[89] As a firm specialized in "exploration," Ambature can license its patents to corporations that benefit from the economies of scale necessary to efficiently exploit them.[90] The out-licensing of patent rights can also maximize profits, while optimizing R&D costs.[91] It can spur the efficient utilization of R&D output beyond the scope of core business and permit the sharing of risks associated with R&D investment.[92] Out-sourcing also gives Ambature, a startup firm, a chance to enhance its reputation while field-of-use restrictions of

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83 *See id.* at 31 (noting, for example, that superconducting quantum interference devices, or SQUIDs, are utilized in extremely sensitive microscopes "allowing for the study of properties of matter that cannot otherwise be observed").

84 MCWILLIAMS (2014), *supra* note 76, at 15.

85 Ambature Business Plan, *supra* note 68, at 4, 9.

86 *Id.*

87 *See* Henry Chesbrough & Roya Ghafele, *Open Innovation and Intellectual Property: A Two-Sided Market Perspective*, *in* NEW FRONTIERS IN OPEN INNOVATION 191, 204–06 (Henry Chesbrough, Wim Vanhaverbeke & Joel West eds., 2014) (suggesting that open innovation can enable intellectual-property assets to be traded to transfer technology and to share ideas).

88 Ashish Arora, Andrea Fosfuri & Alfonso Gambardella, *Markets for Technology and Their Implications for Corporate Strategy*, 10 INDUS. & CORP. CHANGE 419, 427–28 (2001).

89 *See, e.g.*, *id.* at 439–40 (noting that Cambridge Display Technologies "entered into licensing and co-development and manufacturing deals with companies like Philips Electronics, Seiko-Epson, Hoechst and DuPont").

90 *See id.* at 437, 441 (discussing the suitability of "exploitation" and "exploration" for large and small firms).

91 *See e.g.*, *id.* at 436–37 (illustrating the profit and cost optimization using Dow Chemical's reorganization in 1994, which significantly grew patent licensing revenues while reducing R&D costs).

92 *See id.* at 434–37 (discussing the licensing effect on R&D for several large companies); Dubiansky, *supra* note 14, at 183 (discussing the technical risks associated with R&D projects).

licensing agreements assure avoidance of target market-share dilution.[93] The philosophy behind Ambature's patent engine is to develop a portfolio that is difficult to invent around and easy to license because of the value added by the licensor.[94]

Key executives of Ambature can look back at over two decades of experience in IP licensing and litigation,[95] which bears the advantage of a strong track record in negotiating licensing agreements. Senior management of the firm also have an extensive network of potential licensees.[96]

While Ambature prefers to license its IP on amiable terms, it has developed two strategies to manage its costs and inherent risk for patent enforcement. The first strategy is to obtain IP infringement insurance, and the second strategy is to establish relationships with other IP licensing firms that will enforce Ambature's patents at the IP licensing firm's cost. These firms do this as part of their business model in exchange for a share of the litigation proceeds.[97] The latter decision to engage with patent assertion entities is driven by cost because recruiting in-house and outside counsel is expensive, particularly in light of an expensive process and uncertain outcome.[98] The drawback of this tactic is that patent assertion entities keep a significant portion of licensing fees and are, by and large, viewed as problematic.[99] The political debate on the harmful role of patent assertion entities is self-explanatory in this regard.

A. Bilateral Licensing Markets Limit Ambature

As a licensing company, Ambature will be pursuing a bilateral licensing model, which is the traditional model for the transfer of patent rights.[100] The bilateral licensing model is, however, shackled with transaction costs, which can occasionally be so high that they mitigate the entire value that could potentially be generated.[101] This model is thus frequently cited as an inefficient means of extracting value from technology.[102]

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93 *See* David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285, 290 (1986) (discussing the use of contractual relationships by small companies for name recognition and reputation benefits).

94 Ambature Business Plan, *supra* note 68, at 9.

95 *Id.* at 5–6.

96 *Id.*

97 Graham & Sichelman, *supra* note 12, at 1076.

98 *See* Kelley, *supra* note 18, at 119 (discussing patent assertion firms and their motivations).

99 *See* Graham & Sichelman, *supra* note 12, at 1064–65, 1076 (discussing the tactics of "patent trolls").

100 *See* Ashish Arora & Andrea Fosfuri, *Licensing the Market for Technology*, 52 J. ECON. BEHAV. & ORG. 277, 277–78 (2003) (discussing the role of licensing in the technology industry).

101 *See* Dubiansky, *supra* note 14, at 188 ("There is potential risk of patent illiquidity due to the high transaction costs of a licensing deal.").

102 *See, e.g.*, Arora & Fosfuri, *supra* note 100, at 278–79 (discussing the inefficiencies and potential adverse effects of licensing activity).

All licensing deals are the result of "one-off" negotiations, essentially forcing parties to repeatedly go into enormous detail over every facet of the bargain in every licensing transaction.[103] Ambature's licensing model will thus be hindered by the current licensing market structure, which is characterized by serious market shortcomings. The clandestine dynamics of these bilateral licensing transactions hinder Ambature, just like other market participants, from transferring its patent rights in a quick and easy way, effectively limiting the acceleration of technology commercialization.[104] A too-intense collaboration with non-assertion entities may also expose the firm to a host of international criticism associated with these types of corporations.[105]

VII. Ambature's Patent Portfolio

Ambature has filed patents for what may be considered transformative technology. Most importantly, its A-axis thin film technology constitutes a novel approach to creating high-temperature superconductors.[106] The firm is currently in the process of testing to what extents its materials can be used to achieve a superconducting effect at close to room temperature with lower rates of resistance.

At the time of this writing, Ambature's patent portfolio comprises 171 issued and pending patents that cover a significant portion of the emerging superconducting sector.[107] These patents were analysed for this study, although focus is given to a 700-page Patent Cooperation Treaty (PCT) patent, number WO 2012/135683 A1.

VIII. Market Factors

With nascent technologies, there is always some uncertainty in projecting how soon and how extensively a technology will impact the marketplace.[108] One way to assess the market impact of a nascent technology is to compare the projections of various financial analysts, which offer higher confidence in determining how the technology market will develop. The analysts, BCC Research,[109] Mulholland,[110]

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103 *See* Dubiansky, *supra* note 14, at 188–89 (explaining why transaction costs can contribute to the illiquidity of patents).

104 *See* McClure, *supra* note 13, at 14, 18–19 (discussing the limitations of the current IP market and the need for increased transparency).

105 *See supra* notes 97–99 and accompanying text.

106 *See* U.S. Patent Application No. PCT/US2012/031554 (filed Mar. 30, 2012) (published as WO 2012/135683 A1).

107 Ambature's patent portfolio currently comprises 165 provisional applications (published in PCT application WO 2012/135683 A1), 5 granted patents, 9 pending utility applications, and additional pending international applications (information correct as of Oct. 15, 2014).

108 *See supra* note 29 and accompanying text.

109 *See* ANDREW MCWILLIAMS, BCC RESEARCH, SUPERCONDUCTORS: TECHNOLOGIES AND GLOBAL MARKETS 3 (2012) ("BCC Research has been tracking new developments in superconductivity since the publication of its first study of the superconductor industry over 10 years ago.") [hereinafter MCWILLIAMS (2012)].

110 *See* JOSEPH MULHOLLAND, THOMAS P. SHEAHEN & BEN MCCONNELL, ANALYSIS OF FUTURE PRICES AND MARKETS FOR HIGH TEMPERATURE SUPERCONDUCTORS, *available at* http://web.ornl.gov

and Global Industry Analysts,[111] primarily study superconductor markets. Table 1 below shows that analyst expectations for superconductor markets are relatively consistent. Interestingly, two consistent reports from the same analyst vary, with the later report being significantly more conservative on the market capture potential.[112] This seems to indicate a confidence that the technology will bring about a fundamental change but with greater realism as to the initial pace of adoption.

For the purpose of this valuation, this study relied on the figures of BCC[113] because its projections were the most conservative. In using the projections from the most conservative analyst report,[114] the risk from alternative, non-superconducting technologies is effectively eliminated because it is not included in the BCC projections.

According to BCC, the superconductor market is expected to grow from the current level of approximately $2 billion to $3.3 billion in 2017.[115] A conservative extrapolation of this projection gives a market size estimate of $8 billion by 2032, when the patents under investigation here will expire.[116] Table 1 below shows the analyst projections for the various sub-segments of the market for superconductors over the next ten years. Analyst projections show significant early growth in the field of superconducting magnets, particularly in health care (for MRIs) and "science, research, and technology development" (for particle accelerators and detectors).[117] The projections also show important growth from a low base for superconducting current leads and for superconducting RF/microwave filters (for use in cell towers).[118]

A. Ambature's Share of the Market for Superconductivity

Obviously, the share of the market that can be grasped by Ambature is not equal to the total market size for superconductivity. Rather, its market opportunity constitutes only that fraction of the HTS technology sector that can be obtained by licensing its patents. In claiming its share of the market, Ambature will be

/sci/htsc/documents/pdf/Mulholland%20Report%20063003.pdf (discussing high temperature superconductors and their impact on the national electrical system for the next 25 years).

111 *See* GLOBAL INDUS. ANALYSTS, INC., SUPERCONDUCTORS—A GLOBAL STRATEGIC BUSINESS REPORT (2014), *available at* http://www.strategyr.com/Superconductors_Super_Conductors_Market_Report.asp.

112 *Compare* MCWILLIAMS (2008), *supra* note 77, at 35 (anticipating a compound annual growth rate of 13.9% for 2008–2013), *with* MCWILLIAMS (2012), *supra* note 109, at 37 (anticipating a compound annual growth rate of 12.6% for 2012–2017).

113 MCWILLIAMS (2012), *supra* note 109.

114 *Id.*

115 *Id.* at 37.

116 *See infra* Table 1.

117 *See* MCWILLIAMS (2012), *supra* note 109, at 65–66 (predicting a compound annual growth rate of 3.6% for magnets used in health care and 7.5% for magnets used in science, research, and technology development).

118 *See id.* at 129, 147–48 (predicting a compound annual growth rate of 21.1% for current leads and 4.6% for RF/microwave filters).

constrained by competition, the bargaining power of potential licensors, and transaction costs associated with licensing arrangements.[119]

The value of Ambature's patent portfolio is furthermore influenced by external factors such as population growth and the demand for electricity, the costs of electricity and energy, and interest rates, which can be derived from fixed income futures. On the basis of this information, a weighted average of these various means of assessing the startup's share of the market was calculated.[120] This combination of approaches assesses patent value beyond its legal and scientific scope and captures its economic value. The quantitative approach now presented was supplemented in the previous sections by a qualitative assessment of the firm's internal capability to take advantage of this market opportunity. In this way, the valuation model pays justice to theorists of the resource-based view of the firm.[121]

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119 *See* McClure, *supra* note 13, at 19 (discussing various potential difficulties in IP licensing).
120 *See infra* Table 3 (listing Ambature's weighted average share as 25.8%).
121 *See supra* notes 33–38 and accompanying text.

Table 1: Comparison of Analyst Outlooks on Superconductor Markets[122]

Markets for Superconducting Technologies												
$ Millions												
SC RF/microwave filters	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Rev	23.343	23.355	23.367	23.378	23.39	23.401	23.413	23.425	23.436	23.44790454	23.46	23.4711
Utility Patent Distribution							8,830	2845	48%	8094033		
Mullholland, 2006*							4,077	-1908	-32%	3638774	*Interpolated	
BCC, 2008							7,705	1720	29%	2957554		
BCC, 2012							3,328	-2657	-44%	7060704		
							23940	17955		21751065	5E+06	2332
Average							**5,985**	2693	Standard Deviation			45%
BCC Superconducting Market Projections (McKenzie, 2012)							**Actual Data**		**Interpolated Data**			
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Global Market for Superconductivity Applications												
Superconducting magnets	1,633	1,798	1,891	1,990	2,093	2,202	2,319	2,440	2,567	2,700	2,841	2,988
Superconducting transforme	-	-					60	63	67	71	76	81
Superconducting electric ge	-	-					19	20	21	22	24	25
Superconducting electric mc	-						94	99	106	112	119	127
FCLs (Fault Current Limiters)	-						400	425	452	480	511	543
Superconducting power sto	Neg.	Neg.					80	85	90	96	102	109
Superconducting current lea	25	27	33	39	48	58	70	85	103	124	151	182
Superconducting wire and c	-	-					199	211	224	239	254	270
Superconducting ICs	1	1					74	79	84	89	94	100
Superconducting RF/microw	5	5	5	6	6	6	7	7	7	7	8	8
SQUIDs	5	5	6	6	7	7	7	7	8	8	9	10
Total	**1,669**	**1,836**	**1,935**	**2,041**	**2,154**	**2,274**	**3,326**	**3,521**	**3,728**	**3,950**	**4,188**	**4,443**
Global Market by End Use												
Health care	1,072	1,099	1,144	1,191	1,240	1,291	1,347					
Science, research, and techr	589	730	784	843	907	974	1,049	1,128	1,212	1,303	1,401	1,506
Communications	5	5	8	12	19	28	44	67	102	155	238	364
Electric utilities	-	-					593					
Computing	-	-					35					
Transport	-	-					148					
Military/defense	-	-					5					
Other	2	2	4	10	22	49	109	242	538	1,196	2,659	5,914
Total	**1,668**	**1,836**	**1,941**	**2,057**	**2,187**	**2,343**	**3,328**	3,328	3,328	3,328	3,328	3,328
Global Market Superconducting Materials			-	-	-	-						
Low-temperature (niobium	324	354	370	386	404	422	442	462	482	504	527	551
High-temperature (MgB2, YE	9	12	24	48	95	187	370	731	1,443	2,850	5,630	11,118
Total	**334**	**366**	429	504	591	693	**812**	952	1,117	1,310	1,537	1,803
	0	0	0	0	0	0	1	1	1	1	1	1
Superconducting Material in Magnetic Appli			-	-	-	-						
Type of Application			-	-	-	-						
Low-temperature (niobium	324	354	367	381	395	410	426	442	459	476	494	513
High-temperature (MgB2, YE	3	7	9	14	19	28	40	57	81	116	166	238
Totals	**327**	**360**	**376**	**394**	**415**	**438**	**465**	**498**	**540**	**592**	**660**	**750**
HTS/LTS Ratio	1.05%	1.87%	3.35%	4.84%	6.33%	7.82%	9.30%	10.79%	12.28%	13.77%	15.25%	16.74%

122 Table created using data from McWILLIAMS (2012), *supra* note 109, and Mulholland et al., *supra* note 110.

Table 1, Continued

Markets for Superconducting Technologies													
$ Millions													
SC RF/microwave filters	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	
Rev	23.4827	23.494	23.5059	23.51755	23.52916	23.540768	23.5523754	23.5639833	23.575591	23.587199	23.5988069	23.61041477	
Utility Patent Distribution	Market predictions for 2017 from various analysts were compared (in one case interpolating data)												
Mullholland, 2006*	Given the normal range of market projections in high tech areas these are all close to being within												
BCC, 2008	one standard deviation. We will use the lowest to be most conservative but do so confident that the												
BCC, 2012	market will achieve something closer to the mean of these projections (60% higher)												
Average	Relative Standard Deviation												
BCC Superconducting Market Projections (McKenzie, 2012)													
	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**CAGR%**
Global Market for Superconductivity Applications													
Superconducting magnets	3,144	3,307	3,479	3,660	3,850	4,051	4,261	4,483	4,716	4,961	5,219	5,490	5.2%
Superconducting transformers	86	91	97	103	110	117	124	132	140	149	158	168	6.3%
Superconducting electric generators	27	28	30	32	34	36	39	41	44	46	49	52	6.3%
Superconducting electric motors	135	143	152	162	172	183	195	207	220	234	249	264	6.3%
FCLs (Fault Current Limiters)	577	613	652	693	737	783	833	885	941	1,000	1,063	1,130	6.3%
Superconducting power storage	115	123	130	139	147	157	167	177	188	200	213	226	6.3%
Superconducting current leads	221	267	324	392	475	575	696	843	1,021	1,237	1,498	1,814	21.1%
Superconducting wire and cable	287	305	324	344	366	389	413	439	467	497	528	561	6.3%
Superconducting ICs	107	113	121	128	136	145	154	164	174	185	197	209	6.3%
Superconducting RF/microwave filters	9	9	9	10	10	11	11	12	12	13	13	14	4.6%
SQUIDs	11	12	13	14	16	17	18	20	22	24	26	29	9.1%
Total	**4,717**	**5,013**	**5,332**	**5,678**	**6,053**	**6,463**	**6,911**	**7,403**	**7,945**	**8,545**	**9,212**	**9,957**	**6.3%**
Global Market by End Use													***Av. 3 lowest CAGR's**
Health care													4.1%
Science, research, and technology development	1,619	1,741	1,871	2,012	2,162	2,325	2,499	2,686	2,888	3,104	3,337	3,588	7.5%
Communications	556	850	1,299	1,987	3,038	4,645	7,102	10,859	16,603	25,386	38,816	59,349	52.9%
Electric utilities													-
Computing													-
Transport													-
Military/defense													-
Other	13,153	29,253	65,059	144,691	321,794	715,669	1,591,648	3,539,824	7,872,570	17,508,595	38,939,114	86,600,591	122.4%
Total	3,328	3,328	3,328	3,328	3,328	3,328	3,328	3,328	3,328	3,328	3,328	3,328	
Global Market Superconducting Materials													
Low-temperature (niobium alloys)	575	601	628	657	686	717	749	783	818	855	893	934	4.5%
High-temperature (MgB2, YBCO)	21,959	43,368	85,652	169,163	334,097	659,842	1,303,188	2,573,795	5,083,246	10,039,411	19,827,836	39,159,977	97.5%
Total	2,115	2,480	2,910	3,413	4,003	4,696	5,508	6,461	7,579	8,890	10,428	12,233	**17.3%**
	1	1	1	1	1	1	1	1	1	1	1	1	
Superconducting Material in Magnetic Application													
Type of Application													
Low-temperature (niobium alloys)	532	553	574	595	618	641	666	691	717	745	773	802	3.8%
High-temperature (MgB2, YBCO) 3.4 6.6 39.6 43.1	340	487	696	996	1,426	2,040	2,920	4,178	5,979	8,556	12,244	17,521	43.1%
Totals	**872**	**1,039**	**1,270**	**1,592**	**2,044**	**2,682**	**3,586**	**4,870**	**6,697**	**9,301**	**13,017**	**18,324**	
HTS/LTS Ratio	18.23%	19.72%	21.21%	22.69%	24.18%	25.67%	27.16%	28.64%	30.13%	31.62%	33.11%	34.59%	

1. Royalty Rates

This study considers potential revenues from the out-licensing of elements of the portfolio for contemplated products and seeks comparable transactions to estimate likely terms. Since there are very few licensing transactions in the field of superconductivity,[123] licensing rates typical of the sectors where this technology could be applied were studied. Market value is estimated by assigning the typical royalty rates used in different markets to the number of products actually sold. Our internal analysis suggests that the average royalty rate for superconductivity technologies was around 3.5%.[124] The typical royalty rate in industries where this technology could be applied was about 5.3%.[125] As an additional check, the typical royalty rates used in the primary industries impacted by Ambature's technologies were also reviewed. These rates were consistent with the data discussed above and thus help justify the royalty rates used in this patent valuation.

2. Patent Intensity

A search of the patents filed with the United States Patent and Trademark Office (USPTO) over the last ten years in the area of HTS shows that Ambature owns over 50% of the patents issued or filed in this space.[126] Other patent offices are not included since every major development will involve filing with the USPTO either directly or through the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO). This is a very conservative approach; we do not attempt to include any 2013 revenues and almost none in 2014 in our analysis because some patents will presumably be granted during 2014. However, with their delay in funding, that may not be the case now.

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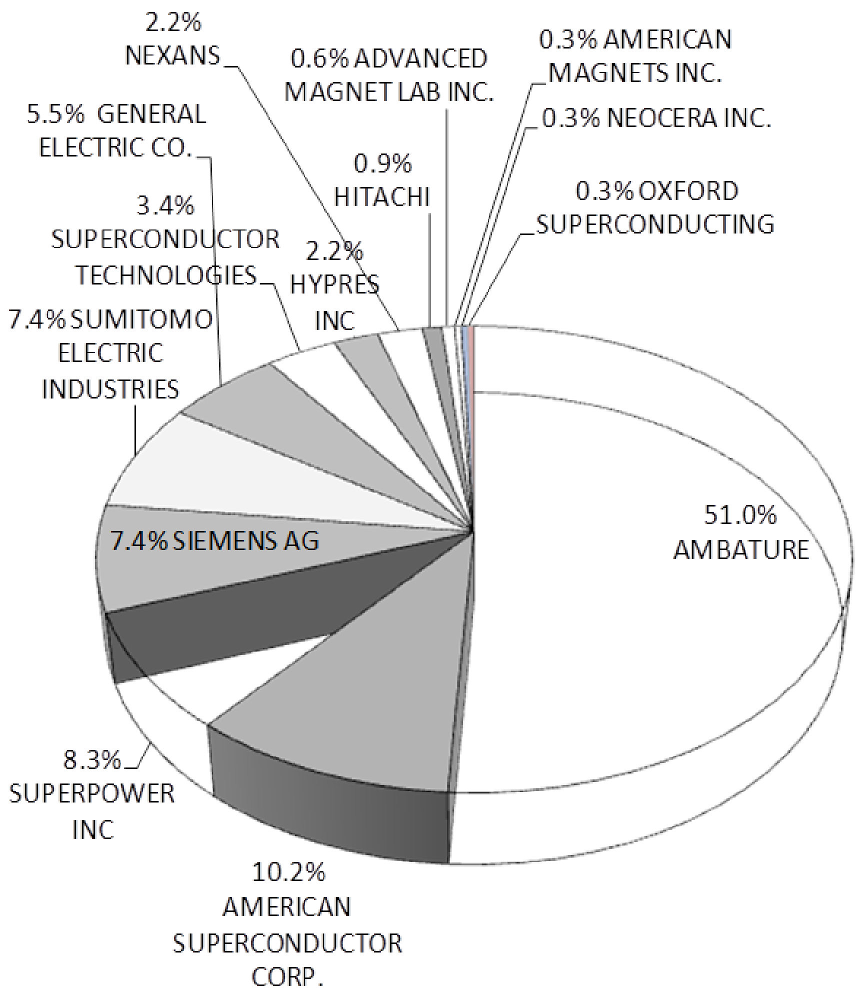
[123] *See* Kelley, *supra* note 18, at 135–36 (observing that licensing agreements are often confidential and require consent prior to disclosure, which is difficult and not feasible on a large scale). For an overview of the wide range of applications for superconductivity, see MCWILLIAMS (2008), *supra* note 77, at 10.

[124] Internal Estimate by Oxfirst (confidential and proprietary) (on file with author).

[125] *Id.*

[126] *See infra* Table 2 (listing the number of high-temperature superconductivity patents held per company).

Table 2: Comparison of HTS Patent Share for Major Industry Players[127]



Ambature's high share of HTS patents derives not just from a solid team of inventors—the lead inventor was ranked 8th among the one hundred top inventors worldwide[128]—but also from the efficiency with which the IP has been harvested. Ambature's process includes gathering the R&D team for extensive meetings, during which all of the team's progress, ideas, technical breakthroughs, including theoretical future possibilities, are carefully documented. Priority is then

[127] Table created using data from *USPTO Patent Full-Text and Image Database*, U.S. PAT. & TRADEMARK OFF., http://patft.uspto.gov/netahtml/PTO/search-adv.htm (enter in "Query" box: (spec/(hts AND superconduct$) AND (ISD/20050101->20141231) AND an/"[*company name*]") (last visited Oct. 15, 2014).

[128] *Top Inventors for Class "Superconductor Technology: Apparatus, Material, Process,"* PATENTDOCS, http://www.faqs.org/patents/top/top-inventors-class-000325329/ (last visited Oct. 15, 2014).

established with a provisional application that is subsequently converted into a patent application.[129] As a result of this process, there is a breadth to Ambature's prospective patent portfolio that makes a range of potential licenses quite probable. This includes potential licenses for the superconducting material itself, the manufacture of the material, the arrangement of the material in coils or lattices, and the transmission of power to and from a device.

3. Patent Claims Analysis

The claims in Ambature's patents cover every currently contemplated aspect of superconductivity, including the materials, the manufacturing processes, and the products incorporating superconducting technology.[130] Some of these claims are very broad, such as the claims for computing, electrical, and mechanical devices, each of which comprises "a component formed at least in part of an extremely low resistance (ELR) material, the ELR material operating in an ELR state at temperatures greater than 150K."[131] A claim's analysis shows that the number of claims in Ambature's patents is above the industry average. Ambature has an average of over 21 claims per patent, whereas the industry average is approximately 17.[132] The median for Ambature is 22 claims per patent compared to an industry median of 16 claims per patent.[133] Table 3 below also compares the number of patents Ambature owns in HTS and ELR materials with the industry average over the last ten years.

[129] *See* 37 C.F.R. § 1.53(c) (2014) (stating the requirements for a provisional application).
[130] *See* MCWILLIAMS (2008), *supra* note 77, at 10 (listing major applications of superconductivity).
[131] U.S. Patent Application No. PCT/US2012/031554, at 395 (filed Mar. 30, 2012) (published as WO 2012/135683 A1).
[132] Dennis Crouch, *Claims in Issued Patents*, PATENTLY-O (Feb. 22, 2013), http://patentlyo.com/patent/2013/02/claims-in-issued-patents.html.
[133] *Id.*

Table 3: Benchmark of Ambature's Patents Claims Against Industry Average[134]

Quantitative Comparison

	Patents	**Ambature Share**	**Weight**
No. of Ambature Superconducting Patents 2014	171		
No. of ELR Patents Dec. 2013	3		
No. of ELR Patents Dec. 2014	3.1	98.2%	0.0%
No. HTS Patents 2013	1,033		
No. HTS Patents 2014	1,068	16.0%	70.0%
No. Ambature HTS Patents Pending & Issued	171	16.0%	
No. of HTS Patents Applied for in Last Ten Years	356		
No. of HTS Patents Applied for in Last Ten Years in 2014	368	46.5%	15.0%
No. HTS Patents Excluding Those Licensed by Ambature	1		
Ambature Share of Major AC Player Patents	171/334	51.0%	15.0%
Weighted Average Ambature Share		**25.8%**	

Claims	**Average**	**Median**
Industry	17	16
Ambature	21	22
% Difference	**26%**	**38%**

[134] Table created using data from Crouch, *supra* note 132, and U.S. PAT. & TRADEMARK OFF., *supra* note 127.

B. How these Market Insights Inform the Income Method

Table 4: Market Insights Gained[135]

Two Year Patent Growth (Derwent, 2012)		**Ambature share of HTS Market (Analyst Reports)**		**Weighting Coefficients (Share)**		
Telecom	7.50%	Share Traditional 2013 Market (Narliker, 2004)	2.1%	ELR Share		0%
Semiconductors	-2.80%	HTS Share of LTS and HTS	9.3%	HTS Share		70%
Medical Devices	15.70%	Tech share of Superconductivity market (McKenzie,2011	20.0%	Recent (10yr) HTS Share		15%
Average 1 year	3.40%	Licensing share of Tech Share of SC market	25.0%	% Major SC Players		15%
		Amb. share of high tech HTS licensing (USPTO)	25.8%			
Predicated on:		Licensing share of SC market (IPTechex, 2013)	4.3%	**Licensing Expenses**		
*Ambature acquires sufficient funding to add all claims		**Ambature share of HTS Market**	**1.1%**	Brokerage Fee (Hutter, 2009)		22%
*DOE maintains HTS support at current levels						

Based on these insights, Ambature's share of the HTS market can be predicted. This study conservatively estimates Ambature's share to be not more than 1.1% of the total market. This figure derives from the size of the HTS market as estimated by analysts, as well as from the licensing revenues that Ambature can expect to obtain in this market. The latter, as previously discussed, was derived from the patent data accumulated from the USPTO (claim's analysis, claim's intensity, and subject matter of the claims), as well as from Derwent's outlook on the two-year patent growth in the sectors where Ambature is most likely to close licensing deals.[136]

The respective metrics are shown in Table 4 above. Because Ambature is a startup active in a nascent technology field, it is not possible to substantiate the weighting coefficients used with solid data. While this may not seem very rigid, it is preferable to a typical practitioner's process, which only uses one single method. Using a range of different coefficients allows for errors inherent in each approach to be minimized.

To allow for the costs of monetizing the portfolio, it is assumed that it will be monetized through a patent broker, and that a fee of 22% will be charged. This fee is justified with reference to major patent brokers, which charge about 25%.[137] Because of the size of the portfolio, it is very likely that Ambature will obtain a discount of at least 3%.[138] Again, this is a conservative assumption because the company could likely license its own technology more efficiently and with lower

135 Table created using data from Ole Tonnesen & Jacob Ostergaard, *High Temperature Superconducting Cables*, *in* HIGH TEMPERATURE SUPERCONDUCTIVITY 2: ENGINEERING APPLICATIONS 537, 563 (Anant V. Narlikar ed., 2004); MCWILLIAMS (2012), *supra* note 109; MULHOLLAND ET AL., *supra* note 110; THOMSON REUTERS, *supra* note 60, at 5; IP Landscaping, IP TECHNOLOGY EXCHANGE, http://iptechex.net/ip-analytics/; Jackie Hutter, *An Introduction to Patent Monetization Resources for Corporations and Entrepreneurs*, IP ASSET MAXIMIZER BLOG (Mar. 20, 2009), http://ipassetmaximizerblog.com/an-introduction-to-patent-monetization-resources-for-corporations-and-entrepreneurs/; and U.S. PAT. & TRADEMARK OFF., *supra* note 127.

136 *See* discussion *supra* Part VIII.A; THOMSON REUTERS, *supra* note 60, at 5.

137 Hutter, *supra* note 135.

138 This discount percentage is based on confidential internal estimates.

overhead costs. Additionally, a patent broker will most likely offer a greater discount for such a significant portfolio.[139]

C. Determining Value by Income Method

1. Determining the Net Present Value

To determine the net present value, a discount rate must be calculated. This was done by averaging the results of three methods: (1) the weighted average cost of capital (WACC) method, (2) the venture capital (VC) method, and (3) the capital asset pricing model (CAPM) method.[140] As shown in Table 5, each of these was close in estimating the discount rate. The discount rate used in the calculation of the present value assumes a substantial level of risk, which is normally associated with a business venture.

Table 5: Establishment of Underlying Indicators for the Patent Valuation[141]

Overview of Indicators				
Market Risk Premium	15.00%	**WACC (Weighted Average Cost of Capital)**		**Method Weight**
Effective Discount Rate	27.30%	Cost of Equity	15%	
US/ROW ratio	22.45%	Weighting Equity	100%	
		Cost of Debt	0	
Betas		Weighting Debt	0	
Am. Superconductor Corp.	1.3	WACC	15%	
Superconductor Techs. Inc.	1.86	**Risk Adjusted WACC**	**30.00%**	33.3%
Average Beta	**1.58**			
		VC Approach	**35.00%**	33.3%
2013 GDP ($ Trillion)				
World GDP	74.7	**CAPM**		
US GDP	16.8	R_f Risk Free Rate	0.70%	
		β_i	1.58	
Predicated on:		R_m Market Return	11%	
*Ambature acquires sufficient funding to add all claims		**Ri Return on Asset**	**16.97%**	33.3%
*DOE maintains HTS support at current levels				

139 *See* Colleen Chien, *Startups and Patent Trolls*, 17 STAN. TECH. L. REV. 461, 482 (2014) (specifying patent broker fees averaging 15–25%).

140 *See, e.g.*, Eugene F. Fama & Kenneth R. French, *The Capital Asset Pricing Model: Theory and Evidence*, 18 J. ECON. PERSP. 25, 29 (2004) (specifying the equation for CAPM).

141 Table created using data from INTERNATIONAL MONETARY FUND, WORLD ECONOMIC OUTLOOK: LEGACIES, CLOUDS, UNCERTAINTIES (2014), *available at* http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/index.aspx; Pablo Fernandez, Javier Aguirreamalloa & Luis Corres Avendano, *Market Risk Premium Used in 82 Countries in 2012: A Survey with 7,192 Answers* 4 (IESE Bus. Sch., Working Paper No. WP-1059-E, 2013), *available at* http://ssrn.com/abstract=2084213; Murray Z. Frank & Tao Shen, Investment, Q, and the Weighted Average Cost of Capital 5 (Apr. 4, 2012) (unpublished manuscript), *available at* http://cn.ckgsb.com/Userfiles/doc/Investment,%20Q,%20and%20the%20Weighted%20Average%20Cost%20of%20Capital.pdf; *American Superconductor Corp.*, REUTERS.COM, http://www.reuters.com/finance/stocks/overview?symbol=AMSC.O (last visited Jan. 10, 2015); and *Superconductor Technologies Inc.*, REUTERS.COM, http://www.reuters.com/finance/stocks/overview?symbol=SCON.PH (last visited Jan. 10, 2015).

According to Fernandez, Aguirreamalloa, and Avendano, the highest risk premium for the U.S. market in 2012 was 15%.[142] This exceedingly high-risk premium of 15% was used because Ambature is an early-stage company that operates in a nascent technology field. This is a very conservative assumption because Ambature is adopting a pure IP-licensing model of a patent portfolio that is either issued or close to being issued. As such, the business and technology risks reflected in the risk rate are most likely lower. These insights provide an adjusted expectation of the revenues to be expected from the Ambature share of licensing revenues in the HTS field.

2. Patent Value Adjusted by Life Cycle

Ambature's revenue streams can be calculated using an estimate of its market share and by assuming the share will remain constant. The goal is to measure the value of the current portfolio, not the value of the future patent portfolio, which can be expected to grow substantially as the firm continues its research in the area.[143] This is an important distinction, as it is the patent portfolio, not the company that is being valued. One can expect the company to continue to acquire patents, and hence grow in value, but that should not be reflected in this revenue stream, which is only taking anticipated revenues from the current portfolio into consideration.

D. Determining Value by the Cost Method

As the claims in this portfolio are quite broad, current value was determined by considering the costs of creating the portfolio.[144] This provides an indication as to what it may cost someone else to invent around the portfolio. With this method, the value was calculated by taking the total investment in cash or deferred costs and then subtracting the value of the current physical and financial assets, as well as any amortization, although there were none in this case. Following the cost method, the combined cost of the amount of funds invested so far; the accounts payable for asset creation; the expenditures on the research phase plus the accounts payable on research related expenditures; the organizational costs; and the cash the company holds at hand is $21.12 million USD. Thus, the value of the company's portfolio would be around $21 million USD.

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[142] Fernandez, Aguirreamalloa & Avendano, *supra* note 141, at 4.

[143] *See* EVERETT M. ROGERS, DIFFUSION OF INNOVATIONS 300–64 (5th ed. 2003) (describing diffusion networks and how they achieve critical mass as the rate of growth accelerates).

[144] *See infra* Table 6.

Table 6: Costs of Creating the Portfolio[145]

Costs	**Value USD $ Million**
Total Funds Invested So Far	15.6
Accounts payable regarding asset creation	5.44
Organizational & Cash	0.083
Valuation Cost Method	**21.12**

IX. Weighted Average of Patent Valuation Methods

Based on these insights, a weighted average of the distinct valuation methods was calculated to provide insights on the value of the patent portfolio of Ambature.[146] This study estimates the patent portfolio to be worth $124.5 million. It must be noted that the weighting coefficients constitute a value judgment that cannot be justified with a rigorous scientific method due to the absence of data. This is one of the challenges associated with the valuation of early-stage technology firms. In spite of this, the weighing of various methods is indeed preferable to only using one single method, as the use of several weighting coefficients allows one to minimize errors inherent in each individual approach.

Table 7: Patent Value by Weighted Average[147]

Value ($ Million)	**Million**	**Weighting**
Valuation Cost Method	$ 21.12	15%
Income Method informed by Market Insights	$142.8	85%
Value (Weight Adjusted)	$ 124.5	

It is cautioned that the valuation of the patent portfolio is predicated on the assumption that the firm will successfully conclude the prosecution of the pending patents in its portfolio with the patents being granted and most of the claims being accepted by the patent examiner; that the firm will continue to raise the capital needed to find licensees; and that the firm will assert its patents if needed. The weight-adjusted value is also based on the assumption that the firm will continue to have access to its original inventors so as to be able to count on their assistance in implementing technologies and defending its patents. Finally, this valuation also reflects the assumption that it is actually possible to leverage superconductivity at close to room temperature on a commercial basis.

In determining the value of the Ambature portfolio, this study consistently erred on the side of the more conservative option by assuming that the future of the superconducting market will reflect the actual market and that no further work would be performed on this existing core technology.[148] Thus, the valuation

[145] Table created using data from Ambature, Inc., Ambature Balance Sheet (Aug. 2014) (confidential) (on file with author).

[146] *See infra* Table 7.

[147] Table created using data from Tables 4, 5, and 6 and internal OxFirst estimations for the weighting between the two valuation methods.

[148] *See* discussion *supra* Part VIII.C.

represents the current value of the existing portfolio of patents filed by Ambature. The valuation is also restricted in that any additional IP resulting from licenses with grantbacks is not considered part of this portfolio but would instead be considered part of a separate portfolio. In reality, this portfolio will probably continue to grow in value due to increasing recognition in the field and the accumulation of grantback rights.[149]

X. Conclusions

While there is sound evidence that economic growth is driven by technological innovation,[150] Arrow already demonstrated fifty years ago that competitive markets fail to provide socially optimal levels of technology investment.[151] Technological innovation is surrounded by uncertainty, imperfect monitoring, and, in some cases, imperfect intellectual property rights.[152] Investors are eager to maximize returns on investments, and, while many are ready to accept a higher risk rate for higher returns, all investors, no matter whether early- or late-stage, are eager to adequately manage risk.

Certainly, risks associated with early-stage technologies, such as technological viability, uncertainty about the size of a potential market, and lack of precedent, make the valuation of early-stage technology firms a non-obvious task to investors. However, an enhanced understanding of the investable value of patents can reveal important pieces of information that an investor needs to determine the risk/reward profile of an investment.

Yet, it is precisely this piece of information that often goes missing. Investors usually invest in companies and not in patents per se. As such, they consider patents, at best, through a legal lens. However, this view hardly allows investors to grasp the actual value of the patents.[153] The inaccurate understanding of the business proposition of patents, paired with a bias that they can't be valued, is a key challenge in financing technology.[154] Ambature illustrates this problem. Ambature's entire business strategy is built around licensing its patent portfolio. A valuation of its patent portfolio is thus of paramount importance for potential investors because this is what will make or break the firm's business success.

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[149] *See* ROGERS, *supra* note 143, at 300–64.

[150] *See* Paul M. Romer, *Endogenous Technological Change*, 98 J. POL. ECON. S71, S71–72, S99 (1990) (discussing the economic effects of technological change).

[151] *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 619, 622 (Harold M. Groves ed., 1962) (discussing the incentives to invent in competitive markets).

[152] *See* Mark Rogers, *Firm Performance and Investment in R&D and Intellectual Property* 3 (Melbourne Inst. of Applied Econ. & Soc. Research, Working Paper No. 15/02, 2002) (discussing potential impediments to R&D activity), *available at* http://melbourneinstitute.com/downloads/working_paper_series/wp2002n15.pdf.

[153] *See* Kelley, *supra* note 18, at 124 ("Patent valuation is inherently challenging, as is readily apparent from the difficulty federal district courts and juries have in deciding damages for patent infringement.").

[154] *See id.* at 128 (discussing the difficulties of patent valuation).

The biggest obstacle in grasping the investable worth of patents seems to be the myth that they cannot be valued and therefore should not be considered a useful metric in making an investment decision. This paper has countered this myth by showing how patents can be valued using commonly accepted financial valuation metrics. It illustrates that the problem is not a lack of available patent valuation methods, but a limited understanding of how to apply them in making investment decisions. As patents play an increasingly important role in corporate strategy, their accurate valuation remains a major obstacle to their emergence as a tradable asset class.[155] Though there are several generally accepted ways to measure the value of patents, further transparency in patent valuation procedures may render investments in nascent technologies significantly more efficient and profitable. Overcoming this barrier to lending is the single most important contribution of this paper.

Several limitations persist, however. Patents are the legal dress of an invention and are therefore, by their very nature, unique. Thus, it is not possible to have an automated approach to patent valuation. Just like a legal opinion, a patent valuation remains an opinion on the financial worth of patents at a given point in time.[156] Another important limitation is imposed by the use of data sources that inform the valuation model. Ultimately, a patent valuation is only as accurate as the underlying analyst reports it refers to in its model. As Collan and Kyläheiko rightly point out, this is an important caveat that needs to be understood when using a patent valuation in an investment decision.[157] Analysts have been known to provide erroneous information in the past. Information used for a patent valuation provides no exception to that. In spite of these shortcomings, this paper posits that patent valuations constitute a crucial, yet so far ill-perceived tool in investment decisions.[158]

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155 European Comm'n, *supra* note 3, at 5.

156 *Id.*

157 *See* Collan & Kyläheiko, *supra* note 29, at 240 (noting that "it is not possible to get answers/valuations that are any more accurate than the accuracy of the expert opinions and judgment that is used as an input" in the valuation calculations).

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