Application of blockchain technology and crowdfunding to solve structural inefficiencies in digital rights and patents - a comparative analysis

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ABSTRACT

The markets for patents and digital rights, in particular music, are both highly inefficient and feature a large number of intermediaries which capture significant shares of the value created. Therefore, the patents and digital rights systems seem to be perfectly suited for disruption by blockchain technology and crowdfunding. This study examines the structural inefficiencies of the two segments and explores how blockchain and crowdfunding could solve these. We find promising use cases for both concepts in the market of digital rights. In contrast, while crowdfunding solves certain inefficiencies in the field of patents, we believe that blockchain technology has only limited impact here.

This thesis is based on academic literature and professional journals in the fields of patents, music, crowdfunding, and blockchain technology as well as self-conducted interviews with industry, legal, and technology experts.

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To our parents whose continuous support, unconditional dedication and guidance have been the guardian throughout our academic career and who provided us with the confidence that we are capable of achieving our goals.

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Table of contents

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1. Introduction

Both the markets for patents and digital rights are highly inefficient and illiquid. As a result, a variety of intermediaries is involved between idea creators (for example, componists, singers, inventors, etc.) and consumers. These intermediaries capture substantial shares of the value created around patents and music (BerkleeICE 2015, pp.16–18; Bessen et al. 2011, pp.1–6; Gans & Stern 2010, pp.805–809; Hagiu & Yoffie 2013, pp.45–46, 51–53, 60–63; O'Dair 2016b, pp.8–9). Hence, the patents and digital rights systems seem to be suitable environments that could be disrupted by blockchain technology and crowdfunding. These concepts aim at reducing the need for intermediaries and bringing consumers, producers, and investors closer together (Crosby et al. 2016, pp.9–13; Gottfried 2015; Ito et al. 2017; Rogers 2015; Tapscott & Tapscott 2016, pp.10–11). However, the patents and digital rights system suffer from very different structural inefficiencies. Therefore, we will explore these inefficiencies in detail and discuss whether crowdfunding or blockchain technology could help overcome these and if so, in what way.

Our motivation to explore patents and digital rights in depth arose from classes we took at MIT Sloan School of Management and Harvard Business School (HBS). Both authors attended the course *'Strategy and Technology'* by David Yoffie at HBS and discussed shortcomings of the patent systems, for example

with Peter Detkin, a co-founder of Intellectual Ventures, one of the largest patent holders in the United States. Moreover, both authors took the class *'Israel Lab'* at MIT Sloan where one of the authors worked on a project with Revelator, a startup which develops a digital intelligence platform for recorded music and publishing professionals (Revelator 2016). This thesis aims at bringing these academic and professional learnings together and providing more detailed research on pressing questions around patents and digital rights and the promising concepts of blockchain technology and crowdfunding.

Our thesis is structured as follows: In Chapter 2 we will give an overview on crowdfunding and describe advantages of the concept and issues around it. Chapter 3 will give detailed insights in blockchain technology, structured in technology, architecture, economics, and applications. In Chapter 4 we will explain how blockchain technology can solve issues related to crowdfunding. Chapter 5 will give an overview on intellectual property with a focus on patents and digital rights and will summarize the issues prevalent in each system. In Chapter 6, we will apply crowdfunding and blockchain technology to address structural inefficiencies around patents and digital rights. Finally, Chapter 7 will conclude our thesis.

2. Crowdfunding

2.1. Definition and differentiation

Most entrepreneurs are resource-constrained and often face difficulties in attracting funding for their early-stage startups (Cassar 2004, p.264; Courtney et al. 2017, p.265). Due to a lack of sufficient capital to fund the commercialisation of their idea, entrepreneurs widely rely on external sources of capital (Gompers & Lerner 2004, p.157). The most common sources of venture funding include the three Fs *'friends, family and fools'*, angel or venture capital investors, and - at a later stage - bank loans and public equity (Belleflamme et al. 2014, p.586; Berger & Udell 1998, p.622). Still, many ventures remain unfunded due to a lack of historical track record, absence of significant cash flows to service debt, uncertainty about future success and information asymmetry between founders and investors (Cassar 2004, pp.254–265; Cosh et al. 2009, pp.1530–1531; Gompers & Lerner 2004, pp.157–158).

Over the past ten years, crowdfunding has emerged as an alternative source of venture financing. With crowdfunding, entrepreneurs accumulate small individual contributions of capital from a large audience (*'the crowd'*), instead of relying on a small group of sophisticated investors. Entrepreneurs typically solicit with the crowd over the internet on so-called *'crowdfunding platforms'* without any other

financial intermediaries (Belleflamme et al. 2014, pp.585–590; Courtney et al. 2017, pp.265–266; Mollick 2014, pp.1–2; Short et al. 2017, pp.149–150). Crowdfunding has been referred to as the democratization of venture funding by alleviating barriers between individual investors and founders (Short et al. 2017, p.150). In the following section, we will evaluate these claims and provide a basic overview of crowdfunding, its dynamics as well as advantages and potential downsides.

One can distinguish between four different kinds of crowdfunding, ranging from (1) reward-based crowdfunding, where backers typically receive the product they have backed in return for their funding, (2) equity crowdfunding, where investors acquire an equity stake, (3) charitable crowdfunding/ donations, where funders donate towards a good cause without any monetary reward, and (4) lending crowdfunding, where backers grant loans in return for a repayment (Belleflamme et al. 2014, pp.585–588; Mollick 2016, p.2; Mollick 2014, pp.3–4).

An approximate of 2,000 crowdfunding platforms exist today, cumulatively generating tremendous economic impact (Drake 2015; Short et al. 2017, p.2): The world bank estimates a market potential of up to USD 96 billion per year by 2025 (The World Bank, Infodev 2013, pp.42–43).

While Kickstarter may be the largest and best known online crowdfunding platform, it was by no means the first one. In 2003, a platform named ArtistShare enabled musicians to gather donations from their fan base to produce records. In return, backers were later able to download the album for free (Cohen et al. 2016, p.1; Freedman & Nutting 2015, p.2). In 2006, Sellaband allowed funders to acquire a share in an artist's future album for USD 10. As soon as 5,000 shares were sold, musicians received the money to record an album. Revenues generated through album sales and ads were then distributed between band, platform, and backers (Agrawal et al. 2015, p.255).

Backers value early access to novel ideas or products as well as the opportunity to be part of a venture's community when considering reward-based donations. In contrast, equity crowdfunding platforms further enable investors to benefit from future financial returns (Catalini et al. 2016, pp.11–13). Given the already high traction of reward-based crowdfunding and the expected impact of Title III of the JOBS Act on equity-based crowdfunding, we will further examine these two categories in the section below while disregarding the others (Drake 2015; Freedman & Nutting 2015, p.6). Due to the novel character of equity-based crowdfunding, most features presented below are drawn from research on reward-based crowdfunding. However, it is assumed that main findings can be applied to both settings. Furthermore, our research will primarily refer to the regulatory environment present in the United States.

2.2. Reward-based crowdfunding

As indicated above, backers of reward-based crowdfunding campaigns receive rewards rather than financial returns in exchange for their contributions. Such rewards can be of *intangible nature*, e.g. being credited in a movie, meeting creators, providing creative input or of *tangible nature*, e.g. receiving the product before the public launch, often to a discounted price. Even though funders of reward-based campaigns might provide input and feedback, they act more like early customers than like financial investors (Mollick 2014, p.3).

Kickstarter and Indiegogo are two widely-known reward-based crowdfunding platforms. Since the launch of Kickstarter in April 2009, 12.5 million backers have contributed close to USD 2.9 billion in about 120,000 successful campaigns (Kickstarter 2017b). A study estimates that Kickstarter alone has generated more than USD 5.3 billion in direct economic impact and led to the creation of 8,800 new companies and nonprofits, employing over 300,000 full-, and part-time employees (Kickstarter 2017d). Crowdfunding platforms act as intermediaries between funders and founders. In return, these platform charge a fee for successful campaigns. For example, Kickstarter asks for 5% of the total contribution raised. An external payment provider will charge an additional 3-5%. Kickstarter follows an *'all-or-nothing-approach'*. Thus, backers will only be charged at the end of a campaign if the predetermined funding goal has been met or exceeded. Entrepreneurs retain ownership of their idea and interest in

their company when successfully raising money on reward-based crowdfunding platforms. Platforms do not get a claim on intellectual property. While Kickstarter reviews projects to ensure basic quality ahead of the launch, the company neither gets involved in campaign marketing nor performs a thorough due diligence. The platform does also not take any responsibility for fulfillment of successful campaigns and can further not be held accountable for refunds of projects that fail to deliver pledges (Freedman & Nutting 2015, pp.2–3; Kickstarter 2017a).

2.3.   Equity crowdfunding

Crowdfunding has been credited as a new source of early-stage financing that democratizes access to venture capital. Equity crowdfunding is better suited for investors that do not necessarily have a personal interest in a product but aim to benefit from successful commercialization. Entrepreneurs that require substantial upfront investments to realize their idea are more inclined to choose equity-, rather than reward-based crowdfunding (Catalini et al. 2016, p.11). Ahlers et al. (2015, pp.957–958) define equity crowdfunding as follows:

"Equity crowdfunding is a method of financing, whereby an entrepreneur sells a specified amount of equity or bond-like shares in a company to a group of (small) investors through an open call for funding on Internet-based platforms."

Until recently, only accredited investors were allowed to participate in equity crowdfunding. In the US accredited investors are required to have a net worth of at least USD 1 million and are regarded both sophisticated in assessing ventures and able to withstand a financial loss (Catalini et al. 2016, pp.3–4). In an attempt to open equity crowdfunding for US-based non-accredited investors, the *'Jumpstart our Business Startups Act'* (JOBS Act) was enacted in 2012. Former President Obama was enthusiastic regarding the regulation, stating that *"for startups and small businesses, this bill is a potential game changer"* (Mollick 2014, p.2). After the U.S. Securities and Exchange Commission (SEC) expressed concerns, it took until October 30, 2015 for Title III to be adopted. On May 16, 2016 the rules finally became effective, allowing startups to issue securities via private placements to non-accredited investors. Given the limited resources and expertise of non-accredited investors, these require more protection than accredited investors. Further, disclosure requirements have been relaxed in order to facilitate costly reporting for startups (Catalini et al. 2016, pp.2, 4–5; Freedman & Nutting 2015, pp.7–8). Table 1 provides an overview of the Title III regulations.

A study composed by the University of Cambridge found that almost half of US-based equity crowdfunding platforms regard the current level of regulation as adequate and appropriate. However, 35% of participants indicated that regulations were too excessive or strict. Only 2% think that regulations are inadequate (Wardrop et al. 2016, pp.65–66).

Rule	Terms
Funding caps on the amounts funders can invest and companies can raise	• $1 million cap on the amount companies can raise over a 12- month period • $2,000 limit on the amount that funders can invest if their annual income or net worth is less than $100,000
Limits on the size of companies and types of vehicles	• Companies with over 500 non-accredited investors and $25 million in assets are required to go public (and subject to much more stringent reporting and disclosure obligations) • Special purpose vehicles, including syndicates, that would aggregate everyday investors into a single fund treated as one shareholder and run by a lead investor are prohibited.
Disclosure obligations for both companies and Title III platforms, which are less burdensome than those required for public offerings	• Companies must disclose how they set the price for their shares, what their financial condition is, who their officers, directors and major shareholders are, and how they plan to use the money they raise • Platforms must inform investors of the type of securities being offered, resale restrictions and investor limits, provide communication channels to permit discussions of offerings, and take certain measures to reduce the risk of fraud
Exemptions for companies and Title III platforms from securities law obligations	• Companies (issuers) seeking to raise between $500,000 and USD 1 million may disclose reviewed instead of audited financial statements (which are less costly to prepare) • Platforms may facilitate the offer and sale of securities without registering with the SEC as broker-dealers • Platforms are allowed to take a financial interest in their listed offerings to the extent that the financial interest is provided as compensation for services rendered

Table 1: Overview: key provisions of Title III rules (Catalini et al. 2016, pp.5–6)

In 2015, equity crowdfunding in North America accounted for a market volume of USD 596 million, while reward-based crowdfunding aggregated to a volume of USD 646 million. However, in terms of year-on-year growth, equity crowdfunding was significantly ahead of reward-based crowdfunding at 119% and 28% growth, respectively (Wardrop et al. 2016, p.34).

One of the oldest and best-known equity crowdfunding platforms in the US is AngelList. Until today, over USD 425 million have been collected on AngelList by over 1,000 companies. AngelList reported an Internal Rate of Return (IRR) of 46% since 2013. DollarShaveClub was one of the ventures that raised money through the platform and was recently acquired for USD 1 billion. Other popular

platforms are OurCrowd (Israel), raising over USD 320 million, and CircleUp (US), raising over USD 300 million (Crowdfund Insider 2017).

While some believe that equity crowdfunding *"will be the future of how most small businesses are going to be financed"* (quote by Duncan Niederauer, CEO of NYSE Euronext (Freedman & Nutting 2015, p.9)), others are more sceptical. Catalini et al. (2016, p.3) conclude that while equity crowdfunding might be a source of capital as well as a means of marketing and community building for small businesses, it is unlikely to create a market for entrepreneurs or investors to fund the next big thing. They state that further advances in market and platform design are needed to overcome information asymmetries, which will be discussed below.

2.4. Advantages of crowdfunding

In addition to just adding an alternative channel of financing, advocates of crowdfunding have identified a number of compelling benefits related to this new form of early-stage funding. Crowdfunding incorporates two major parties, (1) founders who primarily seek funding and (2) funders who offer financial resources (Cohen et al. 2016, p.12). In order to better assess the motivations of both parties, we will segment the benefits obtained by each below.

2.4.1. Founders

Source of capital. First and foremost, founders turn to crowdfunding as a source of low-cost capital. Agrawal et al. (2014, pp.67, 70–71) found that crowdfunding can be a cheaper substitute for other, more traditional sources such as venture capital. They argue that crowdfunding platforms improve matching between entrepreneurs and a global investor base with a higher willingness to pay for novel products or equity ownership in startups.

Skepticists argue that low-quality startups will turn to crowdfunding, while high quality entrepreneurs will raise venture capital instead. This is due to a crowd that has been said to be irrational, helping bad businesses to raise capital before they fail eventually (Cortese 2013).

In contrast, research on creative projects launched on Kickstarter has found that the crowd is well aligned with experts in identifying high-quality projects. However, if the crowd funded projects that experts would not have, no evidence was found that these projects performed worse in terms of quality or fulfillment than the ones selected by experts. The crowd might thus be a viable source of capital identifying quality projects that would otherwise have gone unfunded, thereby democratizing access to funding (Mollick & Nanda 2015, pp.4–5, 29).

Geographic reach. VCs tend to be in close proximity to their portfolio companies. This phenomenon can be explained by activities such as information gathering, monitoring and advisory which are cost sensitive to geographic

distance (Agrawal et al. 2011, p.1). The geographic bias of VC funding is further demonstrated by the fact that the top ten startup hubs in the US (by zip-code) account for 75% of VC investment (Florida & King 2016, p.10).

Crowdfunding has found to increase the average geographic distance between unrelated funders and founders from less than 100 miles to 3,000 miles (Agrawal et al. 2011, pp.1–2). Thereby, crowdfunding has the potential to enable entrepreneurs who are not in close proximity to VCs to access early stage funding (Agrawal et al. 2015, p.271).
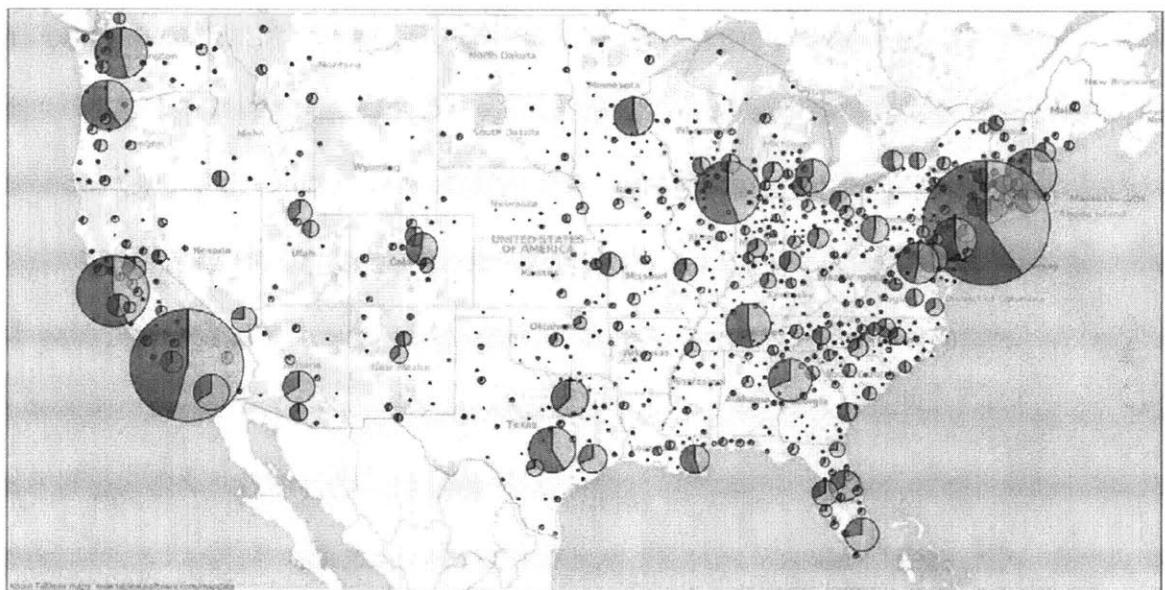
Status	Failure	Success			
N Projects	1	2,000	4,000	6,000	7,106

Figure 1: Geographic distribution of projects by success as of July 2012 (Mollick 2014, p.10)

Feedback and demonstration of demand. Crowdfunding platforms enable entrepreneurs to market their ideas and get engaged with supporters. This community often provides feedback and allows entrepreneurs to learn about early market demands (Belleflamme et al. 2014, p.604; Cohen et al. 2016, p.6; Cowley 2016; Gerber et al. 2012, pp.6–7; Mollick 2014, p.3). Successful crowdfunding campaigns can further be used as a signal for demand when raising follow-on capital from more traditional sources (Mollick 2014, p.3). For example, VCs might require entrepreneurs to raise money through the crowd and demonstrate demand before investing additional capital (Assenova et al. 2016, p.127).

Gender gap. Research has found that crowdfunding also has the potential to decrease the funding gap between male and female entrepreneurs. Studies suggest that only about 1.3% of VC-backed companies have female founders, while women own 40% of private businesses in the US (Greene et al. 2001, pp.75–80; Miller 2010; Mollick & Kuppuswamy 2016, p.539). This phenomenon might be due to the low concentration of women in venture capital, who only account for 14% of investors. Moreover, female entrepreneurs report that there is a strong gender bias, as male VCs prefer male founders (Miller 2010). Thereby, startups have been pushed towards male-dominated teams to increase chances of successful funding (Mollick & Kuppuswamy 2016, p.539). Crowdfunding may be an exception to this rule, where activist choice homophily plays a critical role.

Women have been found to to mutually support female entrepreneurs, thereby closing the funding gap (Greenberg & Mollick 2016, pp.37–45). Crowdfunding platforms thereby act as gatekeepers, granting these previously underrepresented better access to early-stage capital (Younkin & Kashkooli 2016, pp.25–26).

2.4.2. Funders

Access to investment opportunities and new products. Prior to the implementation of Title III of the JOBS act, equity crowdfunding was restricted to sophisticated investors only. The revised regulation enables non-accredited (retail) investors to crowdfund early-stage ventures. Their risk exposure is reduced as funding happens in smaller increments, allowing for a higher degree of individual diversification. In contrast, backers of reward-based campaigns generally value early access to products that are not available on the market yet. Some investors even support projects for philanthropic reasons (Agrawal et al. 2014, pp.67, 73–74).

Community aspect. Backers primarily seek rewards. However, data suggests that funders also value the opportunity to support entrepreneurial ventures. Funders state that they cherish the aspect of being part in a *"community of creators"* (Gerber & Hui 2016, p.7).

Coordination. Crowdfunding platforms act as intermediaries between investors and founders, formalizing the relationship between parties. Investments that might have been made in absence of appropriate documentation are thereby avoided. Family and friends commonly act as early startup investors, both in traditional and in crowdfunding settings (Belleflamme et al. 2014, p.586; Berger & Udell 1998, pp.625, 660). Crowdfunding platforms introduce financial contracts and establish a formal relationship between founders and funders. Thereby, crowdfunding reduces former ambiguity between social relationships and business connections (Agrawal et al. 2014, p.74). Further, better coordination between founders and investors allows for frictionless processing and tracking of contributions, thereby reducing transaction cost (Younkin & Kashkooli 2016, pp.25–30, 39). Moreover, crowdfunding platforms simplify communication by facilitating the exchange of information between founders and a large number of investors, which further enhances progress monitoring by distant funders (Agrawal et al. 2014, pp.67, 74).

2.4.3. Other

Innovation. Apart from the benefits obtained by founders and investors, crowdfunding can stipulate an indirect positive economic impact through innovation. Mollick (2016, pp.10–12) found evidence that 4% of successful Kickstarter campaigns subsequently filed patent applications. Moreover, spillover effects can amplify the benefit of product innovation, as third parties might

develop additional solutions around the initial product (Agrawal et al. 2014, p.87). Recent research indicates that incremental innovativeness of campaigns lead to better funding outcomes, while radical innovations are less likely to be funded. The crowd appears to shy away from complex campaigns that are more costly to learn about and that are inherently more risky. However, the study concludes that attention generated by incremental innovations may ultimately evoke better understanding and more successful funding of radical innovations (Chan et al. 2017, pp.19–22).

Apart from an effect on technological innovation, Kickstarter has had significant impact in creative areas. Kickstarter claims that 63% of successfully funded projects in 2016 were in the cultural areas of Art, Comics, Crafts, Dance, Film & Video, Food, Journalism, Music, Photography, Publishing, and Theater (Kickstarter 2017c). In 2016, four projects launched on Kickstarter were nominated for a Grammy, and 19 crowdfunded movies were featured at Tribeca Film Festival (Kickstarter 2016b).

2.5. Issues related to crowdfunding

While crowdfunding offers a set of compelling advantages, there are also some downsides that founders and investors need to consider. The more common ones are presented below.

2.5.1. Founders

Large and fragmented investor base. While VCs tend to inject large amounts of capital, the crowd generally splits the required funding into smaller portions. This characteristic leads to a fragmented investor base which can be difficult and time-consuming to manage. Shares sold in an equity crowdfunding campaign will disperse ownership, resulting in a highly complex shareholder structure. Furthermore, feedback provided by the crowd might not be useful if founders lack an efficient communication platform (Agrawal et al. 2014, pp.75–76; Cohen et al. 2016, p.12).

Funding is skewed. As indicated above, crowdfunding is not geographically constrained and thereby detaches funders and founders. However, research concludes that entrepreneurs who raise money through the crowd are located in the same geographic areas as the ones raising through more traditional sources of venture capital (Agrawal et al. 2013). This effect could be explained by factors such as concentration of human-capital or complementary assets (Agrawal et al. 2014, pp.65–67). Moreover, even financing obtained through crowdfunding is highly concentrated: On Kickstarter 1% (10%) of campaigns accumulate 36% (63%) of total funding (Agrawal et al. 2014, p.66). The majority of creators is unable to successfully raise capital, as only one third of campaigns achieve their goals (Kickstarter 2017c).

Public disclosure. Crowdfunding platforms act as intermediary between funders and creators. In order to attract investors, platforms require creators to disclose their (potentially innovative) products in a public forum. In an attempt to reduce fraud, Kickstarter demands a clear description of the campaign, use of funds and qualification along with a demonstration of a working prototype: *"Our community is built on trust and communication. Projects can't mislead people or misrepresent facts, and creators should be candid about what they plan to accomplish. When a project involves manufacturing and distributing something complex, like a gadget, we require projects to show backers a prototype of what they're making, and we prohibit photorealistic renderings"* (Kickstarter 2016a). While public disclosure helps backers to assess what stage of development the project is in, it might also invite imitators or have a negative effect on subsequent intellectual property protection (Agrawal et al. 2014, pp.74–75). *'The Fidget Cube'* is a popular example of such a coincidence: The initial goal of USD 15,000 was quickly accomplished and the venture managed to accumulate close to USD 6.5 million from over 150,000 backers. Overwhelmed by unexpected demand and manufacturing related issues, fulfillment was delayed, opening an opportunity for imitators. The internet was flooded with low-quality knockoffs that cost a fraction and shipped long before the original was fulfilled (Polygon 2017).

Retail investors. Apart from financial resources, professional investors usually provide value through experience, industry networks, advisory, reputation and ability to participate in future fundraising (Hsu 2002, pp.23–24). Retail investors are less likely to possess such qualifications. While the crowd might be able to provide input on product development and features, ventures might be unable to identify individuals who could be valuable advisors (Agrawal et al. 2014, p.75). Further, the crowd might lack expertise and might not be qualified to determine what they are investing in. Funders might be unclear about their rights, ownership and protection mechanisms. The low level of regulation and governance might have a detrimental effect on investor engagement and fairness (Cohen et al. 2016, pp.11–12).

2.5.2. Funders

Generally speaking, entrepreneurs have better information about their product, market and business prospects than most investors. Such information asymmetries introduce risk and uncertainty to early-stage investors. In a lightly regulated online crowdfunding setting, where remote investors are less likely to be dedicated or experienced enough to evaluate opportunities, such issues are even more pronounced (Ahlers et al. 2015, p.959; Courtney et al. 2017, p.269). Agrawal et al. (2014, pp.76–78) identify creator incompetence, project risk and fraud as primary disincentives to investors.

Creator incompetence and project risk. Entrepreneurs might lack experience in bringing their idea to market. As a consequence, Mollick (2014, pp.12–14) found that only 24.9% of successful projects delivered on time. Issues related to manufacturing, shipping, certification and scale were presented as the primary causes of delays. His findings suggest that larger and overfunded campaigns are more likely to be delayed. While founders might be over-optimistic regarding their qualification and timeline, they might not be able to assess the risk of their undertakings ex-ante. However, Kickstarter backers appear to be able to differentiate promising campaigns from others. Only 48% of projects were successfully funded, and these that were not funded failed by large margins, raising just about 10% of the initial goal. Only 3.6% of successful campaigns failed to deliver a product - a low rate compared to all early-stage venture undertakings (Mollick 2014, pp.4, 6–7, 11–12). More recent data indicates that only about one third of all Kickstarter campaigns are successfully funded (Kickstarter 2017c). In an attempt to reduce creator incompetence, Kickstarter provides tutorials for creators and expert networks as well as tools to connect entrepreneurs and funders: *"We built a directory of Resources to help creators as they bring their projects to life. We launched a platform for sharing tips on running a Kickstarter project and pursuing creative projects — from us and from across our community"* (Kickstarter 2017c).

Fraud. While some projects might be delayed or fail due to a lack of founder's experience, individuals with bad intentions could take advantage of information asymmetries to commit fraud. However, Mollick (2014, pp.11–12, 14) found that 14 of 381 observed projects (3.6%) failed, of which 3 refunded pledges and 11 had stopped responding to concerned backers. Even if assuming that all of these were started with bad intentions, fraud would be rare and account for only 2.8% of successful campaigns. Using a more recent dataset, Mollick (2015, pp.1, 6) found that about 9.0% of successful projects fail to deliver a reward. He again argues against a systematic problem associated with fraud. Experts indicate that platforms have an incentive to select only the best campaigns and that the large user base is effective in performing a so-called crowd diligence (Assenova et al. 2016, p.128). Kickstarter has demonstrated an interest in curating its platform. In its 2016 benefit report, the platform stated that a dedicated team reviewed 74,575 project submissions and accepted 59,745 (about 80%) for launch. 377 projects were suspended after launch because the creators sent spam or misrepresented information on their campaign pages.

"We want to do more to help backers understand that projects may fail and to encourage creators to be open when they do. We want to encourage greater transparency from creators, better educate backers about the risks and rewards of this system, and further empower our Integrity team in their work to keep Kickstarter safe and trusted" (Kickstarter 2017c).

Exit opportunities. Given the private nature of equity crowdfunding, investors might be unable to trade or sell their shares and realize their investment ahead of an IPO or acquisition. One solution could be a platform tailored for the exchange of shares issued through crowdfunding. However, sophisticated follow-on investors are already shied away by the complex ownership structure of crowdfunded ventures. Allowing funders to trade shares might lead to an even more fragmented ownership base (Agrawal et al. 2014, p.68; Cohen et al. 2016, p.12).

2.6. Resolving information challenges

As outlined above, information asymmetries can have a negative impact on investor sentiment. While research on Kickstarter indicates that reward-based crowdfunding is not negatively affected, the ascent of equity crowdfunding might be hindered if information asymmetries are not resolved. Adverse selection and moral hazard are two problems arising from asymmetric information which could lead to market failure (Catalini et al. 2016, pp.7–8).

Adverse selection. Unsophisticated investors typically lack the ability, time and money to perform a detailed due diligence or effectively monitor startups. While entrepreneurs have these information, the preparation and communication of credible insights is costly. Due to a lack of information, funders might discount the startup value, which gives entrepreneurs the incentive to avoid raising capital

through crowdfunding. In an extreme case, only low-quality entrepreneurs that are unable to finance their idea will turn to crowdfunding (Agrawal et al. 2016, pp.115–116; Agrawal et al. 2014, pp.77–78; Catalini et al. 2016, p.7).

Moral Hazard occurs if one party has an incentive to take risk borne by another party (Boundless 2016). Ex-ante, entrepreneurs can capitalize on funders that do not perform an extensive due diligence by requesting inflated valuations. Ex-post, funders have little insight in a venture's operations and lack the ability to induce desired behaviour after a campaign is closed. In this setting, startups might be prone to trade long-term goals for opportunistic spending. Fraud would be an even more extreme example to exploit such imbalances. Anticipating such undesired behaviour, funders might be discouraged to invest, which would in turn lead to market failure (Agrawal et al. 2016, pp.115–116; Agrawal et al. 2014, pp.77–78; Catalini et al. 2016, pp.7–8; Cohen et al. 2016, pp.10–11).

Potential solutions to overcome information asymmetries are further examined below:

Signaling. In order to mitigate information asymmetries, startups can take actions to send positive signals to investors, providing them with a better view on the underlying quality of the venture (Courtney et al. 2017, p.266). Ahlers et al. (2015, pp.3, 25–30) highlight a positive correlation of signals on financial

roadmaps (i.e., indicating an exit through IPO or trade sale), risk factors (i.e., founders maintain a significant equity stake and provide clear forecasts) as well as internal governance (measured by board size, experience, education) and success in obtaining funding. Courtney et al. (2017, pp.270, 283–285) argue that entrepreneurial experience, patents, positive backer sentiment, professional use of media (i.e. videos in campaigns) as well as third-party endorsement convey credibility in the campaign and founder. In 2016, Kickstarter has introduced *'Live'*, a live streaming tool that allows creators to connect to potential funders, answer questions and demonstrate their products. This attempt to overcome geographic separation appears to be effective in reducing information asymmetries, as 74% of campaigns using *'Live'* have been funded successfully. In comparison, the average success rate on Kickstarter in 2016 was 33% (Kickstarter 2017c).

Syndicates could be another way to tackle information asymmetries. Crowdfunding stipulates a diversified investor base, where returns are distributed to a large number of funders and thus reduces the individual incentive to perform a due diligence (Younkin & Kashkooli 2016, p.38). In contrast, syndicates enable seasoned lead investors to conduct a due diligence, and monitor investments. Follow-on (retail) investors rely on the lead's industry experience in assessing ventures and pay a carry in exchange. The lead typically funds a larger proportion than follow-on investors. Like VCs, lead investors supervise startups, provide mentoring and monitor progress. Syndicates further simplify the

ownership structure, as investors invest in a special-purpose vehicle rather than in the startup directly (Agrawal et al. 2016, pp.111–114).

Crowd diligence. Ultimately, the aggregated judgement of individuals has found to be effective in reducing information imbalances (Mollick & Nanda 2015, p.7). While individuals may not execute a due diligence, the large number of diverse individuals that compose the crowd, might be able to lever a variety of perspectives and identify cases of fraud, potential drawbacks or technical flaws. This collective wisdom is often referred to as *'crowd diligence'* (Assenova et al. 2016, p.128). The crowd might however be prone to imitative behaviour *('herding')*, where investors perceive early funding success as a signal of quality. Family and friends account for a disproportionate amount of early funding. Unrelated investors might rely on the knowledge these early backers have about founders, or perceive it as positive signal for a creator's powerful network. Encouraged by such traction, third-party investors are more likely to commit to the campaign (Younkin & Kashkooli 2016, p.29). While herding can be beneficial in securing funding, it can also lead to irrational behaviour and stock-market-like bubbles (Cohen et al. 2016, pp.10–11).

Rules and regulation can further help reduce information asymmetries. As outlined in Section 2.3 the recently introduced Title III of the JOBS Act has granted non-accredited investors access to equity crowdfunding. Catalini et al. (2016, pp.7–10, 14–15) assessed the potential of the newly enacted regulations in mediating risks related to unbalanced information. With regard to adverse selection, they conclude that funding caps (limiting the amount ventures can raise through and funders invest in crowdfunding campaigns) are too low for funders to provide an incentive to conduct a thorough due diligence. Moreover, they argue that the cost startups face in preparing and disclosing information are disproportionately high for an annual funding cap of USD 1 million. Ventures that raise equity on Title III platforms are further required to go public when their asset base exceeds a value of USD 25 million. An IPO imposes significant disclosure and reporting requirements. Companies that raise early-stage capital through traditional sources are not tied to Title III regulations. Startups with high growth potential and access to other sources of capital might thus avoid equity crowdfunding. Title III might however be suited to resolve moral hazard, as the funding cap incentivizes entrepreneurs to meet milestones and reduce excessive spending. Startups that do not perform according to plan will need to wait for twelve months to raise additional capital through crowdfunding and might face issues in convincing investors to participate in follow-on rounds. On the contrary, lighter disclosure requirements have been criticised as an obstacle for investors to properly assess ventures. Furthermore, Title III forbids the use of special

purpose vehicles and thus restricts syndicates as a measure to protect retail investors by introducing experienced intermediaries.

While the measures presented above have helped to reduce uncertainty about the quality of campaigns, they have not proven sufficient in mitigating the inherent risk of asymmetric information and geographic separation. However, crowdfunding platforms have an incentive to improve the exchange of information in an attempt to curate and select the ventures they feature. More sophisticated platforms will thereby benefit from network effects and attract better investors and ventures. We believe that blockchain technology can be one approach to open data sources and enhance the exchange of information. We will shed light on the technology and provide potential use cases in Chapter 4.

3. Blockchain

3.1. Introduction

"The next big thing" (The Economist 2015), *"[...] a Ledger of Everything"* (Tapscott & Tapscott 2016, p.7), *"We may be at the dawn of a new revolution"* (Swan 2015, p.vii): There has been much hype around blockchain and its potential economic impact over the past years. Despite its popularity, blockchain is far from being a clearly defined technology. Instead, the technology has evolved over time given rapid advancements and progress since it was disclosed by Satoshi Nakamoto in the form of Bitcoin in 2008 (Mattila 2016, p.4; Nakamoto 2008). In its purest form, blockchain is a cryptographically secured, distributed ledger (or database) of recorded transactions which are verified across a network of participants and which can be traced back entirely (Buehler et al. 2015, pp.4–7; Schneider et al. 2016, p.3). The fact that blockchains allow for transactions without the need of a trusted intermediary is considered the most important and disruptive feature of the technology (Buehler et al. 2015, p.5; Tapscott & Tapscott 2016, p.4). For instance, when applied to digital payments, blockchain solves the double-spending problem which formerly required the use of a payment provider such as PayPal (Davidson et al. 2016b, p.2; Nakamoto 2008, p.1). Thus, the disintermediating character of the technology removes friction in the form of costs, delays, as well as credit and liquidity risk in

transactions over the internet (Bogart & Rice 2015, p.3; Buehler et al. 2015, p.5). Underlining the importance of the technology in a digital world, several authors have classified blockchain as a 'general purpose technology' with enormous potential impact on productivity (Andreessen 2014; Davidson et al. 2016a, p.1; Swan 2015, p.vii)[1].

Investor interest in blockchain technology has seen strong growth since its introduction in 2008. The market capitalisation of Bitcoin is now more than USD 19 billion, an increase of overall about 107% over the last years[2]. However, investments in blockchain technology are not restricted to Bitcoin. Surveying executives and experts from the information and communications technology sector in 2015, the World Economic Forum finds that 73.1% of respondents think that tax collection will be conducted via blockchain by 2025. In addition, 57.9% of interviewees indicated that by 2025, 10% of the global GDP will be stored on blockchain technology (Global Agenda Council on the Future of Software & Society 2015, p.7). In another survey, over 80% of business and technology leaders in the banking industry indicated that they expected commercial adoption of the technology by 2020 (Infosys 2016). This confidence is reflected in investments in blockchain technology: Figure 2 shows a record of USD 543.6 million of venture capital invested in bitcoin and blockchain-related companies in 2016, up from $441mio in 2015. However, a decrease in the number of funded

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[1] The economic and societal impact of blockchain technology is discussed in Chapter 3.4.2.
[2] Values were retrieved from https://blockchain.info/charts/market-cap?timespan=all on February 27, 2016; comparison is based on market capitalisation on December 29, 2014

startups since 2014 indicates that the initial hype could be fading and investors are turning to more robust use cases (Fortnum et al. 2017, p.23).
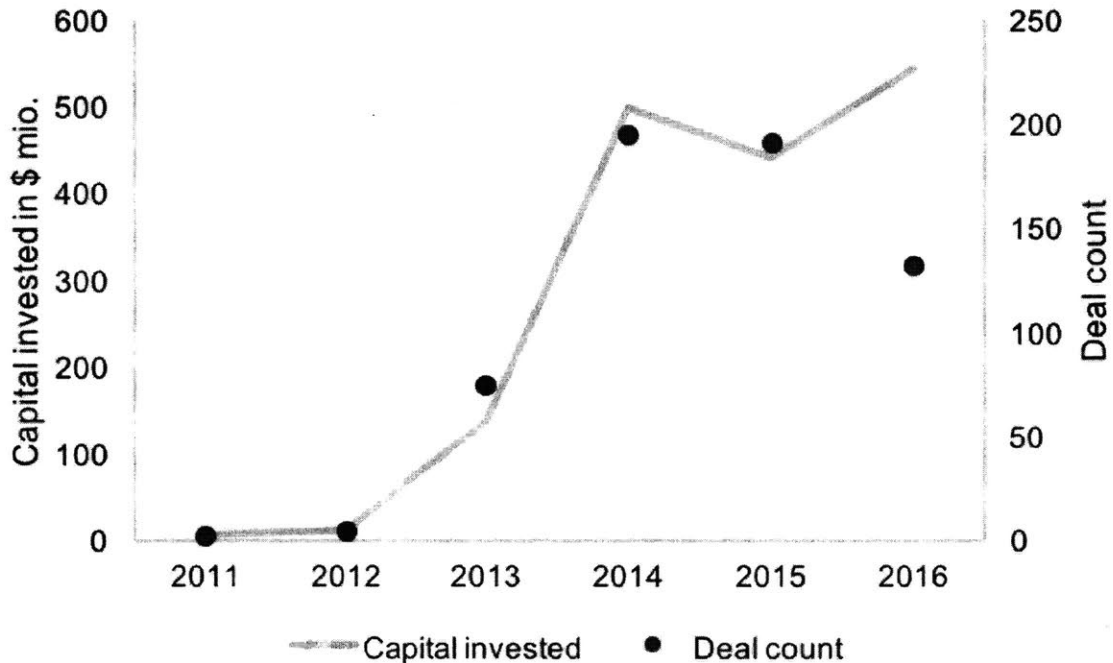
Figure 2: Venture investment in bitcoin & blockchain-related companies between 2011 and 2016 (Fortnum et al. 2017, p.23)

3.2. Technology

As indicated above, blockchain describes a distributed ledger of transactions. This ledger consists of a series of data blocks that are cryptographically chained together. Each of the blocks contains several transactions that happened at roughly the same time. This Chapter will first give an overview on the main technological concepts of blockchain, and then illustrate the mechanics of the technology at the example of a Bitcoin transaction.

3.2.1. Technological concepts

(Cryptographic) hash functions. Blockchain technology applies hash functions extensively. A hash function is a function that transforms an arbitrary input into output, a so-called digest or hash, of fixed length (Preneel 1993, p.162; Rimoldi 2011). For Bitcoin, the digest is a 256-bit number. A cryptographic hash function is a one-way hash function, thus it is technically infeasible to revert the digest (Dwyer 2016, p.3; Pilkington 2015, pp.7–8). Put differently, the digest of a cryptographic hash hides the information of the input: It is almost impossible to restore the input from the output. In addition, a cryptographic hash function is collision resistant: It is very unlikely to find two inputs that hash to the same digest (Ramzan 2013a). As an example, a song of any length could be hashed into a specific digest, e.g., a 256-bit number. If this same song would be hashed again at any later point in time it will always result in exactly the same digest. However, by being in possession of the hash, one cannot trace back the input song.

Blockchain structure. Blockchain technology is based on a decentralized database structure. It does not depend on one single server to guarantee the availability and up-to-dateness of the database (Bogart & Rice 2015, p.3). Instead, each node that participates in the network has its own copy of the blockchain which is synchronized with the copies of the other nodes by using a peer-to-peer protocol (BitFury Group 2015, pp.2–3). Every transaction is

broadcasted to all nodes in the network and is recorded in the public ledger after verification (Crosby et al. 2016, p.10).[3] However, transactions are not always broadcasted in the same order as they are generated, for example due to different internet connection speeds. Therefore, transactions that happen at about the same time are grouped together in blocks which refer to the previous block by including its hash (Böhme et al. 2015, p.217; Bogart & Rice 2015, pp.8–9; Nakamoto 2008, p.2). In Bitcoin, this grouping takes place roughly every ten minutes. The result is a linked sequence of blocks, a *'blockchain'* which allows transactions to be traced back up to the day when the blockchain was initiated (Böhme et al. 2015, p.217).

Distributed consensus mechanisms. Obviously, such a decentralized system is not without risk of abuse as the grouping into blocks takes place at the node level. Put differently, every node can group transactions into blocks and broadcast it to the rest of the network as a suggestion to be added to the overall blockchain. For example, an attacker could spend money and reverse the spending by creating their own block, which does not include the respective transactions (BitFury Group 2015, p.2). Therefore, a so-called consensus mechanism is required. This mechanism ensures that the entire network agrees on which block should be added to the blockchain (Crosby et al. 2016, pp.10–11). The most common consensus mechanisms are *'Proof of Work'* (PoW)

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[3] The verification process is explained more in detail in Chapter 3.2.2.

and *'Proof of Stake'* (PoS) which will be discussed in the following. PoW is the predominant mechanism and will be explained at the example of Bitcoin below. Under PoW, a block is valid only when it can prove that a certain amount of work, i.e. computational effort, has been put into its creation (BitFury Group 2015, pp.2–3). In order to be able to add a block to the blockchain a node - also called *'miner'* in this context - has to solve a computational problem which - as a side-effect - returns a timestamp for all transactions. The node that solves the problem first, broadcasts the solution and gets rewarded in the form of both newly *'mined'* Bitcoins and fees for the timestamped transactions. Basically, all nodes in the network continuously participate in a lottery and each node's chance of winning is proportional to the computing power it brings to the system (Becker et al. 2013, pp.1–2). Other nodes in the system accept the newly created block after they validated that the PoW was delivered and start solving a new computational problem based on new outstanding transactions (BitFury Group 2015, p.2). The difficulty of the computational problem is set so that a solution is found about every ten minutes (Dwyer 2016, p.5). The problem solving and validation process happen on a rolling basis as nodes present their solutions continuously. By doing so, *"[...] miners are in effect 'voting' on the correct record of Bitcoin transactions, and in that way verifying the transactions"* (Böhme et al. 2015, p.217). As a result, different users of the same system can see different states of the system at the same time (BitFury Group 2015, p.3). A consequence of PoW is that it is possible that a block is added to the chain *"[...] but then a few*

minutes later it will be altered because a majority of miners reached a different solution" (Böhme et al. 2015, p.217). This implies that a transaction is only finally validated about one hour after it occurred. Nodes in the network only accept the longest blockchain, i.e. the one in which most computational power has been invested, as the valid one. Hence, it is almost impossible for attackers to validate fraudulent transaction since they have to commit a computational effort larger than all power spent from the point of time they wish to alter to the present status (Becker et al. 2013, p.2; Crosby et al. 2016, pp.12–13; Nakamoto 2008, pp.1–3; Peters & Panayi 2016, p.6). PoW guarantees that a lot of computational power is needed to add a block to the blockchain but it is easy to verify the validity of each of the blocks (Dwyer 2016, p.6; Nakamoto 2008, pp.1–5). However, this mechanism has a major downside: its excessive energy consumption (Becker et al. 2013, p.2; Catalini & Gans 2016, p.9; Dwyer 2016, p.6). Therefore, other consensus mechanisms were suggested, of which the most applied is PoS. In PoS the lottery is not based on computational power but instead on stake in the network. The probability to create the next block is proportional to the node's ownership of respective units in the blockchain system (BitFury Group 2015, p.2). There are two main arguments in favor of PoS. First, in order to fraudulently change transactions, an attacker would need to acquire a majority stake in the system. Depending on the popularity of the blockchain network this stake would be very costly (BitFury Group 2015, pp.2–3). Second, a participant in the network who owns the majority stake in the system has an incentive to act benevolently.

In case of a fraudulent attack, the value of assets in the blockchain would decrease substantially, causing high costs for the majority stakeholder in the system. Often PoW and PoS are combined, for example in 'Proof of Activity' (Patterson 2015). In these hybrid mechanisms, a computational problem has to be solved but stake in the system makes it substantially easier to such an extent that computational power is not the main challenge in mining anymore (Narayanan et al. 2016, p.233). Other consensus mechanisms applied include *'Proof of Burn'* or *'Proof of Capacity'* which are used relatively rarely (Patterson 2015).

Public key cryptography. Instead of relying on trust in an intermediary, blockchain applies cryptographic proof, so-called *public key cryptography,* to execute transactions. *Public key cryptography,* also called *asymmetric cryptography,* uses pairs of keys: Each agent is assigned both a private and a public key. While the private key is kept like a password, the public key is shared with all agents in the system and is publicly visible. The most commonly known application of this technique is the communication between web browsers and HTTPS websites (Böhme et al. 2015, pp.216–217). Public keys act as a kind of address indicating origins and destinations for transactions on the ledger. An important feature of public keys is that they are not tied to a real-world identity by default. As a result, transactions themselves are traceable on the blockchain but identities of the economic agents involved in these transactions cannot be

revealed (Nakamoto 2008, p.6; Pilkington 2015, pp.3–4). However, in order to

spend money an agent has to prove the ownership of the private key - the public

key alone is not sufficient to trigger a transaction (Crosby et al. 2016, pp.9–10;

Nakamoto 2008, p.2).

3.2.2. Transaction on the blockchain: step-by-step explanation

In order to illustrate the underlying technology of blockchain, we will present the

flow of a transaction at the example of Bitcoin below. While Bitcoin is just one of

many applications of blockchain technology, it is covered most extensively in the

literature. Figure 3 and the step-by-step explanation show a schematic, simplified

illustration. In the following example, we assume that party A will transfer 5

Bitcoins to party B.

Step 1. In order to transfer money, party A has to gather the relevant data for the

transaction. First, this includes proof of ownership of the Bitcoins A wants to

send. Therefore, hashes of the previous transactions that prove that the Bitcoins

were indeed before transferred to A are necessary. Second, the public keys of

both A and B are included, which represent addresses for this transaction. Third,

the amount of 5 Bitcoins has to be indicated. Fourth, A assigns a specific

transaction fee for miners. Finally, A digitally signs the information with its private

key. All this information is then broadcasted to all nodes in the system (Ramzan

2013a; Ramzan 2013b).

Step 2. Transactions that are broadcasted to the system are validated by all nodes and hashed in a tree-structure, a so-called Merkle Tree, to a root hash. This method allows to speed up the process of finding transactions and makes it possible to verify transactions without downloading the entire block (Dwyer 2016, p.4; Nakamoto 2008, p.4).

Step 3. Each node independently tries to add the block - which, as described above, contains all transactions that roughly happen at the same time - to the blockchain. In order to add the block to the blockchain the node has to solve a computational problem which is explained in detail in Chapter 3.2.1. Each block consists of both transaction hashes and the block header. The header is composed of the root hash, the hash of the previous block, a timestamp, and a nonce, an open field that is altered as soon as a solution for the computational problem is found (Dwyer 2016, p.4; Nakamoto 2008, p.3).[4]

Step 4. Once a node finds a solution for the computational problem, it broadcasts this solution to the network and suggests to add the block to the blockchain. Other nodes - which have also worked on solving the problem - validate the solution (BitFury Group 2015, p.2).

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[4] It also includes a version number to track software and protocol upgrades and the target difficulty for this block (Dwyer 2016, p.4).

Step 5. Once a majority of nodes 'agrees' on the validity of the new block, it is finally added to the blockchain (Böhme et al. 2015, p.217). As explained above, even when a block is added to the blockchain, it is possible that it is altered because a majority of the nodes comes to a different solution. After consensus on a block is established, the nodes apply the new blockchain as the basis for the next block (Crosby et al. 2016, p.10).
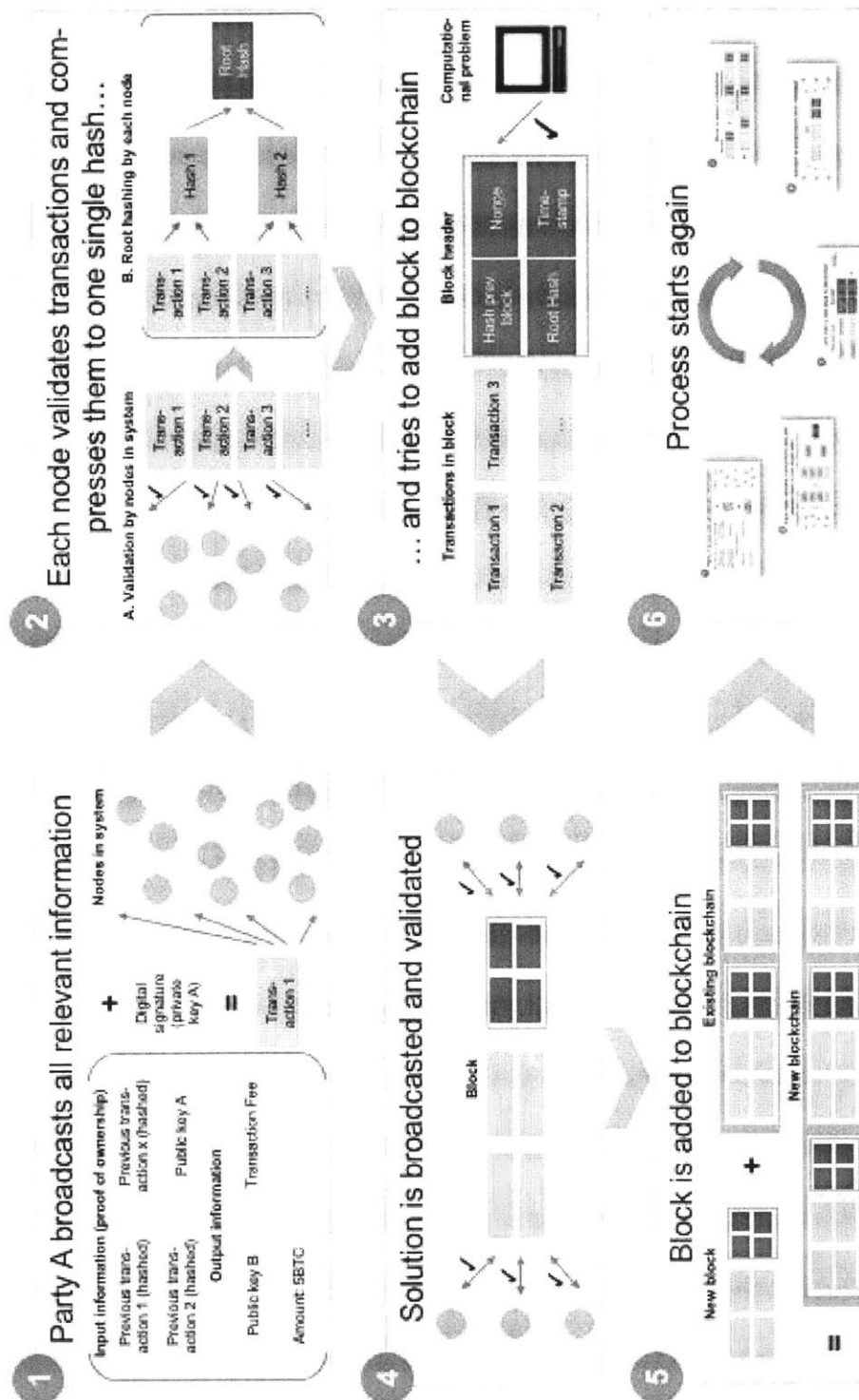
Figure 3: Schematic illustration of Bitcoin transaction; own illustration (Crosby et al. 2016, p.10; Dwyer 2016, pp.3–4; Nakamoto 2008, pp.1–4; Ramzan 2013a)

3.3. Architecture

3.3.1. Overview

Besides the applied consensus mechanisms, the architectures of blockchains are usually defined in three categories. First, it is differentiated whether authorisation is required for validators in the network:

- **Permissionless:** Anyone can participate in the verification process and no prior authorisation is required. In order to verify transactions, nodes just need to provide required assets, for example computational power or stake in the system.

- **Permissioned:** Only members with permission can verify transactions. The specific members are selected by a central authority or consortium (Mainelli & Smith 2015, pp.13–14; Peters & Panayi 2016, p.5).

Second, it is defined how access to blockchain data is restricted:

- **Public:** Anyone can read and submit transactions on the blockchain. Users do not have to be authenticated and as a result cannot be identified.

- **Private:** Permission to read and submit transactions is restricted to specific users, for example within an organisation or a group of organisations (Peters & Panayi 2016, p.5).

Third, one can distinguish between the purposes for which a blockchain is built:

- **General purpose:** Blockchains can be designed so that they are applicable for different functions, for example storing algorithmic code or running customized logical processes (Mattila 2016, pp.8–9).

- **Special purpose:** In contrast, blockchain architectures can be built in a way that they are optimized for a specific task such as tracking assets or transferring value (Mattila 2016, pp.8–9).

Permissionless and *public* or *permissioned* and *private,* respectively, are often used synonymously in blockchain literature (Mattila 2016, pp.7–8; Yermack 2017, pp.3–4). Therefore, in the following discussion we will apply the term *permissioned* to blockchains in which members - both users and validators - are authenticated. As a result, it comprises *private* blockchains as well. Similarly, permissionless blockchains include *public* blockchains - both users and validators are not authenticated (Mattila 2016, pp.7–8). Figure 4 shows a classification of different well-known blockchain networks based on this categorization. Ethereum is an open-source distributed computing platform which features scripting functionality, for example for smart contracts. Hyperledger is an open-source blockchain platform started by the Linux foundation with a focus on business applications allowing for different components for different uses. For instance, IBM's blockchain services are based on Hyperledger (Miller 2017). Eris by Monax Industries allows companies to build on legally compliant smart

contract-based templates to create their own blockchain applications (crunchbase 2017).

general purpose

special purpose

Figure 4: Examples of different blockchain architectures (Mattila 2016, p.9)

3.3.2. Differences of permissionless and permissioned blockchains

The choice of architecture, in particular whether it is designed as *permissionless* or *permissioned,* has a strong impact on what a blockchain can be used for. In general, the main issue at hand is whether the design allows for legal recourse or accountability, which is strongly linked to the ability to identify members and to reverse transactions in the system. Swanson argues that *"[...] existing legal systems will likely never recognize a system of property titles that can be reversed by anonymous validators"* (Swanson 2015, p.25). This is especially important in cases where transactions on the blockchain involve so-called off-chain assets such as art, land ownership, or intellectual property titles. Given the current technical development of blockchain technology, there are inevitable

trade-offs to be made when evaluating which architectural design to choose (Mattila 2016, pp.7–8). Table 2 gives an overview on the differences between permissionless and permissioned blockchains architectures.

	Permissionless	Permissioned
Identification of members	members are anonymous	members are authenticated: can be held responsible, scrutinized, held legally accountable
Irreversibility of transactions	highly unlikely, only through approval of majority of network[1]	possible at any time through authenticated validator(s)
Speed to settle & clear transactions	within minutes	within seconds
Censorship resistance	single transactions cannot be denied	single transactions can be denied by authenticated validator(s)
Energy efficiency	relatively low[2]	relatively high
Scalability	relatively low	relatively high

1 Majority either defined with regard to computational power (PoW) or stake in system (PoS)
2 Strongly dependent on type of consensus mechanism

Table 2: Overview on characteristics of permissionless and permissioned blockchain architectures; own illustration (Mattila 2016, p.8; Swanson 2015, pp.21–28)

It is important to mention that a distributed ledger cannot be authoritative and censorship-resistant at the same time: When users or validators have to identify themselves, transactions by anonymous participants are censored by definition. In contrast, if a system is fully resistant to censorship, transactions by anonymous participants cannot be rejected. As a result, blockchains allowing for transactions that include off-chain assets are usually based on permissioned architectures (Swanson 2015, pp.21–25).

3.3.3. Implementation of different architecture designs

The architectural designs mentioned above are implemented in various ways. In this Chapter, we will give an overview on the main implementations: *colored coins,* dedicated blockchains per asset, and *sidechains.*

	Colored coins	Dedicated blockchains	Sidechains
Purposes	one special purpose for each type of colored coin; can be different from underlying blockchain protocol	both special and general purposes possible	both special and general purposes possible
Underlying infrastructure	same as underlying blockchain protocol	independent infrastructure; either based on other blockchain (fork) or built from scratch	rely on parent chain's measures to maintain scarcity of assets; free experimentation with design features (e.g., trust models, cryptography, etc.)
Exchange rate	same as underlying blockchain	floating	pegged to underlying blockchain
Change of protocol of underlying/ connected blockchain	no	no	yes (for most secure implementation)
Complexity of implementation	low	high	medium

Table 3: Overview on characteristics of *colored coins,* dedicated blockchains, and *sidechains;* own illustration (Back et al. 2014, pp.1–13; Bradbury 2013; Croman et al. 2016, p.1; Narayanan et al. 2016, pp.245–284; Rosenfeld 2012, pp.1–6; Van Valkenburgh 2015)

Colored coins. By its original definition, Bitcoins are fungible: they act as neutral medium for exchange of value. As described above, the Bitcoin blockchain protocol is designed for this special purpose only and can - in its original design - not be used to exchange other types of assets such as ownership of stock (Back

et al. 2014, p.4; Mattila 2016, p.9). However, by *coloring* specific Bitcoins it is possible to use Bitcoins for other specific purposes. A *colored* Bitcoin is one whose origin is tracked and which hence is distinguishable from other Bitcoins. These coins can be ascribed special properties and have value independent of the face value of the underlying Bitcoin. Transactions involving *colored coins* are recognized as normal transactions by regular Bitcoin nodes, but are identified by color-aware nodes when they satisfy specified requirements (Narayanan et al. 2016, pp.245–255; Rosenfeld 2012, pp.1–2). The implementation of *colored coins* on the basis of existing blockchain architectures is relatively easy as they do not need explicit integration in the blockchain protocol. Instead, *colored coins* are a logical layer above the core blockchain protocol (Bradbury 2013). As a result, they share the same infrastructure of technology, software, hardware and services that underlie the Bitcoin protocol and similarly benefit from innovations that are developed for it (Rosenfeld 2012, pp.3–6). In contrast, *colored coins* are similarly affected by problems of the underlying protocol such as the limited number of transactions a protocol can handle or the centralization of mining power (Croman et al. 2016, p.1; Rosenfeld 2012, pp.5–6).

Dedicated blockchains per asset (altcoins). Instead of assigning additional properties to specific Bitcoins, other purposes than that of Bitcoin can also be achieved by creating new blockchains dedicated to these purposes. Usually these blockchains have their own cryptocurrencies, so-called *altcoins* (Back et al.

2014, p.5). Dedicated blockchains can be created in two ways: through so-called

forking or by starting a new blockchain from scratch (Van Valkenburgh 2015).

Forking describes the process of creating modifications to the core blockchain

(Narayanan et al. 2016, pp.96–98). *Forking* can happen in two ways. First

without alteration of the consensus rules and second with alteration of the

consensus rules. In the first case, no separate blockchain is created. Nodes in

the network still agree on the state of transactions on the ledger but certain policy

rules are changed, for example the minimum transaction revenue. The result of

the second case is a split of the shared ledger, a so-called *fork:* Nodes that are

active in this blockchain accept new consensus rules and recognize a different

set of confirmed transactions. This leads to a new blockchain with a new

architectural design, for example a new block structure or a different consensus

mechanism. Examples of so-called *altchains* that arose from Bitcoin are Litecoin

and Dogecoin (Van Valkenburgh 2015). In addition, a dedicated blockchain can

also be created from scratch without being based on another blockchain. Up to

now, Ethereum is the most famous example of this kind. The main advantage of

dedicated blockchains, especially in comparison to *colored coins,* is the

possibility to flexibly design the architecture without restrictions: type of

consensus mechanism, permissionless versus permissioned, specific vs. general

purpose, etc. However, creating a dedicated new blockchain implies costs. First,

barriers to entry are high: Users have to be convinced and incentivised to join the

network and provide their computational power. Second, the value of newly

created *altcoins* often fluctuates as it is traded by only a small group of users: the market is highly vulnerable (Back et al. 2014, pp.14–15). Finally, creating separate blockchains leads to infrastructure fragmentation: Since each blockchain uses its own technology stack, effort is multiplied. This can also lead to lower security standards given that substantial resources are needed to repeatedly review and test the code of new blockchains (Back et al. 2014, p.5).

Sidechains. *Sidechains* build on the concept of *altcoins*. A sidechain is a dedicated blockchain keeping track of its own tokens, which has a pegged exchange rate with Bitcoin or other blockchains (Narayanan et al. 2016, pp.282–283). *Pegged sidechains* allow for bidirectional movement of assets, i.e. assets that are moved to a sidechain can be moved back to the so-called *parent chain* without counterparty risk. In addition, *sidechain* tokens can be transferred between *sidechains* of the same *parent chain*, not just to and from the *parent chain* (Back et al. 2014, p.6). In order to transfer assets from one chain to another, a transaction is created on the first blockchain to lock the assets. Then a transaction on the second blockchain is recorded which validates that the lock was done correctly. After validation, the assets are transferred. The same happens in reverse. A transfer is only possible when the addresses between which the assets are sent are under ownership of the same person. The conversion does not involve any trusted intermediary but is based on mathematically provable statements. These methods are referred to as Simple

Payment Verification (SPVs) proofs between two decentralized networks (Back et al. 2014, pp.6–9; Van Valkenburgh 2015). The main advantage of *pegged sidechains* is the stable exchange rate: It allows users to experiment with new types of blockchains without being at risk to lose their investments. Developers are free to experiment with new transaction designs, trust models, economic models, asset issuance semantics, or cryptographic features. But at the same time, *sidechains* transfer existing assets from the *parent chain* rather than creating new ones. Therefore, *sidechains* cannot cause unauthorised creation of coins. Instead, they rely on the parent chain's measures to maintain scarcity of assets (Back et al. 2014, pp.6–7). In addition, *sidechains* are fire-walled: Problems on *sidechains* cannot damage the *parent chain* or other related *sidechains.* Put differently, if a bug enables the creation or theft of coins on the *sidechain,* it should not result in creation or theft of assets on any other chain (Back et al. 2014, p.6; Narayanan et al. 2016, pp.283–284). However, there are two main downsides of the concept of *sidechains.* First, in contrast to *colored coins, sidechains* are based on their own code which is vulnerable to bugs. As a result, even if users cannot lose the value of their assets due to fluctuation of the exchange rate, they can suffer losses due to flawed code causing creation or theft of assets (Back et al. 2014, pp.11–13). Second, *sidechains* involve significant technical challenges. The conversion process requires *"[...] sophisticated technical arrangement and, for the most secure implementation,*

minor adjustments to the Bitcoin protocol itself - something that will ultimately require the political will of the community to enact." (Van Valkenburgh 2015).

3.4. Economics

Throughout different architectural designs, blockchain technology has several structural advantages over centralized databases. In the following, we will first discuss these advantages and will then point out economic and societal implications. It is important to note that the extent of these advantages depends on the architectural design of the blockchain which we will present below.

3.4.1. Structural advantages

Integrity. As described above, blockchain is a disintermediating technology: it supersedes the need for a trusted intermediary in transactions between parties that do not necessarily trust each other (Bogart & Rice 2015, pp.9–11; Franco 2014, p.6; Tapscott & Tapscott 2016, pp.3–6). Instead, by carrying out instructions exactly as the underlying code prescribes, all parties in a transaction are ensured process and data integrity. The blockchain allows for the commoditization of many transaction and verification steps and hence for costless verification and audit (Catalini & Gans 2016, pp.2–7). By design, the blockchain can perform all three roles of a trusted party: validation (for example, identifying of a certain party), safeguarding (for example, verifying that a payment

was made), and preservation (for example, storing transaction records and relevant documents) (Mainelli & Smith 2015, p.6). As a result, blockchain technology has been described as *'trust protocol'* or *'decentralized trust network'* by several authors (Dahan & Casey 2016; Tapscott & Tapscott 2016, pp.3–6).

Security. There are two main advantages of blockchain over for example centralized databases with regard to security. First, users of a blockchain are forced to apply cryptographic measures. With blockchain technology, these measures are embedded in the system itself through *public key cryptography.* Everyone who wants to participate in the network must use cryptographic encryption, nobody can opt out. This is exceptional compared to other services on the internet. For instance, only 50% of emails are encrypted when they are in transit. End-to-end encryption is even less common (Tapscott & Tapscott 2016, p.40). In contrast, with blockchain the applied *'asymmetric'* cryptography with public and private keys allows members of the network to easily verify the public addresses of transactions while digital signatures (and hence the initiation of transactions) can only be given by the party that is in possession of the private key (Böhme et al. 2015, pp.216–217). Second, transactions are not stored in their original form but as a cryptographic hash. As described above, from these cryptographic hashes it is virtually impossible to get back to the original input. As a result, transaction data, confidential data, or digital assets are securely stored on the blockchain without risk of being hacked (Tapscott & Tapscott 2016, p.40).

Immutability. In its original design, records that are validated on a distributed public blockchain are practically immutable (Nakamoto 2008, p.10). This allows members of the network to operate with the highest degree of confidence that they are working on the basis of a complete and unaltered history of transactions (Bogart & Rice 2015, pp.9–11). In addition, users can be certain that once a transaction was settled - for Bitcoin usually about an hour after the transaction took place - this transaction is not going to be reversed or changed anymore. For these reasons, many authors see immutability as a crucial characteristic of blockchain technology (Futter 2016; Pilkington 2015, p.12). However, others argue that immutable records make it impossible to resolve human error and comply with regulatory rules that require personal data to be easily erased (Lumb 2016; Treat 2016). As an example, in 2016 an investment fund based on smart contracts on the Ethereum platform, called DAO, got hacked after an attacker exploited loopholes in the underlying code. Due to Ethereum's immutability transactions could not be reversed (Vigna 2016). Therefore, Richard Lumb, an executive at Accenture, argues that *"[...] the blockchain's immutability could end up being its own worst enemy"* (Lumb 2016). In response, there have been heavily criticized initiatives, for example by Accenture, to introduce mechanisms called *'chameleon hash'*. The underlying idea is the ability to edit and modify a block in a way that would not compromise the integrity of the entire blockchain (Roberts 2016).

Availability. Blockchain technology in its core is a peer-to-peer network with no single point of control. This has strong implications on the reliability of the system: No single party can shut the system down. The failure of a single node or a group of nodes does not result in the failure of the overall system (Bogart & Rice 2015, p.10; Tapscott & Tapscott 2016, pp.33–35). As a comparison: If the servers of PayPal fail, users of the service cannot make payments anymore. In contrast, if several nodes in the Bitcoin system stop working, users can still transfer Bitcoins and record transactions. Another advantage only applies to permissionless blockchains that are independent of a specific device manufacturer, service provider, or application developer: Users can be sure that the device, service, or application will still work even if the business decides to stop supporting it. This feature is especially relevant in the context of *'Internet of Things'* (IoT) which is characterized by a large number of low-cost products with long lifespans (Bogart & Rice 2015, p.10).

Transparency. Given that blockchain is a distributed ledger which is synchronized among multiple nodes, transaction data is consistent between different members of the same system. Therefore, as the same data is accessible by different parties, changes are apparent and traceable (Bogart & Rice 2015, p.9). This characteristic increases the transparency relative to conventional systems which are often based on multiple *'siloed'* databases (Schneider et al. 2016, p.9). As a result, errors are visible more easily,

procedures and processes are clearer, and corruption is less likely (Burgess & Colangelo 2015, p.13).

Privacy. In online transactions today, parties are often required to provide personal confidential information to access services although part of the information is often not required. Consumers need to trust in privacy and data protection of service providers or intermediaries such as PayPal or Visa. However, recent hacks of databases of companies such as Yahoo, LinkedIn, or Friend Finder show how exposed users are to fraud and identity theft (Burgess & Colangelo 2015, p.12; L. H. Newman 2016; Paul 2016). In contrast, blockchain allows users to expose only the confidential data that is required in a certain social or economic exchange without the need to store it in a central database (Bogart & Rice 2015, p.12; Tapscott & Tapscott 2016, pp.41–45). This allows for more granular data exposure and access than possible today (UK Government Chief Scientific Adviser 2016, p.22). In addition, as described in Chapter 3.3. depending on the architectural design of a blockchain, the public address of a user is not connected to the real-world identity. This allows for anonymous transactions like with Bitcoin (Nakamoto 2008, p.6; Pilkington 2015, pp.3–4). The transaction layer is separated from the identification layer. For example, Bitcoin only confirms that the transaction has taken place and that the sender was in control of the amount and has not spent it yet. *"There's no reference to anyone's identity in that transaction"* (Tapscott & Tapscott 2016, p.42).

3.4.2. Economic and societal implications

As shown above, blockchain enables costless verification and decreases the cost of networking. However, the technology does not only commoditize verification that is directly related to a transaction but also audit in case problems emerge. In fact, blockchain allows for so-called *'sousvaillance'*, costless audit that is embedded within the marketplace itself with the rules of audit decided ex-ante. This feature reduces the risk of a conflict of interest arising after a transaction has taken place. Costless verification has two effects. First, it decreases the price of existing applications (intensive margin effect). Second, new business models and markets will emerge where transactions now become profitable. *"As a result, verification can be economically implemented at a substantially more fine-grained level than before"* (Catalini & Gans 2016, pp.4–6).

Given its profound economic impact, several authors describe blockchain as a *'general purpose technology'* putting it on the same level as for example electricity, transistors, computers, the internet, or mobile phones (Davidson et al. 2016a, p.2; Umalkar et al. 2016). In particular, a comparison with the initial internet technology is often made with blockchain being described as the *'Internet of Value'* or *'Internet of Money'* (Swan 2015, p.xii; Tapscott & Tapscott 2016, p.6). Blockchain technology's impact is significant because it revolutionizes ledgers which modern economies and societies are built upon. Up until now, these ledgers needed to be centralized. This centralization influenced the shape

of modern economies with their centralized government, bureaucracy, and large corporations (Davidson et al. 2016a, p.5). As a *'general purpose technology'* blockchain would have a creative-destructive effect and eventually lead to multifactor productivity growth and subsequent innovation across different industries creating a new technical paradigm and economic growth for multiple years (Catalini & Gans 2016, p.7; Davidson et al. 2016b, p.7).

However, other authors argue that blockchain will have even more profound impact. Davidson et al. (2016b, p.1) claim that the technology *"[...] is actually better understood as a revolution (or evolution) in institutions, organization, and governance"*. The authors point out that instead of just increasing productivity, blockchain allows for the emergence of new ways of economic coordination. It could enable *"[...] a self-governing organization with the coordination properties of a market [...], the governance properties of a commons"* (Davidson et al. 2016b, p.2). As a result, blockchain technology could constitute an alternative institution that coordinates the economic actions of groups of people, eventually competing with firms, markets, and economies overall (Davidson et al. 2016a, p.3). Instead of central companies, one could for example imagine software protocols that are *"[...] developed, governed and owned by the communities they support"* (Ehrsam 2016).

3.5. Applications

As shown above, many stakeholders foresee profound impact of blockchain technology on almost every market by reducing cost of intermediation. However, others are more hesitant. For example, Catalini and Gans (2016, p.2) argue that it is more likely that the scope of intermediation will change *"[...] both on the intensive margin of transactions (e.g., by reducing costs and possibly influencing market structure) as well as on the extensive one (e.g., by allowing for new types of marketplaces"*. Furthermore, the authors claim that blockchain technology will have impact on markets where the verification of attributes (e.g., status of payments) is expensive or network operators enjoy uncompetitive rents for acting as trusted intermediaries. Based on these findings, we will provide an exemplary list of three potential applications in the following.

- **Asset ownership.** Many people in the developing world own assets - such as small plots of land, vehicles, dwellings, equipment, etc. - but lack a formal legal title to these assets. Without proof of ownership, people are often unable to insure their belongings, use their assets as collateral and have a weaker position in negotiations when they want to sell their assets. As a result, they are excluded from financial markets and face substantial economic disadvantages (Schneider et al. 2016, pp.41–43). Blockchain technology can help to solve problems around verification of asset ownership. Instead of having to rely on registries or confirmations of poorly

resourced and corrupt bureaucracies, the blockchain could provide an immutable, universally available, and trusted database in which entries could be validated costlessly and without delay in time (Burgess & Colangelo 2015, pp.55–56). Such a database would also offer substantial advantages in the developed world. For example, reliable and immediate verification of ownership would obviate the need for title insurance which yielded about USD 11 billion of premiums in the United States in 2014 (Schneider et al. 2016, pp.33–41).

- **Smart contracts.** Smart contracts *"[...] are pieces of software, not contracts in the legal sense, that extend blockchain's utility from simply keeping a record of financial transaction entries to automatically implementing terms of multiparty agreements"* (Ream et al. 2016). Smart contracts have three specific characteristics compared to other types of software. First, since the code is recorded on the blockchain, it is immutable and censorship-resistant. Second, smart contracts can control blockchain assets, i.e., it can store and transfer amounts of cryptocurrency. Finally, the program will execute the code exactly as it is programmed without the possibility of interference (Stark 2016). By eliminating the need for trusted intermediaries and expensive audits, smart contracts have many potential use cases (Burgess & Colangelo 2015, pp.45–48). Examples include the transfer of electronic medical records upon multi-signature approval between patients and providers or

automated approvals of loan applications based on data on the blockchain that applicants share with financial institutions (Cant et al. 2016, pp.12–13; Ream et al. 2016).

- **Internet of Things (IoT).** Today, more and more electronic devices are connected through the internet. However, connected devices will only deliver their full potential if they can exchange data with each other and are able to trust the data provided by other nodes (Gantait et al. 2017; Tapscott & Tapscott 2016, pp.152–155). A problem of many centralized IoT systems is that they are siloed and not scalable: A smart fridge cannot access information provided by another smart household device if the two manufacturers have not agreed to share data between their systems. Moreover, in a centralized system, the devices' identities must be maintained by service providers. If these service providers go out of business, the functionality of devices will be lost as well (ConsenSys 2016). Instead, *"open-standards-based distributed IoT networks can solve many of the problems associated with today's centralized, cloud-based IoT solutions, including security, scalability, and cost"* (Gantait et al. 2017). Decentralized IoT networks offer opportunities for completely new business models. An example is ridesharing. Today, service providers such as Uber and Lyft centrally aggregate data, e.g., the availability of cars, ratings of drivers, and payment details, and earn high rents based on these data. In a decentralized system, individuals could form bilateral

agreements without the need for an intermediary because all the necessary data would be publicly stored on the blockchain (ConsenSys 2016).

4. Implications of blockchain on solving issues related to crowdfunding

Issues surrounding crowdfunding were extensively discussed in Chapters 2.5 and 2.6. As outlined in Chapter 3, blockchain technology has the potential to trigger a paradigmatic shift in a wide range of applications. We believe that crowdfunding is one of these applications. In the Chapter below, we will outline potential benefits obtained by the introduction of blockchain technology on crowdfunding.

Decreased dependency on intermediaries. Incumbent crowdfunding platforms act as intermediaries between founders and funders. Platforms screen campaigns, provide tools to market projects and offer features to ensure efficient communication between founders and funders. In return, platforms charge successful campaigns a fee. External payment provider charge an additional commission (Kickstarter 2017a). Like in other industries, blockchain has the potential to substitute crowdfunding platforms as centralized bodies. Advocates of blockchain argue that thereby, crowdfunding would ultimately break up traditional funding methods as it removes any intermediaries between entrepreneurs and investors. Moreover, commissions could be reduced drastically (Rosic 2016). Without a central organization that manages contributions, users would no longer need to trust or depend on any third party

when contributing funds, since transactions would be executed on a point-to-point basis. Moreover, the distributed network of nodes would be more resistant to downtimes and attacks than centralized platforms are (Jacynycz et al. 2016, p.404).

Disclosure. In order to convince potential funders, entrepreneurs need to reduce information asymmetries between parties. However, preparing and disclosing proprietary information is costly. Moreover, founders fear a risk of intellectual property loss due to undue disclosure (Agrawal et al. 2014, pp.74–75). The immutable and encrypted character of blockchain can help to overcome this issue. Through blockchain, entrepreneurs can encrypt, timestamp, and digitally sign documents before sharing them with third parties. Thereby, if a third party claims ownership, entrepreneurs can demonstrate that the document was in fact created by them (Turi et al. 2017, pp.432–433, 438–439). In addition, blockchain technology allows founders to open their data streams to investors in order to prove that certain milestones have been met (Catalini et al. 2016, p.7). If startups stored their data on the blockchain, the technology would allow them to choose which data should be shared with external recipients and which data should be kept internally (Bogart & Rice 2015, p.12; Tapscott & Tapscott 2016, pp.41–45).

Issue and exchange of shares. One common critique of equity crowdfunding is the lack of ability to trade shares or exit investments before an IPO or acquisition (Agrawal et al. 2014, p.68). Blockchain offers a potential solution to this obstacle. Transactions on the blockchain are traceable and ownership can be claimed unambiguously, as founders and investors can review the shareholder structure at any given point in time. The French equity crowdfunding platform SmartAngels has already implemented blockchain in an attempt to make shares tradable. *"This will make crowdfunding investments much more liquid - an issue not given much attention in this sector until now",* claims the service provider BNP Paribas Securities Services that implemented the technology (Parker 2016). Similar to stock exchanges, companies can issue shares on the primary market and investors subsequently trade these on the secondary marketplace. Moreover, payments can now be processed in real-time and investors receive a claim of ownership without delay (Parker 2016).

However, crowdfunding based on blockchain can be even more disruptive. Recently, platforms like OpenLedger have started to allow for immediate and frictionless trading of shares. Instead of relying on a traditional exchange to issue or trade stocks for physical money, the initiative enables creators to issue their own Bitcoin-like blockchain-based cryptocurrency and offer it to investors without any delay. In contrast to SmartAngels, OpenLedger does not operate as an intermediary between founders and funders. The platform is entirely self-governed and automated (Aitken 2016a). Investors acquire a so-called token

that represents a proportion of equity ownership. This process is called *'Initial Coin Offering'* (ICO) (Kastelein 2017). Subsequently, if the project is successfully developed and commercialized, owners of the proprietary virtual currency can benefit from an appreciating value of the underlying company or sell their shares on an exchange. Thereby, investors can realize returns even before commercialization (Aitken 2016b; Aitken 2016a; Ayral 2014; Bort 2016). This approach has been referred to as *cryptoequity*, given its immutable and unforgeable character (Rosic 2016). Blockchain-based ICOs would further help to overcome the issue of recording shares and clearing transactions. Public companies are required to issue equity and clear transactions on a centralized stock exchange. Like exchange-traded institutions, startups which raise capital through equity crowdfunding typically have a large, dispersed group of shareholders. However, their shares are not issued through a highly regulated entity (e.g. a stock exchange), given that crowdfunding platforms currently act as centralized intermediaries instead (Kastelein 2017). The problems of centralized institutions have been discussed extensively in Chapter 2 of this paper. In contrast, the decentralized nature of blockchain may resolve issues related to data security, transparency, and forgery. Moreover, the administrative cost related to paper-based reporting of share issue, ownership, and transfer could be reduced through fully automated blockchain platforms. Thereby, risks of data storage, and integrity would further be reduced, while limiting transaction cost. As a result, regulators would be able to efficiently oversee crowdfunded ventures

and detect fraudulent behaviour, while investors would not need to trust a financial intermediary (i.e. a crowdfunding platform) (De Filippi 2015, p.7; Kastelein 2017; Zhu & Zhou 2016, pp.4–10).

It is unclear whether *cryptoequity* is compliant with existing regulations. While it might be less of an issue for companies that exclusively operate on the blockchain, more traditional ventures might face legal obstacles when issuing equity on blockchain-based crowdfunding platforms (Boase 2014). However, some academics argue that *cryptoequity* can be designed to be different from traditional equity ownership and thus compliant with regulations (Dietz et al. 2014, pp.20–29). De Filippi (2015, p.7) concludes: *"Crowdfunding platforms therefore need to be carefully designed to avoid selling anything that resembles a security [...] cryptographic tokens should not be regarded as securities, but rather as access-tokens that can be purchased in advance, often at a lower rate, in order to subsequently enjoy the services provided by the blockchain-based application that is being backed. This line of arguments has, however, yet to be tested in court"*.

Corporate governance. Milestone-based funding is one measure to overcome moral hazard. Instead of transferring the total amount raised to entrepreneurs at once, pre-determined milestones can be agreed on, which release further funds if reached successfully (Catalini et al. 2016, pp.7–10, 14–15). Smart contracts are one way to implement such functionality. The blockchain-based crowdfunding

platform *Wings* heavily relies on smart contracts in order to establish credibility, trust and community support (EconoTimes 2017). With smart contracts, the platform and contributors themselves maintain control over the collected funds, rather than relying on the creator's goodwill. Project creators set milestones ahead of the campaign launch. These milestones are then formalized as immutable smart contracts. Smart contracts specify milestone deliverables as well as the amount released if the milestone is reached. It is up to the community to decide if a milestone has been accomplished. As soon as the community reaches consensus, the smart contract triggers the release of funds (EconoTimes 2017; Popov et al. 2016, pp.7–9, 12–13). This approach reduces the risk of investors losing contributions if companies fail to fulfill campaigns (Aitken 2016a). Moreover, blockchain technology might offer solutions for shareholders to execute their rights. Tamper-proof blockchain-based voting systems would allow geographically dispersed shareholders to participate in corporate governance at a low administrative cost (Zhu & Zhou 2016, p.7,9).

Crowd diligence. Platforms like OpenLedger work closely with startups to increase the probability of project success. The platform helps entrepreneurs with project conceptualization and even performs a limited due diligence (Aitken 2016a). While this approach is closer to the actions taken by established platforms like Kickstarter, other initiatives rely on crowd intelligence. Again, Wings is a good example of a crowd-governed platform: before a project is

launched, founders submit proposals to the community. The community then has the opportunity to discuss and review proposals. Furthermore, reviewers can recommend amendments to the initial idea. The community then *'forecasts'* the project's chances of success in terms of how many funds will be collected during the campaign. Moreover, the community can vote on proposed amendments and their integration into the project. As soon as the forecasting period has ended, backers can fund a project. These backers might review forecasts in order to identify the most promising campaigns. If a campaign is successfully funded, smart contracts will distribute funds to creators. Moreover, participants who accurately forecasted the actual amount raised are rewarded. If a majority of forecasters mark a proposal as spam, the project will not be listed and the project fee will be distributed to forecasters. Thereby, experts have an incentive to apply their best knowledge in assessing project quality (Popov et al. 2016, pp.1–7, 15). Forecasters who own more tokens and thus have more skin in the game, receive a larger reward than others. The platform relies on a reputation system, where a participant's forecast rating increases if an accurate forecast is made, or decreases in case of an inaccurate assessment. This system further incentivises participants to provide accurate forecasts, as other participants can delegate their right to forecast to a highly-rated forecaster. In return, the reward is shared between forecasters and delegates (Popov et al. 2016, pp.1–7, 15; Turi et al. 2017, pp.432–433). This so-called *'bounty scheme'* rewards all participants. Founders get feedback on project demand, potential improvements and

valuation. Backers get an insight into project quality and attainability based on swarm-intelligence. Forecasters are rewarded according to their ability to determine project outcome (EconoTimes 2017). Entrepreneurs who have previously demonstrated success are more likely to attract funding. The same is true for experienced entrepreneurial teams. Again, a crowdsourced due diligence which is rewarded with a bounty could prove effective in assessing human capital. Swarm, a now defunct blockchain-based platform attempted to use the crowd in order to eliminate scammers or identify bad teams (Ayral 2014; Jacynycz et al. 2016, pp.405–406; Turi et al. 2017, pp.439–440).

While crowd diligence can be achieved without the application of blockchain, the technology offers significant upsides. Smart contracts allow for a frictionless transfer of bounties to a large number of parties. Moreover, given that smart contracts are executed autonomously, no trusted intermediary is needed to supervise the execution or audit the result of the execution. Once agreed, the process of a smart contract cannot be modified anymore and funds cannot be accessed or transferred. As a result, a default of one of the involved investors before certain funds are paid out to the startup does not have an impact on the project. Ultimately, risk induced by asymmetric information can be addressed through platform design as described above (Ayral 2014; Jacynycz et al. 2016, pp.406–410; Popov et al. 2016, pp.7–9, 12–13).

Different platforms. The blockchain could even trigger completely new approaches to crowdfunding. One such initiative is *Betfunding.* Due to the underlying blockchain technology, *Betfunding* is organized on a peer-to-peer basis: *"Betfunding is fully decentralized, and no third-party may tamper with its code, appropriate its funds, or charge commissions to its users"* (Jacynycz et al. 2016, p.409). The platform allows individuals to launch projects or contribute to the bounty of existing projects. Funders do not need to be interested in or have knowledge of the project they propose. Neither do they need (financial) resources to realize projects. The platform aims to attract developers who, unlike innovators, have knowledge on how to develop proposed projects. The platform further allows developers to team up and work jointly on projects. Developers are incentivized by financial rewards in exchange for their work. Last but not least, judges are introduced to evaluate projects and monitor project milestones. Judges will be designated by funders. Funders bet against the project they want to have developed, while developers bet in favour of its completion. Developers' contributions are a sign of commitment. If the project is implemented successfully, developers will get their contribution back, as well as a share of the bounty which is proportional to their contribution. However, if the project is not successful, developers will lose their deposits and funders are reimbursed proportionally to their bet against completion. This system ensures that funders are compensated for their lost efforts and developers are incentivized to complete projects (Jacynycz et al. 2016, pp.406–407, 409–410). The founders of

the platform envision an application in *"[...] the creation of small projects which have a large community of supporters, and which require a low-medium investment like indie games or specialized apps for mobile devices"* *(Jacynycz et al. 2016, pp.409–410)*.

5. Intellectual property

"Intellectual efforts create new technologies, describe new ways of doing things, develop new products and services, and expand the cultural richness of society. They result in intellectual assets, or pieces of information, that may have economic value if put into use in the marketplace. Such assets are called intellectual property to the extent they bear recognized ownership" (Maskus 2000, p.27). The major argument in favor of intellectual property is that it encourages innovation by rewarding inventors in the form of a higher expected rate of return on research and development (Butler 1990, pp.39–40; Helpman 2013, p.1248). However, results of empirical analyses identify different extents to which intellectual property rights lead to economic benefits. In general, the consensus among economists is that overall intellectual property rights *"[...] offer a real, but limited, incentive to create"* (Merges 1995, p.108). In this Chapter, we will give an overview on the different categories of intellectual property and will then discuss the current problems in the markets for patents and digital rights. Given that intellectual property rights vary between jurisdictions, we will focus on the United States.

5.1. Categories

The literature distinguishes between three main types of intellectual property.

- **Patents.** In exchange for a detailed description of the invention, a patent enables the patent holder to prevent others from making, using, selling, offering for sale, or importing the patented innovation. In the United States, there are three different types of patents: *plant patents, design patents,* and *utility patents. Plant patents* cover asexually reproduced plants, while *design patents* protect the ornamental design of an article of manufacture (Besen & Raskind 1991, pp.6–11; Poltorak & Lerner 2011, pp.2–5). However, about 90% of all patents granted are *utility patents* which *"[...] may cover a device or an article, a composition of matter, a method or process of doing or making something, or, less commonly, a new application for an existing device or material, or a product (otherwise known and, therefore, not patentable) made by a particular new process"* (Poltorak & Lerner 2011, p.3). In order to qualify for a patent, an invention must be novel, useful, and nonobvious (Yoffie 2016). A patent is usually granted for 20 years from the date of filing and is, with the exception of pharmaceutical products, non-extendable.[5] Design patents are valid for 14 years from the date of issue (Poltorak & Lerner 2011, p.3; Yoffie 2016).

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[5] Patents for pharmaceutical products can be extended by up to five years for the time lost securing regulatory approvals (Poltorak & Lerner 2011, p.3).

- **Trademarks.** Trademarks are words, symbols, slogans or a combination thereof that distinctly identify the source of the items marked. A service mark performs the same function for a service. Under U.S. law, trademarks have potentially perpetual life: They do not expire as long as the item or the service is used in commerce (Hagiu et al. 2011, p.3; Poltorak & Lerner 2011, pp.22–23). In the United States, trademarks can be registered both on federal and state level (Poltorak & Lerner 2011, pp.24–25).

- **Copyrights:** A copyright conveys to its owner *"[...] the right to prevent others from copying, selling, performing, displaying, or making derivative versions of a work of authorship"* (Poltorak & Lerner 2011, p.28). Copyrights cover creative products (for example, novels, movie scripts, music, song lyrics) but also product manuals, instruction booklets, training materials, marketing and sales publications, and computer software. Although works can be registered at the Copyright Office, copyrights typically exist automatically when the work is fixed in a tangible medium (Besen & Raskind 1991, p.11; Hagiu et al. 2011, p.3; Poltorak & Lerner 2011, p.29). Copyrights protect against actual copying. Thus, a work that is independently created by another entity is not an infringement, even if it is very similar to the copyrighted item. In addition, copyrights protect expressions of ideas, not the ideas themselves (Poltorak & Lerner 2011,

p.28). Under U.S. law, copyrights are granted for the life of the authors plus an additional 70 years (Hagiu et al. 2011, p.3).

Besides the three most commonly used types of intellectual property described above, there are other less commonly used categories which we will discuss below.

- **Trade secrets.** A trade secret is information (for example, price lists, prototypes, drawings, and formulas) *"[...] that is not generally available and that confers a competitive advantage upon its possessor"* (Poltorak & Lerner 2011, p.35). Trade secrets need not be registered, instead it is necessary that the information is treated as a secret which implies that it is marked *'confidential'* or stored in locked cabinets. Trade secrets are valid as long as the information can be kept secret. In contrast to patents, trade secrets are protected against discovery by improper means but not against independent discovery or reverse engineering. In addition, enforcement opportunities are more limited compared to patents: Damages can only be sought by the party that improperly gained access to the secret information, not by the parties that benefited from this information after revelation (Besen & Raskind 1991, p.23; Hagiu et al. 2011, p.3; Poltorak & Lerner 2011, pp.35–38).
- **Mask works.** Semiconductor chips are produced by a chemical etching process that utilizes a stencil, the so-called *mask work.* Since

semiconductor chips are useful and functional products, they are protected by neither copyright nor design patents. Besides, the usual lifetime of these chips is often shorter than the average process period to file for a utility patent and they are often not considered nonobvious (Poltorak & Lerner 2011, pp.38–39). Therefore, in 1984 Congress passed the *Semiconductor Chip Protection Act*. The law protects both chips and mask works effective from the time of registration or commercial exploitation. If registered, protection is granted for ten years, otherwise for two years. Two basic rights are given to the owner of a protected mask work: *"the right to bar the reproduction of the mask work [...] and the right to import or distribute a semiconductor chip product in which the mask work is embodied"* (Besen & Raskind 1991, pp.19–20; Poltorak & Lerner 2011, pp.38–39).

- **Noncompetition agreements.** A noncompetition agreement is a contractual agreement between an employee and their employer with the goal to prevent the employer's intellectual capital to fall into the hands of its competitors. The agreement limits the rights of the employee to accept new employment with competitors in three dimensions: temporal (time period that must elapse before new employment can be accepted), geographical (geographic limitations to accept new employment during agreed time period), and scope (definition of competitor) (Poltorak & Lerner 2011, pp.39–41).

- **Confidential disclosure agreements (nondisclosure agreements).** A nondisclosure agreement (NDA) is *"[...] an agreement that the recipient of specified information will use the information only for a specified purpose and will maintain it in confidence."* NDAs usually have terms not exceeding three years (Poltorak & Lerner 2011, pp.42–43).

5.2. Patents

No week passes without news coverage on large corporations being involved in patent cases such as smartphone manufacturers in the *'smartphone wars'* (Graham & Vishnubhakat 2013, p.73; Osawa 2016). In the following, we will give an overview on the patent system, its players, and legislation. Finally, we will shed light on the main issues leading to inefficiencies in the patent system.

5.2.1. Overview on patent system

In the past years, the number of patents filed with the United States Patent and Trademark Office (PTO) has increased substantially: Figure 5 shows that utility patent applications increased by 178% between 1995 and 2015.
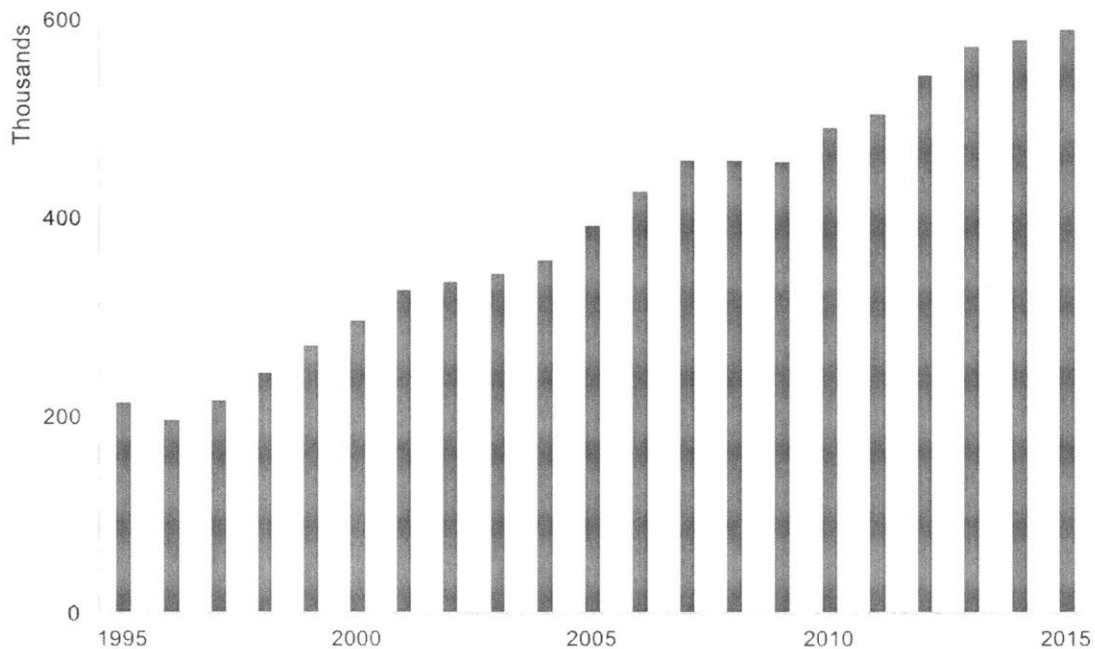
Figure 5: Number of utility patent applications filed at PTO between 1995 and 2015 (U.S. Patent and Trademark Office - Patent Technology Monitoring Team 2016)

There are different explanations for the increase in patent filings. From an economic perspective, in an *'information economy'* or *'idea economy'* where about 70 to 80% of companies' market values are intangible assets, corporations are willing to spend more to protect it (Allison & Lemley 2002, p.78; Kaye 2012; Millien 2008, p.4; McDonough 2006, pp.191–192). From a technological perspective, an increase in technological innovation in the past decades is reflected in a higher number of patents (Allison & Lemley 2002, p.78). Finally, from a legal perspective, the expansion of patentability, to among others software

and business methods, had a positive impact on the number of patent applications (Allison & Lemley 2002, p.78; Coriat & Orsi 2002, p.1496). Despite the growing importance of patents for the overall economy, the market for patents and intellectual property in general is considered small, illiquid, and inefficient. Instead of being traded in an organized market, patents are mainly subject of bilateral transactions in the form of sales or licenses between large companies (Gans & Stern 2010, p.806; Hagiu & Yoffie 2013, p.45; Hagiu et al. 2011, p.3). The market's illiquidity and inefficiency create profit opportunities for intermediaries which explains the large number of these players in the system as we will show in Chapter 5.2.2.

5.2.2. Players in patent system

One can distinguish between three different players in the patent system: *patent creators*, *patent consumers*, and intermediaries (Millien 2013). In addition, public bodies play an important role in the patent system. The government agency PTO issues patents to inventors and businesses while the United States Court of Appeals for the Federal Circuit (CAFC) is the exclusive venue for patent appeals in the United States, from decisions of both the U.S. District Courts and the PTO (Wagner & Petherbridge 2004, p.1115). *Patent creators* are individual inventors or corporations that file patents based on their inventions. Similarly, *patent consumers* are individuals or corporations that use a patented invention. They might purchase or license the right to do so. A person or corporation is often both

'patent creator' and *'patent consumer'* at the same time (Millien 2013). Due to the illiquidity of the patent market, there is a diverse set of intermediaries with different roles: Millien (2013) describes 19 different business models in the intellectual property landscape, most of them with a focus on patents. Intermediaries in the patent system include traditional institutions such as patent brokers, patent pools, or standard-setting organizations but also novel players such as patent aggregators (for example, defensive aggregators or non-practicing entities) and auction platforms (Hagiu & Yoffie 2013; Monk 2009, p.472).[6] These intermediaries try to address the various issues that exist in the system, which are explained more in detail in Chapter 5.2.4. For example, patent brokers aim at reducing their clients' search and transaction costs. They operate both on the buy-side and the sell-side. On the buy-side, they assist technology companies in acquiring relevant rights by crawling the market for strategically important patents. On the sell-side, they support clients to find the right buyers for the clients' intellectual property (Hagiu & Yoffie 2013, p.49; Millien 2013). A controversial case are patent licensing and enforcement companies, often called non-practicing entities (NPEs) or *'patent trolls'*. There is no clear definition of NPEs. In its essence, *"NPEs are firms that do not produce goods, rather they acquire patents in order to license them to others"* (Bessen et al. 2011, p.3). Some authors argue that NPEs fulfill a socially valuable function by providing smaller inventors, who lack resources and expertise needed to market their

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[6] Standard-setting organizations and defensive patent aggregators are explained more in detail in Chapter 5.2.4. under *'Patent Thickets'*

technologies, the opportunity to enforce their patents (Bessen et al. 2011, p.3; Hagiu et al. 2011, pp.4–5; Schwartz & Kesan 2014, p.427). By doing so, NPEs could provide liquidity and improve market clearing (McDonough 2006, p.190). In addition, NPEs of a sufficient size could help licensees to acquire patent rights in a field that is not their focus, for example for defensive reasons (Hagiu et al. 2011, p.9). In contrast, critics argue that patent trolls do not promote innovation (McDonough 2006, pp.189–190; Schwartz & Kesan 2014, p.427). Authors claim that NPEs cause excessive, baseless litigation by seeking *"[...] to generate supra-normal returns on patent-protected technology [...]"* (Reitzig et al. 2010, p.948). R&D-intensive companies and real innovators are said to be most affected by being pushed to license *"[...] vaguely worded patents that can be construed to cover established technologies [...]"* (Bessen et al. 2011, p.3). Two practices applied by NPEs are economically harmful in particular. First, they sue many companies simultaneously for relatively small amounts hoping that defendants will pay license fees instead of risking costly litigation (Hagiu & Yoffie 2013, p.53). Second, they create *'patent hold-up',* situations in which a patent owner sues a company after it has implemented the technology and it is too late for the defendant to change course (Chien 2014, p.1; Elhauge 2008, p.535; Hagiu & Yoffie 2013, p.53; Shapiro 2010, pp.280–282). Some authors estimate that about 60% of new patent lawsuits were filed by NPEs in 2010 (Schwartz & Kesan 2014, p.426). Bessen et. al. (2011, pp.2–5) claim that between 2006 and 2010 the annual aggregate loss of market capitalization of defendants in lawsuits

filed by NPEs was USD 83 billion. Only little of this value was transferred to the actual inventors. In summary, intermediaries such as NPEs aim to heal inefficiencies in the patent market but by doing so create other costs and inefficiencies. It is difficult to evaluate their overall effect (Hagiu & Yoffie 2013, p.61). However, most academics and industry participants agree that the large number of intermediaries in the patent market is an indication of the inefficiency and illiquidity of the system (Yoffie 2017).

5.2.3. Overview on legislation

Over the past decades one could see swings in legislation between strong and weak patent protection. While the 1960s and 1970s saw poor patent protection, the 1980s throughout the 2000s were characterized by extraordinarily strong patent rights. Since 2011, most observers assess patent protection as rather low in the United States (Dierenfeldt-Troy 2016; Jaffe 2000, p.532; Lemley 2016, pp.14–15). In the following, we will discuss the two most important legislative changes, the *Federal Courts Improvement Act* (FCIA) in 1982 and the *Leahy-Smith America Invents Act* (AIA) in 2011.

Federal Courts Improvement Act (FCIA). Congress's adoption of the FCIA in 1982 *"[...] created a unified judicial appellate authority for all cases relating to patent, trademarks, government contracts, tax and international trade [...]"*, the CAFC (Coriat & Orsi 2002, p.1494). The law aimed at standardizing patent law

across the country and reduce the heterogeneity in court decisions among different districts. Hence, it tried to eliminate incentives for 'forum shopping', a practice of litigants of having their legal case heard in courts that are more likely to provide a favorable decision (Coriat & Orsi 2002, pp.1494–1495; Jaffe 2000, p.533; Wagner & Petherbridge 2004, pp.1114–1117). The CAFC took a more pro-patent approach than its predecessor by expanding patentability to software and business models and by alleviating rules for nonobviousness. This policy resulted in stronger patent protection and an increase in patent applications filed, but also a large number of low-quality patents lacking substance (Allison & Lemley 2002, pp.78–79; Jaffe 2000, pp.532–533; Lemley 2016, p.7).[7]

Leahy-Smith America Invents Act (AIA). The AIA, enacted in 2011, represents the most significant change to the U.S. patent system since 1952 (Abrams & Wagner 2013, p.517). First, it addressed the problem of dubious patents, particularly aiming at software patents. The act allowed individuals and firms to challenge the validity of already issued patents. Mechanisms for identifying low-quality patents involved post-grant review[8], inter partes (or third-party) review[9], covered business method patent review[10], and derivation proceedings[11] (Dolin

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[7] The problem of low-quality patents is explained more in detail in Chapter 5.2.4.

[8] Trial proceeding to challenge an issued patent on any ground that could be raised under § 282(b)(2) or (3) (U.S. Patent and Trademark Office 2014b)

[9] Trial proceeding to challenge an issued patent under 35 U.S.C. §§ 102 and 103 based on prior art patents or printed publications (U.S. Patent and Trademark Office 2016)

[10] Trial proceeding to review the patentability of one or more claims in a covered business method patent; it employs standards and procedures of a post grant review, with certain exceptions (U.S. Patent and Trademark Office 2014c)

[11] Trial proceeding to determine that the first person to file a patent application is actually the true inventor (U.S. Patent and Trademark Office 2014a)

2015, p.882; Graham & Vishnubhakat 2013, p.80). By implementing these mechanisms, the AIA substantially changed the role of the public in the patenting system: While patent granting was mostly hidden in the past, members of the public are able to challenge patents since the AIA has been enacted (Armitage 2012, pp.4–10). Second, the AIA changed the U.S. patent system from a *'first to invent'* (FTI) to a *'first inventor to file'* (FITF) system: FTI grants the rights to the inventor who can prove the earliest date of invention, under FITF the right of the patent is granted to the inventor who filed an application for this patent first, regardless of the timing of invention. A prime motivation for FITF is to reduce interferences and uncertainty associated with potential claims about who discovered an invention first (Abrams & Wagner 2013, pp.523–524; Armitage 2012, pp.93–94). However, critics argue that FITF disadvantages smaller inventors, which seem less likely to win the race to the patent office (Bagley 2008, pp.7–8). Overall, the reaction to AIA is mixed. While the change to FITF, a system that is used in all other countries in the world, has been received favorably overall, the implementation of measures to challenge patents already issued has drawn criticism - especially from NPEs and companies in the software industry (Dolin 2015, pp.884–885; Lemley 2016, pp.11–14; Yoffie 2017).

5.2.4. Structural inefficiencies in the patent system

As shown above, the market for patents is illiquid and inefficient and has been widely criticized for not drawing on its full potential in promoting innovation in the United States (Gugliuzza 2015, pp.279–280; Hagiu & Yoffie 2013, p.46; Lemley 2013, pp.83–85). In the following, we will discuss shortcomings and structural inefficiencies in the patent market that lead to its illiquidity and inefficiency. All of these issues have in common that they are mainly caused by a lack of transparency (Hagiu & Yoffie 2013, p.45). Therefore, we will not address intransparency as an issue itself but as an underlying driver of all inefficiencies.

Patent thicket. A patent thicket is *"[...] a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology"* (Shapiro 2000, p.120). The overlapping intellectual property rights are typically owned by different right holders which makes it very costly for users to license these rights. Patent thickets usually apply to components of a modular and complex technology such as smartphones or semiconductors (Hall et al. 2012, pp.2–6). As an example, all typical features of a modern smartphone are patented: curved sides, a swipe to unlock, auto-correction, and emails *'pushed'* to the phone without request to the server (Lewis 2013). Patent thickets can constitute a barrier to entry because of increased transaction costs due to multiple ownership stakes, especially for individual investors or small entities (Hall et al. 2012, pp.5–6). These high

transaction costs result in underuse of the underlying technology which may eventually stifle innovation (McDonough 2006, p.203). Companies apply several solutions for patent thickets. First, cross licenses allow companies to use each other's patents for the same technology. This is typically done by larger corporations such as HP and Xerox (Shapiro 2000, pp.129–131). Second, patent pools allow companies to license patents to each other or to third parties: *"A patent pool involves a single entity [...] that licenses the patents of two or more companies to third parties as a package"* (Shapiro 2000, p.134). Common examples are patent pools for Bluetooth or MPEG-4 (Hagiu & Yoffie 2013, p.50). Third, standard-setting organizations enable coordination on and certification of technical standards. Participants in the relevant industries usually adopt the standards set by the organization and agree to cross-license or pay the required royalties to the standard owner(s) (Hagiu & Yoffie 2013, p.50). An example is the CD standard established by Sony, Philips, and others in the 1980s (Shapiro 2000, p.137). Finally, participants in the patent market apply defensive patent portfolios, either by creating a portfolio themselves or by joining a defensive aggregator such as RPX. With a defensive patent portfolio, a corporation can counterattack with its own patent infringement claims if it is sued for infringement. This technique results in lower incentives to sue the patent user in the first place (Hagiu & Yoffie 2013, pp.56–58; Hall et al. 2012, pp.5–6; McDonough 2006, p.203). Per default, smaller entities are disadvantaged because they own smaller patent portfolios - if any (Hall et al. 2012, p.10).

Approval of low-quality patents. Not all patents granted by the PTO are held valid when subject to litigation. Allison & Lemley (1998, pp.251–252) find that litigated patents were held valid only 54% of the time between 1989 and 1996: Many patents are granted for innovations that are not novel and/ or nonobvious (Mireles 2006, p.715). In other words, a large number of economically viable products is protected by *weak patents,* i.e. patents that would likely be invalidated if they were subject to litigation (Encaoua & Madies 2014, p.4; Ford 2013, p.71). Loose patent granting standards can cause considerable social costs: For example, corporations may have to pay high amounts to litigate, license invalid patents or avoid research due to potential infringement liabilities (Lemley 2016, p.10; Thomas 2001, pp.319–320). Because patent litigation is expensive, it often makes more sense for a defendant to license an invalid patent rather than to fight an infringement claim (Gugliuzza 2015, p.280). The pressure to settle for defendants is intensified by *'patent hold-up'* situations as shown above. As a result, entrepreneurs may be incentivized to *"[...] divert resources from productive activities into speculative patent acquisition and enforcement ventures"* (Thomas 2001, pp.319–320). Other authors argue that the problem is not that the PTO issues a large number of invalid patents. Instead, Lemley claims *"[...] that the PTO issues a small but worrisome number of economically significant bad patents and those patents enjoy a strong but undeserved presumption of validity"* (Lemley 2013, p.84).

There are different potential reasons for the increase in the number of patents of relatively low quality in the past decades. First, as shown above the number of patents has been increasing rapidly since the 1980s. Given this rise in combination with limited funding, the PTO might be unable to conduct a comprehensive and meaningful review of patent applications and is instead incentivised to process applications quickly and at the lowest cost (Mireles 2006, p.716). Second, since the 1980s, software and business models have become patentable in the United States (Coriat & Orsi 2002, p.1496). Patents on software and business methods are litigated more frequently because they have *'fuzzy boundaries'*: These patents are characterized by unclear scope, vague language, they are harder to find, and technology companies often do not understand what they claim (Bessen et al. 2011, p.2; Lemley 2013, p.84). Social costs of invalid patents for business methods and software may even be higher than for other types of invalid patents (Lemley 2013, p.84; Thomas 2001, p.320): They cover products that exhibit lock-in and network effects which typically result in a monopolistic, winner-take-all market. The consequence is *"[...] that software and business method patents need not be considered valid for very long in order to have substantial market impact"* (Thomas 2001, p.320). Finally, the CAFC - created by Congress in 1982 - has led to a more pro-patent practice by expanding the scope of patent eligibility, weakening the standards of novelty and nonobviousness, improving the enforceability of patents and expanding damages (Coriat & Orsi 2002, p.1495; Lemley 2016, p.7; Mireles 2006, p.718).

However, recent developments show a trend towards a decreasing number of *'bad patents'*. As shown above, the AIA enacted new rules for granting patents and changed the review process for already issued patents: *"[...] whereas prior to 2012 patent challengers had just one, however powerful, tool to harass patentees, now they have four. And each of these tools has been consistently used for that exact purpose"* (Dolin 2015, p.884). In addition, the Supreme Court and CAFC took several decisions that weakened patent rights: For example, it is now easier to invalidate a patent as obvious and to file a declaratory judgment action to challenge a patent. Winning a patent suit does not automatically justify an injunction anymore. It is more difficult now to expand the reach of a patent claim. It is also easier for prevailing defendants to recover legal fees (Lemley 2016, pp.11–12). In the widely debated *Alice* decision, the Supreme Court also held that *"[...] patents are not appropriate for laws of nature, natural phenomena, and abstract ideas, casting significant doubt on the validity of many business method, software, genetics, and medical diagnostic patents"* (Lemley 2016, pp.11–12). As a result, the academic opinion has changed towards a fear that reforms have been taken too far and the patent system has been weakened as a whole (Dierenfeldt-Troy 2016; Dolin 2015, p.882; Lemley 2016, p.12).

Difficult valuation. Patents are more difficult to value than most other goods (Pitkethly 1997, p.5). This is due to three main reasons. First, patents are intangible. While tangible assets can only be in one place at once, patents can

be used in multiple places at one time without depleting the original (McDonough 2006, p.206). Second, by definition patents have to be novel and unique: They lack comparables that are usually applied for valuation. Third, as previously shown, patents are subject to strong complementarities and portfolio effects (Hagiu & Yoffie 2013, pp.46–47). Patents are rarely of value in isolation, instead they often require complementary assets and patents, especially in industries like semiconductors or high-tech consumer electronics. As a result, individual patents can be heavily discounted or not tradable at all (Gans & Stern 2010, pp.807–808; Hagiu & Yoffie 2013, pp.46–47).

Limited access for small inventors. Individual inventors and small companies benefit less from patent markets than bigger firms (Schwartz & Kesan 2014, p.427). While in 2008 about 60% of patents originated from individual inventors, universities, and research labs, this group only received less than 1% of patent licensing revenue. The remaining 99% of licensing revenue went to large corporations which only filed 40% of all patents (Hagiu et al. 2011, p.22). This imbalance is explained by two main factors. First, individual inventors often lack resources and expertise needed to successfully license or enforce their patents (Bessen et al. 2011, p.3; Hagiu & Yoffie 2013, p.47). The average cost of patent litigation is about USD 2 million while the cost of receiving and maintaining a patent for twenty years is on average USD 25,000. This relatively high cost prevents individual investors and small corporations to enforce their patent

claims against large corporations (McDonough 2006, p.210; Vallone 2005, p.183). A consequence of individual inventors' and small companies' inability to enforce their patent rights is so-called 'patent hold-out': a "[...] practice of companies routinely ignoring patents and resisting patent owner demands because the odds of getting caught are small" (Chien 2014, p.1). In addition, even if a party is victorious and can enforce their claims, much of the litigation cost will not be considered when damages are calculated (Ronspies 2004, p.186). Second, portfolio effects do not just increase difficulties in valuing patents but they create unfavorable conditions for smaller inventors: "Potential buyers or licensees may not place much value on a given patent sold by itself unless it complements a portfolio they already own". As a result, the number of potential buyers is reduced which leads to asymmetries between large corporations and individual inventors and small companies. Put differently, individual inventors and small entities have lower bargaining power and thus are often reluctant to monetize or litigate (Hagiu & Yoffie 2013, p.47).

High search costs. Both patent owners and patent users face high search costs. For patent owners, it is costly to find all current users and potential applications of their patents (Hagiu & Yoffie 2013, p.47). In addition, so-called 'user reproducibility' often makes it difficult for patent owners to exploit the full value of their assets: Disclosures or access to ideas may allow users to reproduce or expropriate ideas, especially when the patent owner is not able to

enforce its rights, for example due to high legal costs (Gans & Stern 2010, p.808). For patent buyers and users, it is expensive to find prior art and other patents that affect the specific patent. Usually patent applications only disclose the minimum information necessary to obtain a patent and use broad and unspecific language on purpose. As a result, finding applying patents is resource-intensive, even though comprehensive public and private patent databases are available (Hagiu & Yoffie 2013, p.47). Besides, the increasing complexity of patents in the United States has a negative impact on search costs: *"By almost any measure - subject matter, time in prosecution, number of prior art references cited, number of claims, number of continuation applications filed, number of inventors - the patents issued in the late 1990s are more complex than those issued in the 1970s" (Allison & Lemley 2002, p.79).*

High likelihood of expropriation. By definition, patents are intangible and nonrival. These characteristics allow other entities to use an invention without the patent holder knowing about it. In order to protect a patent holder from infringement, a patent grants the holder the right to exclude others from making, using, selling, offering for sale, or importing the patented invention. However, while in criminal law trespass or theft is prosecuted by the state, a patent owner can only enforce her entitlement in a civil lawsuit. But as shown above, the average costs for patent litigation are about USD 2 million, which is often too much for individual investors or small corporations. Therefore, the threat of

litigation is often not credible (McDonough 2006, pp.206–210). As a result, patent infringements often go without consequences, particularly for large corporations (Vallone 2005, p.183).

5.3. Digital rights

As mentioned above, copyrights are typically granted automatically as soon as a creation is fixed in tangible form. However, this characteristic does not make this subsegment of intellectual property any less complex than for example patents (Besen & Raskind 1991, p.11; Hagiu et al. 2011, p.3; Poltorak & Lerner 2011, p.29). The music industry is likely the largest segment where copyrights are applied. Moreover, the industry has experienced dramatic change due to the digital revolution triggered by the internet economy (CISAC 2016, p.29). Therefore, we will base our copyright analysis on the music industry and more specifically on the issues introduced by the shift from physical to digital audio consumption.

5.3.1. Music industry overview

According to a study conducted by the Berklee Institute of Creative Entrepreneurship (2015, p.6) the global music industry encompasses a total market size of USD 45 billion. After almost 20 years of decline and stagnation due to music piracy, the industry has grown over the last two years (CISAC 2016, p.4; IFPI 2016a, p.5). This development is mainly driven by increased digital consumption, which has been cannibalizing physical sales for the last ten years. Nielsen Music (2017, pp.2–5) found that overall music consumption in the U.S. increased by 3% in 2016. According to IFPI (2016a, p.9), the digital music market

(streams and downloads) has overtaken the physical subsegment in 2015, now representing 45% of global revenues. Within the digital subsegment, on-demand audio streaming has surpassed digital sales in the form of downloads for the first time ever in 2016. Audio streams are now the predominant means of music consumption (Nielsen Music 2017, pp.3–4). A more recent report concludes that streaming alone accounts for 51% of total US music revenue, growing by 68% year-on-year (Clover 2017). Close to a billion users worldwide now consume music on-demand, streaming 431 billion songs in 2016 in the US alone (IFPI 2016a, pp.8, 22; Reuters Editorial 2017).

Music streaming has revolutionized the way users consume and pay for digital audio. Today, there are more than 400 services that legally distribute on-demand content (Pro-Music 2016). The two predominant business models within on-demand streaming are subscription-based platforms and advertising-supported services. Users of subscription-based services pay an ongoing fee to access the whole music catalogue a platform offers. Ad-supported services are free to use in exchange for listening to and/ or viewing of ads (BerkleeICE 2015, p.7). Ad-supported services are frequently used as a means of customer acquisition. For example, Spotify offers both, a free ad-supported service and a premium subscription, which is priced at about USD 10 per month. However, free users only have access to a limited catalogue, stream in lower quality and enjoy a reduced set of features (Flanagan 2017; Schäfer 2017). At

over 50 million paying users, Spotify is the largest subscription-based platform. Between March 2016 and March 2017, the company added more than 20 million paying subscribers. It is rumoured that an additional 100 million enjoy the ad-supported service. With about 20 million paying users, Apple Music is the second largest service (Cross 2017; Russell 2017). Ad-supported services such as YouTube reach about a billion users. However, most revenues are derived from subscription-based services. In 2015, an estimated 68 million paying subscribers of services like Spotify and Apple Music accounted for USD 2 billion in revenues distributed to creators. In contrast the 900 million free users from ad-supported platforms like YouTube accounted for only about USD 634 million in distributed revenues. This disparity between consumption and revenue generation has been referred to as *value gap* and criticized by the industry (IFPI 2016a, pp.5, 8, 22–24).
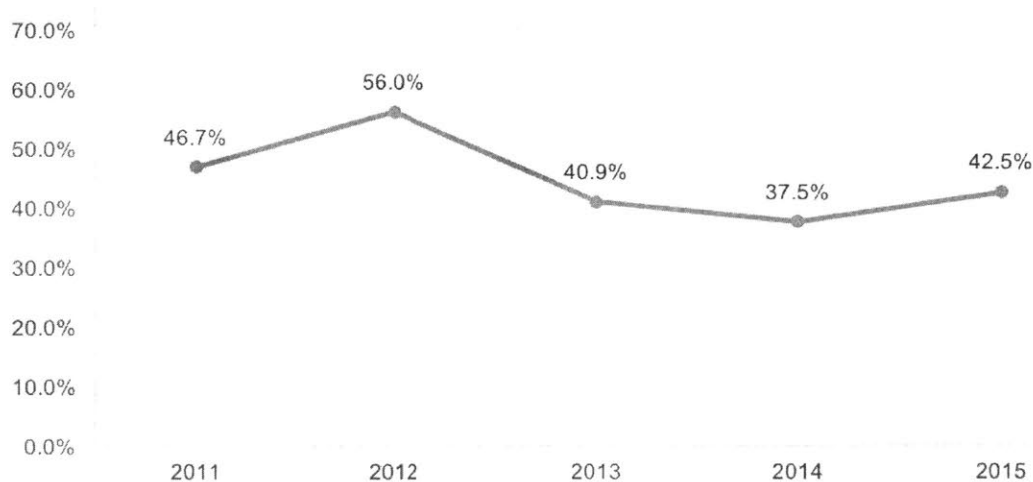

Figure 6: Streaming growth year-on-year between 2011 and 2015 (IFPI 2016a, p.17)

5.3.2. Copyrights and parties involved

In order to address the predominant issues of the music industry, we first shed light on the underlying market dynamics, introduce various types of copyrights, and analyze revenue streams.

Copyrights. Musical creations are automatically legally protected through copyrights as soon as they are fixed, for example through recording or writing. Creators are assigned ownership of the copyright, which is automatically split equally if more than one creator is involved. Copyright laws vary between countries and jurisdictions. In the United States, these copyrights have a lifetime of 70 years after the death of the last creator. Copyrights can be transferred or licensed to other parties, and grant owners control over reproduction, distribution, performance and creation of derivatives (Voogt 2014; PRS for Music 2017).

Each musical creation is assigned not one but two types of intellectual property: (1) the *song copyright* and (2) the *recording copyright*. The song copyright (also referred to as '*musical composition copyright*') protects the lyrics and composition (i.e. sheet music) of a piece of music. Creators of a song typically include individuals or groups of songwriters, lyricists and composers. In contrast, the recording copyright protects the actual recording of written music (i.e. sound), which is typically recorded by an artist or group of musicians (BerkleeICE 2015, p.10; Cooke 2015a, pp.6, 9; Voogt 2014).

Both copyrights provide owners with a set of controls. The most important ones are the following (Cooke 2015a, pp.16–17):

- **Reproduction control.** Right to make copies of a creation.

- **Distribution control.** Right to distribute/ sell a copy to the public.

- **Performance control.** Right to perform a creation in public.

- **Communication control.** Right to broadcast a creation to the public.

Reproduction and distribution control rights are commonly grouped together and referred to as *reproductive* or *mechanical rights*. Likewise, performance and communication control is bundled as *performing rights (CISAC 2016, p.12; Cooke 2015a, pp.16–17)*.

When musicians want to record and subsequently sell a song, they need to compensate songwriters in exchange for a *mechanical license*. If musicians perform a song at a concert, they exploit the *performing right* of a composition owned by a songwriter. It becomes more complex if a third party now burns a song onto a physical medium (i.e. CD) or makes it available on a streaming service (i.e. Spotify) as they need to pay a *mechanical royalty* to both the owners of the *song copyright* (i.e. songwriters) and the owners of the *recording copyright* (i.e. the musicians). If a song is streamed or played on the radio, services exploit the *performance control* of both, the *song copyright* and the *recording copyright* (Cooke 2015a, pp.7, 16–18; Voogt 2014).

Parties. Due to the underlying complexity of copyrights, it is common practice that songwriters/ musicians transfer or license copyrights to third parties. These parties can be subdivided into two groups, the *publishing industry* and the *record industry* (Rethink Music 2013, pp.3–5).

Publishers typically represent compositions and find ways to monetize catalogues (Rethink Music 2013, p.6). For example, they commonly monitor usage and collect royalties, help to facilitate releases on labels, promote broadcasting, match artists to create new creations and encompass deals with streaming platforms and the movie industry. In return for their service, publishers demand a share of between 33% and 50% of royalties collected (Rethink Music 2013, p.6; Rubin 2005; Voogt 2015a). It is common practice that publishers do not negotiate with licensees directly, but appoint so-called *'collective management organizations'* (CMOs) instead. Thereby, publishers maintain a lean structure and simplify the collection of (international) royalties from various streams. Usually, the value derived from a single use of a creation is relatively modest, but a whole catalogue can be very valuable (CISACUniversity 2015, pp.2–4). This circumstance makes it more practical for publishers to outsource collection and intermediation. In some jurisdictions rights owners are forced to grant a reproduction license, and CMOs can be better positioned to negotiate such deals. CMOs have established deals with streaming services, which further facilitates distribution. Moreover, when royalties are collected in a foreign country, CMOs rely on established partnerships to make sure these revenues are

transferred to the right owner (CISACUniversity 2015, pp.2–4; Cooke 2015a, pp.18–19). Publisher commonly work with several CMOs that are specialized in the collection of one specific right. Reproduction rights are managed by *'mechanical right societies'* (MRS) while *'performing right organizations'* (PRO) handle performance rights (Voogt 2014; Cooke 2015a, pp.8, 15–19). The Harry Fox Agency would be an example of an MRS. The major PROs in the United States are ASCAP, BMI and SESAC (CISAC 2016, p.60; Voogt 2014). Publishing deals are typically exclusive, embody the whole catalogue of a creator and last for at least three years. Contracts are usually extended on a yearly basis and if creators choose to switch producers, the current catalogue may only be transferrable - if at all - after ten years (Voogt 2015a).

Record companies (or labels) are for musicians what publishers are for songwriters. Labels commercialize the recording copyright (i.e. the actual sound). The largest *(major)* labels are Universal Music Group, Sony Music Entertainment, and Warner Music Group, who collectively aggregate 62% of global recorded music revenues. The rest can be attributed to a large number of dispersed independent *(indie)* labels (WIN 2016, p.40). Labels act like venture capitalists, who provide musicians financial resources as well as a network of support. Record companies finance the recording of tracks and get engaged in distribution of copies to stores and digital platforms. Labels also promote artists to broaden the fan base and train musicians to increase the probability of mainstream success (Voogt 2015b). In doing so, labels take an up-front risk, as the

commercial success of artists is difficult to determine. However, labels recoup investments through favourable deals. Given the upfront risk labels face, labels demand a higher share of royalties than publishers do. It is common industry practice that artists receive about 15% of income generated from a song, which is paid only after the up-front investment has been recovered. Like publishers, labels may outsource some collection services to CMOs, even though to a lesser extent, which again adds to the complexity of the industry (Cooke 2015a, pp.8–9, 11, 30, 40).

5.3.3. Structural inefficiencies in the music industry

"Perhaps the biggest problem artists face today is that lack of transparency" - David Byrne, Rock and Roll Hall of Fame-awarded musician (2015).

As mentioned earlier, sound recordings are composed of two distinct copyrights. Recording copyrights are initially owned by musicians or bands, while song copyrights are property of composers and lyricists. It is common practice for musicians and songwriters to subsequently sell rights to record labels and publishers (BerkleeICE 2015, pp.16–18). However, such deals may be assigned for a limited period of time only, restricted to certain controls (i.e. recording or distribution) and involve different entities in various countries. Intermediaries might appoint CMOs in some areas while licensing directly in others. Ultimately, whenever a song is streamed, broadcasted, reproduced or sold, multiple parties can claim part of the royalty revenues earned. Each of these intermediaries will

likely claim a fee before processing payments to artists. This highly bureaucratic process might take up to several months for artists to receive their income, while stripping away any insight in the underlying data (Bartlett 2015; Wallach 2014). In recent years, this problem has increased in significance. While historically, revenues were earned whenever a song was sold on a physical medium, the rise of streaming services has triggered a consumption-based business model. Nowadays, the music industry derives most of its revenues from streaming. Each stream is only worth a fraction of a cent, while tracks and albums are sold for cents, a dollar or more (Nicolaou 2017). Streaming has increased the amount of data intermediaries need to process, however, the industry has yet to cope with this development (Cooke 2015a, pp.26, 69–70).

Major problems arise from the use of antiquated technologies, a lack of integration and industry practices that have not been altered to address demands of the internet economy. The most pressing issues are discussed below.

Uncertain ownership of copyrights.

"[...] I counted 13 writers and 17 publishers on a recent Flo Rida hit. These co-writers might not all be based in the United States, and likely belong to rights societies in their own territories. This is now a global problem. Without rock-solid data about who owns what slice, some people may not get paid on time or at all" Casey Rae (2015).

As outlined above, it has become more and more difficult to correctly identify all parties involved in the creative process of writing and recording music. In an attempt to simplify royalty collection, the *'International Standard Recording Code' (ISRC)* has been encoded into music files as a unique identifier for recordings. While this digital fingerprint helps to determine artists and labels, the code lacks insight in the underlying composition, which is likely owned and administered by different parties. To overcome this issue, the *'International Standard Musical Work Code' (ISWC)* was introduced. While the ISWC incorporates composers and lyricists, the standard lacks information on royalty splits between parties. Moreover, ISWC and ISRC cannot be matched unambiguously, making it difficult to pair compositions that are associated with recordings and vice versa (BerkleeICE 2015, p.3; Cooke 2015b; D. Newman 2016, pp.1–2; Matteo 2015).

As a result, organisations generally rely on their own, unsynchronized databases to claim ownership. Thereby, a high level of ambiguity to licensees is introduced, as they might not have access to these information and thus be unable to compensate the rightful owners (Wallach 2014). Streaming services generally assume that recording copyrights are owned by the party (i.e. label) that provided the song. Labels will receive 55-60% of the total subscription revenue, 15-20% of which they then distribute to artists (Cooke 2015a, p.11). However, the services lack detailed information on song copyrights as well as any further metadata. Spotify and Apple Music offer a portfolio of 30 million songs, and are thus unable to enrich metadata themselves. Instead, they report consumption data to each

publisher/ CMO (Russell 2017; Wallach 2014). These right owners are then required to identify their compositions. Subsequently, streaming services approve claims to reduce the risk of paying twice. The publishing organisations jointly receive 10-15% of subscription revenue, while the remaining 30% are maintained by the streaming service. Finally, if publishers did not choose to license directly with streaming services, CMOs split revenues into reproduction and performance rights, which are then distributed among various songwriters and publishers (Cooke 2015a, pp.11–12, 25–26, 43–45, 70–71; Wallach 2014). While these intermediaries are supposed to simplify licensing and royalty collection, they add to the structural problems of the industry and charge a substantial fee for their service (De Filippi 2015, pp.3–4).

Opaque accounting and payments. Because of the fragmented structure of the industry, musicians receive payments from multiple parties for different copyrights. Even today, royalty reports are provided in non-standardized paper-form. Reports are often only created with months of delay and are segmented by regions and copyrights. Ultimately, artists are overwhelmed by hundreds of pages of data and are thus unable to audit payments in an efficient manner (BerkleeICE 2015, pp.3–4, 16, 19–20; Cooke 2015a, p.23; Revelator 2015a).

Moreover, artists have little insight in the compensation structure labels negotiate with streaming services. Apart from a *per-stream fee*, major labels receive

payments from three more sources. They (1) demand significant advances for the use of their catalogue, (2) they incur a catalog service payment for old songs and ultimately (3) commonly receive equity stakes from streaming services in return for sub-market license rates (Byrne 2015). While per-stream royalties are said to be shared with artists accordingly, advances cannot be attributed to individual creators and are thus retained by labels. Ultimately, significant amounts of royalties end up in a so-called *'black box'* instead of being distributed to creators. Moreover, if CMOs are unable to identify the rightful owner, they place royalties in escrow accounts, which are distributed to labels and publishers according to market share. Again, these funds are not distributed to artists (BerkleeICE 2015, pp.4, 16–17; Messitte 2015; Howard 2015h).

"Some people would argue that the labels have been complicit in the sense that by not having great data—and not having a worldwide database—it just makes it easier for money to go to the black box [...] they have such a huge market share that they know they're going to get a huge chunk of the black box" (Messitte 2015).

Inability to access data and draw marketing insights. As mentioned earlier, artists are not provided with an integrated report on usage and royalty collection. Apart from financial implications, artists are unable to spot trends and engage with fans. In recent years, revenues earned from live performances have become

more important to artists. Tremendous value could be created from real-time information on an artist's fan base and regional popularity. Insights in streams would allow artists to engage with consumers and build a loyal fan-base, which could ultimately increase a creator's popularity (Revelator 2015b). A study composed by Nielsen in 2013 revealed a potential incremental revenue increase of USD 450 million to USD 2.6 billion if the industry would offer better experiences to fans (Peoples 2013).

Not just artists struggle with the ongoing explosion of data. Antiquated systems and a lack of an integrated database have resulted in slow and inefficient data processing. Streaming services provide labels with monthly reports which can amount to several gigabytes in size, making real-time processing difficult. Major labels would need to process billions of transactions per day, but currently still manage data in Microsoft Excel (Cooke 2015b). Moreover, since most streaming providers offer more than one service, reports are split by business model and region. Ultimately, large labels would need to process hundreds of reports per month for streaming only, and subsequently share these with artists (Cooke 2015b; Mutter 2017; Owsinski 2016). Even though vast amounts of data exist, organizations are either unwilling or not capable of sharing it. Labels often regard data as proprietary and are thus reluctant to give it to outsiders (Wallach 2014).

Wrongful claims and inability to prevent exploitation. While royalty distribution between artists and labels is a common topic of discussion, the industry as a whole suffers from claims made by or accounted to wrong parties. YouTube is often at the center of discussion given that the ad-supported platform reaches over a billion users worldwide (YouTube 2016). While some regard this as a unique opportunity to engage with users, the industry criticises that ad-supported platforms represent the largest audience but just account for 4% of global music industry revenue in 2015 (IFPI 2016a, p.5). Some argue, that YouTube exploits *safe harbor* regulations. These rules were initially established to protect online platforms that host user-generated content from liability claims of copyright owners. Under the regulation, websites like YouTube are not required to ensure that, when uploaded, content does not infringe copyrights. Platforms only need to act if copyright owners request to take down content (Bridy 2015). Representatives of the music industry argue that the *safe harbor* rules were not established for companies like YouTube that actively engage in music distribution. Experts claim that YouTube thereby takes unfair advantage of outdated legislation and undermines competition (Kafka 2016b; Dredge 2015). Subscription-based services like Apple Music cannot take advantage of *safe harbors* and thus need to negotiate with copyright owners before making music available. Copyright owners thus can choose whether they want to license content, whereas on YouTube they can only ask to take down content once uploaded (Dredge 2017; IFPI 2016a, pp.22–24; Sanchez 2016).

YouTube has built a proactive tool called *Content ID* which automatically screens videos against a database of copyrights. If the system identifies content, copyright owners can decide to take down, mute or monetize videos through ads (Rethink Music 2013, pp.20–21; YouTube 2017). In 2014, 98% of copyright removal claims came through Content ID. However, rather than flagging videos for removal, major labels choose to monetize 95% of content identified by the tool. YouTube expressed that these statistics are signals for the tool to be efficient. In contrast, labels estimate that the system fails to identify upwards of 40% of unlicensed content. Furthermore, Content ID only tracks creations that labels have uploaded to the system (Singleton & Popper 2016). Thus, some argue that the systems are too slow and require copyright owners to constantly monitor the platform (Kafka 2016a). Still, record companies state that given the popularity of YouTube, they simply have no other choice than making content available (Singleton & Popper 2016).

If labels choose to monetize content, YouTube remunerates creators based on a share of ad-revenues (55%), which have been decreasing over the years (Club G Music 2016). YouTube has been found to pay creators about USD 1 for 1,000 streams, while Apple Music pays USD 7 for the same number of streams (RIAA 2017). A study has estimated that the exploitation of *'safe harbor'* regulations amounts to undistributed royalties of up to USD 1 billion in the US in 2015 alone (Beard et al. 2017, p.3).

Even if YouTube decided to pay fair rates, the challenge to identify and reward the rightful owner remains. The increasingly fragmented industry and lack of detailed databases creates friction. For example, if an artist licenses music for a compilation which is subsequently uploaded and monetized on YouTube, the platform will likely pay the creator of the compilation instead of the artist (Revelator 2015a). The same might happen if artists switch labels or publishers as such changes might not be communicated to all parties (Cooke 2015a, p.22). The situation becomes more complex if someone creates a remix of a song. Samples/ remixes are a form of 'derivative work', which is commonly distributed without a license from the original creators. Thereby the creator of the remix infringes the rights to distribute, reproduce and perform or broadcast owned by the initial artists. However, takedown systems might be unable to identify the underlying creative work, leaving the initial creator uncompensated (Howard 2015e).

Time lag of compensation and data insights. Royalty distribution is not just opaque it is also very slow. Artists usually wait between 60 to 90 days before they get paid from labels (Cooke 2015b). However, especially if royalties are incurred from international performances, the process of identifying, tracking and transferring fees from foreign rights managers can take up to several years. Each party involved will deduct a fee for their service. This has a detriment on artists who have no visibility on future payments (BerkleeICE 2015, p.20; Revelator

2015a). Furthermore, as indicated above, musicians lack insight in streaming data. Even if such data would be made available to musicians, little insight could be drawn if information is only provided with a significant time delay (Revelator 2015a).

Outdated compensation and limited sources of funding. The rise of streaming services has shifted consumption from physical media to on-demand platforms. Still, the structure of the music industry has largely remained unchanged. Artists complain about low royalty rates, which have been decreasing over time. Even on platforms like Apple Music that pay above industry average rates, artists need hundreds of streams to earn one dollar (Plass-Flessenkämper 2017). In 2014, Taylor Swift has publicly criticised the compensation structure offered by streaming services, as she pulled all her content from Spotify and threatened Apple to do the same if they would not pay for streams by users who were still in the trial-phase (Bajarin 2015; Linshi 2014). Artists believe that labels do not necessarily work in their favor, given that they still offer compensation structures created for the distribution of physical media (Masnick 2015). Record deals usually dedicate 15-20% of income to artists, which is paid only after initial cost and service fees have been recouped. Many artists feel that such a split is too low, given that the risk and cost of streaming is significantly lower than of the production and distribution of physical records. They perceive it as a sign that the industry has yet to cope with the structural

changes induced by the internet economy (Cooke 2015a, pp.11, 22–23; Resnikoff 2016). A study reveals that both creators and their representatives feel that the current split is outdated. However, labels have little incentive to denote a higher cut to artists and decrease their own margins, especially after creators have become popular (Cooke 2016, pp.35–37).

Several artists have spoken out against low streaming revenues, which make it harder - especially for young artists - to make a living (Kafka 2016a). Arguably, artists today can themselves get engaged in the production of their creations. Electronic music can even be created at home with the use of software. Furthermore, distribution through online platforms can be done by creators themselves without the need of a costly record label (Howard 2015a; Rethink Music 2013, pp.10–12). The fact that musicians are still widely dependent on record labels is due to the seed funding they provide. Most artists need significant up-front investments for recording and marketing purposes. Such investments for signing an international artist can amount to between USD 500,000 and USD 2 million. The majority of albums do not break even and these that do take a long time to get there. Today, record companies are the major 'investors' in young talent, providing USD 4.5 billion (27% of their revenues) in 2015 alone (IFPI 2016b, pp.3, 5–6). Furthermore, labels provide artist and repertoire management services, as well as support with promotion, merchandising, accounting and distribution. Artists that require such advances are often reliant on labels' expertise and deep pockets (Cooke 2016, p.37).

6. Application of concepts to address structural inefficiencies in intellectual property

In the last Chapter we have extensively discussed structural inefficiencies of intellectual property at the example of patents and digital rights. We will now analyze how blockchain technology and crowdfunding could be applied to solve the predominant issues. We will first look at the two markets individually and then form a joint conclusion.

6.1. Patents

6.1.1. Patent thicket

As shown in Chapter 5.2.4., a patent thicket describes a set of overlapping patent rights for a certain technology which are typically owned by different right holders. Traditional solutions to patents thickets are cross licenses, patent pools, standard-setting organizations, and defensive portfolios. In the following, we will argue that smart contracts can alleviate the impact of patent thickets.

Smart contracts in place of patent pools. Patent thickets increase transaction costs due to dispersed ownership stakes. If a company wants to apply a certain technology, it has to negotiate licenses with multiple right holders. This process is not just costly but also delays innovation. However, instead of individual negotiations with separate parties, smart contracts based on blockchain

technology could be applied. The implementation of such smart contracts could be as follows: Right holders with patents of the same technology could agree on terms to license their patents as a package - similar to how patent pools are designed (Hagiu & Yoffie 2013, p.50; Shapiro 2000, p.50). These terms would define items such as the licensing period, the share of the overall licensing royalties attributed to each patent owner, etc. In addition, right holders could also define who would be able to license the technology. These terms would be saved in a smart contract and automatically executed without the need for interaction between licensees and licensors (Ream et al. 2016). Royalties would be automatically paid out to right holders based on the terms they agreed on without the need for expensive audits and without the risk of conflict of interest arising after the technology has been licensed (Catalini & Gans 2016, pp.4–5). One could even imagine that licensees share some of their data streams, for example to verify the revenues which are generated by the licensed technology through the blockchain (Catalini et al. 2016, p.7). By lowering transaction costs, smart contracts could decrease barriers to entry for smaller players: Smaller players would not have to pay for expensive and long negotiations with multiple right holders but would only have to agree to the licensing terms coded in the smart contract. In addition, the terms of the smart contract could be designed in a way that royalties are lower for smaller players or companies that generate only low revenues with the respective technology[12]. However, most academics and

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[12] However, many patent pools are constrained by Fair, Reasonable, and Non-Discriminatory (FRAND) requirements: They cannot grant more favorable terms to one third party without discriminating against other similarly situated licensees (Lim et al. 2010).

practitioners are rather skeptical that smart contracts have the potential to automate patent licensing negotiations (Yoffie 2017). Licensing negotiations take several months to complete, especially with multiple parties involved (European Patent Office 2008). As an example, negotiations of Intellectual Ventures, one of the largest owner of patents in the United States, are lengthier and more complex than the company initially expected. Donal Merino, general manager of acquisitions, describes: *"We find that every company wants a customized IP deal that involves detailed due diligence on our portfolio as well as intelligent bundling on our part. These deals can take 18 months or longer to negotiate, and they require experts to understand the nuances"* (Hagiu et al. 2011, p.9). For these reasons, smart contracts are unlikely to replace traditional solutions for complex patent thickets such as patent pools. However, besides the so-called *'mega-pools'* for well-known technologies such as Bluetooth or MPEG-4, smaller, *contract-based pools* exist. The *"[...] small-scale pools are often nothing more than multilateral contracts incorporating [...] two basic elements"*, namely (1) consolidation of property rights in a central entity (i.e., contract), and (2) establishment of a valuation mechanism to divide up royalties (Merges 1999, pp.22–23). Therefore, while full automation of licensing negotiations through smart contracts is unlikely even for small-scale pools, certain aspects of the process such as the division of royalty streams could be based on smart contracts.

6.1.2. Approval of low-quality patents

Many patents that are granted by the PTO are not held valid when subject to litigation. Because of high legal costs, defendants might choose to license these patents rather than to fight them. This could reduce incentives for 'real' innovators to develop intellectual property. In the following, we will argue how bounty schemes in combination with blockchain technology could help to tackle the issue of low-quality patents and will discuss the example of Unpatent.

Invalidation of patents through crowd diligence/ bounty schemes. As shown in Chapter 5.2.3., the AIA substantially changed the role of the public in the patenting system: Through multiple measures members of the public can now challenge patents (Armitage 2012, pp.4–10). However, patent challenges present problems of collective action. In particular, patent challengers have an incentive to free-ride off another's opposition to a patent since the benefits of an invalidated patent are nonexcludable. These benefits can be enjoyed by everyone in the public while the cost to challenge the patent is born only by the party that actively challenges it (Thomas 2001, pp.333–340). Crowd-based bounty schemes could be a solution to address this problem. Thomas (2001, pp.340–344) suggests a reward system at the patent examination stage, before a patent has been granted. Third parties could provide the PTO with additional information that has not yet been identified by the PTO or submitted by the applicant. After the applicant has submitted its list of prior art references but

before closely examining the compliance with patentability criteria, the PTO would publish the application together with additional prior art based on its own research. Informants could then submit additional, not yet included, prior art information: *"Informants would be required to provide a copy of disclosed references, a short explanation of their relevance, and a fee"* (Thomas 2001, p.342). The purpose of the fee would be to *"[...] discourage reference flooding"* (Thomas 2001, p.344). If *"[...] the examiner issues a final rejection of any claim in the application over noncumulative prior art submitted by an informant, then the applicant would be fined and the informant paid"* (Thomas 2001, p.342). Thomas (2001, p.345) suggests to set the bounty at a fixed rate based on *"[...] current acquisition and search fees, the sums associated with other bounty regimes, and behaviors we might influence by appropriately adjusting to the bounty"*. The proposed scheme would offer two main benefits. First, it would provide the PTO with more detailed prior art references and would hence unburden the overloaded PTO staff. Second, by penalizing patent applicants, the system would incentivize applicants to reveal as much information on prior art as possible, which would improve the overall quality of applications. As a result, fewer low-quality patents would be granted (Miller 2004, p.697; Thomas 2001, pp.343–344). In contrast, Miller suggests that a bounty scheme should be introduced at the litigation- rather than the examination-stage as invalidated patents have a higher market significance (Miller 2004, p.701). He proposes a *"[...] bounty in an amount equal to the net profits the patentee has earned up to*

the date of judgment by practicing the technology that the patent purports to cover" (Miller 2004, p.705). No matter how exactly a specific bounty scheme is designed, blockchain technology could support its execution. We identified two main aspects how blockchain technology could be beneficial. First, one main challenge of a system that requires informants to pay is that submissions need to be published promptly to potential informants to minimize duplicative searching (Thomas 2001, p.344). Blockchain could substantially increase transparency in the system: With a patent database based on blockchain, informants could directly refer to the patents they identified as important prior art in their submission. Their submission could then be immediately shared with the public and all participants in the bounty scheme would have access to the same data - potentially even to detailed information of all patents cited. All future informants would be able to see what the patent applicant/ holder, the PTO, and previous informants submitted and could work on the foundation of this cumulative knowledge. Second, blockchain could help to distribute rewards, especially in cases with multiple patent challengers within one trial (Miller 2004, pp.705–706).

Case study: Unpatent. *"We invalidate patents that shouldn't exist"* (Unpatent 2016c). Unpatent is a crowdfunding/ -sourcing platform with the goal of refuting *'bad patents'*. The venture is based on Miller's concept and aims at patents in the litigation stage. For each *'bad patent'*, there is a 4-step process. First, users can start a crowdfunding campaign which has to meet a goal of at least USD 20,000.

The first USD 16,000 are used to cover legal and PTO fees. The rest is distributed to these who find valid prior art. Second, everybody can submit prior art references. The Unpatent team reviews all the submissions and rewards these that invalidate the respective patent. Third, Unpatent prepares all the paperwork and files an *'ex partes'* reexamination at the PTO. Finally, the PTO will take about five months to reexamine the patent and issue a final decision (Masnick 2016; Unpatent 2016c). Their first campaign aims at invalidating the patent *'Method and apparatus for presenting personalized content relating to offered products and services'* and is currently still at the crowdfunding stage and has not yet met the campaign target[13] (Unpatent 2016b; Masnick 2016). Unpatent is driven by a *"[...] dream of a world in which intellectual property is free, and everyone is able to benefit from it"* (Cuende 2016). The founder Luis Cuende argues that first, patents are mostly only little protection for inventors. Instead, execution trumps intellectual property. Second, he claims that transparency with regard to technology, makes companies more attractive to talent who are in turn the most important asset a company can have (Cuende 2016). Given that Unpatent was founded only in September 2016, it is too early to draw conclusions on the success of this venture. However, similar projects such as BountyQuest, initiated by Jeff Bezos and Tim O'Reilly in 2000 did not survive in the long run (Masnick 2016).

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[13] As of April 14, 2017

6.1.3. Difficult valuation

In Chapter 5.2.4. we have shown that patents are more difficult to value than most other goods. There are three main reasons for this phenomenon: (1) Patents are intangible, (2) by definition patents lack comparables because of their novel character, and (3) patents are subject to strong complementarities and portfolio effects. In this Chapter, we will claim that crowd diligence can alleviate the difficulties in patent valuation and will give the example of the successful crowd diligence initiative Article One Partners.

Crowd-based patent landscaping and due diligence. The crowd cannot change the facts that patents are intangible and lack comparables. But as shown in Chapter 2.6, a large group of individuals can lever a variety of perspectives and gather information such as technical details. These abilities can also be applied to intellectual property/ patent due diligence and patent landscaping. Intellectual property due diligence *"[...] is a legal exercise wherein skilled IP counsel defines, examines and analyzes an IP portfolio of a target company, either offensively (to purchase or in-license) or defensively (to sell or out-license)"* (Bosch & Burgy 2006). The purpose of intellectual property due diligence is to reveal the underlying value of intellectual property *"[...] by examining the strength, scope and enforceability of the IP, the ownership rights surrounding the IP, and the future potential to be derived from the IP"* (Bosch & Burgy 2006). A patent landscape *"[...] provides an overview of the patenting activity and trends in*

a field of technology" (Trippe 2015, p.29). Tasks relevant for patent due diligence and patent landscaping include searching for prior art, identifying comparable granted and pending patents, drafting ownership structures of intellectual property, and conducting competitive and institutional analyses (Bosch & Burgy 2006; Bubela et al. 2013, p.202; Trippe 2015, p.29). Traditionally, patent due diligence and patent landscaping activities are conducted by patent attorneys, research institutions, or companies themselves (Bosch & Burgy 2006). There are several advantages of a crowd-based model over the traditional expert-based approach. First, crowd diligence can attract researchers from all over the world with different language skills. Such diversity can help as evidence in any language is usually applicable in court. Second, a large enough crowd is likely to contain someone who is able to answer an inquiry without the need to search for the answer. For example, a professional with work experience in the respective field. Finally, crowd diligence allows for *'friendly competition'* among members of a community which potentially leads to improved results compared to a traditional expert-based setting (Manjoo 2012).

Case study: Article One Partners. Article One Partners applies crowd diligence to multiple patent solutions structured in Defend (for example, Patent Landscaping), Innovate (for example, Patent Purchasing), and Monetizing (for example, Evidence of Use) (Article One Partners 2016b). Article One Partners' crowd consists of over 37,000 researchers in 170 countries and is open for

registration to everyone. In order to guarantee confidentiality of projects with high importance or asset value, Article One Partners ranks its researchers based on past performance. Certain cases such as *'ExpertSearch Studies'* are open only to the best, individually selected researchers with strong track records.

Researchers that reliably deliver high-quality research over a substantial period of time can gain access to programs with guaranteed payments (Article One Partners 2016a; Manjoo 2012). Services that are conducted by the Article One Partners community include - among others - the identification of prior art references, the identification of parties or patents at risk, patent landscaping, and the identification of valuable patents to enrich the already existing patent portfolio (Article One Partners 2016b; Empson 2012; Manjoo 2012). According to its own data, Article One Partners has paid out more than USD 7 million in rewards to its researchers (Article One Partners 2016a).[14]

6.1.4. Limited access for small inventors

Individual inventors and small companies benefit less from patent markets than larger participants, mostly because they often do not have the resources to successfully protect or monetize patents. Many small players lack capabilities and expertise in patent law or simply do not have the resources to regularly scan the patent market for prior art and comparable patents (Hagiu et al. 2011, pp.4–5).

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[14] As of April 14, 2017

Crowdsourcing without financial compensation. These problems can be addressed by crowd diligence and bounty schemes as described in Chapters 6.1.1. and 6.1.3. through which smaller players can outsource complex and knowledge-intensive tasks to the crowd through platforms such as Article One Partners. However, even when using bounty schemes, the cost of filing, maintaining, and enforcing patents can still be prohibitive as shown in Chapter 5.2.4. For example, Article One Partners pays out rewards for successful researchers varying between USD 5,000 and USD 10,000, often still exceeding the financial resources of individual inventors (Manjoo 2012). However, crowdsourcing also allows for forms of collaboration without monetary compensation as demonstrated at the example of AskPatents below.

Case study: AskPatents. The free crowd diligence initiative AskPatents is a collaborative project by Stack Exchange, the PTO and the Google Patent Search team. AskPatents is integrated in Google Patents, linking every patent on Google to the respective discussion on AskPatents. While one of the main goals of AskPatents is to *"[...] reduce the number of patents mistakenly granted for obvious, unoriginal noninventions [...]"*, the website also allows everyone to ask and answer questions about patent applications and patent law in general (Spolsky 2012). Therefore, the website provides an opportunity for free exchange between patent lawyers and inventors (Lee 2012). As a result, AskPatents can improve the access of small inventors to the patent system. Exemplary posts on

the website show that the project offers promising results. On April 14 2017, user

Robert asked: *"In reference to the patent US8807568: I would like to know how*

this patent works. Is it only a utility patent for a certain part of the game or is the

patent broader, i.e the whole game is patented? [...]" On the same day, another

user *Eric Shain* replies *"Briefly reading the claims, it looks like only the apparatus*

and how it is constructed is claimed. The claims don't specify the rules of the

game [...]" and provides more details on the scope of the patent (AskPatents

2017).

Crowd-based patent financing. Crowdfunding can provide smaller players with

the necessary financial means to finance their patenting activities. In Chapter 2.1.

we distinguished four different kinds of crowdfunding: (1) reward-based

crowdfunding, (2) equity crowdfunding, (3) charitable crowdfunding/ donations,

and (4) lending crowdfunding. Theoretically, all these types of crowdfunding are

possible in the context of patenting. (1) Reward-based crowdfunding can allow

funders to raise the financial means needed to protect their intellectual property

in exchange for the developed product. As shown in Chapter 2.4.3., Mollick

(2016, pp.10–12) finds that about 4% of successful Kickstarter campaigns filed

patent applications. In order to protect their patents, founders usually file a

provisional patent application before starting a crowdfunding campaign. This

application buys founders one year of time to decide whether to move forward

with the patenting process (Almerico 2015). (2) Equity crowdfunding can also

help founders to raise funds to protect their intellectual property. However, as in the case of (1) reward-based crowdfunding, public disclosure requirements may have a negative impact on intellectual property protection (Agrawal et al. 2014, p.75). The venture Unpatent, which is described more in detail in Chapter 6.1.2. is an example of (3) charitable crowdfunding/ donations in the patent context: In order to invalidate *'bad patents'*, a company or an individual has to start a campaign and raise sufficient funds of at least USD 20,000 to cover legal and PTO fees, and reward researchers for their prior art references (Masnick 2016; Unpatent 2016c). However, backers of the campaign do not monetarily participate in the successful invalidation of the patent: *"What do I get in return? - You are helping to get that stupid patent killed! You will also get the perfect breakdown of where we spent the money collected to the last cent"* (Unpatent 2016b). Hence, financial participation by Unpatent funders is solely based on their altruistic motivation of *"[...] fixing the innovation framework"* (Unpatent 2016a). Finally, there are methods of (4) lending crowdfunding with regard to patenting imaginable. Although not currently based on crowdfunding, BlueIron IP provides an example of a business model that could potentially be applied to crowdfunding. After extensive due diligence, BlueIron IP funds the intellectual property of seed, angel, and Series A startups by *"[...] investing $60,000 or more [...] to help those with patent-worthy IP make it through the patent process much faster than they otherwise might [...]"* (Business Wire 2016). In return, the patents are transferred to a BlueIron IP financed patent holding company which

exclusively licenses the patents back to the previous patent holder in a conventional commercial lease-back model. Hence, the patents can be compared to collateral for a loan. The previous patent holder has an option to buy out the assets at any time (BlueIron IP 2016; Krajec 2017; Krajec 2016; Quinn 2016). This model could theoretically be applied to crowdfunding with a group of individual investors providing the funds to finance a company's patenting activities. However, there are several problems with regard to crowdfunding. First, in order to convince potential investors, companies would have to make detailed information on their intellectual property publicly available which would put the patentability of their assets at risk (Krajec 2017). Second, companies financing patents such as BlueIron IP provide thorough patent due diligence and legal advisory to support startups in patenting their ideas in the most efficient way (BlueIron IP 2016; Krajec 2017). Therefore, in a crowdfunding setting, the platform would need to provide legal and market expertise which individual investors in the crowd could not support (Krajec 2017).

6.1.5. High search costs

Patent owners, users, and buyers face high search costs. In order to monetize their intellectual property, patent owners need to find current users and applications of their patent. In contrast, patent users and buyers have to find prior art and other patents that affect the specific patent. Both patent offices and private databases provide comprehensive lists of all patents in circulation which

are often keyword coded and searchable. However, patent applicants usually reveal only the minimum information necessary to obtain a patent, use dense and technical language resulting in broad and opaque descriptions. As a result, it is difficult to figure out the relationship between patents and prior art (Hagiu & Yoffie 2013, p.47; Manjoo 2012). In the context of our analysis, we define two potential ways to reduce search costs: blockchain-powered databases and crowd diligence/ bounty schemes. We will discuss these concepts below.

Decentralized database. In Chapter 3.4.1. we defined the main structural advantages of blockchain technology over centralized databases: integrity, security, immutability, availability, transparency, and privacy. Hereby, the most important feature of blockchain technology is its ability to allow for transactions without the need for a trusted intermediary (Buehler et al. 2015, p.5; Tapscott & Tapscott 2016, p.4). However, these advantages do not address the main issue causing high search costs in the patent market. While blockchain technology can help to increase transparency by providing various parties access to the same data in real-time, the quality of the database still depends on the quality of the data input. Put differently, the main problem in the patent system with regard to search costs does not lie in the lack of available information, its accessibility or in a time lag but in the quality of the data input, namely information provided in patent applications (Yoffie 2017). Even if the information was made available on the blockchain, patent owners, users and buyers would still have difficulties in

interpreting the information since the quality of the underlying data would not have changed.

Crowd-based patent research. Instead, crowd diligence and bounty schemes can help to reduce search costs for participants in the patent system. As described in Chapter 2.6., the aggregated judgement of individuals has proven to be effective in reducing information imbalances (Mollick & Nanda 2015, p.7). In Chapters 6.1.2., 6.1.3, and 6.1.4. we have provided examples of projects such as Article One Partners, Unpatent, and AskPatents that allow inexperienced market players to identify prior art, invalidate 'bad patents', or conduct patent landscaping reports through the knowledge of a large crowd. By doing so, these mechanisms also reduce search costs for patent owners, patent buyers, and patent searchers.

6.1.6. High likelihood of expropriation

In Chapter 5.2.4. we have shown that patent infringements often go without consequences due to limited financial resources of patent holders. In the following, we will describe how crowdfunding can help individuals and companies to litigate their patent claims.

Crowd-based patent litigation financing. As described in Chapter 6.1.4., all four different types of crowdfunding can potentially be used with regard to patenting. In addition, players in the patent system could also apply crowdfunding to patent litigation. In general, litigation financing is a relatively common way to provide companies or individuals with third-party funding for litigation. The industry is dominated by large players such as Gerchen Keller Capital, Bentham and Burford Capital LLC with assets under management of between USD 1.4 billion and USD 500 million in assets under management (Bushey 2016; Randazzo 2016a; Strickler 2015). In addition, there are platforms such as LexShares and Trial Funder that allow individual investors to crowdfund litigation cases. However, these platforms do not focus on patents or intellectual property, but feature all types of litigation. In general, both defendants and plaintiffs can be funded (Randazzo 2016b). Funding amounts vary but are rather small. As an example, LexShares targets commercial cases that need between USD 100,000 and USD 1 million, which is often too little for traditional litigation financing funds but still significant for companies affected by litigation. Usually, litigation crowdfunding platforms pre-select cases with high chances of success before they enter the campaign stage (Krause 2015; Randazzo 2016b). In a patents context, one could imagine a platform that allows companies to finance their litigation - potentially on the defendant - as well as on the plaintiff side. Similar to LexShares, the platform would pre-select cases and start campaigns when the outcome is promising. The funds would be used to finance legal costs. In case of

success, backers would receive a share of the amount won in litigation. If the case is unsuccessful, backers would lose their investment. Crowdfunding-based litigation financing could allow smaller players to enforce their intellectual property and reduce the likelihood of expropriation. As a result, threat of litigation would become more credible and larger companies could be more willing to enter licensing agreements with smaller players (McDonough 2006, pp.206–210; Vallone 2005, p.183).

6.2. Music

"[...] 'In the race to adopt new technologies, the music industry historically has finished just ahead of the Amish.' As much as I love the quote, I can't help but think that's unfair to the Amish" Benji Rogers, CEO dotBlockChain Music & Founder PledgeMusic (2015).

In Chapter 5.3 we discussed the prevalent issues of the music industry. Blockchain technology is believed to address some problems by introducing speed, efficiency, and transparency in the collection and distribution process, while crowdfunding could potentially alter how artists raise funds (Music Ally 2016, p.2).

"I can imagine a ledger of all that information and an ecosystem of killer apps to visualize usage and relationships. I can imagine a music exchange where the real value of a song could be calculated on the fly. I can imagine instant, frictionless micropayments and the ability to pay collaborators and investors in future earnings without it being an accounting nightmare, and without having to divert money through blackbox entities like ASCAP or the AFM" - Zoe Keating as cited in Howard (2015b).

6.2.1. Uncertain ownership of copyrights

As previously discussed, copyrights impose an enormous administrative burden on right owners and the music industry as a whole (O'Dair 2016b, p.26). Today there are myriads of databases, owned and curated by independent parties, none of which features every track ever created. Not only are these databases not comprehensive, they are also not synchronized among each other (O'Dair 2016b, p.7). This leads to three main issues. First, licensees are not able to unambiguously determine who owns copyrights and how owners should be compensated. The process of licensing music for commercial use can take several weeks. Thus, artists might not be rewarded if representatives of their creations are difficult to identify, as potential licensees might opt for alternative creative works or infringe copyrights (Wallach 2014). Second, copyrights are regularly assigned or transferred to other parties. Over the lifetime, representatives of copyrights may change multiple times. Licensees might not be informed over such changes and thus be unable to award the rightful owners appropriately (Howard 2015b; O'Dair 2016a; Wallach 2014). Finally, intermediaries that are supposed to simplify the process of licensing and royalty collection add to the inherent opaqueness of the industry and charge a substantial fee for their services (De Filippi 2015, pp.3–4).

Most experts agree that a central database of music copyrights would already address some of the current issues (Silver 2016, pp.34–35, 43–45). An industry-wide database could serve as a single source of truth, identifying all

parties that were materially involved in the creation and promotion of lyrics, composition and recording of sounds (BerkleeICE 2015, pp.26–28; Howard 2015b; Music Ally 2016, pp.2–3). In 2008, the *'Global Repertoire Database'* *(GRD)* aimed at creating a single register of global music copyrights and controls. The initiative's goal was to accelerate the licensing process and cut out intermediaries such as CMOs. As a result, licensing would not only be faster, but also less expensive given that cost of administering licenses and intermediation between parties would be reduced (Bartlett 2015; BerkleeICE 2015, pp.26–27; Silver 2016, p.52). The initiative failed after the few incumbent participants cut their funding. However, it is unlikely that the solution would have prevailed, as many of the structural problems were not addressed and the database would have been maintained by a few parties who would have had conflicting perspectives. The big players were reluctant to cede power they had gathered over time (The Problem 2015).

Comprehensive decentralized database. As outlined above, the music industry is too corrupt to trust a few player in maintaining a central database and share data openly (O'Dair et al. 2016, p.12). Blockchain technology could help overcome this lack of trust. One of the major features of blockchain is its ability to enable transaction without the need of a trusted third party (Buehler et al. 2015, p.5; Tapscott & Tapscott 2016, p.4). In contrast, control is shared among all users instead of power given to a few dominant gatekeepers (Howard 2015c;

O'Dair 2016b, pp.22–23). A decentralized approach would not require consensus of some large stakeholders with conflicting interests. The networked ledger could be built incrementally by labels, musicians, fans and other intermediaries. This approach would not only be cheaper, but also limit the risk of one party sabotaging the initiative as it was the case with the GRD. Ultimately, a decentralized solution would break up the inherently complex structure of the industry (Silver 2016, pp.21, 51–53).

A comprehensive blockchain-based solution would further contain all copyrights and their owners, thereby simplifying the process of licensing music. Companies and individuals who are looking to license digital assets could quickly identify the rightful owners and ensure that all stakeholders are compensated accordingly (Rogers 2015). Moreover, digital assets on the blockchain are encrypted and information is synchronized across the network and available to all users. Thus, changes to metadata and ownership of rights can quickly be transferred between parties, while ensuring that the blockchain as a whole maintains data integrity (Howard 2015j; O'Dair 2016a). This feature would help mitigate problems related to transferring ownership of copyrights. Since modifications to information on the blockchain are broadcasted throughout the network, the rightful owners would always receive their fair share, even if they change their representatives or transfer their copyrights (Cooke 2015a, p.22). This feature would further eliminate the demanding and costly task of streaming services to approve claims

made by CMOs. Being invoiced twice for the same song would be a thing of the past (Cooke 2015a, pp.11–12).

Disintermediation of third parties. Today, intermediaries such as CMOs provide artists with services like collective bargaining and royalty collection. While the vast number of intermediaries adds to the opaque structure, creators are generally not able to manage these tasks themselves (De Filippi 2015, pp.3–4). In contrast, since transactions on the blockchain are executed on a peer-to-peer basis, the need for a trusted intermediary can be eliminated (O'Dair et al. 2016, p.16). Instead of relying on collection agencies, artists could simply store the terms at which they want to license their creations on the blockchain. Users could use the blockchain to search the global music catalogue and filter for certain characteristics. Individuals could for example search for specific genres and limit results to creations that can be broadcasted for free or below a certain rate (Howard 2015k; O'Dair 2016b, pp.17–18). An application would then issue a license directly to the user and collect royalties for the service. These would then be distributed directly to the artists. Ultimately, blockchain-based automation would take over licensing and royalty collection tasks that are currently handled by third parties. Hence, the fees currently associated to intermediaries could be reduced drastically (O'Dair 2016b, pp.22–23). Artists might still assign copyrights to third parties, but the blockchain provides them with the option to do so or not (Howard 2015c; Howard 2015k; Music Business Worldwide 2017). While

disintermediation would likely come to the benefit of artists, third parties disrupted by blockchain will likely be reluctant to embrace the technology. However, some argue that at least a few intermediaries would remain. Artists may not be willing to curate the blockchain themselves or prefer to rely on a third party to handle administrative tasks (Music Ally 2016, p.6). It is likely that intermediaries that add value would remain, but the split of royalties might change in favour of creators. Music publishers for example would no longer collect royalties, but concentrate on tasks related to data verification and dispute resolution (O'Dair et al. 2016, p.6; O'Dair 2016b, p.23). In our interview with George Howard, he mentioned that the industry would only embrace a new technology if third parties receive a financial benefit they currently do not have. It is thus unlikely that we see a push by the major labels to introduce blockchain. However, the true value of blockchain comes from an industry-wide adoption. He believes that the blockchain will grow slowly as uprising creators will choose the technology over traditional labels. He could also imagine, that some highly successful musicians initiate a push. For example, artists might go onto the blockchain as their copyrights are about to run out, embracing a fair use of their creative works (Howard 2017). He further argues, that incumbents are better off if they were to implement the blockchain into their systems. Thereby, they could establish the basic design of the database and reduce the risk of disruption (Howard 2015k).

Crowd diligence/ bounty scheme to ensure data integrity. While the blockchain could serve as a single source of truth, the technology is not failure-proof. The quality of the blockchain is only as good as the data that is stored on it. A high level of data integrity is difficult to achieve due to the sheer volume of data associated with music copyrights (O'Dair et al. 2016, pp.9–10, 26). In order to promote wide blockchain adoption, curators would need to benefit from their work on an open platform. Like miners that contribute computing power to the Bitcoin blockchain, participants of the music blockchain could be rewarded for curating metadata (Tapscott & Tapscott 2016, pp.240–243; Wallach 2014). One potential solution could demand a small service fee from every user that accesses information on the blockchain. This payment could then be distributed to anyone who curated this specific data. Such an incentive scheme would encourage users to promote a high level of data integrity and provide metadata previously not associated with digital rights. A crowd of highly regarded users could also engage in tasks such as arbitration of contradictory data submissions (Silver 2016, pp.45–49; Wallach 2014). While this is theoretically possible, it is still unclear how disputes would be resolved. It is likely that parties would still need to settle their disputes or go to court (O'Dair et al. 2016, p.19). Reputation-based engines would grant trusted parties a higher degree of credibility and thus responsibility (Howard 2015d; Silver 2016, p.38). Artists could even incentivize third parties to take extra care in curating their tracks by offering bounties such as concert tickets or merchandise. Thereby, fans might be more

inclined to maintain data integrity (Howard 2015g). In order to promote adoption, right owners and representatives might only be required to provide a limited amount of data next to their creation. The crowd could then provide further metadata and be rewarded for their actions in promoting the platform while musicians could focus on content creation (Music Ally 2016, pp.2–6; Silver 2016, pp.47–49).

Case Study: Music right societies. The recent hype around blockchain has led some intermediaries to embrace a technology that could have the potential to disrupt them. The collection societies ASCAP (USA), SACEM (France) and PRS (UK) have teamed up to build a blockchain-based copyright ledger. Their aim is to build a platform that links music recordings and music work by matching International Standard Recording Codes (ISRCs) and International Standard Work Codes (ISWCs). The societies are working with IBM and use an open-source blockchain (Allison 2017). The societies aim at improving royalty matching in order to speed up licensing while lowering transaction costs. Moreover, the nature of the blockchain could reduce ambiguity and resolve conflicts between different identities for the same creative work (Music Business Worldwide 2017).

6.2.2. Opaque accounting and payments

We mentioned earlier that royalty payments are slow and opaque (O'Dair 2016b, p.20). Because of the inherently complex structure of copyrights, numerous intermediaries deduct a fee for their service while some royalties end up in *'black boxes'* instead of being shared with artists. Moreover, archaic systems reduce traceability (BerkleeICE 2015, p.20; Revelator 2015a; Silver 2016, p.25). Blockchain is said to have the potential to address these issues.

Micropayments. The rise of streaming services has altered the means by which artists are compensated. The industry is moving from a *single payment* towards a *pay-per-use* model where artists receive a fraction of a cent per stream (Howard 2015f). However, artists are still paid on a monthly or quarterly basis, proportional to a label's streaming revenue (Cooke 2015a, p.44). *Pay-per-use* payment models are almost impossible to implement with traditional technologies due to high transaction costs (Dickson 2016). Blockchain-based cryptocurrencies significantly reduce transaction cost and thereby make it feasible to issue payments amounting to a fraction of a cent (O'Dair et al. 2016, pp.10–11). The introduction of micropayment systems would further allow services to issue payments directly to artists as music is consumed. Royalties would no longer need to flow through costly and slow intermediaries. Thereby, the current issues of revenues ending up in *'black boxes'* instead of being distributed to artists would be mitigated (Howard 2015f; Silver 2016, p.53).

While the advantages of cryptocurrencies might initiate wide adoption, they also pose some risks. A majority of users still relate cryptocurrencies with criminal activities and platforms like Silkroad. While such preconceptions might be resolved over time, other downsides like the fluctuation of virtual currencies, the danger of a cryptocurrency collapse, money laundering activities, etc. are still ongoing limitations to mainstream adoption (O'Dair 2016b, pp.25–26).

Transparent accounting through smart contracts. Another prominent feature of blockchain technology are machine-readable smart contracts. Smart contracts would ensure that licensing fees are paid automatically to a copyright's rightful owner instead of being processed by multiple intermediaries. Thereby, royalties could be transferred not just to one individual, but to all contributors involved in the creative process, based on a predetermined split (Gottfried 2015; Rogers 2015). Parties could even decide to alter splits or payees over time. Artists themselves may define whom they want to grant a licence and how much they would want to charge for various use cases. Such systems would grant them more power over their own creations (Rogers 2016). Given that smart contracts are machine-readable, the blockchain might serve as more of a technological backbone, on top of which developers could build user-facing applications (Howard 2015j). The industry would no longer depend on error-prone, paper-based contracts and creators would not no longer need to undertake cumbersome label audits (Howard 2015h; O'Dair 2016a).

Case study: Ujo Music.

"I might decide, today's my birthday, I'm going to give all of my music to everyone for free today. At the moment, I can't do that. Because it's out there, and once it's out there, I don't really have a say in it any more" Grammy-winning artist Imogen Heap (Ingram 2015).

Ujo is an open music ecosystem based on the Ethereum-blockchain. Ujo's vision is to give back control to artists and creators through its transparent, decentralized database (Ujo Music 2015b). A prototype launched in late 2015 allows creators to upload compositions on the platform and publish policies on how music can be used for a certain price. British singer, songwriter and composer Imogen Heap was the first to release one of her songs on the platform (Bartlett 2015; Chester 2016; Gansky 2016). Users cannot just buy songs, but also access information on who was involved in the production, alongside with background information and licensing terms (Ujo Music 2015a). When a song is acquired, payments are automatically split according to the information saved in blockchain-based smart contracts and attributed to collaborations (Bitcoin Magazine 2015; Ingram 2015). Users can even see how payments are distributed and how much each of the individual musician has earned thus far (Music Ally 2016, p.10). Currently, a song can be streamed for USD 0.006. DJs can even acquire a license to sample songs. For USD 45, they receive a package of all tracks (Gottfried 2015).

6.2.3. Inability to access data and draw marketing insights

Even though music consumption has grown exponentially with the introduction of streaming services, the industry has done little to capture consumption data or make use of it (Rogers 2015). Today, streaming services only provide unstructured reports with significant delays in time (Revelator 2015a).

Fans who just listen to a song repeatedly might increase an artist's streaming revenue, but such increases are likely insignificant given the low royalty payment per stream. In contrast, passionate fans are inclined to pay for live performances, buy merchandise, albums or even subscriptions to exclusive content (Howard 2013). However, archaic technologies are unable to process data to identify these in real time and share it with artists (D. Newman 2016, pp.2–5).

Undistorted access to data. As outlined by Revelator founder Bruno Guez (2015c), artists suffer from asymmetric information. While fans know where to find songs and information on artists, creators know little about their fans. The data currently offered by labels is often generic and outdated.

A major feature of blockchain is the ability to enable transactions without the need for a trusted intermediary. By cutting out intermediaries that distort data, blockchain technology would allow artists to identify trends, directly engage with their fans, and draw valuable insights from consumption data (Dickson 2016). The problems artists currently face by not being granted access to data held by intermediaries could thereby be reduced (Rogers 2015). Blockchain-based tools

could for example present consumption data as heat maps, allowing artists to identify demand for live performances (Howard 2015g). Moreover creators could monitor how labels exploit copyrights and where revenues are derived from. Similarly, labels could assess how broadcasters or streaming services use digital assets (Howard 2015i).

User involvement. Apart from levering data, the blockchain has the potential to bring the direct-to-consumer relationship even further. By gathering insights from fans, artists might trigger feedback loops to improve the quality of their creations (Howard 2015h). This however would not be a one-way relationship as fans could for example also team up and convince artists to tour in certain areas. Through campaigns, fans might engage other listeners to demonstrate demand for live performances or even crowdfund concerts in untapped locations (Howard 2015g; Tapscott & Tapscott 2016, p.236).

Bounty scheme for reviews. Musicians might not just act upon insights on fans, but also foster feedback from experts. The platform Slicethepie relies on a bounty scheme that rewards song reviews with a small cash payment. The more/ better reviews a user submits, the higher the reward. Feedback is subsequently shared with creators, allowing them to act upon predictive insight prior to the public release of their creations (SliceThePie 2017; Spellman 2008).

Case study: PeerTracks. PeerTracks is a blockchain-based digital services platform built with the aim to foster relationships between musicians and fans. Through PeerTracks, fans can download or stream songs. The platform charges a 5% fee for its service and distributes royalties instantly according to predefined smart contracts using cryptocurrencies (Redman 2016). PeerTracks' customer-centric approach sets it apart from other solutions. The application encourages users to discover new artists and buy so-called notes. Notes are tradable VIP passes, granting access to exclusive content. In return, notes act as reward, allowing artists to crowdfund their creations and assess fan engagement (Bitcoin Magazine 2015). Artists can decide what perks they want to offer, varying from discounts on merchandise to tickets, backstage passes, etc. Like stocks, notes are limited in number and increase or decrease its value according to an artist's popularity. Even though notes reward investors for their crowdfunding contribution, they should not be confused with equity, as they do not represent a share in future revenue (SuperbCrew 2015). Notes are however a means of measuring fan engagement and identifying superfans. Artists can thereby engage with their biggest fans on a more personal basis. The platform relies on blockchain in order to make notes tradable and transactions secure, while also reducing the need of a third party and thus limiting transaction cost (Chester 2016).

6.2.4. Wrongful claims and inability to prevent exploitation

The unauthorized use of creative works on social media platforms has been widely criticized by the music industry. On YouTube and Facebook, music is synced to videos, shared or modified in remixes, often without a license from the rightful owner. Billions of views are generated and monetized without rewarding the appropriate owners. *'Safe harbor'* regulations have proven to be inefficient in protecting creators and reduced their ability to engage in fair negotiations (Israelite 2016). Some argue, that in the current setting most if not all players in the industry lose out somewhere: First, platforms like Soundcloud, YouTube and Facebook that heavily rely on user-generated content and derivatives are required to put significant effort in taking down unlicensed content. Second, creators might not be recognized as originators and thus be unable to monetize creations (Dickson 2016; Howard 2016). Some estimate that 25% of music on streaming services is unlicensed (Perez 2017). Third, users are often unable to identify and remunerate copyright owners. If users upload content to virtual networks without an appropriate license, their creations might be taken down or may not be monetized (Dina LaPolt 2017; Howard 2015e).

Unequivocal identification of rightful owners. The nature of blockchain technology might prove effective in mitigating some of these issues. By encrypting creations and assigning them a unique ID and timestamp, assets stored on the blockchain are effectively unalterable. Immutable metadata baked

into creations ensures that right owners can be identified easily and rewarded for their works (Dickson 2016). Artists using existing content to create derivatives would no longer need to search for copyright owners or go through cumbersome licensing channels (Rogers 2015). The blockchain would not only enable users to unambiguously verify creators, but also allow artists to trace how their creations are used. Musicians might find it interesting to assess the reach of their creations and derive value from such data (Howard 2015b; Silver 2016, p.40). Since derivatives of original creations would link back to the *'genesis track'* as well as its copyright owners, all proceeds would be distributed accordingly (Howard 2015g). Through an industry-wide integration of blockchain, platforms would no longer need to check for copyright infringement and take down content (Rogers 2015). Platforms like YouTube and Facebook would also likely benefit from the application of blockchain. Unlike today, social networks could legally monetize all content while no longer spending significant resources on identifying infringement, notifying right holders and resolving disputes (Rogers 2016). Penalties like the USD 25 million paid by Spotify for unlicened content would be a thing of the past (Perez 2017).

"YouTube would realise that they can put ads on 90% more content than they do, because they wouldn't have to figure out disputes within it. No one likes to have their business model shaken up, but if right now they monetise 10% of their views, imagine if they could triple that" Benji Rogers, CEO dotBlockChain Music & Founder PledgeMusic (Music Ally 2016, p.8).

Smart contracts to outline licensing terms. Machine-readable smart contracts, would enable artists to control how their creations can be used and monetized (Rogers 2016). Content owners may decide to license certain tracks for free while charging a predetermined amount for others. They could establish different rules for various use cases and for example allow streaming of music while restricting the use of a title as background music on YouTube. In addition, musicians might choose not to monetize creations in order to promote their content. Ultimately, creators could recapture control over their creations. The issues related to *'safe harbour'* regulations would be resolved and artists could finally decide how they want their creations to be used and monetized (Howard 2015j; Silver 2016, p.39).

6.2.5. Time lag of compensation and data insights

Structural inefficiencies and a lack of synchronized data used by multiple parties make it nearly impossible to process insights efficiently or issue payments in real time (BerkleeICE 2015, p.20; Revelator 2015a; Silver 2016, pp.17–18). The advantages of blockchain discussed in Chapter 6.2.2. and 6.2.3. not only introduce a higher level of transparency and improve quality of data, but also allow for faster data transfer across the network.

Real-time micropayments. The introduction of micropayments on the blockchain would enable artists to receive payments as creations are consumed and backtrace sources of funds. The technology would greatly alter how artists are compensated, mitigate problems related to delayed payments and future visibility (Wallach 2014). Instantaneous micropayments could even trigger new forms of royalty rates, where consumption is metered and rewarded by the millisecond (Tapscott & Tapscott 2016, p.233).

Immediate synchronization of data. Instant, network-wide synchronization is not limited to payments but works for any kind of data and information (Gottfried 2015). Thereby, artists could draw marketing insights from real-time data. The more recent the data, the more actionable are the insights artists may draw from it. Cretors could for example identify which platforms serve best to promote music at any given point in time or test which ads are most successful (Revelator 2015a).

6.2.6. Outdated compensation and limited sources of funding

It is widely acknowledged throughout the industry, that the royalty split between artists and labels is no longer fair. Nowadays, music distribution on digital streaming services occurs at zero marginal cost and production can even happen on personal computers. Still, the industry has yet to adopt to these changes (Gottfried 2015; O'Dair 2016b, p.9; Tapscott & Tapscott 2016, p.229). The issue

is two-folded. First, artists have few opportunities other than selling their rights to labels to gather the up-front funding needed to record and distribute music (De Filippi 2015, pp.1–3; Howard 2015a). Second, artists have little power in negotiating compensation according to their preferences (Ingram 2015). We believe that blockchain and crowdfunding could disrupt the industry towards a more artist-friendly environment (Tapscott & Tapscott 2016, pp.231–232).

Flexible forms of compensation. We discussed earlier how smart contracts and blockchain would allow musicians to decide how and at what price their creations could be used. Artists would no longer depend on labels to negotiate royalties but machine-readable contracts would execute themselves. Thereby, anyone could search the global catalog for pieces that fit their desire and match preferences like price and usage. Microtransactions would furthermore allow for instantaneous and secure compensation (Howard 2015l; O'Dair 2016b, pp.16–18). Some hope that the blockchain thereby could lead to a fair compensation structure, where everyone in the value chain gets an appropriate share and one only has to pay for what they want to hear (Rogers 2015). Microtransactions could also enable alternative compensation structures where creators accumulate funds through tips or *'pay-what-you-like'* schemes (Suzor 2013, p.325).

Diverse sources of funding. Smart contracts and the transparency offered by blockchain not only have the potential to improve the current compensation structure, but also to offer better means of funding to creators. Sellaband was one of the first crowdfunding platforms that allowed fans to invest in bands. Shares were valued at USD 10 and as soon as USD 50,000 were reached, the money was transferred and the band could start production. In return, revenues derived from the sale of CDs were shared between artists and funders, while Sellaband would hold on to the copyright for twelve months (Spellman 2008). While Sellaband opened a new source of funding and levered *'direct-to-consumer'* relationships, the platform was far from perfect. Like on many crowdfunding platforms, backers were not able to perform a due diligence and assess a creator's potential for success (Agrawal et al. 2014, pp.71–72, 76–77). The transparency introduced by blockchain could help investors to better monitor creator's past and current success to reduce the risk of fraud and moral hazard. Thereby, investors would be able to assess and mitigate the inherent risk of an investment and might therefore be more likely to invest (O'Dair et al. 2016, pp.13–14). Furthermore, through smart contracts funders would be guaranteed to receive their appropriate share of future income if they invest in a *profit-sharing* crowdfunding campaign. No longer would investors be dependent on musicians' goodwill, but automatically executed contracts would distribute royalties (O'Dair 2016a). However, crowdfunding could not just be limited to profit-sharing models. One could also imagine equity crowdfunding-like platforms where funders

acquire tokens that represent a share of ownership in an artist's creations. Artists would raise money through ICOs, which are further discussed in Chapter 4. Investors would be attracted by the potential appreciation in value an artist might accomplished over time (Ayral 2014; De Filippi 2015, pp.6, 8). A discussion with Revelator founder Bruno Guez revealed that through the blockchain, music could be traded like shares on a stock exchange, and artists might raise money for recording music or tours through that exchange (Guez 2017; Silver 2016, p.31). Like profit-sharing models, equity crowdfunding platforms would not necessarily need to use blockchain as underlying technology. However, as already discussed in Chapter 4 of this paper, blockchain introduces valuable features such as transparency, security, frictionless exchange of tokens, monitoring of artists and fan engagement while also lowering transaction cost through third-party disintermediation (Chester 2016). Ultimately, blockchain-based crowdfunding of creative campaigns would open a new source of early-stage financing to artists, while limiting dependence on labels. In addition, it would also bring fans and artists closer together, promoting *direct-to-fan* engagement (Rethink Music 2013). Moreover, given that the crowd becomes an active shareholder in artistic creations, funders have a vested interest in promoting creators to increase their reach. This could ultimately shift the industry as a whole to become more collaborative and inclusive (De Filippi 2015, p.8). Apart from crowdfunding, the blockchain might also foster accelerator-like platforms. These accelerators could potentially identify and select the most promising artists automatically though

bundling blockchain-based data streams around user engagement and real-time

consumption trends. Selected musicians might then receive funding as well as

hands-on mentoring (O'Dair et al. 2016, pp.13–14).

7. Conclusion

In this thesis we have given an overview on crowdfunding and blockchain technology. Furthermore, we have identified structural inefficiencies in both the patent and the music market. Finally, we have shown how crowdfunding and blockchain technology can be applied to address these inefficiencies and have given examples of initiatives. Our findings are summarized in Table 4.

Overall, we identified two main patterns in the application of crowdfunding and blockchain technology on the patent and music markets. First, we identified a larger number of promising application for both crowdfunding and blockchain technology within music and digital rights. Second, for patents only crowdfunding has potential to have substantial impact. Blockchain technology does not solve the main structural issues we identified for patents.[15]

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[15] Both use cases we identified - smart contacts in place of patent pools and a decentralized database - have very limited scopes as described in the respective Chapters.

Table 4: Summary of applications of crowdfunding and blockchain technology on structural inefficiencies in the patents and music markets; own illustration

	Crowdfunding	Blockchain
Patents		
Patent thicket		- Smart contracts in place of patent pools
Approval of low quality patents	- Invalidation of patents through crowd diligence and bounty schemes	
Difficult valuation	- Crowd-based patent landscaping and due diligence	
Limited access for small inventors	- Crowdsourcing without financial compensation - Crowd-based patent financing	
High search costs	- Crowd-based patent research	- Decentralized database
High likelihood of expropriation	- Crowd-based patent litigation financing	
Music		
Uncertain ownership of copyrights	- Crowd diligence/ bounty scheme to ensure data integrity	- Comprehensive decentralized database - Disintermediation of third parties
Opaque accounting and payments		- Micropayments - Transparent accounting through smart contracts
Inability to access data and draw marketing insights	- User involvement - Bounty scheme for reviews	- Undistorted access to data
Wrongful claims and inability to prevent exploitation		- Unequivocal identification of rightful owners - Smart contracts to outline licensing terms
Time lag of compensation and data insights		- Real-time micropayments - Immediate synchronization of data
Outdated compensation and limited sources of funding		- Flexible forms of compensation - Diverse sources of funding

We found that crowdfunding has a wider range of use cases than blockchain: Theoretically, forms of crowd diligence, bounty schemes, or crowd-based financing can be applied to almost any problem with the exception of information that for legal reasons cannot be shared with the public as this can be the case with patents.[16] In contrast, blockchain technology is a powerful tool which - based on the findings of our analysis - however, can only fulfill its potential if certain conditions are met. We identified these conditions as the following:

- **Assets and its use cases should be identifiable and traceable.** A song is unambiguously identifiable: It can be hashed and the internet can be crawled for this hash to identify usage. In contrast, usage of patents is more difficult to identify. In Chapter 5.2.4. we have shown that patent applications usually only disclose the minimum information necessary to obtain a patent and use broad and unspecific language on purpose (Hagiu & Yoffie 2013, p.47). As a result, it cannot be easily identified whether a patent has been infringed. Instead, the month-long process of detection requires the know-how of patent and industry experts (Hagiu et al. 2011, pp.9–10). Therefore, it is not possible to crawl the internet for patent infringements as opposed to copyright infringements for music.

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[16] However, as shown above, there are measures such as provisional patent applications to protect intellectual property when using crowdfunding/ -sourcing platforms

- **It should be possible to standardize licensing agreements to a certain degree.** Blockchain technology could allow for a broader range of licensing opportunities for content owners. They could give away some of their music for free while charging for other creations or allow use on certain websites while restricting it on others (Rogers 2016). While such licensing agreements are theoretically possible for patents as well, patent licensing negotiations are usually far more complex. Patents are subject to strong complementarities and portfolio effects (Hagiu & Yoffie 2013, pp.46–47). Furthermore, intellectual property rights for one technology are often distributed between many different right holders (Hall et al. 2012, pp.2–6; Shapiro 2000, p.120). As a result, licensing deals can take several years and need customization for every company. Usually a licensing agreement with one licensee cannot be easily applied to another licensee (European Patent Office 2008; Hagiu et al. 2011, p.9).

- **Data on asset usage should be available online.** Blockchain can help to track where and how music is consumed online and can distribute royalties based on this information (Howard 2015i; Rogers 2015). However, blockchain technology cannot be applied to identify whether a street musician plays a content owner's song as long as there is no digital copy of the performance. With the same logic applied, blockchain cannot help to find out whether a company in China infringes a patent when it builds a non-digital product. As long as there is no detailed and

standardized information digitally available where it is evident that a certain technology is used, there is only limited use for blockchain technology as a tool to trace usage.

We are aware that this thesis is only an overview on potential applications of blockchain technology and crowdfunding. While current blockchain solutions are very early-stage and still in their infancy, crowdfunding applications are reaching mainstream adoption. As shown in this paper, we are convinced that nevertheless these concepts offer promising solutions for many of the structural inefficiencies in the patents and music system. Overall, we believe that blockchain technology and crowdfunding have the potential to revolutionize the music industry and improve the patent system, although to a substantially lesser extent. In our opinion, the crowd can tackle some of the structural efficiencies such as the approval of low-quality inventions and the difficult valuation of patents. However, most of these initiatives just scratch the surface. As shown above, the reasons for their limited impact are manifold: the broad and opaque language used in patent applications, the characteristics of patents with their complementarities and portfolio effects, the market structure of the patent market with a small number of large and influential players, the specific niche expertise needed in patent law, the small incentives to cooperate given the high stakes of many players in the high-tech industry, etc (Bessen et al. 2011, pp.2–5; Encaoua & Madies 2014, pp.3–5; Gans & Stern 2010, pp.805–809; Hagiu & Yoffie 2013,

p.47; Yoffie 2017). In order to solve most of the issues shown in this thesis, we believe that eventually legislative changes are necessary, the discussion of which, however, would exceed the scope of this thesis.

In contrast, we see large potential for the music industry. While crowdfunding has already been widely accepted by musicians, blockchain still faces some limitations to mainstream adoption. As of writing, a number of issues remains unsolved. First, the association of blockchain and cryptocurrencies with criminal online activities and money laundering often overshadows its benefits. In one of our interviews, *Berklee College of Music Professor* George Howard (2017) emphasized the importance of publicly promoting the technology. However, he believes that stakeholders now need to understand that the blockchain is not disruptive per se, but only an enabler of transparency. Platforms should not advertise that solutions are blockchain-based. Instead, they should work towards better user experience and promote the opportunities of solutions rather than outline complex benefits of a technology. Second, while the benefits of disintermediation are apparent, it is a blessing and curse at the same time. Intermediaries that fear obsolescence through disintermediation might block the adoption of the technology. To overcome this issue, third parties would need to understand what financial benefits they could derive from the technology (O'Dair et al. 2016, pp.19–20). The fact that three of the largest collection societies have joined forces to build a blockchain-based solution to simplify licensing

demonstrates that even a private and permissioned blockchain can solve some of the industry's problems (Music Business Worldwide 2017). Third, fundraising through ICOs and tokens is still a legal grey-zone. While the SEC has not yet taken actions against this method, legal certainty is needed to open the path for mainstream adoption (De Filippi 2015, pp.6–7). Finally, even the blockchain will require governance systems to ensure data integrity. While reward-based crowdsourcing mechanisms might be a measure to curate metadata, it is still unclear how exactly disputes of ownership between parties would be settled (O'Dair et al. 2016, p.19). Certainly, reputation-based systems might help to establish credibility, but a functional implementation of such systems has yet to be found (Howard 2015d; Silver 2016, p.38).

In the short term, we might end up seeing multiple versions of purpose-built music blockchains, some of which will be public and permissionless while others may be private and permissioned. Over time, these might move together, gradually transforming the music industry as we know it today. However, such a process might take years or even decades (Silver 2016, pp.58–60).

8. Appendix

8.1. List of abbreviations

AIA	Leahy-Smith America Invents Act
CAFC	United States Court of Appeals for the Federal Circuit
CMO	Collective Management Organizations
FCIA	Federal Courts Improvement Act
FITF	*'First Inventor to File'* system
FTI	*'First to Invent'* system
GRD	Global Repertoire Database
HBS	Harvard Business School
ICO	Initial Coin Offering
IoT	Internet of Things
IP	Intellectual Property
IPO	Initial Public Offering
ISRC	International Standard Recording Code
ISWC	International Standard Musical Work Code
MIT	Massachusetts Institute of Technology
MRS	Mechanical Right Society
NDA	Nondisclosure Agreement
NPE	Non-Practicing Entity
PRO	Performing Right Organization
PTO	United States Patent and Trademark Office
SEC	U.S. Securities and Exchange Commission

8.2. List of figures

8.3. List of tables

8.4. List of interviews

Interviewee	Position	Organization	Date
Guez, Bruno	CEO & Founder	Revelator	April 9, 2017
Howard, George	Associate Professor Music Business/ Management	The Berklee College of Music	April 21, 2017
Johnson, Simon	Ronald A. Kurtz (1954) Professor of Entrepreneur-ship, Professor of Global Economics and Management	MIT Sloan School of Management	April 12, 2017
Krajec, Russ	Co-Founder	BlueIron IP	April 20, 2017
Shemesh, Adoram	Co-Founder	PatentAngels. com	February 27, 2017
Yoffie, David	Max and Doris Starr Professor of International Business Administration	Harvard Business School	February 28, 2017

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