FREE LOVE, LINUX AND LEISHMANIASIS:

DEVELOPING A BUSINESS MODEL FOR

COMMUNITARIAN INNOVATION

by

David Brent Francom

A dissertation submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Economics

The University of Utah

May 2012

The University of Utah Graduate School

STATEMENT OF DISSERTATION APPROVAL

The dissertation of **David Brent Francom**

has been approved by the following supervisory committee members:

Kenneth P. Jameson	, Chair	**March 2, 2012** Date Approved
Mark A. Glick	, Member	**March 2, 2012** Date Approved
David M. Kiefer	, Member	**March 2, 2012** Date Approved
E. K. Hunt	, Member	**March 2, 2012** Date Approved
Thomas A. Kursar	, Member	**March 2, 2012** Date Approved

and by **Thomas N. Maloney** , Chair of

the Department of **Economics**

and by Charles A. Wight, Dean of The Graduate School.

ABSTRACT

Through a case study analysis of 19th and 21st century communitarian innovation groups, this dissertation develops a business model that promotes innovation without the incentives of monopoly profits provided by patents. Social Utopian communities of the 19th century and Free and Open Source Software development communities share similar contributors' incentives and comparable organizational structures which provides a foundation for a business model that can be transported to other industries, specifically biotechnology. Communitarian innovation groups already exist within the biotechnology sector but have not yet been proven effective or capable of applying the communitarian business model through all stages of research and development. This dissertation provides the business model for communitarian innovation as well as recommendations on how to apply the business model to all stages of biotechnology innovation.

TABLE OF CONTENTS

Appendices

LIST OF TABLES

Table

CHAPTER 1

INTRODUCTION

"… The essence of open source is not the software. It is the process by which software is created … Production processes, or ways of making things are of far more importance than the artifacts produced because they spread more broadly." (Weber, 2004, p 56)

Finding an organizational structure for successful communitarian innovation can be an important step in achieving societal goals such as developing effective drugs for neglected tropical diseases and improving the developing world's food supplies. According to Ostrom (1990, pp. 89-90), an important component of understanding cooperation is an understanding of the institutional "design principles," or organizational characteristics, that lead to successful cooperative innovation. Ostrom contends that a comparison of organizational design characteristics within cooperative communities will help academic understanding move toward a general theory of cooperation. In this dissertation I develop an organizational (or business) model for cooperative innovation within communitarian case study groups. The model is formed by collecting the strands of academic inquiry in the fields of innovation and cooperation and tying together the communitarian movements of the 19^{th} and 21^{st} centuries.

In order to move toward an understanding of an organizational structure for communitarian innovation, I select six case study communities, three each from the 19^{th} century and 21^{st} century, and analyze the organizational structure common to each. This understanding of the organizational structure of communitarian innovation groups initiates a theoretical model that explains complexities of economic behavior beyond existing theories of innovation (Ostrom, 2010).

> To explain the world of interactions and outcomes occurring at multiple levels, we also have to be willing to deal with complexity instead of rejecting it. … When the world we are trying to explain and improve, however, is not well described by a simple model, we must continue to improve our frameworks and theories so as to be able to understand complexity and not simply reject it. (Ostrom, 2010, p. 25)

The case study analysis forms the basis for a theory of organizational structure or a business model for successful communitarian innovation groups in order to export this model to different industries and to achieve societal goals as yet unattained through current business models. The communitarian innovation business model is a method of knowledge creation much different than the status quo which relies on Intellectual Property Rights (IPRs) to protect private property. The communitarian innovation model works within the existing economic structure of market and commercial incentives; however, the communitarian organization promotes innovation and knowledge creation based on incentives that promote community agendas and societal goals.

Chapter 2 of this dissertation looks at the importance of innovation to the US economic system and the role of Intellectual Property Rights (IPRs) in motivating innovation. The impact of IPRs on the incentive to innovate has been an important part of academic inquiry and I review this literature as well as the academic literature on cooperative communities that investigates the organizational structure of cooperative innovation communities.

In ***Chapter 3*** of this dissertation, I examine the theoretical and historical development of private *real* property and its impact on the development of private *intellectual* property. By connecting the histories and theories of real property with those of intellectual property, I provide a framework of economic thought regarding property ownership and the creation of common resource communities. I also review the historical development of common resource communities in the United States.

Chapter 4 reviews the historically extraordinary period of communitarian growth in 19th century USA and provides background and context for a detailed discussion of cooperative innovation within three case study communities. In ***Chapter 5*** I identify and analyze three FOSS case study groups and discuss the historical development of the communities and the impact of the cooperative innovation on the software industry.

Chapter 6 connects the 19th century communitarian groups with the current communitarian FOSS groups by showing comparable incentives to participate and contribute to the community. My study of journal entries, interviews and other primary and secondary sources provides insight into the incentives of cooperative innovation contributors within the case study communities. The 19th century case study contributors' incentives are then linked to the Free and Open Source Software (FOSS) contributors' incentives. These five incentives to contribute are to:

- meet contributors' unfilled need;
- enhance contributors' own or community reputation;
- provide contributors with fun and enjoyment;
- promote contributors' personally important social agenda; and
- encourage commercial potential of the innovation.

The three 19th century and three FOSS case study groups form the foundation on which I develop my organizational structure for cooperative innovation presented in ***Chapter 7***. Based on my analysis of the 19th century case study communities, I identify five main categories with subcategories of organizational attributes that positively influenced the success of communitarian innovation leading to leading to specified social outcomes:

- Governance and Leadership
    - Motivational Leadership
    - Shared Leadership
    - Adaptive Leadership
- Socioeconomic Structure
    - Fundamental equality
    - Property distribution
- Organization of Labor
    - Method of organizing labor
    - Sub-group structure
- Communication and Evaluation
    - Open communication
    - Peer review
- Member Commitment
    - Membership levels
    - Member agreements

Chapter 7 then compares the elements of each organizational attribute found in the 19th century case study communities to the FOSS case study communities which reveals the comparable identifying organizational structure across all case study communities. From this analysis, I conclude that these characteristics form the necessary organizational structure to promote communitarian innovation.

In ***Chapter 8*** I introduce biotechnology communitarian innovation groups and explore the portability of the five organizational characteristics to biotechnology innovation communities. In this chapter I analyze three biotechnology case study communities and assess the importance of the organizational structure on the success of innovation. In conclusion, I provide recommendations for biotechnology communitarian groups to succeed at their societal goal of developing and delivering life-saving pharmaceuticals to those who are unable to afford high-priced drugs developed under the traditional pharmaceutical research model. The communitarian innovation business model shows that the profit incentive can be used to achieve social goals rather than traditional corporate incentive of individual wealth maximization.

CHAPTER 2

OVERVIEW

> If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea… that ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition seems to have been peculiarly and benevolently designed by nature. (Thomas Jefferson as quoted in Foley, 1900, p. 433)

In his classic work, *“The Theory of Economic Development,”* Schumpeter (1934) analyzed the role of innovation and entrepreneurs in capitalism’s future. He argued that profit is created through entrepreneurial innovation of methods, systems and products that produce competitive advantages. It is this innovation that, according to Schumpeter, will provide the means for capitalism to continue to grow and even continue to exist. Without it, profits will gradually decrease to zero and the highly productive capitalist system will collapse.

Knowledge creation, or innovation, has moved humankind forward for millennia. Innovation has been the foundation of modern industrialized nations which has led to a deep interest in the motivation of individuals to seek new knowledge and to innovate. Some assume that the promise of financial reward is a necessary and sufficient motivation to innovate. However, as shown in the academic literature there is increasing evidence to the contrary.

Given that knowledge is nonrival, nonexcludable and has high initial costs of production, many economists assume that within a market free of government intervention incentives to produce knowledge would provide considerably less innovation than optimal. It is understandable that knowledge creation and innovation should attract the attention of a wide segment of society due to its impact on economic growth, wealth and well-being, without which life-saving pharmaceuticals and labor-saving software would not exist. The framers of the US Constitution recognized the importance of innovation to the national well-being and, in order to encourage innovation, included Article I Section 8 to the Constitution which states, “Congress shall have power . . . To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.”

The topic of “exclusive rights” for “limited times” has generated a great deal of discussion regarding the impact of patents on innovation and the dissemination of knowledge. Economic, legal and social studies literature abounds with academic papers criticizing or condoning the impact of current IP regimes on innovation. The question commonly posed by this literature is whether or not innovators would be sufficiently motivated to invent without the incentive of monopoly rights. Put another way, the question is whether monopoly protection created by IPR regimes provide the optimal method for motivating innovation. The recent success of open source knowledge creation has rekindled interest in the question of incentives and motivation.

While it is important to understand the motivation to innovate, equally important is the question of what societal and organizational structures motivate innovation. Even so less attention has been given in to the organizational structure of communities that successfully innovate. For the remainder of this chapter, I look at the impact of the current patent structure on innovation – in ***Section 2.1***, I provide an overview of IPRs, specifically, patents. ***Section 2.2*** begins the literature review on the impact of patents on innovation. I first look at the research supporting patent rights as a key incentive for innovation, and then discuss the literature on the reasons why patents can hinder innovation. I then review the relatively limited literature on understanding the non-traditional innovation model.

2.1. Intellectual Property Rights

"Intellectual Property" (IP) is a current catch-phrase which combines together patents, copyrights, trademarks and trade secrets. The types of protection the laws afford each of these "properties" are vastly different, making for an imprecise analysis when they are all categorized together (Gay, 2002). For example, trademarks and trade secrets have no definite termination of their property rights while copyright laws provide a much longer protection than patents. Patent protection is very different from copyright, trademark or trade secret protection in that a patentee must prove novelty and utility prior to the granting of property protection. This dissertation deals mostly with the existing patent system and its impact on innovation. This section briefly reviews the US patent system and the increased emphasis on international enforcement of patent rights.

Traditionally, it has been assumed that the modern patent system exists for two reasons: (1) to stimulate innovation through monopoly protection and (2) to provide detailed descriptions of new ideas to other inventors thus furthering overall innovation and progress. More recently, theoretical and empirical studies regarding strong IPRs question whether patent protection slows the transfer of knowledge, and therefore retard progress. Nobel Prize recipient, Joseph Stiglitz, has been a high-profile critic of developed nations' IPR regimes, especially as imposed on developing nations. He contends that strong IPRs not necessary for innovation and that they may indeed impede innovation and progress because of the monopoly power conferred to the IP holder. (Rosenzweig, 2009)

Given that innovation can accelerate economic growth and that IPRs, by definition, create barriers to entry and provide opportunity for monopoly rents, economists have attempted to reconcile the apparently conflicting goals of stimulating innovation and maximizing social welfare. Most researchers recognize that it is not ethical to place profits above human lives, and many also concede that society should not prioritize profits above unfettered access to knowledge, technology and innovation. However, many of the same researchers also question whether innovation would exist at all without monopoly protection of government enforced IPRs. The question remains whether innovation relies on a strong IPR regime and potential for monopoly rent. Finding a solution to the "motivation vs. social welfare" problem has produced a wide range of economic discussions. Mainstream economists generally assume that without IPR protection, little incentive exists for innovation and therefore production of knowledge is limited. On the other hand, because innovation produced under patent laws excludes those who cannot afford monopoly prices, some researchers find the social costs to be unacceptably high for patented knowledge. Additionally, because the social infrastructure of corporate profitability is often built around monopoly profits through

IPRs, social goals such as lifesaving drugs for the poor are often unachieved in the status quo.

2.1.1 IPR Status Quo

The number of patent applications filed and issued has increased significantly over the past two decades. Based on data collected from the World Intellectual Property Organization (WIPO), Figure 2.1 shows the annual patents granted worldwide increased nearly twofold from 1985 to 2008 ("WIPO Resources", 2011).

This increase raises the concern that the current patent system is ill-equipped to handle the increase of patent filings. Critics point out inefficiencies of the patent system including the numerous patents that are filed on “technology” that is without merit as a “useful art.” One example of an apparently frivolous patent is the “Method of exercising a cat” (US Patent and Trademark Office (USPTO) patent number 5,443,036) which explains that the method consists of “directing a beam of light” from a hand-held laser onto the wall or floor in an “irregular way fascinating to cats.” ("USPTO Patent Full-Text and Image Database", 1995, Abstract). Another example (USPTO patent number 5,934,226) is a patent for a “Bird diaper” featuring “an enclosed pouch for receiving and containing excrement, and apertures to accommodate both the wings and the tail of the bird.” ("USPTO Patent Full-Text And Image Database", 1999, Abstract). Beyond the frivolous, there are many patents that are never commercialized. One study shows that more than 95% of patents have “little economic value” (Adelman, 2006). The relatively small percent of patents that represent commercialized technology have, however, packed the patent courts with infringement disputes. This increased burden on the patent system

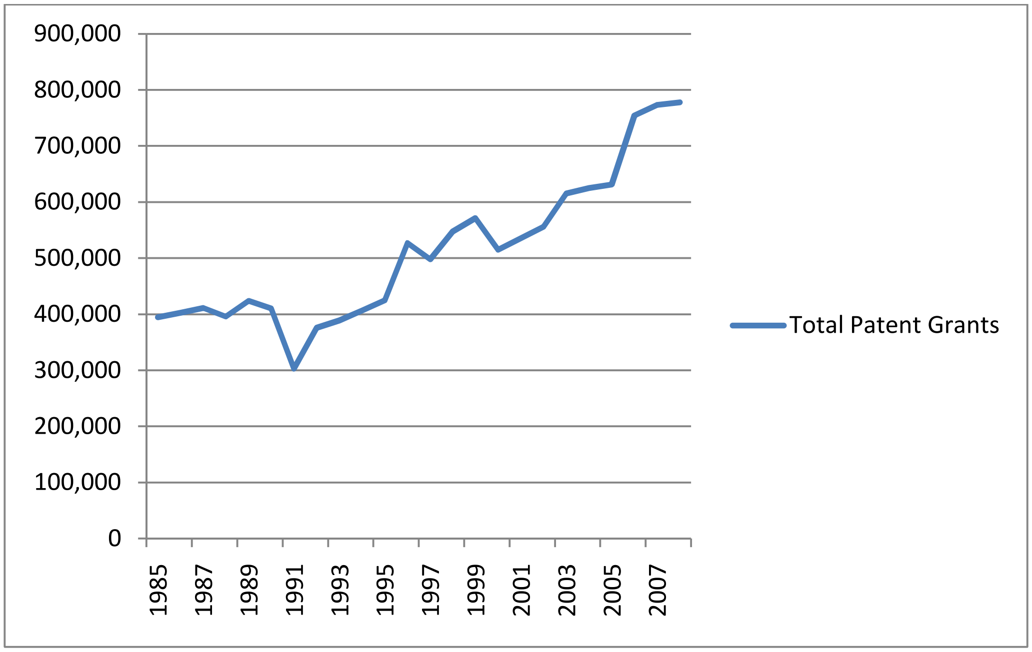

FIGURE 2.1 – Total Patent Grants 1985-2008

slows the IPR process and potentially increases the reliance on litigation to resolve property disputes.

> The granting of a large number of questionable patents has increased the likelihood that a given invention will infringe one or more existing patents, thus provoking a barrage of litigation. Moreover, since the mid-1990s, the delay in processing patents has increased by more than 50 percent, and the backlog of applications has more than doubled. (Gallini, 2002, p. 147)

In 2011, President Obama signed into law H.R. 1249, "America Invents Act" which is intended to reduce the number of frivolous patents, protect the rights of "early inventors," and also provide more incentive to manufacturers to implement innovations. The law changes the method of granting patents – rather than granting a patent to the first to invent which often resulted in costly litigation to prove invention timelines, the new law grants patents to the "first to file." Additionally, H.R. 1249 intends to "reduce the time it takes to review and issue a patent" and reduce the cost of "frivolous litigation"

("United States House of Representatives Committee on the Judiciary", 2011, America Invents Act of 2011, H.R. 1249 One-Page Bill Summary).

At its core, the prevailing IP regime presumes that the promotion of the useful arts is contingent on a period of enforced exclusivity for the patent holder. This presumption has resulted in a recent effort to standardize patent protection across all nations. The World Trade Organization (WTO), which promotes the goal of global free trade, has promoted the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (UNDP, 2000).

Under TRIPS, member nations of the WTO must "provide patent protection for any invention, whether a product (such as a medicine) or a process (such as a method of producing the chemical ingredients for a medicine), while allowing certain exceptions." (World Trade Organization, 2006, Obligations and Exceptions). As a result of TRIPs, patented innovations have obtained the protected legal status of government sanctioned monopolies in most developed and developing countries around the globe. The justification for promoting a globally harmonized patent system is the desire to encourage continued innovation; however, it is far from unanimous that the current system is a success in this respect. (See Appendix A "Global Harmonization of IPRs" for further discussion on TRIPS.)

2.1.3 Innovation Communities

If, in fact, innovation is motivated only through private property rights, then the goal of increased social welfare via uninhibited access to new knowledge and technology may be unattainable. However, there is evidence that innovation outside government protected monopoly regimes does occur. Community based cooperative innovation and knowledge creation has a solid historical basis of innovation that has succeeded outside the boundaries of strong IPRs. Communities have created and shared beneficial knowledge without the protection of monopoly power for millennia. Specifically, innovation developed by aboriginal groups, currently defined as Traditional Knowledge (TK), has been developed and managed by communities for generations. Additionally, 19^{th} century communitarian groups recorded examples of innovation without patent-enforced monopolies.

A current example of communitarian innovation is the open source movement (most notably software development) which has kindled academic inquiry into cooperative innovation and its incentives. Several academic studies have examined the economic incentives to contribute knowledge to Free and Open Source Software (FOSS). Even so, there has been little attempt to connect FOSS with its intellectual predecessors of community based cooperative innovation throughout history. The 19^{th} century communitarian groups are connected with the modern FOSS communities by showing common incentives to contribute and equivalent business models.

2.2 Literature Review

The incentive to innovate is central to the academic inquiry of patents and cooperative innovation. Although the debate is still evolving, there is a large body of literature on the impact of IPRs on innovation. In this section I first review the literature on the prevalent system for motivating innovation – government enforced monopolies through patent protection. This literature shows not only how the patent system motivates innovation but also the negative impact on innovation.

I have organized the literature conceptually rather than historically or methodologically. The literature is broadly divided into studies contending that a strong patent system is necessary to motivate innovation, and studies that argue IPRs retard innovation. The literature is categorized into opposing sides of the debate that support the arguments. The limited literature on organizational structure of successful innovation communities is also reviewed.

2.2.1 Arguments that Strong IPRs Motivate Innovation

Innovation is motivated by the profit incentive based on traditional neoclassical economic thought. There are studies that correlate IPRs with increased innovation. Patent monopoly protection is assumed to increase incentives to innovate and the literature identifies this incentive as the most important rationale for a patent system with strong IPRs. However, there are few studies that directly measure the relationship of incentives with patents.

2.2.1.1 Patents Motivate New Innovation and Disseminates Knowledge

The US patent system, in return for patent protection, requires the patentee to disclose the patented technology and the best method of implementation. This disclosure of knowledge within the patent filing is made available to a wide audience and allows the underlying technology of the patented innovations to be diffused to a wide geographic area (Moser, 2005). In return for the disclosure of knowledge, a patent provides monopoly protection for a period of time.

The debate regarding incentives and the current patent system is complicated due to the lack of a clear measurement of innovation. Several proxies for measuring innovation have been proposed in the academic literature, each with its own problems. Two measurement candidates used have been research and development expenses (R&D) (Griliches, 1984) and patents (Marasco & Boyer, 2001). Measuring the number of patents filed and granted is straightforward; however, measuring quantity and quality of innovation is much less straightforward. Patents are a problematic measure of innovation since not all innovation is patented; also, not all patents represent viable innovation. On the other hand, R&D is not an accurate measure because the reporting of R&D is not uniform across firms or across industries (Marasco & Boyer, 2001).

Royalties paid on patent licensing is another measurement method used by researchers to measure innovation that is commercially successful (Rosenzweig, 2009). Although this is arguably a fair measure of commercial viability and, therefore, value of an innovation, not all valuable innovations are licensed. Many useful innovations are freely available without license and others are patented but not licensed by the original patentee and therefore do not represent a correct measure of innovative activity. Another consideration is change in legal structure of the patent system as with the Bayh Dole Act. In 1980, Congress passed the Bayh Dole Act, which allowed universities, and other government funded entities, to maintain control of the intellectual property produced by such funding. Based on the level of royalties collected by academic institutions funded by the US government, one researcher concluded that because royalties have increased, innovation has increased as a result of the change in law (Rosenzweig, 2009).

2.2.1.2 Design Around

The most commercially successful patented products tend to spark increased attempts to innovate and find noninfringing alternatives, which may, in turn, be patentable. Because of this ability to "design around" the patented technology, those who support a strong IPR system do not consider patents as a disincentive to innovation (Epstein & Kuhlik, 2004). Indeed one researcher (Lee, 2004) cited the patent system as a means of forcing new would-be innovators to find a completely new research paradigm and advance the science even further because of the forced change from the existing limited scope of knowledge.

2.2.2 Arguments that Strong IPRs Hinder Innovation

Although there is little empirical research, there is significant theoretical discussion that strong IPRs actually slow innovation for several reasons including patent thickets, royalty stacking, overly broad claims, transaction costs, and patent races.

2.2.2.1 Shot gun, Scarecrow and Dragnet

Although the debate among academics has intensified in the past decade, many of the same issues were identified over 70 years ago by Alfred Kahn in his article *Fundamental Deficiencies of the American Patent Law*, published in 1940.

> A single … monopoly of a minor cog in that huge mechanism of interlocking processes and contributions which make up an advancing art can for [the life of the patent] seriously retard continued research… industry after industry has been checkmated by the patent law and has been forced to set aside the individual

> patent both as a basis for production and as a stimulus and reward for invention. (Kahn, 1940, p. 482)

Kahn identified three basic problems of the patent system, each of which is employed to deter competition and effectively limit new innovation. (1) The *shotgun* – a company that uses patents to scare off competitors. "From a business standpoint they are patent factories: they manufacture the raw material of monopoly" (Kahn,1940, 485); (2) the *scarecrow* – a company that uses a patent which appears to protect an important innovation but, in fact, represents little or no contribution to the art and its presence is for no other purpose than to threaten legal action; (3) the *dragnet* – a company that files a large number of patents with the patent office covering all potential aspects of the field and continuously revises those applications to cover any new invention subsequently developed in the field and "then take[s] out the patents as their own and sue[s] to protect them" (Kahn, 1940, p. 485).

2.2.2.2 Patent Thickets and Royalty Stacking

Large numbers of patents are filed and granted in certain fields which tend to create difficulties in designing around a given technology because of the potential of infringing one or more of the numerous patents. As the number of patents increase in a field creating a so called "patent thicket," the incentive to innovate in the field is stifled. Patent thickets hamper future R&D as potential innovators, fearing the possibility of unwittingly infringing an existing patent, choose not to innovate in the field rather than risk litigation. New technological advances are avoided because there are so many patents and patents pending that it is increasingly difficult and potentially impossible to know if a new innovation would infringe an existing patent or a soon to be patented technology (Gay, 2002). Patent thickets have slowed innovation in certain fields because "each patent holder [has] a potential veto right over the innovations of others" (Epstein & Kuhlik, 2004, p. 1).

Patent thickets may not be a problem for large corporations with a portfolio of patents that can be used as a cross licensing tool (Epstein & Kuhlik, 2004). Through cross licensing, the firms obtain needed technology and, perhaps more importantly, protection from potential litigation. However, this same opportunity is usually not available for an inventor with few patents who cannot leverage a small portfolio of patents against a large patent portfolio (Gay, 2002). A single patent is rarely "large enough to exploit by itself" (Kahn, 1940, p. 481).

Similar to patent thickets, royalty stacking can retard new innovation. Within complex technology sectors it is rare that any single technology is comprised of only one patent. Royalty stacking is the consequence of many patent licenses on a single product and a large number of patents comprised in a single product can stall incentives to innovate because the increased risk of litigation. Further, the profits of such a product are already consumed in the royalties paid to the many existing patent holders leaving little, if any, available to new innovators (Gay, 2002).

2.2.2.3 Litigation and Broad Claims

The USPTO reviews every patent filing to determine novelty and non-obviousness. The reviewing patent clerk may issue the patent with narrowly or broadly defined claims delineating the scope of property rights assigned to the patent holder. Broad claims mean greater coverage of patent rights and provide more monopoly control over future innovation in the field. By definition, a broad claim encompasses a very large scope and has few limits on the coverage of property rights. Patents with broad claims leave little room for additional innovation in the corresponding field due to patent infringement concerns. In a field with broad claim patents, even non-patented innovations cannot be implemented because of the scope of property rights awarded to the existing patent holder (Wu, 2006). For example, the USPTO issued a patent to Thomas Edison for the incandescent light with very broad claims. The broad claims of Edison's patent are seen to have slowed the progress of innovation in incandescent lighting and centralized the investment decision for an entire technology onto the individual patent holder (Wu, 2006). Broad claims issued by the USPTO may block the best ideas from being commercialized in the future because of patent restrictions (Wu, 2006). Furthermore, if the patent holder is unwilling to license pioneering technology to other inventors, incremental innovation could be negatively impacted due to the legal restrictions on using the existing technology (Duffy, 2004).

2.2.2.4 Patent Races

Current US patent law awards patent rights to the inventor who is first to file with the USPTO (HR 1249). One outcome of this law is the creation of races between companies to be the first to file and can lead to over-investment in R&D as firms are motivated to be the first to file. Only the winner of the patent race will have IPR protection leaving other competing firms with R&D expenses that may be redundant and, if implemented, infringing on the patentrace winner's IPR (Maurer & Scotchmer, 2002). Although the 2011 patent law has attempted to change this, these duplicative efforts have resulted in inefficient use of R&D and eliminate those resources for innovation in other fields (Duffy, 2004).

2.2.3 Organizational Structure of Cooperative Innovation Communities

Organizational structures provide the foundation upon which economic motives are realized. The existing organizational structure of IPRs has led to innovation outcomes based on financial incentives through government enforced monopoly protection. There are other organizational structures that motivate innovation such as that seen in FOSS and other communitarian innovation groups. The literature on the organizational structure of these groups is limited but includes a discussion on "horizontal innovation networks" of collaborating innovators who work on separate pieces of a project while improving each others' work through feedback and input (von Hippel, 2007). Knowledge production in cooperative innovation communities often improves quality outcomes through the iterative process of peer review and "open critical discussion" (Lave & Wenger, 1991; *see also* Brown & Duguid, 1991).

Other researchers identified cooperative innovation communities as "Communities of Practice" (CoP) which are defined as communities that create their own cultural norms and practices for the innovation process. These innovator community cultures provide the foundation of cooperation and act as a "social control mechanism" within the community to create rules and quality outcomes (Ash & Roberts, eds, 2008). CoPs are "A group of people bound together by their interest in a common working practice. Social groups organized around a certain activity (practice). Groups sharing a same practice and oriented towards the resolution of common problems" (Ash & Roberts, eds, 2008, p. 1). Examples of CoPs include government funded projects such as ARPANET which is the precursor to the modern internet. Other examples include industry consortia such as sporting equipment communities.

Similar to CoPs, the term “Collaborative Innovative Networks” (COINs) has been used to define cooperative groups which utilize electronic networking structures such as the internet so that “each team member can be reached quickly.” There is very little hierarchical structure and the groups are “self organizing, unified by a shared vision, shared goals, and a shared value system” (Gloor, 2006, Ethic codes in small worlds)

> These common values act as a substitute for conventional management hierarchies, directing what every COIN member “has to do.” COINs have internal rules by which they operate, for how members treat each other, for how supportive behavior is rewarded, and for how members are punished when they do not adhere to the code. There is a delicate internal balance of reciprocity, and a normally unwritten code of ethics with which members of the COIN comply. (Gloor, 2006, Ethic codes in small worlds)

COINs include so called “breakthrough technology communities” which establish themselves during the exploration phase of a new technology. Sharing during this phase creates huge learning potential among participants (Osterloh & Rota, n.d.). However, often the breakthrough technology communities will separate during the commercial phase of development in order to capitalize commercially on the technology (Osterloh & Rota, 2007.). Gloor (2006, p 90) also states that “…meritocracy, consistency, and transparency comprise the defining elements of an organizational culture for COINS, swarm creativity, an ethical code, and a small-world network of trusted relationships among team participants.”

The research on COINs and COPs provide some insight into components of successful cooperative innovation communities. Other research suggests that there are limits to the effectiveness of cooperative innovation such as large, expensive projects that cannot be easily divisible among many contributors are likely not a good candidate for open source development (Maurer & Scotchmer, 2002). Also, some have hypothesized that innovation fields not already covered by strong IPR are the only areas in which successful cooperative innovation can occur (Maurer & Scotchmer, 2002).

Collective action efforts have certain benefits over market solutions. In the area of proprietary software, bugs are more difficult to find in private software because the source code is kept secret from the beta testers and end users. Open systems also promote student learning and can allow commercial opportunities for third party developers of complementary services and products (Shapiro & Varian, 2003). In pharmaceutical testing, market solutions to FDA requirements lead to outsourcing which "gives contract researchers obvious incentives to suppress and even falsify data to keep test programs alive." Nonmarket solutions avoid this problem by relying on volunteers who have no incentive to keep the project alive (Maurer & Scotchmer, 2006).

The patent system and its impact on innovation have received significant academic attention – the literature shows both positive and negative influence of patents as a motivator to innovate. To motivate innovation, alternatives to the patent system exist but the academic literature is limited on the structure of these organizations. With the success of FOSS, the question of cooperative innovation is becoming more prevalent in the economic literature and there are advantages to cooperative innovation over the status traditional business model.

CHAPTER 3

THEORIES OF PROPERTY RIGHTS

> [J]ust as a feast to which many contribute is better than a dinner provided out of a single purse. For each individual among the many has a share of excellence and practical wisdom, … for some understand one part, and some another, and among them they understand the whole. Aristotle (Quoted in Walden, 1995, p. 564)

An invention of humans, property "rights" removed property from its primal state of public domain into legally enforced private ownership. Legal scholars carefully define property rights as distinct from private property powers, privileges and immunities (Cole, 2002). Indeed, legal property rights can be quite different than economic property rights as is shown in the example of the thief who has *economic use* of the stolen property in spite of the fact that he does not possess *legal rights* to the property (Cole, 2002). Even with these differences in perspective, much of the legal and economic foundation for private property rights is based on theories of specialization, efficiency and improved output (Cole, 2002). Even so, throughout modern history there have been groups that have organized with the premise of converting individual property rights into community property rights. This devolution of property rights has occurred with real and intellectual property in several communitarian eras in the US and is currently occurring with intellectual property as manifest by FOSS communities.

In ***Section 3.1*** of this chapter I discuss the evolution and theoretical development of *real* private property starting with commonly held property and progressing to private property laws. In ***Section 3.2***, I analyze the evolution of knowledge as personal property, moving from common to private ownership. I look at the impact that *real* property rights have had on *intellectual* private property rights specifically with regard to the US patent system. ***Section 3.3*** considers the "devolution" of private property rights based on economic and theoretical grounds. The devolution from private property rights to commonly held property is exemplified in historical communities that have rejected individual private property rights and instead emphasized common pool resources among their membership. I review the major US historical eras of common pool communities in the US beginning in the 1690s with the Colonial Period through the 1970s "Free Thinking" or "Hippie" era.

3.1 Private Property

Property rights began with commonly held property and progressed to semi-commons and then to private property (Levmore, 2002). As complexity of production and output increased so did the rationale for private property rights – land type and availability of technology helped motivate the legal structure enforcing private property rights.

Locke's classic theory of private property begins with the hypothetical primitive or natural state of mankind wherein "God-granted goods" are held in common. In this primitive state, there are enough goods to go around and no one need infringe on goods appropriated by others. Individuals transform these goods into private property by "exerting labor upon them." This labor adds value in such a way that the goods can be enjoyed by humans (Hughes, 1988).

As long as there is "enough and as good" property for others, everyone is only limited by the amount of labor they are willing and able to apply to make the property their own. This "enough and as good" condition works in Locke's theory because the capacity of work by a single individual naturally limits the amount that can be appropriated through labor. Locke also provides a "nonwaste" condition that condemns waste as an "unjustified diminution of common stock of potential property" and violates the "Law of Nature." (Hughes, 1988, p. 8). This labor theory, in its primitive state, turns into a meritocracy where those who are willing to do the work can obtain as much property as they are capable (Hughes, 1988).

Many ancient groups allowed "ownership" of consumption goods but held to moral beliefs that precluded ownership of goods in excess of ones own personal needs. Any excess beyond that needed by an individual or family was viewed as common property and shared with the community (Levmore, 2002). Property rights in ancient communities evolved as society progressed through various stages of production and distribution. During the hunting and foraging stage of production, community property rights developed due to the nature of production. However, as communities moved away from hunting and foraging, common property was no longer seen as efficient and individual property rights developed as a means to promote land improvement during the agricultural and farming stage of production (Demsetz, 2002; see also Levmore, 2002).[1]

---

[1] Both Aristotle and St. Thomas Aquinas addressed the apprehension of unequal property distribution as morally unjustifiable. However, both recognized the need for private property in order to promote the care of property, order, and peace in society. Aquinas declared that private ownership of property is not against

Types of property also determined how property rights developed. For example, as settlers entered the North American continent, those settling in the Northeast encountered vastly different land qualities than in the Great Plains regions and, as a result of the differing land endowments, different property rights developed. The forested areas of the Northeast resulted in overhunting which was ameliorated by private property rights; however, on the "Great Plains and Southwest, where animals ranged over large tracts of land, private rights to land did not develop because land ownership could not confer effective control of animal stocks" (Demsetz, 2002, p. S656). Private property rights in these areas were ineffective until technology provided low-priced barbed wire fencing allowing control of property and animals. Other technology also motivated change from the commons to private property. Along with fencing, tree cutting and irrigation technology provided economic incentive to create farms and increased the value of the land and intensified the motivation for private property (Levmore, 2002).

As cultures evolved and expanded to more complex legal property rights, issues of inheritance, distribution, as well as, the moral and ethical aspects of property ownership became increasingly relevant (Levmore, 2002). Underlying theories of property rights developed into differing legal foundations. For example, French and British colonization of numerous countries extended corresponding interpretation of

---

God's natural law but is rather in addition to God's law and is made by human agreement. He deemed private property as necessary for human life because ownership produces more care, more orderly conduct and resulted in better preserved peace among people. Aquinas also made clear that the use of property must be at the service of the common good and not for the "private interests of one or more citizens" (Dougherty, 2003). Similarly, Aristotle emphasized that property ownership is stewardship and concluded that the best method of property distribution is to enforce private property rights but make the use of privately held property available for the good of all.

Further, Christian and Muslim scholars recognized that without private property it would not be possible to perform acts of charity, an important religious tenet (Dougherty, 2003).

property rights. Depending on which country brought the ruling law, a very different concept of property rights evolved in the colonized country. Historically, French civil law minimized judicial interpretation and emphasized the rights of the state resulting in a state-oriented system within the French colonies (Levine, 2005). Early French economic theorists, the Physiocrats, viewed private property as essential to the prosperity of the economic system and that all institutions resulted from property rights. They held that private property was the basis of wealth and happiness but also recognized that property rights were determined by the state and considered that social and public utility was the supreme law and superseded the individuals' right to private property (Samuels, 1961). On the contrary, British property rights, through its courts and political system, developed into British common law which was "predominately a law of private property" (Levine, 2005). During the British Industrial Revolution, increased productivity reaped from specialization further motivated and economically justified the concept of private property rights. As a result, British colonies developed a stronger personal property law (Demsetz, 2002).

The strong British private property laws played a prominent role in Adam Smith's theory of the production process and class structure of the capitalist system. From Smith's class theory of capitalists, landowners and laborers, subsequent economists developed opposing theories of value: the utility theory and labor theory. Importantly, the perspective on value, whether based on utility or labor, leads to very different philosophical, social and economic theories on property rights. The labor theory of value is based on the concept that labor power is the only 'force' that can produce a surplus, i.e. the efforts of labor produces more than the cost of inputs to provide the labor, thereby generating a surplus (Hunt, 2002). The labor theory of value also recognizes the various classes of the capitalist society and emphasizes the struggle between the capitalists, landlords and labor classes. Referring back to Locke's theory of property rights, "exerting labor" is the means by which individuals transform goods into private property. However within the capitalist system, wealth created by labor and its attendant property rights does not remain with the laborer but transfers to the capitalist class. This perspective of the labor theory of value has led to criticism of capitalism wherein the capitalists retain the surplus value created by labor power thus concentrating property in the capitalist class.

John Stuart Mill saw the capitalist system of production as an individualistic and competitive system and as "essentially vicious and anti-social" because it was based on opposition of interests rather than harmony of interests (Mill, 1879/1987). The efforts of the capitalist to amass wealth and property necessarily placed the laborer and capitalist at odds. Mill wrote that the condition of workers under the capitalist system in France and England were worse than the conditions "the most savage tribes" had ever known (Mill, 1879/1987). Individualism and opposition of interests were the foundation of capitalist property distribution, Mills wrote:

> [Capitalism] is the principle of individualism, competition, each one for himself and against all the rest. It is grounded on opposition of interests, not harmony of interests, and under it every one is required to find his place by a struggle, by pushing others back or being pushed back by them. … Morally considered, its evils are obvious. It is the parent of envy, hatred, and all uncharitableness; it makes a natural enemy of all others who cross his path, and everyone's path is constantly liable to be crossed. Under the present system hardly any one can gain except by the loss or disappointment of one or of many others. (Mills, 1879/1987, p 72)

Marx agreed with Mills and also believed that creation of wealth and property was an “inherently social process” which should join people together – rather than tear them apart (Crain, 2000).

> The individual and isolated hunter and fisherman, with whom Smith and Ricardo begin, belongs among the unimaginative conceits of the eighteenth-century Robinsonades… In this society of free competition, the individual appears detached from the natural bonds etc which in earlier historical periods make him the accessory of a definite and limited human conglomerate. (Marx, translated 1953, "Independent Individuals. Eighteenth-century ideas")

Although morally attracted to a more cooperative creation and distribution of property, Mill saw a host of problems with the emerging theories of socialism and communism. According to Mill, one of the most significant problems facing the socialists was motivating work from the “natural man” with a tendency to laziness. Without an incentive to work for more wealth, there may be problems in the socialist structure. Furthermore, there would be no incentive for the most capable individuals to take upon themselves the added responsibilities of management. The ideal system needed a leader that would divide the work fairly and justly according to capabilities -- but again, human nature caused Mill to question whether fraud and bribery would make even this fundamental aspect fail. To make socialism work, Mill thought there needed to be a “dispensing power, an authority competent to grant exemptions from the ordinary amount of work, and to proportion tasks in some measure to capabilities” (Mills, 1879/1987, p 128). Mill writes of another concern with the proposed socialist communities, that is whether the “joint management will be as efficient as the ‘managements of private industry by private capital” (Mills, 1879/1987, p 118-19). Mill recognized the need for a new social order and encouraged trial experiments in order to determine how best to bring about a higher social condition. Mill seemed particularly encouraged by the communitarian ideas of Fourier and Owen. (See Appendix B "Three Short-lived 19th Century Communitarian Groups" for a discussion on these communitarian experiments.)

Possibly due to these problems with community ownership, Modern economic studies based on the theory of efficient markets and rational self interest take a simplistic view of property rights and assume the existence and necessity of private property rights. An overview of neoclassical economic theories reveals very little on the concept of private property rights other than an assumption of optimum property rights system based on market equilibration theories and rational behavior (Demsetz, 2002). However, some economists recognize the need for more robust economic theories of production and property rights including those based on the concept of cooperation.

> Almost all [neo-classical] economic models assume that all people are exclusively pursuing their material self-interest and do not care about "social" goals per se. This may be true for some (maybe many) people, but it is certainly not true for everybody. By now we have substantial evidence suggesting that fairness motives affect the behavior of many people. …Reality provides many examples indicating that people are more cooperative than is assumed in the standard self-interest model (Fehr & Schmidt, 2006, pp. 817-18).

3.2 Knowledge as Property

Over time, as real property rights developed, knowledge and intellectual property rights also expanded. Locke's three propositions that provided theoretical foundation for real private property also have been used to explain the justification of intellectual property. Locke's three propositions applied to knowledge as private property are: 1) innovation and knowledge require labor, 2) knowledge is "appropriated from a 'common' which is not significantly devalued by the idea's removal," and 3) knowledge can be made property without violating the nonwaste condition (Hughes, 1988). Similar to real private property, the development of intellectual private property has evolved from commons to semicommons to legally enforced private property.

3.2.1 Knowledge as Common and Semicommon Property

Before knowledge creation became private property, indigenous communities created ideas and innovation through community cooperation. The use of early technology – the rudimentary tools – provided the foundation for cooperation and "gave rise to uniquely human traits such as advanced intelligence and speech." (Crain, 2000, p. 217) Communities formed and led to social production through cooperation and use of technology. "Tool-use also led to new modes of cooperation and communication. As technologies advanced, people discovered the advantages of working together. For example, they found that they could more effectively build a hut or a boat by joining forces." (Crain, 2000, p. 217).

Historically, communities developed innovative knowledge, or Traditional Knowledge (TK),[2] over many centuries that was passed down from generation to generation (Correa, 2001). Indigenous groups have relied on TK for centuries for health remedies, work procedures and agricultural methods. Many of these groups continue to increase knowledge cooperatively and freely share that knowledge without any property rights limitations (Correa, 2001). TK continues to impact these communities and provides knowledge benefitting the health and food needs of millions of people in

[2] WIPO defines TK as scientific, literary, or artistic works and other scientific and artistic innovations and creations that are based on tradition (Correa, 2001).

developing countries who rely on this ancestral knowledge for their day-to-day wellbeing (Correa, 2001).

Indigenous groups have found in the past several decades that commonly held TK without legally protected property rights has led to exploitation by individuals and corporations.

> Indigenous people often believe that intellectual property law is neither a necessary, nor a desirable, means of encouraging innovation within their communities. As a consequence, they are sometimes easily willing to share this knowledge, which leads to its exploitation… This situation gives raise to concern because, although the original holders have not acquired any benefit, the exploiters have benefited from the knowledge…. (Ragavan, n.d., “Traditional Knowledge and Indigenous Societies”, Para. 8)

Recently, TK has earned a high profile in world trade discussions because of its continued inferior legal status as protected property in world courts as compared to formally copyrighted, trademarked and patented knowledge. There are several cases of TK used for holistic remedies in indigenous groups that have been appropriated and patented by corporations. Examples include neem, turmeric, rosy periwinkle, ayahuasca, and sangre de drago (United Nations Development Programme, 2000). Unless the originators of the TK also benefit from any commercialization of this knowledge, this misappropriation for economic gain is referred to as biopiracy. (See Appendix A “Global Harmonization of IPRs” for further discussion on TK and biopiracy.) Some consider biopiracy as comparable to the imperialism practiced by various conquerors in earlier centuries – the assets are taken by the conqueror and used for their sole benefit (Hafstein, 2004). This attitude is seen historically in the takings of real property from indigenous groups in North America. In spite of strong private property laws, the US Supreme court ruled in *Johnson v. M’Intosh* that the Painkashaw Indians were not owners of the land but merely “inhabitants.” Justice Thurgood Marshall stated that the original inhabitants had no ownership rights either individually, collectively or as a nation but only the right of “occupancy” thus legally justifying the taking of the real property (Bratspies, 2004). This imperialist attitude toward indigenous groups and forcible control of real property rights is comparable to the attitude currently applied to intellectual property created by original inhabitants of many countries.

As civilizations developed, the common ownership of TK evolved into a semi-commons arrangement among particular crafts and trades. Production and commercial advantages often required keeping some of the knowledge secret from competitors. In Greece and Rome, families passed down craft knowledge through many generations, requiring that production information to be kept as proprietary knowledge (Long, 1991). Craft guilds also developed in medieval Europe as communities of artisans combined together to share craft secrets and innovations.[3]

With increasing technological advancements, some countries provided property protection of innovations. Because of differing intellectual property policies, the type of intellectual property protection available in a country helps determine the path of technological innovation and the nature of resulting inventions. Historically, countries with weak IPR systems produced industries that tended to protect their inventions as trade secrets and encouraged highly complex technology that was difficult to reverse engineer – such as Switzerland and its specialty in watches. This pattern can be seen at least as far back as the Industrial Revolution, when regions of the world focused on

[3] Guild members provided intercessory prayers for the souls of deceased members which contributed greatly to the discipline of guild members – sanctions were put into place to reduce future prayers if guild members got out of line (Richardson & McBride, 2008).

specific technological advances. England, for example, with its property protection of innovation developed textile manufacturing technology in the early 1800s and Switzerland, due to its reliance on trade secrets, became known for precision mechanics (Moser, 2005).

3.2.2 Knowledge as Private Property

Throughout much of the history of innovation, patent monopoly was absent and the incentive to innovate was based on utility, reputation, pleasure, duty or other motivation. However, many countries gradually moved knowledge and innovation into a government protected monopoly status. In the US, the Constitution grants the government power to enforce monopoly rights for innovators and the judicial system has upheld a strong IPR system. Knowledge as property was confirmed in the 1834 Supreme Court ruling *Wheaton v. Peters* when the Justices agreed that intellectual property rights are not "natural" rights that were passed down from before civilization, but were creations of civilization as rights of government legislation (Mossoff, 2007, p.6). The Court held to the idea that labor creates property in both real and intellectual arenas, "[t]hat every man is entitled to the fruits of his own labor must be admitted; but he can enjoy them only, except by statutory provision, under the rules of property, which regulate society, and which define the rights of things in general" (Mossoff, 2007, p.6). The Court continued to interpret the concept of patent rights as equivalent to real property throughout the 19^{th} century. In 1846, the court "instructed the jury that "[a]n inventor holds a property in his invention by as good a title as the farmer holds his farm and flock" (Mossoff, 2007, p.7).

As intellectual property rights were enforced by the courts, the *perception* of knowledge creation shifted away from a social community based process to a solitary individual process. The enforcement of strong IPRs has fragmented the social aspect of innovative knowledge into individual components – promoting the concept that inventors are individual lone geniuses rather than one component of a long incremental process. Freidrich Hayek noted in 1945 that knowledge cannot be concentrated in a single mind but rather is dispersed among many people (as cited in Cole & Lee, 2003). Even the most profoundly transformative innovations are based to some degree on existing knowledge and prior art. Thus, building on previous work, innovators sequentially developed new and better technology (Boyd & Richerson, 1985).

3.3 Devolution of Property Rights

Some groups have responded to the social and financial cost of private property by creating communities that reject private property and have returned to the practice of common property. One theory in real property rights may help explain this so called "devolution" of property rights based on transaction costs (Levmore, 2002). A toll road, for example, at one point may have a geographic monopoly which encourages private property; however, as competition builds other routes and more efficient transportation methods are developed, the upkeep of the toll road exceeds its income and it is therefore more advantageous for the private property owners to abandon the road and allow it to become common property with common upkeep (Levmore, 2002).

Historically, some communities have returned personal property rights back into common pool resources. These groups include religious and intellectual groups of the

19th and 20th centuries such as the Amish, Owenites, Fourierists, Shakers and "hippie" communities of the 1960s and 70s. Anthropologists have identified five periods of communitarian social experimentation in the United States referred to as "intentional" communities (Brown, 2002).

1) The Colonial Period (1620-1776) with the Amish, Moravian Brethren, and the Shakers;
2) The "Shaker Influx" Period (1790-1805), references the growth of Shaker communities and rise of other communitarian systems at the turn of the 19th century;
3) "Utopian Socialist" Period (1824-48) which included "Bible Socialist" experiments founded on Christian ideals and secular communitarian experiments;
4) "Anarchist Movement" at the turn of the 20th century; and
5) "Free-Thinking" movement of the 1960s and 70s (associated with the "Hippie" movement) which was based on a radical rethinking of prevailing social values.

Applying the theory of the devolution of real property rights to intellectual property, there is evidence that transaction costs have caused knowledge creation, in some cases, to move away from government enforced monopoly protection. There is evidence of historical common resource communities that cooperated to innovate without protection of monopoly exclusivity (Von Hippel, 2002). Additionally, during the last decades of the 20th century to the present, thousands of intentional communities have formed over the internet to develop innovation knowledge, most prevalently FOSS. I have identified this period of FOSS creation as a sixth period of intentional communities with common-pool resources. FOSS communities include geographically dispersed community members who typically do not maintain common real property but rather common-resource intellectual property. I refer to this period as the "Online Innovation Movement" and add it to the previous five eras of intentional communities as shown in Figure 3.1.

6) "Online Innovation Movement" includes geographically disperse contributors who create knowledge that is freely available to community members.

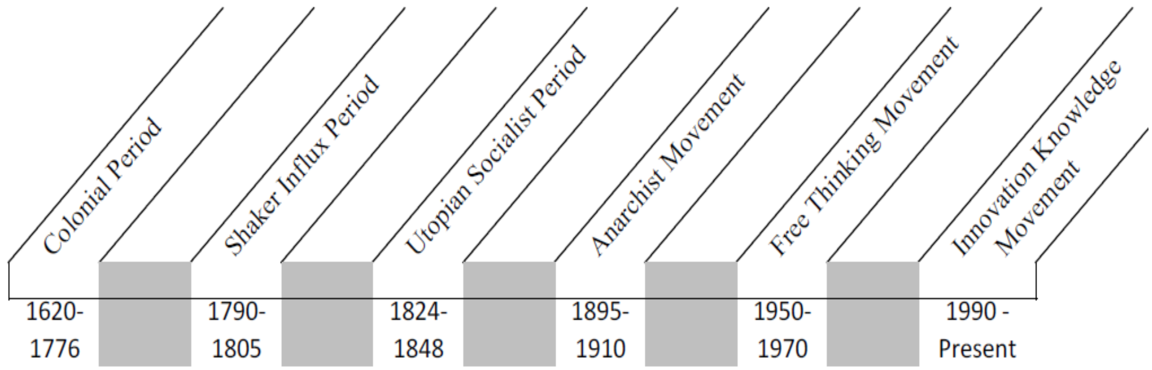

FIGURE 3.1 – Intentional Communities with Common-Resource Property Rights

The above timeline is based on the previously identified five periods of intentional communities (Brown, 2002) with updated information to include the "Online Innovation Movement." Online innovation communities are comparable to the previous five periods of intentional communities in that people combine efforts to achieve a common social agenda and to share common-pool resources. Online communities differ from their predecessor communities in that real property is not held in common but rather participants' intellectual property is contributed to the community and held in common. No physical location of the online community is required because the innovation knowledge is collected via the internet and only a portion of the participants' time and effort is contributed to the common cause of the community. Because real property is not held in common, a complete lifestyle focused on the intentional community is not required in these knowledge creation communities. Online communities narrow the focus of the community more specifically to the creation of common resource intellectual property.

In summary, strong property rights developed over time based on production efficiencies, available technology and types of property. Legal protection of private intellectual property rights grew out of real private property theories. IPRs follow a similar historical development to real private property with increased protection based on theories of production methods and innovation incentives.

Some have criticized strong real private property rights based on inequitable distribution of property. Based on economic and social concerns private property rights in some cases have devolved to common-property rights. Similarly, private intellectual property rights have devolved into common-pool intellectual property within some communities.

CHAPTER 4

COOPERATIVE INNOVATION: SOCIAL UTOPIAN CASE STUDY COMMUNITIES

> As to their cooperative mode of working and living, who can say that there is not in it the germ of a principle which will yet be needed to reform the evils of money-grabbing and monopoly? (Staff Correspondent, 1881, p. 5)

In ***Section 4.1*** of this chapter, I introduce 19th century US communitarian groups and identify three case study communities that also have record of communitarian innovation: Shakers, Mormons and Oneida Perfectionists. Each of these three case study communities were founded as religious communities during the Shaker Influx and Utopian Socialist periods (as discussed in ***Chapter 2***) and overlapped in time and geographic region during the 1800s in the Northeastern United States. Primary and secondary source records for each of these communities provide evidence of cooperative innovation outside the incentives created by patent monopolies. In ***Sections 4.2 – 4.4*** I provide an overview of each group's socioeconomic foundation and the communitarian innovation for each of the communities.

4.1 19th Century Communitarian Groups

A map of the world that does not include Utopia is not even worth glancing at for it leaves out the one country at which humanity is always landing. (Wilde, 1891, p. 16)

The burnt over district of upstate New York, so called because of the extreme religious upheaval fomented by numerous itinerant preachers, gave birth to several Bible Socialist communities. During this time, not only were communitarian groups formed by domestic idealists, but also many religious and economic refugees from Europe came to the United States anxious to put into practice the communitarian theories not allowed in their home countries. “No other period comes close to matching the record of the first half of the nineteenth century,” for the creation of communitarian experiments (Bestor 1953, p. 506).[4]

> America experienced an intense wave of social reform in the decades leading up to the Civil War. This wave broke in many directions: antislavery, temperance, Christian revivals, new religious sects, communal living, socialism, Fourierism, San Simonism, feminism. … [and] others branched off into experiments with new types of communities. What is noticeable is the role that formal organizations played in all these efforts. … [S]ome reformers… looked forward, and sought ways to reconcile market freedom with moral frameworks of order inherited from republicanism through “modern” methods, particularly methods of organization. Through organization, they did not reject the market, but rather sought to rationalize it. (Lipartito & Sicilia, eds., 2004, pp. 95 - 96)

Table 4.1 below is created from two contemporaneous publications of the 19th century: “American Communities: Brief Sketches of Economy, Zoar, Bethel, Aurora, Amana, Icaria, The Shakers, Oneida, Wallingford, and The Brotherhood of the New

[4] During the first half of the 19th century there is record of over 100 communitarian experiments in the United States. Some of these experiments took place in the frontier states of Indiana, Wisconsin, Missouri and Illinois; however, many more took root in the more established states of New York, Pennsylvania and Ohio, giving reason to question the theory that the prospect of the harsh frontier life motivated communitarian practices (Bestor, 1953).

TABLE 4.1 – 19th Century Communitarian Groups

Community Name	Location
Amana	*Homestead, Iowa*
Aurora	*Aurora, Oregon*
Bethel	*Bethel, Missouri*
Fountain Grove	*Santa Rosa, California*
Salem-on-Erie	*Brocton, New York*
Harmony	*Economy, Pennsylvania*
Icarian	*Corning, Iowa*
Oneida	*Oneida, New York*
Wallingford	*Wallingford, Connecticut*
Zoar	*Zoar, Ohio*
Alfred (Shaker)	*Alfred, Maine*
Canterbury (Shaker)	*Shaker Village, New Hampshi*
Enfield (Shaker)	*Enfield, New Hampshire*
Enfield (Shaker)	*Thompsonville, Connecticut*
Gloucester (Shaker)	*West Gloucester, Maine*
Groveland (Shaker)	*Sonyea, New York*
Hancock (Shaker)	*West Pittsfield, Mass.*
Harvard (Shaker)	*Ayer, Mass.*
Mt. Lebanon (Shaker)	*Mt. Lebanon, New York*
North Union (Shaker)	*Cleveland, Ohio*
Pleasant Hill (Shaker)	*Pleasant Hill, Kentucky*
Shirley (Shaker)	*Shirley Village, Mass.*
South Union (Shaker)	*South Union, Kentucky*
Union Village (Shaker)	*Lebanon, Ohio*
Watervliet (Shaker)	*Shakers, New York*
Watervliet (Shaker)	*Preston, Ohio*
Hopedale	*Millford, MA*
Owenites	*Harmony, Indiana*
Fourierists	*Brook Farm, NY and others*
Skeneateles Community	*Unknown*
Beizel's Community	*Unknown*
Snowberger Community	*Unknown*
Ebenezer Community	*Unknown*
Janson Community	*Unknown*

Life" (Hinds, 1878) and "The Oneida Community and American Socialism" (Estlake, 1900). This list provides representation of the diversity of communities and locations but is not exhaustive of the many communitarian projects implemented in the 19th century.

Although the 19th century was unprecedented for the number of geographic communitarian experiments that were initiated, most of these experiments did not last beyond a few years. These "utopian settlements above all else [were] attempts to change structures and thereby to change the conditions under which individuals act and live" (Cooper, 1987, p 2). The practice of common-pool resources attracted a large number of participants based on ideals of equitable distribution and social agendas; however, the organizational structure of these communities did not always lead to successful community building. (See *Appendix B* for a discussion on three short-lived 19th century communitarian groups.)

A serious concern for the success of these communities, as noted by John Stuart Mill, was the lack of incentive to work and especially the lack of incentive for the most qualified individual to undertake difficult leadership responsibilities. However, the influence of the *Second Great Awakening* on social reform in the 19th century provided significant member motivation and charismatic leadership to many of these communitarian groups. The evangelical movement of the early 1800s had a profound impact on communitarian experimentation. The founders of religious movements accepted the onus of community leadership along with the position of religious leadership as a call from God. Indeed, a religious tenet was a focus on salvation and millennial hope by preparing a better society of people (Cook, 1985). Charismatic religious leaders consolidated groups of likeminded believers into social and economic structures.

Charismatic religious leaders headed many of the most successful communities, including Father Rapp (Rappites), Joseph Smith (Mormons), John Humphrey Noyes (Oneida Perfectionists) and Ann Lees (Shakers).

Many of the religious communitarians adapted to harsh conditions and established new policies and locations when social and economic forces required. Some experiments, such as the Mormons in the Great Salt Lake Basin, deliberately established in areas considered so hostile that no other group would bother to challenge their religious, social or economic system. Others, to preserve economic solidarity and social isolation, settled in populated areas but maintained their own foreign language upon moving to America rather than learn English. Examples include the Rappites and Amana Colonists who kept their native language to isolate themselves from the surrounding world. These were attempts to preserve community organization and structure from the often hostile attacks of the outside world.

Furthermore, several communities created innovative knowledge and developed new technology used to ease their own labor or improve the community's financial status through commercial success. Based on the available record of innovation, three communities were chosen for use as case studies: the Shakers, Mormons and Oneida Perfectionists.

4.2 Shakers

A group of Quakers in Manchester England accepted Ann Lees (shortened to Lee after immigrating to the US) as the "Mother in Christ." Lee and eight followers left England in 1774 for New York and in 1780 the Shakers succeeded in proselytizing several new members to join their small group (Blinn, 1884). Late in the 18th century, Shakers began the move to communitarian principles and shared property. One Shaker Elder wrote, “The time is come to give up yourselves and your all to God – your substance, your temporal property -- to possess as though you possessed not” (Cosgel, Miceli, & Murray, 1997, p 132). In 1795, the Shakers’ first community covenant asked members to give all their worldly property to the “Joint interest of the Church.” Based on the communitarian principles, all members would have equal rights and there would be no differences based on what any individual brought to the community (Cosgel, Miceli and Murray, 1997, p 132). By the early 19th century when Father Joseph Meacham and Mother Lucy Wright became co-leaders the Shakers were practicing the communitarian ideal of shared property (Alexander & Keep, 1995).

The change to communitarian principles and common property was successful for the Shakers and by 1888 (at the publication of the autobiography of Shaker Elder Frederick Evans) the Shakers had grown significantly and amassed a fair amount of wealth. At that time, there were approximately 70 small Shaker communities with several (three to eight communities) located closely together with adjoining land to form a Society. There were 17 Societies of US Shakers comprised of “between four and five thousand individuals” located in New York, Massachusetts, Connecticut, New Hampshire, Maine, Ohio, and Kentucky (Evans, 1888, p 260).

As an offshoot of the Society of Friends (Quakers), the Shakers believed in many of the same concepts such as “the peace principles, the no poverty principle, the plainness of dress and language” but also added celibacy as a means to a higher spiritual perfection (Evans 1888, p. 259). The Shakers did not expect every group member to practice celibacy but only those of a higher spiritual nature. Celibacy was considered an important step to spiritual perfection and was also considered a practical measure to curb global overpopulation (Evans 1888, p 215).

A "central idea" of the Shaker religion was the "duality" of the "Deific Essence" defined as a male and female god (Evans, 1888). Based on this doctrine, within Shaker communities women had equal religious, economic, social influence and power as men. The Shaker community was one "where woman has absolutely the same freedom and power as man in every respect" (Evans 1888, p. 268). Communities were organized into groups referred to as "families" with leadership responsibilities shared between the male and female members. Families varied in size and economic circumstances depending on geographic location, business ventures and abilities (Cooper, 1987, p. 4).

> …each of these communities was further divided into semi-autonomous subdivisions called Families. Each Shaker community consisted of two to six Families, units ranging in size from about ten to more than one hundred persons. … Those living in a Family worked and consumed together, sharing income and assets. (Cosgel, Miceli, & Murray, 1997 p. 133)

Shakers strongly believed in effective use of time and implemented labor saving devices of their own design and others. During the 1800s, Shakers were widely considered as savvy inventors of technology which they used to improve efficiency and production of quality goods. Shaker Elisha Myrik (as cited in Becksvoort & Sheldon, 2000, p. 11) explains the Shaker attitude toward innovation as "every improvement relieving human toil or facilitating labor [gives] more time and opportunity for moral, mechanical, scientific and intellectual improvement and the cultivation of the finer and higher qualities of the human mind." Based on historical records including newspaper articles, journals, and interviews numerous inventions were attributed to the Shakers.

The New York Daily Tribune reported in 1881 (Staff Correspondent) that Shakers invented the machine manufacture of "wire cards" for wool and flax.

Additionally, *The Shaker,* a community produced newsletter, reported in 1877 (as cited in Buckingham, 1877) that Shakers invented the:

- manufacture of corn-brooms and improved the process for creating broom handles;
- planing-machine;
- self-acting cheese press;
- Clothes-pins;
- Shaker washing machine;
- Mowers and reapers;
- machinery for twisting whip handles;
- pea-sheller;
- printing presses used by the Shakers of Lebanon and Watervliet for printing seed bags and herb papers; and
- machine for filling seed-bags,

The Shaker (as cited in Buckingham, 1877, p. 59) also reported that "the first circular saw ever made was invented by the Lebanon Shakers, and may be seen to-day in the "State Geological Department," at Albany, N. Y., where it was deposited by Bro. G. M. Wickersham." In an interview published in The Boston Sunday Globe (as cited in Rothschild, 1981, p 314-15), Eliza Babbit (a Shaker Eldress) remembers her cousin Tabitha Babbit as the innovator of the circular saw in 1810:

> One day while watching the men sawing wood, she [Tabitha Babbit] noted that one half the motion was lost and she conceived the idea of the circular saw. She made a tin disk, and notching it around the edge, slipped it on the spindle of her spinning wheel, tried it on a piece of a shingle and found that her idea was a practical one, and from this crude beginning came the circular saw of today. Sister Tabitha's first saw was made in sections and fastened to a board. A Lebanon Shaker later conceived the idea of making the saw out of a single piece of metal.

The Globe Republic of Springfield, Ohio reported in 1886 that the Shakers invented cut nails. A 1904 study on Shakers explained how the cut nails were conceived and developed as "Sister Tabitha" watched the men manufacture nails she realized that nails could be cut from a sheet of iron; the idea was "worked out to a success" to produce cut nails (as cited in Carson, Lanier, & Carson, 2000).

The St. Paul Daily Globe (1895, n.a.) printed that the Shakers invented a cure for dyspepsia and also reported in 1905 (n.a.) that the Shakers were credited with inventing:

- A type of alloy metal;
- Rotary harrow;
- Modern harness; and the
- Stove lid lifter

Other inventions attributed to the Shakers by modern researchers, among many others, include "hair caps" for balding Shaker men; a device for paring, coring and quartering apples; revolving oven; machines for box cutting and basketry; and, a dough-kneading machine (Carson, Lanier, & Carson, 2000).

The list of inventions is extensive because Shakers were motivated to improve their conditions. Father Meacham stated, "We have the right to improve the inventions of man, so far as is useful and necessary, but not to vain glory or anything superfluous" (as cited in Andrews & Andrews, 1974, p. 152).

Based on the available information, there is evidence that Shakers practiced communitarian innovation among those who worked on the circular saw and the cut nails. Also, different Shaker communities cooperated together to innovate. The Lebanon community of Shakers invented the printing presses for printing seed bags and herb papers and the Watervliet Shaker community improved the process (Buckingham, 1877).

4.3 Mormons

Founded in New York by Joseph Smith in 1830, the Mormon religion, like many others at that time, was a response to the millennial hope of a perfect society. Fleeing persecution, Mormons established successive communities in New York, Ohio, Missouri, Illinois/Iowa, and finally Utah. The Mormons practiced formal communitarian principles during two of those periods: one in Missouri and the other in Utah (Gardner, 1922).

The first period of Mormon communitarian practice came about after Mormon missionaries converted an Ohio Campbellite preacher, Sydney Rigdon, and his congregation. Rigdon had formed a Utopian Socialist experiment called "The Family" based on Robert Owen's Indiana experiment (Cook, 1985).[5] After meeting Rigdon, Joseph Smith introduced communitarianism to the Mormon membership with the revelation of the "Law of Consecration" (Cook, 1985). The Law explained that all property rightfully belonged to God and individuals were only "stewards." Soon after Smith announced the law some members implement the concepts by assigning all of their property to the community and received back only according to their needs and capabilities. Members were expected to sign deeds of gift and contract with the bishop (a community leader responsible for members' welfare) who would in turn guarantee provision for the steward and his family in case of infirmity or old age (Arrington, 1976).

Mormons who "consecrated" their property to the group would then receive back only the amount needed for their family. Any excess output at the end of the year would

---

[5] See *Appendix A* for a discussion on Owen's Indiana experiment.

again be consecrated to the group.[6] The idea was to place all families on equal psychological and physiological footing -- "considering the family obligations, circumstances, needs and 'just wants'" (Arrington, 1976, p. 15). In this way each person maintained responsibilities of ownership but gave all excess to the group. As stewards of property, individuals were responsible for what they did with their allocation. Goods were provided free of charge from the storehouse to members in need and any excess was sold outside of the community for profit (Cook, 1985).[7] Even if distribution of resources was not exactly equal based on quantity, it was intended to be equal based on need (Romney, 1966). Similar to the other case study communities, Mormon leaders implemented a nontraditional family structure. Several male leaders practiced polygamy and married women who were otherwise unmarried. Although strongly rejected by outsiders, polygamy provided a means to include women in the socioeconomic structure created by the Law of Consecration.

---

[6] Another problem considered by Smith was that consecrating the surplus back to the community could threaten the incentive for profit. Nevertheless, he felt that the annual negotiation with the bishop for the 'needs' of each family could indeed influence the profit motive of the stewards and raise the living standard of all in the community (Cook, 1985).

[7] Section 42, verses 32-33, of The Doctrine and Covenants (Smith, 1981, p. 72), a Mormon scripture, explains the process of consecration and the stewards' responsibilities. Also, the scripture discusses the use of excess property.

> 32) And it shall come to pass, that after they are laid before the bishop of my church, and after that he has received these testimonies concerning the consecration of the properties of my church, that they cannot be taken from the church, agreeable to my commandments, every man shall be made accountable unto me, a steward over his own property, or that which he has received by consecration, as much as is sufficient for himself and family.
>
> 33) And again, if there shall be properties in the hands of the church, or any individuals of it, more than is necessary for their support after this first consecration, which is a residue to be consecrated unto the bishop, it shall be kept to administer to those who have not, from time to time, that every man who has need may be amply supplied and receive according to his wants.

Mormons implemented varying degrees of the Law of Consecration once they were forced out of Missouri and removed to Illinois, Nebraska and Iowa. Although the practice of the law ultimately failed due to practical and legal problems, it remained an ideal to which each member was to aspire (Arrington, 1971). The practice of tithing, payment of "one-tenth of all their interest annually" (Smith, 1981, p. 238), was introduced to prepare community members for the complete practice of the Law of Consecration at a later time. The Mormon scripture explains:

> The Lord had previously given to the Church the law of consecration and stewardship of property, which members (chiefly the leading elders) entered into by a covenant that was to be everlasting. Because of failure on the part of many to abide by this covenant, the Lord withdrew it for a time and gave instead the law of tithing to the whole Church. (Smith, 1981, p. 238)

Getting to the Great Salt Lake Basin was a life threatening matter which required extensive cooperation among members. The attitude of cooperation included an example of cooperative innovation that occurred during the exodus from Nauvoo to the Rocky Mountains. The Mormons left their settlement, Nauvoo, founded on the East shore of the Mississippi in Southern Illinois to make their way toward the Rocky Mountains. The first group leaving for the Rocky Mountains created daily travel logs in order to facilitate travel by later groups. William Clayton, one of several mileage log keepers in the group, counted the revolutions of a wagon wheel and kept records of each revolution in order to calculate the distance travelled (Wright 1997-98). At the end of each day there were widely divergent estimates from those keeping track of the distance travelled. This variance motivated Clayton to initiate an innovation that would more accurately measure the distance each day.

The personal journals of William Clayton, Orson Pratt and Appleton Harmon provide record of cooperation among the members of the wagon train to create a device that measured the distance traveled during each day and from landmark to landmark (Wright 1997-98).[8] Because numerous people were involved in the creation of the odometer, there is debate among a few scholars today as to who should actually receive credit as "inventor" of the Mormon odometer or the "roadometer." Based on primary source journals and several secondhand accounts I have reconstructed some of the events surrounding the cooperative invention of the Mormon odometer and found that no single person can be credited with devising the entire invention but rather several individuals collaborated throughout each stage of invention: concept, design, manufacture, reworking and refining.

During the idea and design stage, Clayton (1921) recorded in his journal on Monday April 19th that he had "advanced" the idea of an odometer to several other men in the party who seemed to agree that idea had merit. On April 22nd, Clayton (1921) further discussed the idea of an odometer and described the concept of the machine he had in mind:

> I again introduced the subject of fixing machinery to a wagon wheel to tell the distance we travel, describing the machinery and the time it would take to make it &c several caught the idea and feel confident of its success.

There was no further report of progress on an odometer until May 8th when Clayton (1921) reported in his journal that he is more certain that the mileage estimates

[8] Although available for purchase in England and elsewhere, the Mormons failed to bring an odometer with them on the trail westward. However they did have other measuring and scientific tools including: "one circle of reflection, two sextants, one quadrant, two artificial horizons, one large refracting telescope, several smaller ones, two barometers, several thermometers, besides nautical almanacks [sic], books, maps, &c. (Wright, 1997-98, page 84)

of others were too high, increasing the need for a more precise measure obtained from an odometer:

> This morning I determined to take pains, to know for a certainty how far we travel to day. Accordingly I measured the circumference of the nigh hind wheel of one of brother Kimballs wagons being the one I sleep in, in charge of Philo Johnson. I found the wheel exactly 14 feet 8 inches, in circumference, not varying one eighth of an inch. I then calculated how many revolutions it would require for 1 mile and found it precisely 360 not varying one fraction which somewhat astonished me. I have counted the whole revolutions during the days travel and I find it to be a little over 11¼ miles. (20 revolutions over.) … Some have past the days travel at 13 and some 14 miles, which serves to convince more strongly that the distances are overrated. I have repeatedly suggested a plan of fixing machinery to a wagon wheel to tell the exact distance we travel in a day, and many begin to be sanguine for carrying it into effect, and I hope it will be done.

With wagon wheel measurements and calculations of revolutions required to measure a mile, Clayton developed an initial design for the measuring device. Two days later, on May 10, 1847, Orson Pratt wrote in his journal that Brigham Young wanted Pratt to design a device to record more accurate mileage (as cited in Wright 1997-98). There is no record of Clayton's specifications for his odometer design; however, Pratt did provide in his journal a detailed specification of an odometer design. The outcome of the final instrument was significantly different than that proposed by Pratt and was very likely modified by a team working on the creation of the device as the original design proved to be impractical (Wright 1997-98).

At this stage of the innovation Appleton Harmon, a skilled wood worker, became involved with building the odometer from wood and likely provided input regarding the practical implementation of the original design. Upon completion of the wooden odometer, Amasa Lyman wrote in his journal that the communitarian innovation included an added wheel to the odometer to count ten miles (as cited in Wright, 1997-98).

Another design improvement was necessary once the instrument was exposed to rain which caused the wood to expand and resulted in cogs that would not work properly and break. The problem was solved by creating a wooden housing to protect the cogs from the weather. Later, Clayton (1921) wrote in his journal that the roadometer did not work properly on steep descents but that the next day he got the roadometer fixed during a breakfast break. Once arriving in the Salt Lake valley, the Mormons improved and repaired the roadometer in preparation for a group of men who were to return and help others make their way to the valley. William King manufactured a new machine with an additional improvement of measuring one thousand miles (Wright 1997-98). Records also show that along with King others were involved in this stage of improving the instrument including Clayton and Orson Whitney (Egan, 1917).

There is no evidence that any of the roadometer innovations or improvements were patented but a guidebook titled *"The Latter-day Saints' emigrants' guide"* was published based on the mileage records obtained from the improved roadometer (Crawley, 2005).[9]

4.4 Oneida Perfectionists

Similar to the many other utopian experiments of the mid-19th century, the Oneida Perfectionists established a community of common property and equal work opportunities. As with the Mormon community, some of its social practices implemented

[9] The complete title is: The Latter-day Saints' emigrants' guide: being a table of distances, showing all the springs, creeks, rivers, hills, mountains, camping places, and all other notable places, from Council Bluffs, to the Valley of the Great Salt Lake. Also, the latitudes, longitudes and altitudes of the prominent points on the route. Together with remarks on the nature of the land, timber, grass, &c. The whole route having been carefully measured by a roadometer, and the distance from point to point, in English miles, accurately shown. By W. Clayton . *St. Louis : Mo. Republican Steam Power Press-Chambers & Knapp. 1848.*

in later years were highly controversial and ultimately contributed to the dissolution of the community in 1881.

As a student at Yale Divinity School in 1834, John Humphrey Noyes declared over the pulpit that he had no sin. His perception of sin was much different than the typical Congregational Church view at Divinity School and Noyes was expelled due to his unorthodox teachings (Oneida Association, 1849, p.3).

By 1848, Noyes and a small number of followers (several family members and a few other believers) established a communitarian society in Oneida, New York. In its First Annual Report (Oneida Association, 1849) the community reported businesses of saw mills and lumber operations to finance their association but did not expect these operations "or any other labors to meet the expenses of the year, but looked mainly to the capital coming in with its members, and the subsidies of its friends" (Oneida Association, 1849, p. 6). Comparable to the many other struggling contemporary communitarian groups, Oneida Perfectionists' ability to become self-sustaining depended on the arrival of new members with assets which they would commit to the society. Unlike most contemporary groups of the time, Oneida not only became self-sufficient but also financially successful.

Even though the Community optimistically reported in 1849 (Oneida Association) that it would become self-supporting by the following year, it was another seven years before its operations in lumber, fruit bottling, silk machinery, and especially animal traps provided sufficiently for its members (Oneida Community, 1867).[10] For the Oneida

[10] The Oneida Community Handbook published in 1867 ("Financial Experiences and Conditions", para. 1) stated:

Perfectionists, the concept of communitarian property included sharing food and living quarters with each other in a large community family. For Noyes, a logical outcome of the concept of shared property was to establish the doctrine of "complex marriage" where every man and woman in the community was shared with each other and only discouraged "exclusive relationships" between one man and one woman (Oneida Association, 1849).

Oneida Perfectionists gathered into groups and practiced what was referred to as "Mutual Criticism". This practice provided a forum to group members to air grievances and give feedback to other group members regarding their behavior and performance in work, religious and social interactions (Oneida Community, 1876). An alignment of several important factors brought about the success of animal trap manufacturing for Oneida. First, the move to Oneida NY brought the group of Perfectionists within a few miles of Samuel Newhouse's farm. At that time, Samuel Newhouse had been making and improving traps since his teenage years and established a local reputation as a quality trap maker *(Noyes, J. H., Ed. 1865).*

In 1835 Newhouse married one of the members of the Oneida Community and converted to the Perfectionist views *(Noyes, J. H., Ed. 1865).* He became a resident and member of the Oneida community and for the first several years as Community member,

---

"… Oneida was not, for the first eight years of its existence, self supporting, owing to many causes, such as the lack of well-organized businesses, the printing of a free paper, extortions of seceders, outside enemies, etc.; but since 1857 there has been a gradual improvement in its circumstances. … Community members are employed in the different mechanical branches carried on. Beside the ordinary businesses of carpentry, blacksmithing, shoemaking, tailoring, dentistry, etc., there is a large satchel-factory on the site of the old Indian saw-mill. At another location there is an iron foundry and saw-mill. At another there are large machine-shops and extensive trap-works, where are annually made many thousands of Newhouse's celebrated steel traps... The earnings of the Community for the last ten years have averaged $18,000 a year, clear of expenses.

Newhouse was forbidden to make traps, possibly to prove his loyalty to the Association and belief in its ideals or possibly because trapping did not coincide with the community belief in nonviolence. However, when a letter arrived for Newhouse requesting a production order of 500 traps, Noyes recognized the potential for financial gain and decided to begin the business of trap-making (Newhouse,1865).

Beginning in 1855, the Community began manufacturing traps for commercial purposes and within a short period of time the Newhouse trap provided much needed financial success to the Community. Along with the good fortune of gaining a member with trap making skills, the rise in fur prices and the Westward expansion in the US greatly increased the demand for traps. Noyes was prescient enough to realize that the success of his community depended on a strong business venture and focused efforts on improving the manufacturing process and the performance of the traps (Newhouse, 1865).

Through the cooperation of several within the Community, “mechanical appliances” were invented to more efficiently manufacture the traps and increase production. Members of the group invented machines for “cutting or stamping the various parts, which quickly do the hand-work of ten or fifteen men.” (Oneida Community, 1867). Several unnamed “young men” along with Newhouse and Noyes invented machinery that took the production of traps from a handmade process to a machine driven process and dramatically increased the output of traps (Newhouse, 1865).

> Among them were several young men, who, together with Messrs. Noyes and Newhouse exercised their inventive powers in devising mechanical appliances to take the place of hand-labor in fashioning the different parts of the trap. A power-punch was the first machine introduced, then a rolling apparatus for swaging the jaws. (Newhouse, 1865, p. 117)

In addition to making the manufacture of traps more efficient through mechanization, the Oneida Community also collaboratively improved the traps. The type of materials used and the mechanism of the spring component were improved upon by the Community efforts.

> Soon it was found that malleable cast-iron could be used as a substitute for wrought-iron, in several parts of the traps. … One by one the difficulties in the way were overcome by the ingenuity of our machinists, until at length the whole process of forming the spring, from its condition as a steel bar to that of the bent, bowed, tempered and elastic article, ready for use, is now executed by machinery almost without the blow of a hammer. (Newhouse, 1865, p. 117)

Through cooperative innovation the production and function of the animal traps were improved and commercialized to become one of the most successful traps of the time. The Oneida traps gained national and international reputation and, in a short time, demand exceeded the ability of the Community to supply the traps which drove the community to increase mechanization of the trap production. In 1856, the community moved production to a bigger space with more efficient production machinery and in 1857 the community produced 26,000 traps, which was more than the total combined for the first 5 years (Wonderley, n.d.). Although there is no clear record that the Oneida Perfectionists rejected patent protection on religious or moral principles, a review of the US Patent and Trademark Office records shows no filing for a patent by Newhouse or Noyes for the trap innovations. Additionally, there is evidence that the Oneida Perfectionists rejected IP projection based on competitors that pirated the name and design of the trap.

> The reputation which has come to [Newhouse] on this basis, has made it seem desirable to other manufacturers, in some instances, to pirate his name to give currency to their imitations of the “Newhouse Traps.” (Newhouse, 1865)

Due to outside pressures against Complex Marriage and internal strife, in 1880 the community disassembled as a communitarian group and restructured as a stock company with five businesses – “the making of spool silk, traps, chains, canned fruit, and silverware” (Lowenthal, 1927, p. 114).

In summary, although there were many communitarian experiments in the 1800s, I have chosen three for case study analysis based on available records of innovation and successful communitarian socioeconomic structure. I have reviewed the Shaker, Mormon and Oneida Perfectionist social and economic organization along with the communitarian innovations in each of the communities.

CHAPTER 5

COOPERATIVE INNOVATION: FOSS CASE STUDY COMMUNITIES

In the previous chapter, I selected three historical communitarian groups as case studies for communitarian innovation. In this chapter, I look at FOSS communities that promote *intellectual* common-pool resources. ***Section 5.1*** reviews the origins of FOSS culture beginning in the mid-20th century and discuss the impact of strengthening IPRs on the development of FOSS. Of the thousands of FOSS communities established in response to the privatization of software innovation, I identify three communities for case study analysis, Linux, Apache and Firefox, which have created successful community structures and produced innovation that is widely implemented. ***Sections 5.2 – 5.4*** provide an overview of each FOSS case study community and briefly discuss each community's invention.

5.1 Software Intellectual Property Rights

During the early history of computers, from WWII to 1975 (when IBM separated its operating system software from its hardware), cooperation among innovators of software was expected and considered common practice. Developers continuously shared modifications with each other and code changes were made available to anyone who cared to see them. At the 1965 Fall Joint Computer Conference, well before open source software became a topic of discussion, a technical paper presentation introduced the Multics System software (Corbato & Vyssotsky, 1965, The Multics System). This presentation provides insight into the foundations of software creation and the then current FOSS psychology. The paper and presentation explained that the Multics System should be freely available in order to "withstand public scrutiny" and to "make the inner operating system as lucid as possible" for current and future users (Corbato & Vyssotsky, 1965). Code that was accessible to everyone increased the potential that the software could become even better.

> The system will evolve under the influence of the users and their activities for a long time and in directions which are hard to predict at this time... It is expected that most of the system additions will come from the users themselves and the system will eventually become the repository of the procedure and data knowledge of the community. (Corbato & Vyssotsky, 1965, Conclusions)

As computers became faster, smaller and more powerful, an important part of the software developer and academic culture in the 1960s and 70s was the persistent free sharing of computer code. The source code was made freely available with the understanding that it would be subjected to further changes and modifications which, in turn, would be made available to all others who may want to use it as is, or modify it further.

Unix, a timesharing software system, is an example of the openness in which software was developed at that time. Bell Laboratories developed Unix and provided the software to universities and research labs at very low cost and allowed them open access to the code which encouraged users to fix bugs and share enhancements to the software. UC Berkeley developed its own versions of Unix under the name Berkeley Software

Distributions (BSD) and added network capabilities and other features (UNIX Operating System, 2003).

> The openness of the Unix system, together with its popularity in academic circles, has always encouraged its users to fix bugs and to add new tools freely in the spirit of mutual cooperation. Important and useful utilities were frequently replaced by more sophisticated and extended versions. (UNIX Operating System, 2003, Evaluation)

During this same timeframe, the US military's Advanced Research Projects Agency (ARPA) initiated a system to network long distance computers. Its growth and evolution was motivated by users of the system who shared ideas resulting in the ARPAnet, the precursor to the internet. "Request for Comments" (RFCs) became standard solicitations for ARPAnet contributors to review each other's work and collaboratively build several standard operating procedures of the internet such as, Transmission Control Protocol (TCP), IP (Internet Protocol), and Simple Mail Transfer Protocol (SMTP) (Taylor, 1996).

Despite this foundation of freely shared software code, in the 1970s and 1980s many software companies began publishing proprietary software which hid code from users and developers and prohibited modifications or improvements. Even Unix, which started as an open code system, ultimately limited the accessibility of its code and made it unavailable for changes or the ability to share the modifications with other developers and users (Wheeler, 2007).[11]

---

[11] At about this same time, in the late 1970s a Stanford math professor and computer enthusiast, Donald Knuth, was writing a math book and was interested in finding an appropriate digital font that could handle mathematical and scientific equations. Over a course of 10 years he researched and wrote the code to a font, TEX, which has been used widely by commercial, academic and private entities. Knuth wanted a system that could be changed by others to meet their own needs and would be widely used in the scientific publishing industry. The TEX code has been integrated into several proprietary products. Although not originally organized as cooperative innovation, the process of developing the source code came about through input from several sources which Knuth implemented into the software. The source code is freely

The incentive to keep source code restricted through proprietary IP increased as the courts increased IPR protection. Initially, copyrights were used to enforce software intellectual property rights and any modification to proprietary source code was restricted through copyright law (Gay, 2002). Any written work is protected by copyright law and copyright law is less restrictive than patent law in terms of obtaining IP protection. However, copyright legal protection covers only the manner of expression and not the ideas or innovation. Alternatively, patent protection covers the manner and method of the invention and restricts use by would be competitors thus providing the potential of significant economic profits. Patent protection provides the patent owner the ability to prevent others from "making, using or selling" the patented invention compared to copyrights that only prevent copying of an expression of an idea. Copyright protection does not prevent the invention of other software based on the same idea (Tysver, 1996-2008, II.A).

The U.S. courts gradually shifted their interpretation on the validity and legality of software patents. In the 1960s the USPTO held that computer programs were "mental steps" and not patentable and created specific guidelines formalizing its position on software patents which was frequently challenged in court. One such challenge, *Gottschalk v. Benson* (1972), resulted in a decision by the Court of Customs and Patent Appeals (CCPA) which stated that a software program effectively turns the computer into a "new machine" and therefore is patentable. However, the Supreme Court disagreed with the CCPA and denied patentability. The Supreme Court decision was based on the

---

available and improved versions of the software have evolved into several versions including (La)TEX which is organized as a FOSS project based on large-scale collaborative innovation (Guadeul, 2007).

concern that mathematics is an abstract idea and, therefore, not patentable because the software algorithm used math to convert binary-coded decimal numbers to true binary numbers. The 1978 Supreme Court decision in *Parker v. Flook* confirmed that algorithms were not patentable even with an additional step beyond the mathematical calculation (Tysver, 1996-2008, "History of Software Patents").

In 1981, however, the US Supreme Court decided *Diamond v. Diehr* in favor of software patentability and forced the USPTO to grant a patent on software. The invention was a software code that controlled the heating and curing of rubber and also included additional steps on rubber processing. The Supreme Court ruled that the invention was more than a mathematical algorithm and was actually a "process" for manufacturing rubber. The Court stated that the algorithm (the Arrhenius equation) did not preempt other uses for the equation because the claimed use was only for "a process for curing rubber" (Tysver, 1996-2008, II.A). The Court stated:

> [The inventors] do not seek to patent a mathematical formula. Instead, they seek patent protection for a process of curing synthetic rubber. Their process admittedly employs a well-known mathematical equation, but they do not seek to pre-empt the use of that equation. Rather, they seek only to foreclose from others the use of that equation in conjunction with all of the other steps in their claimed process. (Tysver, 1996-2008, II.A)

In 1998, further legal clarification and strengthening of software patentability came in the Court decision *State Street & Trust v. Signature Financial Group*. Signature Financial had obtained a patent on software which computed mutual fund returns and distributed the percent of ownership to a variety of proprietary portfolios. The Court upheld the patentability of the business method and solidified the ability to patent software (Tysver, 1996-2008, II.A). In late 2008 many hoped for a reversal on software patentability when the U.S. Federal Circuit Court decided "*In re Bilski*." However, the court decision only set forth requirements for determining patentability: "(1) it is tied to a particular machine or apparatus, or (2) it transforms a particular article into a different state or thing" (Tysver, (1996-2008), II.A).

Not everyone in the software development community was happy with the closing of software code and strengthening of software IPRs. Richard Stallman, a researcher at MIT's Artificial Intelligence Lab, decided to leave his position rather than become a part of the proprietary software system and refused to sign nondisclosure employment documents. Stallman left MIT to create free software in 1983 as a protest to the closing of software code among fellow developers (Gay, 2002, p. 19). Stallman, considered by many as the author of the FOSS movement, wrote the free software manifesto 1983 to explain and clarify his position on the importance of freely accessible software code. His goal was to create code that was freely available and open to changes in order to counter the closed proprietary software. In 1984, he initiated the GNU ("Gnu Not Unix") project. The project created many software tools through collaborative efforts and grew as the internet allowed more access to users and contributors (Gay, 2002). In 1985 Stallman initiated the Free Software Foundation (FSF) and, in order to further promote the concept of free software among developers and to keep the software code freely available, he created the GNU General Public License (GPL) which is widely used by many other FOSS projects (Wheeler, 2007). This license included in a "viral" term that required all changes to also remain freely accessible.

> GNU is not in the public domain. Everyone will be permitted to modify and redistribute GNU, but no distributor will be allowed to restrict its further redistribution. That is to say, proprietary modifications will not be allowed. I want to make sure that all versions of GNU remain free. (Gay, 2002, p. 2)

During the 1990s and into the 21st century many more “free” software projects were developed without monopoly incentives. One of the best known and most widely used is Linux which began in 1991 when Linus Torvalds, a university student in Finland, posted the beginning of the kernel to a Unix based system on the internet inviting others to contribute and make comments.

The term originally applied to these projects was “free software;” however, some felt that using the word “free” implied that there was no cost to obtain the software. Contrary to that misperception, free software did not mean that there was no cost but rather that the code was freely accessible to users and developers and that modifications could be freely made and shared. Free did not mean non-commercial but rather free to use the program as best suits the user needs and share the improvements with others as desired (Wheeler, 2007). Some leaders of the cooperative software community were concerned regarding confusion surrounding the term “free” and in 1997 they coined the term “open source” to express the open nature of the code. Not everyone, however, has adopted the term and therefore software with open code is often referred to as “free and open source software” or FOSS.[12]

In the early stages of FOSS development, some questioned whether a free software program could compete against proprietary software in terms of quality and technical support. One of the advantages of the FOSS organizational structure is that every user has access to the source code providing the opportunity for each user to find and repair defects (“bugs”) in the code. Because FOSS code is easily accessed by

[12] Another abbreviation commonly used is OSS/FS. “Libre” is a term sometimes used in the community to specify software with freely visible code but that is not to be modified or shared with others. As a result sometimes the term free/libre and open-source software or FLOSS (or F/LOSS) is used.

anyone, finding bugs and defects can be quicker than with comparable proprietary software. Additionally, quality of the code is increased due to the many contributors who review and fix it.

Within the past two decades, thousands of FOSS communities have formed online to innovate cooperatively based on incentives other than government protected monopoly. SourceForge.com – a major internet site for FOSS community creation – reported that in 2011 over 2.7 million developers and over 260,000 FOSS projects (Sourceforge, 2011, About, para. 2). Some of these communities attract many members and others are unable to attract sufficient members to complete the cooperative innovation project. Based on the number of downloads, the most popular FOSS project on Sourceforge is eMule which has been downloaded over 500 million times. Some of the other popular projects registered with Sourceforge (2011, top all time) are shown in Table 5.1.

I have chosen three FOSS projects for my case study analysis: Linux, Apache and Mozilla Firefox (each of which have their own development site and are not registered with Sourceforge). Although there are thousands of FOSS communities, I have selected these three based on the success of each community and its innovations, longevity and available information. For the remainder of this chapter, I provide background information on each of the three FOSS case study communities and create a foundation for analyzing the organizational attributes of successful cooperative innovation communities.

TABLE 5.1 – Sourceforge Top Software Downloads

Project Name	Downloads
eMule	569,340,646
Azureus / Vuze	515,256,618
VLC media player	341,641,184
Ares Galaxy	300,271,005
Smart package	184,141,774
7-Zip	142,816,233
FileZilla	126,324,459
MinGW	108,623,884
PortableApps.com	102,309,644
GTK+ and GIMP	93,726,452
Audacity	76,311,801
AutoAP	62,108,501
DC++	59,727,759
VirtualDub	57,383,014
PDFCreator	56,038,998
16 Shareaza	55,674,052
BitTorrent	52,059,123
Pidgin	47,195,619
WinSCP	43,778,859
CDex	43,222,871
aMSN	41,047,883
XAMPP	35,520,351
guliverkli	34,634,730
eMule Plus	31,634,854
TortoiseSVN	31,333,805

5.2 Linux

As discussed above, Stallman began the FOSS movement with his Manifesto and GNU software in the early 1980s; however, at that time there was no freely available operating system on which to use the GNU tools. August 25, 1991 Linus Torvalds sent a post to the MINIX (a proprietary operating system) online newsgroup stating:

> Hello everybody out there using minix [sic] – I'm doing a (free) operating system (just a hobby, won't be big and professional like gnu) for 386(486) AT clones. This has been brewing since april [sic], and is starting to get ready. I'd like any feedback on things people like/dislike in minix, as my OS resembles it somewhat (same physical layout of the file-system (due to practical reasons) among other things). (Hasan, "New Baby", 2005, para. 6)

A few weeks later, in mid-September, Linux version .01 was released on the internet. Many code writers downloaded and tested the software returning their findings to Torvalds who on October 2nd of that year released version .02 of Linux with a post on the Minix newsgroup stating where the source code could be found on the internet and provided the full kernel without any proprietary code. Two months later, in December, Linux contributors had improved the code sufficiently to release version 0.10 (Hasan, 2005).

The Linux operating system was powered by the various programs developed in the GNU project and was itself licensed under the GNU General Public License (GPL). By 1996 Los Alamos National Laboratory chose Linux to power a super computer comprised of 68 connected PCs. The cost was one-tenth what it would have been with proprietary software and the machine was able to function at 19 billion calculations per second in a very stable environment. By 2005, four of the world's five fastest super computers were powered by Linux as their operating system (Hasan, 2005).

> Linux is a well-known and highly successful example of freely-available code that has brought the concept of FOSS to the attention of academics and theorists. Linux – based on the commercially available Unix server – provides software that is free of charge and that can be changed or modified to meet the needs of the user. (About Linux Foundation, 2009)

In addition to the high perceived quality of Linux, cost savings is an important reason that many implement the software. A survey found that the major reason (77%) for companies implementing Linux is the low cost. Nearly as many (73%) implemented Linux software in response to security issues. A majority of Linux users (74%) found the software to be "secure or very secure" while significantly fewer users (38%) found Microsoft's proprietary server to be "secure or very secure" (Wheeler, 2007, p. 52-54).

Many commercial vendors such as Red Hat and VA Linux provide technical support or have developed software programs based on Linux and support the continued development of Linux by providing financial support and software developers. (Lerner & Tirole, 2002). Linux has obtained a reputation for stability and quality which many businesses have modified and implemented the operating software for their specific needs. The Linux Foundation estimated that the GNU/Linux "ecosystem" would reach $50 billion in 2011 (Gerloff, 2010).

5.3 Apache

Rob McCool of the National Center for Supercomputing Applications (NCSA) developed the public domain HTTP daemon (HTTPD). Progress on the software stalled in 1994 after McCool left NCSA. Because the HTTP server source code was freely available to everyone and the license allowed user modifications and free redistribution (Apache, 2011), instead of letting the project die, a small online community of individuals formed in order to provide technical support and improve the software through online collaboration (Apache, 2011). Individual webmasters continued to use the HTTPD software and shared patches and bug fixes – two of the webmasters, Brian Behlendorf and Cliff Skolnick, created a mailing list to share information between the developers. Only eight core contributors formed the original HTTPD development group (Apache, 2011). The software code fixes and modifications contributed by the group members were referred to as "patches" which some believe led to the name of the project, "Apache" (Apache, 2011).[13]

The HTTPD software development group developed into Apache software and by April 1995 the group released its first version software which became very popular and the Apache user community grew rapidly. By August of that year, the group had already released another two versions and by December 1, 1995, after extensive beta testing, Apache 1.0 was released (including a new set of documentation). Apache software became the most used web server software and in 1999 the Apache Group created the Apache Software Foundation (ASF) as a means of providing "organizational, legal and financial" support to the software efforts. The ASF provides the structure for users and developers to provide new code and bug fixes (Apache, 2011; see also Taft, 2010). From the original eight contributors, the Apache Foundation currently reports more than 800 contributors to the Apache Server project (Apache, 2011).

One of the goals of the ASF was to encourage wide usage of the Apache Software including commercial organizations. There are no reciprocal requirements that the adopting company contribute to future development of the software (Licenses – The

[13] The original Apache group included Brian Behlendorf, Roy Fielding, Rob Hartill, David Robinson, Cliff Skolnick, Randy Terbush, Robert Thau, and Andrew Wilson (Apache, 2011).

Apache Software Foundation, 2010). As of April 2007, the Apache software was found on nearly 114 million sites representing nearly 60% of the market share with Microsoft's competing proprietary software representing slightly more than 31% of the market share (Wheeler, 2007). By January 2011 Apache software had increased to 161.5 million domains representing 59% market share with Microsoft falling to 21% market share (March 2010 Web Server Survey – Netcraft, 2010).[14]

The Apache projects do not include any positions that are compensated including officers of the foundation. However, some contributors to the software code are paid for their time by other companies that employ them to work on the Apache project (Apache, 2011).

5.4 Mozilla Firefox

Another example of cooperative FOSS innovation is the Mozilla project which provided the kernel for Firefox internet browser. Firefox was originally designed as the commercially produced software, Netscape, and was a pioneer in the internet browser software and gained a large portion of the market share for internet browsers. However, by 1998 Microsoft's Internet Explorer dominated the browser arena with faster software (Freedman 2007). The FOSS movement was growing during the 1990s with Linux and other FOSS projects as high quality competitors to commercial software. Netscape saw an opportunity to keep Microsoft from obtaining a monopoly in the browser industry by

[14] Another survey, E-Soft's Security Space, reported on January 1, 2011 that 71.33% of servers used Apache Software with Microsoft as the next largest installed server software with 16.02% of the market (Security Soft - Web server survey, 2011).

taking the proprietary software into open source development (Freedman 2007).[15] In 1998 the Mozilla project was established to “coordinate the open source development of the Netscape Communicator 5.0 source code” (Ten years ago today: Netscape launches mozilla.org, 2008; see also Raymond, 2002).

For the first several years, the transition from the commercial Netscape to FOSS Mozilla Firefox was difficult and unsuccessful. Shortly after initiating the Mozilla open source project one of its principals, Jamie Zawinski, resigned stating that “open source is not magic pixie dust" and referred to problems with mismanagement and missed opportunities (Raymond, 2002).

Mitchell Baker, one of Mozilla’s key leaders was fired early in the FOSS project which left the community without clear leadership. Baker, the attorney who put together the open source structure that converted Netscape into Mozilla, was an unusual choice as a non-developer to become the leader of Mozilla. Shortly after her appointment, she was laid off by the parent company, AOL, because the company was unable to see any prospects of returns. Since Baker had already earned respect in the FOSS community and Mozilla was an independent organization, Baker stayed on as an unpaid volunteer. After nearly a year of unpaid volunteer work the non-profit organization Open Source Applications Foundation provided a small salary to Baker (Freedman, 2007).

---

[15] Linux had received a great deal of attention due to its novel development approach and success of widespread acceptance. Eric Raymond’s book “The Cathedral and the Bazaar” provided an analysis of the Linux success and was an early and influential book on the emerging power of open source. Raymond’s book was credited with greatly influencing the decision of Netscape Communications to move its source code to an open source model (Raymond, 2002).

In 2003, an independent nonprofit Mozilla Foundation was created with backing from AOL, IBM, Red Hat and Sun. The Mozilla Foundation promoted free and open source software and released FOSS projects Thunderbird and Firefox. Months prior to its official November 2004 release date, Mozilla Firefox had already gained market share and increased downloads by 26%. In November 2004 the Foundation released Firefox 1.0 internet browser and within a year the Firefox software was downloaded more than 100 million times (History of the Mozilla project, 1998-2010).[16]

In June 2004 the US Department of Homeland Security's CERT (Computer Emergency Readiness Team) recommended against using Microsoft's proprietary Internet Explorer due to critical security vulnerabilities that inserted malicious code into IE users' computers. The code provided the hackers with stolen keystroke information to potentially steal credit card and other sensitive information. There is some evidence that Microsoft was aware of the problem for nearly 9 months and did not fix it until it became public (Wheeler, 2007).

---

[16] This increased interest in Firefox was at least in part due to the severe security problems Microsoft Internet Explorer was experiencing at the time. The US CERT (Computer Emergency Readiness Team), part of the Department of Homeland Security of the US Government advised in July 2, 2004 that there were several security vulnerabilities related to Microsoft's Internet Explorer

> Several vulnerabilities in IE could allow a malicious web site or HTML email message to install software on your computer. This software could be used to steal sensitive financial information or perform other actions. Recent incident activity has been referred to as Download.Ject, JS.Scob.Trojan, Scob, and JS.Toofeer.
>
> Microsoft has released a security update for IE that provides increased protection against this type of attack. Note that this update may not prevent attacks in all cases. (National Cyber Alert System, Cyber Security Alert SA04-184.A., 2004)

US-CERT also recommended that due to the "number of significant vulnerabilities in technologies relating to the IE domain/zone security model," that using a different web browser might reduce the exposure to these.

One study showed that Firefox had fewer “severe vulnerabilities” than Microsoft’s Internet Explorer – and that Firefox fixed the vulnerabilities much quicker. The study was undertaken between July and December 2004 by Symantec Corp. which found seven “severe vulnerabilities” in Mozilla Firefox and nine in Microsoft Internet Explorer. Once identified, the number of days to fix the vulnerabilities was significantly longer (an average of 43 days) for the proprietary software, IE, compared to the open source software, Firefox (an average of 26 days) (Wheeler, 2007). Additionally, during 2004 and 2005, Microsoft took an average of 134 days to release patches for security problems compared to an average of 37 days for Mozilla (Wheeler, 2007). Since 2004 Firefox internet browser has received several quality awards in the industry, including (Mozilla awards, n.d.):

- PC Magazine Editors’ Choice Award, 2009, 2008, 2006, 2005
- CNET Editors’ Choice, 2008, 2006, 2005, 2004
- American Business Awards Most Innovative Company, June 2008
- PC World 100 Best Products of 2007, 2006
- PC Magazine Editors' Choice, October 2006
- CNET Editors' Choice, October 2006
- PC Magazine Best of the Year Award, December 27, 2005
- PC Pro Real World Award, December 8, 2005
- CNET Editors' Choice, November 2005
- UK Usability Professionals' Association Award Best Software Application 2005
- Forbes Best of the Web, May 2005
- PC Magazine Editors’ Choice Award, May 2005
- LAPTOP Magazine Editors' Choice Award - Best Web Browser, October 2004
- Innovation of the Year in the software category, by PC Professional 2004/2005

In 2010, Firefox browser had increased market share around the world representing nearly 153 million users (or 39% of the market) in Europe. Firefox was also strongly represented in other parts of the world with 100 million users in North America

(26% market share), 31.7 million users in South America (31.4%), 5.6 million users in Africa (29.7%), 68.7 million users in Asia (26.6% market share), 6.7 million users in Oceania (28.7% market share) (Mozilla metrics report Q1 2010, 2010). As of June 14, 2010, Mozilla Firefox reported 714,675,993 downloads of its Firefox 3.6 version (Firefox, 2010). In 2010, Firefox "celebrated its 6th birthday" and its website reports that Firefox is the browser of choice for over 400 million people worldwide and that it is available in 70 languages. The Mozilla Blog states that the success of Firefox is "due to the passionate and dedicated Mozilla community, comprised of tens of thousands of developers, localizers, testers, ambassadors and campus reps" (Jostedt, 2010).

In summary, this chapter reviews three FOSS case study groups that practice communitarian innovation of intellectual property. Linux, Apache and Mozilla develop FOSS that competes successfully with proprietary software and is used for commercial purposes.

CHAPTER 6

INCENTIVES TO CONTRIBUTE

In this chapter, I analyze incentives of FOSS contributors and show comparability to 19th century case study contributors' incentives. In spite of the differences between the19th century and FOSS case study groups, common incentives to participate strengthen the link between these communitarian innovation groups. This commonality provides a foundation on which to compare the organizational structure across communitarian innovation groups.

Nineteenth century communitarian experiments compared to online FOSS projects reveal several physical incongruities including common location and types of common-pool property. Members of FOSS communitarian groups developed knowledge creation through electronic communication allowing wide geographic dispersion of members compared to 19th century communities that located physically close together in order to create a functional organization. Electronic communication has allowed FOSS community members to remain geographically dispersed avoiding significant lifestyle changes to participate in the community. Electronic communication has allowed FOSS communities to disaggregate not only geographically but also socially and economically. Physical disaggregation enabled communities to implement narrow membership requirements that focused on specific goals including the creation of cooperative innovation. The narrow membership requirements allowed FOSS community members to join several different groups and choose the amount of labor and intellectual property they wanted to commit to any community. As a result, FOSS case study membership agreements did not require complete commitment of property, labor or ideas from any member.

Incentives to contribute to communitarian innovation can be partially understood in terms of Frey's intrinsic (personal) and extrinsic (group) psychological factors. Not all motivation to participate in cooperative innovation is intrinsic to the participant; a great deal of incentive is focused externally on the success of the group rather than the individual. Extrinsic and intrinsic motivators frequently overlap for members of cooperative groups because the success of the group provides substantial individual satisfaction (Benkler, 2004).

Based on my analysis of the 19th century and FOSS case study groups, I have identified five incentives that motivate contributors to participate in communitarian innovation. Several of these key incentives have been scattered throughout the FOSS academic literature but have not previously been connected to the 19th century communitarian groups (Malone, Laubacher, & Dellaroca, 2009; Osterloh & Rota, 2004). These five incentives to contribute are to:

- meet contributors' unfilled need;
- enhance contributors' own or community reputation;
- provide contributors with fun and enjoyment;
- promote contributors' personally important social agenda; and
- encourage commercial potential of the innovation.

Section 6.1 of this chapter addresses each of the five contributors' incentives found in FOSS case study communities and ***Section 6.2*** provides a comparison of these five incentives for contributors to the 19th century communitarian case study groups.

6.1 Incentives for FOSS Contributors

The discussion on incentives to participate in communitarian innovation has not been a high priority in academic literature until the recent success of FOSS products in commercial markets. Within this body of literature written on the motivation question, several factors are identified but with little agreement on the outcomes.

> [A]fter several years of research, there is no agreement in the literature on what the primary motivation factors for open source participation are. Explanations vary from career management concerns and market signaling incentives (Lerner and Tirole), through gift culture reciprocities (Raymond) and a hacker ethic (Himanen) to personal profits induced by the non-rival nature of software (Weber). (David & Tsur,2005, p. 15)

The influential work by Lerner & Tirole (2002) showed that much of the reward to FOSS contributors comes in the form of social status and future financial gain via better paying job offers based on demonstrated performance within the FOSS community. In other words, the motivation to contribute to FOSS is simply the ability to signal technical skills to future employers. There have been several surveys with varying outcomes. The results of a Boston Consulting Group (Bates, Lakhani, Wolf, 2002) survey showed that nearly 45% of the respondents contributed to FOSS because it is "intellectually stimulating." Also, just over 44% contributed to FOSS because they believed code should be open (33.1%) or to enhance open source reputation (11%). Only 41% of the responders stated that contributing to FOSS improved their skills (Bates, Lakhani, Wolf, 2002).

What has come from these various studies is that there are several motivators and that individuals contribute to FOSS for more than one reason. Studies on FOSS contributors' motivation have focused on furthering the economic theories of rational behavior and utility maximization. Neoclassical economists conclude that rational self-interest does indeed still hold; however, the rewards may be postponed.

6.1.1 Meets Unfilled Need

Contributors to FOSS, whether the initial developer or those who provide subsequent enhancements, are often fulfilling an unmet personal need that commercial software cannot meet. The fact that others may also benefit from the contributions of code is irrelevant because the individual's (or firm's) needs have been specifically met and the other users will have to take what they get unless they also provide code to customize to their own needs (von Hippel, 2002). Some empirical surveys find that the most important incentive to FOSS innovation is need of the innovator (von Hippel & von Krogh, 2009).

> [FOSS contributors] face general needs in a marketplace but face them months or years before the rest of the marketplace encounters them. Since existing companies can't customize solutions good enough for them, [FOSS contributors] go out there, patch things together and develop their own solutions. They expect to benefit significantly by obtaining solutions to their needs. (Wheeler, 2007, "There is ample evidence" para. 5)

Increasingly, the "user need" is that of corporations that are either implementing the software for their own internal business purposes or for improving the marketability of the software for which they provide technical support (von Hippel, 2002).

Additionally, those who contribute FOSS code benefit from a large audience to review the work and locate errors and bugs for no cost thus improving their innovation. Thereby, both the code developer and the reviewer benefit from cooperation (von Hippel, 2002). Those who benefit from FOSS are often those who contribute to it by "providing feature enhancements, bug fixes, and support for others in public lists and newsgroups" ("Apache, Http Server Project", 2011).

6.1.2 Enhances Own or Community Reputation

Individual reputation can also be a strong motivation for contributing to FOSS projects. There are those who are willing to join the FOSS community and contribute time and creativity in order to enhance their own credentials within the software developer community. "Ego boosting" is a form of utility maximization strategy among certain FOSS community participants. "Egoboo" (short for ego boosting) is "the basic drive behind volunteer activity" (Raymond, 2002, "The Social Context of Open-Source Software," para. 19). Eric Raymond (2002) core innovator of fetchmail FOSS project states:

> Both the fetchmail and Linux kernel projects show that by properly rewarding the egos of many other hackers, a strong developer/coordinator can use the Internet to capture the benefits of having lots of co-developers without having a project collapse into a chaotic mess. (Raymond, 2002, "The Social Context of Open-Source Software", para. 19)

The online developer community provides substantial opportunity for FOSS contributors to demonstrate their skills. The widespread practice of formally recognizing major contributors to FOSS tends to increase the contributors' reputation within the hacker community. This reputation "signaling" can also be potentially beneficial to future employers who are seeking employees with proven talents. Recognition of important contributors to a successful project increases the contributor's reputation within the hacker community. Less experienced contributors and those looking for entry into the community esteem those with the best reputation within the community and seek them out as potential mentors (von Hippel & von Krogh, 2009).

Also, social relations and enhanced privileges both in and outside the FOSS community can be motivation to join and contribute to the FOSS projects (von Hippel & von Krogh, 2009). The incentive of increased credentials, social relations, or enhanced privileges is most likely to succeed in small groups according to one study (von Hippel & von Krogh, 2009). FOSS projects, can also act as a sort of clearing house with developers demonstrating their skills and employers finding individuals to hire. Because the code is available for all to see, FOSS projects act as forums for prospective employers to evaluate the skills of those contributing code. Additionally, active volunteers on certain projects (such as Mozilla) may become paid employees (Wheeler, 2007). With respect to those who worked on the Mozilla Firefox FOSS project, Walt Scacchi of the University of California at Irvine's Institute for Software Research stated, "If you've contributed to a software system used by millions of people, you've demonstrated something that most software developers have not done" (Wheeler, 2007, "Will OSS/FS Destroy the Software Industry, para. 15).

6.1.3 Fun and Enjoyment

Even though finding and fixing software bugs has not become a widely popular form of entertainment, within the hacker community finding and fixing bugs or adding new functionality can be considered a recreational pastime. The fact that what hackers do for fun might also help someone else is of secondary importance to their own enjoyment of solving an interesting problem.

> I want to suggest what may be a wider lesson about software, (and probably about every kind of creative or professional work). Human beings generally take pleasure in a task when it falls in a sort of optimal-challenge zone; not so easy as to be boring, not too hard to achieve. A happy programmer is one who is neither underutilized nor weighed down with ill-formulated goals and stressful process friction. Enjoyment predicts efficiency. (Raymond, 2002, “On Management and the Maginot Line”)

Additionally, contributing to the FOSS community is an enjoyable means of creative interaction with others who have similar interests. The Boston Consulting Group Hacker Survey (Bates et al., 2002) found that 61.7% of the survey respondents state that their contribution to FOSS was, or was equal to, their “most creative effort.” Also, 72.6% of the respondents revealed that they “always” or “frequently” lost track of time when programming – potentially an indication of enjoying the work done in FOSS.

6.1.4 Fulfills Social Agenda

The ideal of free sharing of knowledge has, until relatively recently, been an important aspect of many other scientific and academic pursuits – ideas were freely shared among other researchers and scientists in the field (Hess & Ostrom, 2003). The software developer community grew within a culture of freely shared ideas and provided the foundation for the FOSS community culture.

Promoting a positive perspective of FOSS is critical for those who believe free access to ideas is an ideologically superior position over proprietary knowledge. For those who are so motivated, “group fate” is of utmost importance and outweighs the cost of contributing time and creativity to the community (von Hippel & von Krogh, 2009). Some FOSS contributors are motivated mainly to provide a viable alternative to commercially available software as was the case with the FOSS browser software

Mozilla Firefox and what might otherwise have been a browser software monopoly by Microsoft's Internet Explorer. Mozilla Firefox "achieved Netscape's original goal, which was to deny Microsoft a monopoly lock on the browser market" (Raymond, 2002, "Epilog: Netscape embraces bazaar"). Apache's website declares its social agenda to be that of making software available to everyone and states that "the tools of online publishing should be in the hands of everyone" (Apache, Http Server Project, 2011, "Why Apache Software is Free"). The mission of Apache Software FOSS group is to build reliable software systems that remain open for both individual and commercial use and that the protocols of the internet must remain open source in order maintain a "level playing field" for all companies of every size (Apache, Http Server Project, 2011, "Why Apache Software is Free"). "Thus, "ownership" of the protocols must be prevented. To this end, the existence of robust reference implementations of various protocols and application programming interfaces, available free to all companies and individuals, is a tremendously good thing" (Apache, Http Server Project, 2011, "Why Apache Software is Free").

6.1.5 Commercial Potential

Within the cooperative community, innovating users may benefit financially from freely revealing their innovation and gaining a wider diffusion for their innovation (von Hippel, 2009). A wide audience may help uncover bugs more quickly. A wide diffusion of FOSS may provide for commercial opportunities such as technical support, add-on software, or other services and products not offered through FOSS. According to Joel Spolsky (2002), much of what commercial ventures are succeeding at in the open source software arena is explained in microeconomics through the increase in demand of a product by decreasing the price of a complementary good. As the price of an operating system drops there will be more demand for the complementary services of technical support and resulting in more revenue and profit for the company.

Some of the largest and best known companies are participating in open source development. Sony, Nokia, Samsung and others implement Linux into their products and work within the FOSS communities to ensure a quality product (Corbet, 2010). James Boyle (2004), professor of law at Duke University, pointed out that "…IBM now earns more from what it calls "Linux-related revenues" than it does from traditional patent licensing, and IBM is the largest patent holder in the world." In 2003 HP reported $2.5 billion in "Linux-related" revenue and Red Hat, a company which distributes a version of Linux, was valued at $2.3 billion in 2002 (Wheeler, 2007).

6.2 Incentives for 19th Century Communitarian Contributors

Research of historical records shows comparable incentives for 19th century case study communities as found in the FOSS communities. I have found that contributors to the case study communities show similar motivation in each of the five areas identified as incentives for FOSS contributors. These five incentives to contribute are to:

- meet contributors' unfilled need;
- enhance contributors' own or community reputation;
- provide contributors with fun and enjoyment;
- promote contributors' personally important social agenda; and
- encourage commercial potential of the innovation.

6.2.1 Meets Unfilled Needs

The 19th century case study groups innovated cooperatively in order to ease the burden and improve the efficiency of necessary tasks. In each case, the need for these communities to find a better method prompted cooperative innovation. The Shakers invented products based on the group's need to make their work more efficient. Shakers believed that work was a form of worship and any waste of time or productivity was a sin. Shaker Elisha Myrick (as cited in Alexander & Keep, 1995, p. 366) wrote in his diary:

> … every improvement relieving human toil or facilitating labor [gives] time and opportunity for moral, mechanical, scientific and intellectual improvement and the cultivation of the finer and higher qualities of the human mind.

Many of the labor saving inventions of the Shakers, including the circular saw, provide evidence of the need to become more efficient in everyday work so that higher-level activities could be pursued. "Such innovativeness reflected in part the necessity to solve problems…" (Cooper, 1987, p 5).

Mormons, emigrating by wagon train across the North American plains, developed a mechanism to more accurately measure distance travelled. The need for accurate mileage count was critically important to the success of subsequent caravans travelling the same route to the Great Salt Lake basin. The existing method of physically counting the wagon wheel rotations was too imprecise given the wide variation in estimates from the various counters.

In the case of the Oneida Perfectionists, most members of the group did not utilize the traps themselves. However, innovation to improve manufacturing processes helped increase output in order to meet increased demand. The Oneida community also improved the type of materials used and the mechanism of the spring components. Cast iron replaced wrought iron for several trap parts and machinery was invented to manufacture the trap spring from a steel bar. The manufacturing process was mechanized to the point that the traps were produced “almost without the blow of a hammer” (Newhouse, 1865, p. 117). The demand for the traps had increased beyond the production capacity of the Oneida community which prompted the need for more efficient production methods.

6.2.2 Enhances Own or Community Reputation

Personal and community reputation was an important motivator for the 18th century communities. Shakers were zealous in their individual work efforts and distinguished themselves through the quality of their work. Individual reputations were enhanced within the Shaker community through the quality of work performed. Additionally, the Shaker communities gained improved reputations by producing high quality products including furniture and herbal remedies (Carson, 2000). Shakers periodically published “The Shaker Manifesto” which reads as though it is intended for readers both in and outside of the Society. In these publications, several articles dealt with the innovative reputation and history of the Shaker community. The publication appears to focus on increasing the reputation of the community among its members as well as community outsiders who were interested in reading the publication.

William Clayton provided evidence in his journal of his interest in individual reputation within the Mormon community. On May 14, 1847, Clayton wrote of his concern that Harmon was trying to take credit for inventing the odometer even though both men along with others were involved. “I discover that brother Appleton Harmon is trying to have it understood that he invented the machinery to tell the distance we travel, which makes me think less of him than I formerly did” (Clayton, 1921, May 14 1847).

The commercial success and quality of the Newhouse traps improved the reputation of the Oneida Community internationally. The success of the traps increased the visibility of the community leader, Noyes, and the core inventor, Newhouse. Many community publications included details about the traps and their economic importance. Based on interviews published in the Oneida Annual Report, I found Community members were generally more interested in group reputation rather than individual. One community member stated that her “individual interests were being swallowed up in the general interests of the body [of the community] (Oneida Association, 1849, p.15). Another community member, Hial M. Waters, stated, “… I find that love, confidence and esteem, are a far stronger *stimulus* than money or necessity. The thought that we are laboring for those who are dear to us, inspires us with new energy, and makes work sport” (Oneida Association, 1849, p.15).

Additionally, each of the 19th century case study communities raised awareness of their successes through self-published newspapers, brochures, books and other informational articles. Based on my reading of several of these publications, a common purpose shared by each publication is to inform the public and increase acceptance of the virtues of the communities’ nontraditional socioeconomic structure and enhance the community’s reputation, often for commercial purposes. This was especially clear in the case of Oneida, the group enthusiastically promoted its reputation based on the success of its Newhouse animal traps in its publication of the “Trapper’s Guide” (Newhouse, 1865).

6.2.3 Fun and Enjoyment

Members of the 19th century case study communities had little time to pursue personal hobbies for pleasure in the same way 21st century community members pursued fun and enjoyment. However, records show that "fun and enjoyment" motivated 19th century case study community members. Members of the case study communities found enjoyment in laboring for the common benefit of the community. Also, members of these communities were encouraged to perform the work that best met their own interests and desires. Shaker members found joy and pleasure in their work because each member was allowed to do the work "he likes best" (Evans, 1888, p. 229). The Shakers' enjoyment is their service to community and God, "… when a Shaker is put upon the soil, to beautify it by his tilth, the difference between his husbandry and that of a Gentile farmer, who is thinking solely of his profits, is likely to be great. While the Gentile is watching for his returns, the Shaker is intent upon his service" (Dixon, 1867 as cited in Carter & Geores, 2006, p. 19).

William Clayton's journal provides insight into the motivation to contribute. Clayton shows a determination to provide an accurate mileage count and appears to enjoy the process of developing a device that will prove his theory that therefore the miles travelled had been miscounted (Clayton, 1921, Journal entry April 22, 1847).

Several Oneida Community members expressed that labor took on a new meaning when working for a higher level goal and that enjoyment came from working together towards that goal and helping the community to succeed. One Oneida community member, Stephen R. Leonard, stated that he found the "stimulus to labor to be far greater and much more effectual than in the world" (Oneida Association,1849, p.15). Another member, James L. Baker, that he now had "…an infinitely higher motive to action in doing all that I do for the glory of God, and find work unattended with exhaustion" (Oneida Association,1849, p.15).

6.2.4 Fulfills Social Agenda

The 19th century case study groups were part of the religious movement that took their community model from the Bible rather than the contemporaneous popular socialist theory (Cosgel et al., 1997). Shared goals and beliefs served as motivators to carry out a unique social agenda for each case study community. Shaker members emphasized the importance of the community's social agenda. A key component driving the efforts of the Shaker members was the "public spirit of community…and a strong religious conviction of duty that ma[d]e members work together harmoniously for the common good" (Staff Correspondent, 1881, p. 5).

Mormon contributors were also motivated by the desire to facilitate the safe removal of the community to the remote Great Salt Lake Basin. By successfully moving the group members to a distant location, the Mormons could continue to practice their beliefs away from persecution. The travel guide that resulted from the roadometer measurements became popular among Mormon emigrants who needed directions and information on the trail west (Crawley, 2005).

Oneida Community members reflected on the significance of the community's social agenda as motivator to contribute to the group. One community member, Jonathan Burt, stated that "[t]o labor for the friends of God has a stimulus in it far exceeding anything [he] had previously known." Another stated that his feeling of laboring for

"God's kingdom" has provided more motivation to labor "far exceeding anything [he] had previously known" (Staff Correspondent, 1881, p. 5).

6.2.5 Commercial Potential

Some theories have suggested that communitarian experiments succeeded in the US because of its extensive frontier allowing growth and isolation for communitarian groups. Importantly, most communities that remained close to commercial markets were more financially successful than those that moved into isolated areas (Bestor, 1953). Commercial potential motivated Shakers to develop and manufacture many of their innovations. Shakers invented for their own use and also for commercial reasons to meet the "demands of the outside world" (Alexander & Keep, 1995, p. 370). The commercial potential of the innovation is an important motivating factor for members of the Shaker community (Cosgel et al., 1998). Many of the labor-saving inventions created by the Shakers were motivated by "community self-sufficiency" they also produced goods to trade with other Shaker groups and also to sell to outsiders (Cooper, 1987).

Although the Mormons' first priority with the odometer was to help subsequent Mormon travelers to the Great Basin, ultimately the mileage record obtained from the invention developed into a commercial venture with the publication of a guide published and sold to travelers to California and Oregon.

Oneida's founder recognized that staying close to commercial centers and manufacturing goods for profit was the basis for success in communitarian experiments (Bestor, 1953). The ability to continue their way of life depended greatly on the business success of their innovations. The Oneida community initiated trap manufacturing for its commercial potential and its success financially sustained the community. The fact that the majority of the Oneida community members did not use the traps for themselves provides evidence that a significant motivating force was financial and commercial.

Contributors to the FOSS case study groups share the same motivations as those who contributed to the 19th century case study groups. This comparability of incentives provides a foundation on which an organizational structure can be established. The dissimilar innovations and community locations (physical compared to online) of the 19th and 21st century communities are inconsequential in the factors that motivate communitarian innovation. Establishing comparable contributor incentives across all case study communities helps provide the foundation for determining the organizational structure that fosters these incentives.

CHAPTER 7

ORGANIZATIONAL CHARACTERISTICS OF COMMUNITARIAN INNOVATION

> "… Incentives clearly play an important role in the design of organizations but they are not the sole determinant of structure" (Beggs 2001, p. 298).

The recent success of FOSS has fueled an interest in the economic theories of cooperation. An emerging body of literature discusses the motives of FOSS contributors but reveals little with respect to the organizational structure of successful communitarian innovation communities. An understanding of the institutional "design principles," or organizational structure, of successful communitarian innovation groups could help move toward a general theory of communitarian innovation (Brumann, 2003).

The challenge of structuring a successful communitarian innovation group is to create an organization that motivates members to contribute and maximizes the combined talents of the group. In pursuit of understanding the organizational and structural aspects of cooperative innovation, I have analyzed the characteristics of the 19th century and FOSS case study communities and uncovered evidence of structural elements common among each group. These organizational attributes produced a community structure that motivated members to innovate cooperatively.

In spite of the differences in physical concentration between the geographically aggregated (19th century groups) and disaggregated (FOSS groups) communities, each type of community shares significant organizational characteristics necessary for cooperative innovation. These common organizational attributes of the case study communities serve to establish a foundation for a theory of communitarian innovation which can be transported to innovation in other industries.

I have identified five main areas of organizational structure with subcategories that are shared among each of the case study groups:

- leadership
  - motivational
  - shared
  - adaptable;
- socioeconomic design
  - property distribution
  - fundamental equality;
- organization of labor
  - self-selected, not compulsory
  - subgroup structure;
- internal communication
  - open communication
  - peer review; and
- member commitment
  - membership levels
  - member agreements.

I determined these organizational characteristics through first researching the 19th century case study communities and identifying common characteristics shared across these communities and then confirmed the application and importance of each organizational characteristic as manifest in the FOSS case study communities. In

Sections 7.1-7.5 of this chapter I provide evidence of organizational elements found in the 19th century communitarian case study groups and show comparability to the FOSS case study groups. I provide evidence from each of the six case study groups for the organizational characteristic: leadership, socioeconomic design, organization of labor, internal communications and member commitment. For each of these categories, I first provide a general discussion on the organizational characteristic and then present evidence of importance for each of the 19th century and FOSS case study groups. The case study application of each characteristic is summarized in table format at the beginning of each section.

7.1 Leadership

> I began to appreciate the difference between acting on the principle of command and discipline and acting on the principle of common understanding. … the aim can be achieved only through the severe effort of many converging wills. (Brandes & Kropotkin, 2009/1899, p. 216)

My analysis of the case study groups revealed three common attributes of the case study community leadership. First, motivational leaders defined the social agenda and motivated the community members to achieve the agenda. Second, case study leaders broadly shared management and decision making responsibilities among community members. Third, because of the shared leadership responsibilities, communities quickly adapted to the needs and abilities of the membership. ***Table 7.1*** summarizes the leadership attributes of each of the case study communities.

TABLE 7.1 – Leadership

	Motivational	***Shared***	***Adaptable***
Shakers	Promoted contributions through inventor leadership and social agenda	Many members involved in rotating leadership positions	Flexible lifestyle codes based on abilities and needs of members
Mormons	Promoted contributions through inventor and community leadership	Many members involved in rotating leadership positions	Changed form of property sharing from Law of Consecration to Tithing
Oneida	Promoted contributions through inventor and community leadership social agenda	Many members involved in rotating leadership positions	Accepted trap-making in spite of earlier ban
GNU/Linux	Promoted contributions through inventor and community leadership	Many members involved in rotating leadership positions	Contributors determine outcome of project
Apache	Promoted contributions through inventor and community leadership	Many members involved in rotating leadership positions	Contributors determine outcome of project
Firefox	Promoted contributions through inventor and community leadership	Many members involved in rotating leadership positions	Contributors determine outcome of project

7.1.1 Motivational Leadership

Communitarian innovation leaders focused on motivating community members rather than monitoring employees. By comparison, traditional corporate leaders structure their organization with “low-powered” incentives and “extensive administrative controls” (Garrouste & Saussier, 2004, p. 181). Traditional corporate leadership creates hierarchical pyramids to ensure productivity and efficiency and governance is based on the principle of command through a line of authority.

Case study leadership rejected traditional power hierarchy and implemented motivational leadership that focused on members’ incentives for contributing to the community. Leadership by command is unlikely to succeed in a cooperative innovation community – contributors will leave under a power hierarchy organization. Management of a group of volunteers, as in communitarian innovation, requires a leadership structure very different than the traditional corporate power hierarchy. Communitarian leadership must be focused on the "principle of understanding" and "converging of wills" (Brandes & Kropotkin, 1899/2009, p. 216). Cooperative innovation leaders "inspired and persuaded" others to create an environment conducive to cooperative innovation; leaders kept contributors focused on the goals of the community (Raymond, 2002).

> In order to build a development community, you need to attract people, interest them in what you're doing, and keep them happy about the amount of work they're doing. … The personality you project matters, too….it helps enormously if you have at least a little skill at charming people. (Raymond, 2002, Necessary Preconditions for the Bazaar Style)

Case study leaders established the social agenda of the community and unified members to achieve the social agenda by creating an environment in which individuals willingly contributed outside of the traditional hierarchy and profit structure.

7.1.1.1 19th Century Case Studies

Motivational leaders in the 19th century case study groups promoted the importance of their community's social agenda. Leaders of each community emphasized self-improvement and the importance of work to achieve that goal. Shaker, Mormon and Oneida communities produced innovation leaders who produced a core innovative concept to the group in the form of a functional idea. Shaker and Mormon *religious* leaders were only marginally or not at all involved in the innovation process but established the organizational structure that fostered cooperative innovation.

Shaker leadership taught that work improved self and society. Members sought to produce high quality goods as a form of worship and self satisfaction and associated work with worship. Shakers sought quality-improving and labor-saving innovation as part of their worship. While watching the nail-making process performed by fellow Shakers, the core inventor observed that instead of rolling out each nail a more efficient method would be to cut the nails from a sheet of iron. From her observation, a group of Shakers developed the idea into a successful innovation (St. Paul Globe, 1905).

Mormon leaders taught that members are stewards and through work will improve self and benefit others. Mormon community members fulfilled their stewardship by improving upon their labor. These teachings established a foundation for the core inventor's proposal and functional design for the roadometer. Leaders motivated interest in the invention through discussion of his design and convinced other group members of its need and likely success.

Oneida leaders established the importance of individual and community improvement as part of the Perfectionist creed. Noyes was involved in the innovation process after the core invention was brought to the community by Newhouse. Together they provided motivational leadership for further innovation on production and design of the traps.

7.1.1.2 21st Century Case Studies

As with the 19th century case study leaders, FOSS case study leaders motivated others to join and convinced contributors of the community's potential of succeeding (Raymond, 2002). Innovation leaders initiated cooperative innovation by providing the core innovative concept to the group in the form of a functional idea – in the case of FOSS, the functional idea was the software framework or “kernel.” Innovation leaders motivated individuals to become community members in order to solve a personal need, satisfy curiosity or fulfill a social agenda. Linus Torvalds initiated Linux and with a post on an internet newsgroup and provided the functional idea (the Linux kernel) to the right group of developers (MINIX newsgroup). Torvalds encouraged developers to engage in making the project better and within weeks the kernel was updated to include the contributors’ ideas and a software version was quickly released (Hasan, 2000). Linux leadership established the community agenda and motivated participation by quickly updating the code to reflect member contributions and encouraging others with an interest to share in leadership positions.

Apache leadership took an existing functional software program as its functional idea and created a user list to share information among developers in order to improve the software. By maintaining open communication among interested developers, the community leaders were able to encourage improved innovation and within a short period released an updated software version (Apache, Http server project, 2011).

Mozilla motivational leadership during the transition from commercial Netscape to open source Firefox was difficult as Netscape was still owned by AOL. However, Mitchell Baker who had been laid-off from her position continued, without pay, to promote the open source agenda. Baker also continued to provide motivational leadership through the restructuring of the Mozilla Foundation, and encouraged contributions by community members which allowed the foundation to release Firefox 1.0 (Freedman, 2007).

7.1.2 Shared Leadership

Each case study community implemented a broadly shared governance structure that involved many members of the community in decision making and leadership positions. The division of community responsibility and decision making naturally followed from the communities' shared property rights among members. Shared property rights provided an "identity between authority and ownership" for the community members (Garrouste & Saussier, 2005, p. 181) and the need for layers of managerial hierarchy was eliminated as the shared community leadership created an environment in which members observed problems and helped to find potential solutions.

7.1.2.1 19th Century Case Studies

The Shakers created an organizational structure of small groups governed by two male and two female members and assisted by two deacons and two deaconesses (Evans, 1888). In one Shaker village there is record of 77% of the village as part of the group leadership (Alexander & Keep, 1995). Shakers often rotated lay leadership positions among the members so that participation in organizational governance was widely shared.

During the Mormon westward migration, the group organized into teams of ten wagons with each team headed by a team leader. Every 5 teams had an additional leader with another leader over groups of 10 teams. This organizational structure involved several group members in leadership responsibilities during the trek (Clayton, 1921). Leadership within the Mormon community is widely shared and frequently rotated.

Oneida community leadership was widely shared with the group administration divided into 21 “standing committees” and 48 “functional departments.” Even with the broadly shared leadership, the entire community shared decision making for major decisions (Cooper, 1987, p. 8).

7.1.2.2 21st Century Case Studies

Similar to the 19th century case study communities, the FOSS case study communities shared leadership widely throughout the community. Member contribution and activity levels helped determine leadership roles and responsibilities in the case study communities. Although complete commitment of resources was not required of FOSS community members, responsibilities were widely shared among members who were willing to do the work.

The Linux kernel, initiated by Torvalds, is now managed by several community members due to the complexity and size of the project. The Linux project has more than 100 “subsystem trees” over which a “maintainer” reviews and signs off on each new code contribution that is to be added to the kernel (Corbet, 2010).

Numerous managers are involved in the Apache project due to its size and the fact that management is comprised entirely of volunteers who have other jobs and cannot devote large amounts of time managing the project (Herbselb & Mockus, 2002). Leaders on the Project Management Committee (PMC) are elected to the position based on merit and are responsible for the overall software project ("How The ASF Works," 2011). The software project lead is given authority over development of the software, and “is given a great deal of latitude in designing its own technical charter and its own governing rules" ("How The ASF Works," 2011).

Management of the Mozilla project is spread over many community members through module "ownership" (Mozilla Modules and Module Ownership, 2011). Modules are small sections of the project code for which the owners are responsible. Module owners receive help from "peers" who approve code for submission into the project. Module owners rely on these peers to check their own code because no member is allowed to check their own contribution (Mozilla Modules and Module Ownership, 2011).

> The Mozilla project is far too big for any one person – or even a small set of people – to make ongoing decisions regarding code appropriateness, quality or readiness to be checked into the CVS source repository. … decision-making is distributed to a range of participants through its "modules" and module ownership. A module is a set of files that implement a piece of functionality with reasonably defined boundaries. (Mozilla Modules and Module Ownership, 2011, para. 1)

7.1.3 Adaptive Leadership

Another component of case study leadership is its adaptability to the various and diverse abilities of the community members. The case study projects evolved and adapted through changes in membership and community objectives. Based on the changing environment, leaders took advantage of new opportunities and changed direction as required by circumstances.[17] The shared governance discussed above

---

[17] Eric Raymond, originator of the FOSS fetchmail project and author of the seminal essay on FOSS "The Cathedral and the Bazaar", recognized the importance of adapting the project to the abilities of the contributors and the necessity of the kernel author to accept code that improves the project. Often the

provided a structure in which member needs and abilities determined the direction of the community. The ability to adapt to membership needs resulted in community success and longevity for each of the case study communities.

7.1.3.1 19th Century Case Studies

Leaders of the 19th century case study communities were aware of members' aptitudes and weaknesses and at critical junctures changed course in order to keep the community intact. Adaptable leadership was better able to keep the community together and provide an environment which best utilized members' abilities to contribute to cooperative innovation. Oneida Perfectionists, Shakers and Mormons were viewed as strict doctrinal adherents; however, leaders of these communities were willing to adjust their religious requirements, as well as, work and community structure in order to adapt to their memberships' abilities.

Early Shaker leaders resisted written codification of beliefs and it wasn't until 1821 that the first "Millennial Law" was issued which set forth in writing the concepts practiced since the early Shaker period. Even with the Millennial Law in place, the Law was changed regularly and individual villages were "given permission to adapt the laws as needed according to the time and place in which the village existed" (Carter & Geores, 2006). Often only handwritten copies of the rules were kept due to the tendency to change – one version of the Millennial Laws lasted only 5 years before being rescinded (Alexander & Keep, 1995). Regulations that had been enforced were "modified or

---

project originator will need to put aside their code in order to implement a better code contributed by another volunteer. (Raymond, 2002) dropped altogether" by Shaker leaders (Hinds, 1878, p. 99). Additionally, Shaker leaders adapted to new technologies and innovations whether developed from within the community or outside. "Labor was allocated flexibly to the different branches of production, allowing communities to adapt to changing circumstances" (Cooper, 1987, p. 4).

Mormon leadership focused on the needs and abilities of the community members by discontinuing strict adherence to the Law of Consecration when it was seen to not be working and tithing was instituted in its place (Arrington, 1971; see also Smith, 1981, Section 89). Leaders again implemented communitarian principles once established in Utah which they adapted to the harsh conditions of the Salt Lake Valley by cooperatively developing irrigation canals for agriculture (Gardner, 1917). Mormon community members did not act according to "a definite code of rules and regulations previously drawn up, but because with their nature and ideals and under their environment, their course was the natural and logical one to follow" (Gardner, 1917, p. 472). Both religious and innovation leaders encouraged the group to adapt to a potentially better method of counting miles through innovation (Wright, 1997-98).

According the Hand-book of the Oneida Community (Oneida Community, 1867), Oneida Perfectionists were convinced that a community run by rigid laws and rules was a "grave mistake" and would serve to destroy the "affective bonds of community" with a focus on legal prescriptions. As such, the community was able to change from its previous direction that restricted animal trap production to become an important producer of high quality animal traps when the opportunity for commercial success was presented (Newhouse, 1865). "…[V]arious lines of manufacturing and commerce were taken up…

[t]he point was to adapt as circumstances required yet always in the service of Community ideals" (Cooper, 1987, p. 8). When the opportunity arose to make money from the production of traps, leaders motivated members to produce and improve the animal traps by reconciling the community's peaceable and vegetarian practices with their teachings that the world would reach its perfect state only through ridding it of vermin and rodents facilitated by their traps. Oneida members had a "preference for creative flexibility [which] helped to shape the economic practices that developed" (Cooper, 1987, p. 15).

7.1.3.2 21st Century Case Studies

The importance of adapting the project to the abilities of the contributors is seen in the flexible direction of each FOSS project. Often the project originator puts aside their own code in order to implement a better code contributed by another volunteer. (Raymond, 2002). Each of the case study projects illustrated the importance of moving the software in the direction of the developers' talents and abilities.

Linux moves in the direction of the best code contributions. Any of the developers can "improve Linux and influence the direction of its development" (Corbett, 2008, p. 2). The Linux leadership focused on including the best quality code and allowed the project to go in the direction of the best code contributions.

Instead of letting the HTTPD web server project die when the core inventor left, a small online community of individuals formed in order to provide technical support and improve the software through online collaboration. This transition of leadership adapted to the needs of the community and provided leadership for developing the HTTPD software into Apache software. As Apache software became the most used web server software, the Apache Software Foundation (ASF) was formed to meet the financial and legal responsibilities of the community and implemented a system through which its bylaws are modified and changed through the votes of its board members (Taft, 2010).

Mozilla described its system of adapting to the best contributed code as a "meritocracy" and has determined it is a "resilient and effective" method in leading the community (Mozilla Roles and Leadership, 2011). Leaders have a "fair amount of flexibility" in how they function. Mozilla does not have an "elaborate set of rules or procedures" (Mozilla modules and module owners, 2011).

7.2 Socioeconomic Structures

Sin and self, produce private property. Innocence and self-denial, produce community of property (Evans, 1888, p. 186).

Table 7.2 summarizes the socioeconomic structure of each of the case study communities. Distribution of property and equality is significant to the purpose and function of each case study community.

Each of the case study groups created non-traditional socioeconomic structures that emphasized fundamental equality among community members. Fundamental equality, including access to community property, was a key principle of the six case study groups and influenced production and social relationships among group members. Table 7.2 summarizes the practices of communitarian property distribution and fundamental equality.

TABLE 7.2 - Socioeconomic Structure

	Property Distribution	***Fundamental Equality***
Shakers	Shared property based on early Christian teaching	Equal opportunity for male and female members. Implemented celibacy to avoid unequal power
Mormons	Property re-distribution based on need according to "Law of Consecration"	Implemented polygamy to provide fundamental equality to unmarried women
Oneida	Shared property based on "heavenly association"	Women and men shared business leadership and work duties. Implemented Complex Marriage to share all thing
GNU/Linux	Free and open access to intellectual property	Virtual community relationships based on meritocracy
Apache	Free and open access to intellectual property	Virtual community relationships based on meritocracy
Firefox	Free and open access to intellectual property	Virtual community relationships based on meritocracy

7.2.1 Equality of members

The case study communities shared real or intellectual property and sometimes both among its group members which set the foundation for fundament equality in social and economic relations, including the organization of labor, community governance, and communication. Fundamental equality, as opposed to absolute equality, is defined as equality in "important relevant and specified respects" and not the "implausible principle of treating persons equally" (Gosepath, 2009, para. 2). Based on the premise of fundamental equality, each case study community defined equality differently and, as a result, implemented different socioeconomic structures. Based on the concept of fundamental equality, each of the socioeconomic structures implemented nontraditional methods of production and property sharing.

7.2.1.1 19th Century Case Studies

Nineteenth century case study communities based production and distribution of resources on nontraditional social and economic structure that emphasized fundamental equality. [18] The traditional 19th century family structure, with wife and children viewed as economic property of the male, established the prevailing relationship for production and distribution of property. Much of the economic production and distribution was focused on family-based business, agriculture and in-home production. The household was the "institutional nucleus" (Katz, 1997, p. 277) that served to reinforced the traditional family unit as the economically and socially relevant structure. The communitarian movement created social and economic structures based on fundamental equality that challenged the status quo. Each of the 19th century case study communities implemented very different socioeconomic structures of celibacy (Shakers), polygamy (Mormons) and polyandry (Oneida Perfectionists). Even so, each of these non-traditional socioeconomic structures emphasized fundamental equality and shifted the focus away from the existing economic unit of the traditional family to the larger economic structure of the community "family." To reinforce the concept of community family, community members often used familial terms to reference each other: brother, sister, father, and mother.[19]

---

[18] In theory, the concept of member equality was critical to all 19th century communitarian experiments, at least in terms of real property ownership. Even so, many of the groups that disbanded quickly were unable to practice the theory of property equality with success. New Harmony fell apart as Owen tried to salvage his fortune and sold off parcels of land to the community members (Smith, 1897). Other communities attracted members who were not committed to the concept of equality in practice leading to confusion, jealousy and ultimately dissolution.

[19] Christoph Brumann compared monogamous communities with celibate and other nontraditional family arrangements. He concluded that "communes built on monogamous marriage have proved more successful." He contradicts Kanter who found that celibacy or free love was associated with community

For Shakers the concept of equality through shared property was an essential component of their religious beliefs founded on the early "original Christianity." The distribution of income and wealth was "essentially equal" and based on the idea of "to each according to his needs" (Cooper, 1987, p. 4). The Shaker community was organized into smaller groups of "Families" which were economically independent of each other and shared their wealth with other members of their own Family. During times of need, Shaker Families redistributed the available food equally to other Shaker Families (Cosgel et al., 1997).

Inequality of males and females in traditional social and economic structures was resolved by the Shaker community through the practice of celibacy. "Where there are husbands and wives and private property, there will be "fightings," and these necessarily lead to disintegration and dissolution" (Evans, 1888, p. 184-85). Shaker males and females were equal in government and work although they "were kept separate in occupation as in most other areas of life" (Cooper, 1987, p. 4). Although separated in work and living arrangements women were "as free as men to speak in their meetings; … to write for their paper; … [and to] manage their own departments of industry independently of the men" (Hinds, 1878, p 102).

The Mormon "Law of Consecration" [20] provided fundamental socioeconomic equality through re-distribution of property. "That you may be equal in the bonds of heavenly things, yea, and earthly things also, for the obtaining of heavenly things. For if

---

longevity by "erasing the family as a potential competitor for members' loyalties, they strengthen the larger social unit of the commune." (Brumann, 2003, pp. 398 & 417)

[20] The Law of Tithing, a law implemented to prepare for the higher Law of Consecration, also required each member's "surplus property to be put into the hands of the bishop" (Smith, 1981, p. 238).

ye are not equal in earthly things ye cannot be equal in obtaining heavenly things…" (Smith, 1981, p. 147).

Members contributed property to a common storehouse from which the property was redistributed based on the needs and fair desires of each family. It was left to the judgment and conscience of each individual steward and the Bishop (a leader of a small group) to determine what was fair (Gardner, 1922). The practice of polygamy provided fundamental economic and social equality for women within the community who otherwise would be hampered in their practice of the Law and remain in a vulnerable economic and social position.

Oneida Perfectionists based their shared property belief on Christian teachings and taught that "…one of the leading principles of heavenly Association, is the renunciation of exclusive claim to private property" (Oneida Association, 1849, p. 3). The Oneida Perfectionists created a socioeconomic structure in which shared property ownership extended to marriage relationships. "For Noyes and the rest of the Oneida Community, selfishness, the major sin of the outside world, was inherent in two basic institutions: exclusive marriage, which subjected women to a condition of slavery, and private ownership of wealth, which encouraged greed and acquisitiveness" (Olin, 1980, p. 291).

Based on their interpretation of fundamental equality, the Oneida Perfectionists redefined the concept of marriage and instituted polyandry which they referred to as "Complex Marriage." The practice of Complex Marriage restricted any one man to claim "ownership" of any one woman and promoted fundamental equality in social relationships. Fundamental equality was also promoted within business ventures among the genders, "…two of the leading businesses of the Community are superintended by women, … Women also keep the accounts of the community…and are allowed a fair chance with their brothers in education and labor" (Oneida Community, 1876, p. 19).

<u>7.2.1.2 21st Century Case Studies</u>

Similar to the 19th century case study groups, FOSS communities also challenged the prevailing socioeconomic structure of property rights – in these cases, intellectual property rights. By the late 20th century, corporations held the "social, political, and economic context" of software production to which FOSS communities reacted and fought against (Cole & Lee, 2002). FOSS communities transformed the prevailing proprietary development and distribution methods of software and implemented cooperative software development. The FOSS case study communities discarded traditional corporate power structure and implemented fundamental equality by disregarding the member's position or authority (Raymond, 2000). All members of the community were respected for their contributions to the community and not for their position (Raymond, 2002).

Contributing to Linux development is accessible to anyone with the necessary skills (Corbet, 2008). The concept of equality extends to each community member, whether users or developers. Torvalds noted that the person who understands how to fix the problem is not necessarily the person who identifies the problem. Both parts of the problem – finding and fixing – are equally important (Raymond, 2002). Furthermore, users of FOSS are critically important in finding and reporting bugs. "Treating your users as co-developers is your least-hassle route to rapid code improvement and effective debugging" (Raymond, 2002, The Importance of Having Users).

Apache software development was centered on virtual relationships which created physical, social and power relation anonymity among members and helped promote fundamental equality within the community (Apache, HTTP server project, 2011). Corporate affiliation or position did not determine priority of a contributor's code – only the merit of the code determined inclusion in the software releases and the direction of the project. Because of this, even board members or directors rarely acted in an official capacity within the cooperative innovation communities (Apache, HTTP server project, 2011).

As with the other FOSS case studies, any individual could participate in the Mozilla community through code development or through becoming a user. For those who developed code, merit not position or authority determined which code was admitted to the final releases (Mozilla Roles and Leadership, 2011).

7.2.2 Property Distribution

All case study communities redefined traditional property ownership structures and disassociated the distribution of output from member contribution. Access to knowledge created through cooperative invention was openly available to all community members. The inventions resulting from communitarian innovation were sometimes patented to protect the property from misappropriation. Intellectual property developed in both the 19th and 21st century case study communities was often used by those outside the community for commercial purposes.

7.2.2.1 19th Century Case Studies

Regarding distribution of intellectual property rights, information is limited on the attitudes and beliefs of the 19th century case study groups. However, there is evidence that the inventions of these groups were often not patented except in rare cases and usually to protect against misappropriation by those outside the community.

Shakers made their position clear on intellectual property and were, on moral principle, against patent and monopoly profits as "contrary to God and godliness, and destructive of the means of right living" (Evans, 1888, p. 255).[21] Shakers believed that "whatever [a Shaker] invents is for the use of the whole world." This attitude provided opportunity for others to appropriate and profit significantly from some of the Shakers' inventions (White & Taylor, 1904; see also n.a., 1905).

There is no record that the Mormon roadometer innovation was ever patented. However, a guidebook titled "*The Latter-day Saints' emigrants' guide*" was published based on the mileage records obtained from the improved roadometer and was used extensively by other emigrants.[22]

There is no clear record that the Oneida Perfectionists rejected patent protection on religious or moral principles; however, a review of the US Patent and Trademark Office records shows no patent for Newhouse or Noyes for any trap innovations.

---

[21] Evans clarified that this position against monopolies applied specifically to those items essential to human subsistence – the Shakers did patent a small number of their patents to protect their interests (Evans, 1888).

[22] The complete title is: The Latter-day Saints' emigrants' guide: being a table of distances, showing all the springs, creeks, rivers, hills, mountains, camping places, and all other notable places, from Council Bluffs, to the Valley of the Great Salt Lake. Also, the latitudes, longitudes and altitudes of the prominent points on the route. Together with remarks on the nature of the land, timber, grass, &c. The whole route having been carefully measured by a roadometer, and the distance from point to point, in English miles, accurately shown (Crawley, 2005).

Additionally, there is evidence that other trap makers pirated the trap designs and name of the popular “Newhouse Trap” (Newhouse, 1865).

7.2.2.2 21st Century Case Studies

The basis of property distribution in the FOSS communities was to maintain free access to the intellectual property created by the community. Community members who contributed to or who used the community’s intellectual property legally agreed to maintain free access to the innovation.

The Linux license is designed to ensure “freedom to distribute” software copies and to “change the software or use pieces of it in new free programs” (GNU Operating System, GNU GENERAL PUBLIC LICENSE Version 2, 1991, Preamble).

The Apache FOSS community was initially established through an online mailing list of interested users. The intent was to keep the software freely available and to provide a forum for updates and patches – the objective of keeping the software freely available to all who want to use, access or change the software has continued throughout Apache’s growth and popularity (Apache, HTTP server project, 2011).

Mozilla was created to take the Netscape browser from commercial software to openly available software. Netscape changed the structure of its organization and became an open source project with the intellectual property freely available to anyone who wanted it (Raymond, 2002).

7.3 Organization of Labor

> …members of a commune might actually have a more positive attitude toward work itself. Because communes, unlike private firms, attract individuals to a strong ideology or religious belief that often views work as good or even as worship, a self-selection mechanism might ensure that only hard workers join the commune. (Cosgel et al., 1998, p. 555)

None of the six case study communities compelled its members to work but rather encouraged them to contribute labor based on self-identified abilities and interests. According to their interests and abilities, members formed subgroups to perform their work. ***Table 7.3*** summarizes the organization of labor in each of the case study communities.

7.3.1 Labor Self-Selected, Not Compulsory

According to Radner (1992, p. 1388) corporations centralize information and require managers to "monitor the actions of other firm members" and set the goals and values of each employee. Put differently, the "control of individual behavior through organization is what defines the modern managerial corporation" (Lipartito & Sicilia, 2004, p. 96).[23] Labor in the case study communities was seen as a means of enjoyment and self-improvement, as well as a way to meet individual and group needs and also enhance the individual's or community's reputation. The organizational structure of each 19th and 21st century case study community generated a cooperative environment in

[23]One example of rigid traditional hierarchy and control is within NASA which has been criticized for its "command and control" structure. This rigid structure is blamed for hampering innovation and leading to unfortunate results. Crash investigators of the Columbia space shuttle failure stated that NASA's culture "discouraged dissenting views on safety issues." The flow of information and the organizations view of criticism discouraged dissenting views from those who disagreed with the institutional results with disastrous outcomes (Gloor, 2006, p. 80).

TABLE 7.3 - Organization of Labor

	Method of Organizing Labor	***Subgroup Structure***
Shakers	Self-selected and regularly rotated positions	Communities organized into Families - cooperative innovation through subgroups
Mormons	Self-selected based on own abilities	Community organized into small subgroups – cooperative innovation through a few individuals
Oneida	Self-selected and regularly rotated positions	Community organized into various business subgroups - cooperative innovation sub-groups improved technology and mechanized production
Linux	Self-selected and based on own abilities	Subgroups led by core developers and assisted by periphery developers built on original "kernel"
Apache	Self-selected and based on own abilities	Subgroups led by core developers and assisted by periphery developers built on original "kernel"
Firefox	Self-selected and based on own abilities	Subgroups led by core developers and assisted by periphery developers built on original "kernel"

which members participated based on the contributors' self-identified skills.

7.3.1.1 19th century case studies

The objective of the 19th century community was not to make labor compulsory but to make it a means of worship and self-improvement. Member commitment to advance the community's social agenda was tied to religious teachings of labor as a joyous endeavor and a means to achieve personal improvement. Work was considered a "sacred activity and meant to be joyous" (Cooper 1987, p. 12).

Work was a form of worship for the Shakers, and as such was an important part of the personal development process. Efficiency in labor was sought after and any waste in time or energy was considered a sin (Alexander & Keep, 1995). Shakers found a great deal of variety and personal expression in their work (Alexander & Keep, 1995). Individuals were encouraged to work in areas that they found interesting and enjoyed (Andrews & Andrews, 1974). Each member was free to work in various areas and mastered several different skills.

Under the Law of Consecration, Mormons worked as they chose in order to meet the mandate of faithful stewardship. Individuals were expected to work in a manner that suited their own skills and talents and "laboring as far as practicable in the sphere of his choice" (Gardner, 1922).

The Oneida Perfectionists encouraged labor as a desirable activity and means of self-improvement. The Oneida Handbook (1867, p. 20) summarized the community's position on labor: "Compulsory labor is neither sought nor permitted in the Communities. The aim is to make labor attractive, and a means of improvement." Community members wrote on a slip of paper his or her preferred area of work. From these requests, the organizing committee would make work appointments based as closely as possible to the stated preferences of the members (Oneida Community, 1867).[24] The group encouraged members to invent new ways of producing goods and providing services in order to enhance efficiency and reduce necessary labor time.

[24] … a conspicuous bulletin invites every one to hand in a written slip, stating what department of business he would like to engage in, etc. An organizing committee is appointed at this annual meeting who select foremen for the different departments of business, and apportion the help, keeping in view as much as possible the expressed choice of individuals. (Oneida Community, 1867, p. 13)

7.3.1.2 21st Century Case Studies

FOSS case study groups created an organizational structure that encouraged members to self-select their own work. Contributors to the FOSS case study communities determined which project best suited their own talents, abilities and interests and chose where and at what level to contribute (Benkler, 2002; see also Wheeler, 2007). The system of organizing labor in the FOSS case study groups was comparable to the 19th century groups even though FOSS members were widely dispersed and rarely met face-to-face.

Each community member chose how they wanted to contribute to the development of the Linux project. Based on each member's self-identified abilities they could contribute code, identify or fix bugs, or even contribute to Linux by adding information to the Linux website or contributing scholarly articles (Corbet, 2008).

Contributors to the Apache software chose problems to work on based on their own interests – typically those areas of code with which they were most familiar. The software is divisible into "core functionality of the server, which every site needs, from the features, which are located in modules" (Herbsleb & Mockus, 2002). This divisibility into smaller projects was important to the ability of workers to choose specifically the areas that interested them and where they wanted to contribute (Apache Foundation, 2010).

Mozilla organized its code development into modules with module owners and contributors chose to develop in the module of most interest. As with the other FOSS case study groups, Mozilla included contributions from code developers, identifiers and fixers of bugs and also those who simply used Firefox software (Modules and Module Owners, 2011).

7.3.2 Subgroup Structure

Group structure within cooperative communities is important in developing reciprocal relationships (Cosgel et al., 1997). In the case study communities, subsets of the communities provided a structure in which members created reciprocal relationships through peer review of work which contributed to the efficiency and quality of knowledge creation (Cosgel et al., 1997). Communities created subgroups both formally and informally and members often moved between subgroups depending on their desire to contribute. This subgroup structure provided an environment within which members contributed innovative ideas – as community members saw a need or observed an opportunity, they put forth ideas to others in the community and a subgroup of members brought the idea to a final success.

7.3.2.1 19th Century Case Studies

Nineteenth century case study communities developed innovation in subgroups of members who provided the needed skills for creating or improving the innovation. The subgroup structure was informally implemented in the Mormon community and more formally in the Shaker and Oneida communities.

Shakers organized into subgroup called "Families" dispersed in several states. These subgroups produced a variety of new knowledge made available to the larger group of communities. For example, the Lebanon group invented the circular saw

(Rothschild, 1981), and the printing press used for printing seed bags was invented by the Shakers at Watervliet and improved by the Lebanon Shakers (Buckingham, 1877).

The Mormon roadometer invention was initiated by two core inventors, Clayton and Pratt, and several other community members contributed to the invention through engineering skills, quality review and technical refinements. The subgroup of cooperative innovators changed during different phases of the invention based on contributors who had the necessary skills for the job.

Noyes, Newhouse and "several young men" formed a subgroup of the Oneida Perfectionists who developed improvements to the trap and to the trap-making process. Through the "ingenuity of [the community's] machinists," the production process was improved and the subgroup created machinery to produce the spring which before was handmade (Newhouse, 1865).

7.3.2.2 21st Century Case Studies

According to Richard Stallman, the core inventor of GNU, coordinating many part-time workers to develop a new software program would normally be a very difficult problem; however, in developing a new Unix system this problem did not occur because the program "contains hundreds of utility programs, each of which is documented separately" (Gay, 2002, p. 35). Software programming projects were easily divisible into various subcomponents which helped in coordinating members' work contributions through online communications. FOSS contributors could simultaneously work on various subcomponents of the project without close coordination of other members' contributions. The outcome was that many small contributions were added together to create an operating software (Gay, 2002).

Among Linux developers there is a relatively small group of core contributors who contributed the majority of the code used in the Linux kernel. The contributors on the "periphery" are sorted into those who contributed code and those who identified or fixed software bugs (Cole & Lee, 2003; see also Corbet, 2010).

Separate subgroups within the FOSS communities worked on different aspects of the cooperative innovation which helped to organize hundreds of members "united by a common set of goals" (How the ASF works, 2011). One study of the Apache Group (AG) shows that small subgroups of active "core" developers work on specific sections of code (or "projects") at any given time. "[C]ore developers at any point in time include the subset of AG [Apache Group] that is active in development (usually 4 to 6 in any given week) and the developers who are on the cusp of being nominated to AG membership (usually 2 to 3)" (Herbsleb & Mockus, 2002, p. 3).

For the core developers who contribute the majority of the code and other changes, the size of the core team in those modules studied by the analysis ranged from 22 to 35 members (Herbsleb & Mockus, 2002).

The Mozilla community organized into subgroups based on skills, level of contribution, and area of the project. One study found that the team of "core developers" who submitted the majority of the code used in the Firefox software was relatively small (25 to 35 contributors) compared to the number of community members who submitted bug fixes (47 to 129 contributors) and those who found and reported software bugs (119 to 623 contributors) (Herbsleb & Mockus, 2002).

7.4 Peer Evaluation and Open Communication

Each case study community created an environment of peer evaluation which focused on improvement of the innovations. Communities practiced open discussion among community members to disseminate objectives and outcomes. The creation of new knowledge is based on open communication, with criticism and error correction as a fundamental aspect of the process (Popper, 1989 as cited in Cole & Lee, 2003). A "communication network" through which individuals obtain and share knowledge is important for creation of new knowledge (Radner, 1992). The case study groups developed organizational structures in which openly evaluating each other's work and disseminating information was a key element within the cooperative communities. ***Table 7.4*** summarizes the leadership attributes of each of the case study communities.

7.4.1 Peer review

Each of the case study groups developed a method to improve knowledge creation through peer evaluation. Peer evaluation allowed case study communities to implement error correction in the communitarian innovation process.

7.4.1.1 19th Century Case Studies

Each of the 19th century case study groups relied on peer review as an important aspect of the knowledge creation process. Critical review of colleagues' work provided needed information and improved the innovation. Oneida Perfectionists formalized the

TABLE 7.4 – Communication and Peer Review

	Open Communication	***Peer Review***
Shakers	Open communication through meetings and inter-community visits	Informal process by peers working on project
Mormons	Informal open discussion among member and formal meetings	Review of innovation by peer
Oneida	Formal community business meetings	Mutual Criticism
GNU/Linux	Informal open email discussion among members	Formal procedure for all code submitted to the software
Apache	Informal open email discussion among members	Formal procedure for all code submitted to the software
Firefox	Informal open discussion among member and formal meetings	Formal procedure for all code submitted to the software

peer review process within their community; however, the Mormon and Shaker peer review process was less structured and based on informal communication between members.

Shakers visited and communicated among different communities in order to freely share innovation knowledge between groups. Representatives were often invited from other Shaker communities to share techniques and learn new methods of production (Carson et al., 2000). The Shaker "Manifesto" states that to have a united and improved community, members must "… cherish and strengthen all that is worthy, and what is not try to correct and make it worthy..." (Blinn, 1884, p. 155).

Once arriving in the Salt Lake valley, leaders felt the roadometer should be improved and repaired before a group of men were to return east to help others make their way to the valley. Through the peer review process on the original roadometer, William King and others created additional improvements to the device (Wright, 1997-98; see also Egan,1917).

The Oneida Community formally practiced the concept of “Mutual Criticism” as part of their community interaction. Mutual Criticism facilitated the community members’ goal of achieving perfection and made no distinction between business, physical or spiritual activities (Oneida Community,1876). The system of peer review allowed each person to periodically stand before the body of the community and receive input on what the person must do to improve in their work and community life (Oneida Association, 1849). Based on the group’s observations, mutual criticism provided opportunity for recognition and praise. Mutual criticism created an atmosphere of improvement as well as positive recognition (Oneida Community,1876).

7.4.1.2 21st Century Case Studies

Each of the FOSS case study groups practiced a formal peer review process in which code written by community members went through a peer evaluation process prior to inclusion into the software kernel. Each innovation of software code was subjected to a review process performed by colleagues. This review process improved the quality of the innovation through the diversity of reviewers’ skills and abilities (Cole & Lee, 2003).[25] “No matter how strong the original developer’s skills are, this review process invariably finds ways in which the code can be improved” (Corbet, 2010, pp. 15-16).

---

[25] Torvalds wrote in an email to the Linux kernel mailing list that the point of a peer review and open development is that people with diverse backgrounds will often catch mistakes of other contributors (Cole & Lee, 2003).

Each contribution of code was openly available to every community member who could then choose to review and evaluate the proposed contribution. Open access to code encourages criticism as a "cultural norm in the FOSS communities and increases the likelihood of uncovering error" (Cole & Lee, 2003, p. 639). One FOSS leader stated that "decentralized peer review trumps all the conventional methods for trying to ensure that details don't get slipped" (Raymond, 2002, "On Management," para. 22).

It is a good idea to post "in-progress work" in order to get the community's feedback on improving the code contribution (Corbet, 2010). The review process begins with a post to the appropriate Linux mailing list corresponding to a particular part of the Linux code in question. After responses from the mail list members, there is a "wider review" which opens the review to the larger Linux community. At this stage, any successful new code or patch will be merged into the main Linux kernel (Corbet, 2010). "[C]riticism and error correction serv[ed] as a driving force for Linux development" (Cole & Lee, 2003, p. 640).[26]

Apache PMC helped to develop and maintain a community culture of peer review. Section 6.3 of the ASF Bylaws (How the ASF works, 2011).

> …the role of the PMC is to further the long term development and health of the community as a whole, and to ensure that balanced and wide scale peer review and collaboration does happen. Within the ASF we worry about any community which centers around a few individuals who are working virtually uncontested. We believe that this is detrimental to quality, stability, and robustness of both code and long term social structures.

Anyone can subscribe to the Apache mailing lists and proposed software code changes "…are reviewed by many people outside the core development community, which often

[26] The critical review process eliminates unacceptable code innovation – one study showed that only 23% of the Linux code submissions made it into the final release (Cole & Lee, 2003, p. 644).

results in useful feedback before the software is formally released as a package" (Herbsleb & Mockus, 2002, p. 175).

Mozilla code changes are subjected to a peer evaluation process. A minimum of two engineers who are familiar with the overall code must review the new code prior to further testing and evaluations. At that point the code is released to the entire Mozilla community whose members review and test the code changes in the code test releases which occur two or three times a day (Wheeler, 2007).

> Code review is our basic mechanism for validating the design and implementation of patches. It also helps us maintain a level of consistency in design and implementation practices across the many hackers and among the various modules of Mozilla. We currently have two levels of review, known as "review" and "super-review." (Knous, 2011, "What is the purpose of code review?")

7.4.2 Open Communication

In addition to peer review procedures, each of the case study communities developed an environment of open communication and discussion enhancing the process of cooperative innovation.

7.4.2.1 19th Century Case Studies

Each of the 19th century case study communities practiced open communication among group members and shared information and knowledge among each other. Oneida Perfectionists held official business meetings open to all members; Shaker communities also held open business meetings and traveled extensively among the various communities sharing innovation and new knowledge. Mormon communication was mostly informal and occurred spontaneously among individuals and in group meetings.

At Union Village in Ohio, the Shaker family met once a week "male and female, young and old…were gathered to overhaul the accounts of the week and to discuss all the industrial occupations of the Family" (Hinds, 1878, p. 102). Although these meetings do not appear to be universal among all Shaker Families, the Shakers published The Shaker Manifesto which provided an opportunity to communicate between community members. Also, Shakers designed community buildings to include a room large enough for "union meetings" where the men and women come together, sitting on opposite sides of the room, "spend an hour in conversation, or reading, or singing, as they choose" (Hinds, 1878, p. 110). Shakers openly shared knowledge and information among members of the communities and members would visit other Shaker communities to share new procedures and innovations.

The Mormon community communicated ideas and information through formal and informal communication avenues. Camp meetings were used as a communication venue for the entire community and spontaneous communication among individuals and smaller groups. Communitarian innovation was discussed in group settings (camp meetings) where the concept of the roadometer was discussed. The merit of the idea was discussed with the group as was the estimated time to completion (Wright, 1997-98).

Oneida Perfectionists practiced open communication through daily meetings and a weekly business meeting. Every member of the community was invited to the Business Board meetings where all of the heads of the different Oneida business met to discuss business issues and decisions. The evening after the Business Board meeting, the secretary would read to the entire community the business report and the members were given the opportunity to discuss on any measure passed by the Board. Business matters were frequently "referred for discussion and decision by the Board to the general meetings." The objective was to keep "constant communication" between the Board and the community and unanimity was sought by the committees, Business Board and the community (Oneida Community, 1865, pp. 12-13). [27] Oneida operated with broad management with input from the community members, "[a]dministration of the group's affairs fell to the lot of 21 standing committees and 48 functional departments … but major decisions were taken at general meetings" (Cooper, 1987, p. 8).

7.4.2.2 21st Century Case Studies

Similar to the 19th century communities, the FOSS case study communities kept communication open to the entire community. Unlike the 19th century communities, however, FOSS community communication occurred via asynchronous electronic means rather than face-to-face communication.

Development work on the Linux kernel is done through email lists where anyone can join and email traffic is very high and conversations can be "severely technical." This

[27] "…Business Board, comprising the heads of industrial departments and such others as choose to attend its sessions…. All the members of the Community are free to participate in the deliberations of this Board, and it is a limited body only because all who are not especially interested in managing, generally choose to stay away. The report of the secretary is read to the entire Community on the evening following the session of the Board, and opportunity is then given for discussion of any measure resolved upon by the Board; and business matters are frequently referred for discussion and decision by the Board to the general meetings; so that constant communication is kept up between the Board and the mass of the Community…. In determining upon any course of action or policy, unanimity is always sought by committees, buy the Business Board, and by the Community." (Oneida Community, 1865, pp. 12-13)

open electronic forum for the Linux kernel is the venue "where the kernel development community comes together as a whole" (Corbet, 2010, p. 9).

For the Apache community, group communication is also generally done through mailing lists and online forums or "virtual meeting rooms." Anyone who wants to participate in the Apache software development can join a developer mailing list and receive messages, join technical discussions, changes in the code and reports of problems, among other types of messages (Herbsleb & Mockus, 2002). These asynchronous communications are archived and accessible to the FOSS community at any time (How the ASF works, 2011). An example of the open communication policy is the ASF announcement in 2010 regarding the serious intrusion into the Apache systems. ASF explained in detail a full analysis of the attack and the weaknesses that were exploited. This open communication to contributors, users and others is particularly remarkable when compared to the secrecy and closed communications that are practiced within proprietary software firms (Phipps, 2010).

Mozilla similarly practices open communication. Every week Mozilla holds a meeting for anyone who is interested and provides the meeting access information to community members as well as the general public. Comments are not monitored and anyone can join the discussions and the minutes for each of the weekly meetings are archived at the Mozilla website (Knous, 2011.). Because of the constant and open communication within the community, the fanfare that would typically surround the release of proprietary software was missing when Mozilla announce the public release of Firefox 2 (Freedman, 2007).

7.5 Member Commitment

> The incorrigible idler seldom inflicts himself on them, and when by chance he does, it is he who is the miserable person, for the whole tone is “work and be happy,” and so he finds no suitable environment, and soon departs. (Evans, 1888, p. 261)

Community members within each case study group committed to community requirements through a signed or verbal agreement. Members were free to choose the commitment level at which they would contribute real or intellectual property. The level of membership did not determine the distribution of property.

The case study groups allowed for different levels of membership dependent on the commitment level of each member. Members determined the degree of commitment and contribution they were willing to provide to the community. Nineteenth century case study communities united social and economic aspects into a comprehensive member commitment. By comparison, FOSS membership agreements limited member commitment to intellectual property. ***Table 7.5*** summarizes the member commitment attributes of each of the case study communities.

7.5.1 Membership Levels

Each of the case study communities offered levels of membership with varying degrees of commitment. Those willing to contribute property and labor were subject to a different agreement than those with more narrow membership involvement.

7.5.1.1 19th Century Case Studies

Each of the 19th century case study communities provided a choice to potential members as to the level at which they wanted to contribute to the community. The level

TABLE 7.5 – Member Commitment

	Membership Levels	***Member Agreements***
Shakers	3 levels: Novitiate, Junior and Senior	Fully practicing members signed agreement to contribute all property. Rejected patents on moral principle but did patent some inventions for protection.
Mormons	Two levels of commitment - baptized members and Law of Consecration covenanted members	Law of Consecration and Law of Tithing. No clear policy against patents, but did not patent roadometer; others appropriated written record based on invention findings.
Oneida	New members went through period of apprenticeship or period of testing.	All property committed to the community. No available information regarding position on patents; no record of trap being patented; others appropriated name of trap.
Linux	Code contributors and users who are potential bug identifiers – other ways to contribute to community	Agreement signed to license intellectual property to community
Apache	Code contributors and users who are potential bug identifiers– other ways to contribute to community	Agreement signed to license intellectual property to community – additional changes could be kept proprietary
Firefox	Code contributors and users who are potential bug identifiers– other ways to contribute to community	Agreement signed to license intellectual property to community

of commitment determined the level of membership in the community; however, distribution of property was not dependent on the level of membership.

The Shaker community was organized to accommodate different levels of member commitment. Individuals joined one of three distinct groups: new members (Novitiates); more seasoned members (Junior Members) who did not practice all requirements; and the proven faithful (Senior Members) who freely contributed all property to the community (Hinds, 1878; see also Cosgel et al., 1997). Members of the "Novitiate" level were similar to members of any traditional religious group in that they maintained their traditional family living arrangement and retained their own personal property (Hinds, 1878). These members could move into one of the other groups depending on their desire to sign a “covenant” that “consecrated self and service and all one possessed to the cause” (Andrews, 1963 as cited in Alexander & Keep, 1995, p. 364). At the Junior Level, property contributions were optional and property would be returned if a Junior member left the community. Senior Level members committed all of their possessions, time and efforts to the Society. Shakers at this level also agreed that they will not be able to recover any of their committed property if they leave the community (Hinds, 1878).

Membership commitment in the Mormon community consisted of two levels. Each member on being initiated into the group was baptized, indicating a commitment to the teachings in the doctrinal works of the Mormon Church. Those Mormons who advanced and were considered worthy based on past performance to the community ideals were presented with the opportunity to enter into a more in-depth commitment to the principles of property sharing and community ideals (the Law of Consecration) and verbally committed to these ideals in a covenant ceremony (Endowed from on high, 2003). Those who accepted to the Law of Consecration committed property and labor for the benefit of the community. Those who were baptized only were not required to commit to the Law of Consecration.

The Oneida Perfectionists provided two levels of membership comprised of a probationary membership period which was implemented to determine if new members could live the community standards and contribute to its success. No claim by probationary members could be made for work performed and the community determined when and if a probationary member was ready to join in full membership (Estlake, 1900; see also Oneida Association, 1849, p. 16).[28]

7.5.1.2 21st Century Case Studies

In each of the FOSS case study communities, there were two broad levels of membership: contributor and user. The FOSS user is anyone who uses the software and is the most basic community member. FOSS users can also be distinguished between those who find bugs and alert the rest of the community and those who use the software as developed. FOSS users are critically important in finding and reporting bugs. Both parts of the problem – finding and fixing – are equally important (Raymond, 2002). FOSS case study groups treated their users as co-developers which led to code improvement through debugging (Raymond, 2002; also Cole & Lee, 2003).

Linux, Apache and Mozilla contributors were organized into an informal two-tiered organization comprised of the relatively few "core contributors" and the much more numerous "periphery contributors" (Cole & Lee, 2003). The Linux community encourages input at several levels, including developer and user contributions. Other contributions include writing articles or tutorials, creating a blog, ask friends to join Linux.com", or create a new developer group (How to participate in Linux.com, 2011).

---

[28] As to the *legal* [emphasis in original] titles of land and other property, no special measures were taken to secure the Association from individuals. Those who owned or purchased lands in their own names at the beginning, retained their deeds, and no formal transfer of any property brought in by the members, was made to the Association. The stock of the company was consolidated by love, and not by law. (Oneida Association, 1849, p. 16)

Apache defines a user as a person who "uses" the Apache software. Users contribute by giving feedback on bugs and new feature suggestions. Developers are those members who contribute code or documentation to an Apache project. Developers are also included in the management of the Apache projects including the "committer" who is allowed access to the code (How the ASF works, 2011).

As with Linux and Apache, Mozilla also had membership levels among contributors and users. Users were encouraged to submit "crash" reports if a software application unexpectedly quits (Get involved with Mozilla, 1998-2010). Code contributors determined their level of commitment and activity in the development of the project. Mozilla also encouraged users to contribute in ways other than source code. Writers and designers contribute skills to develop and improve websites (Get involved with Mozilla, 1998-2010). Mozilla included several minimum levels of commitment including those members who only want to contribute unused bandwidth which allows Mozilla to increase service to millions of people (Get involved with Mozilla, 1998-2010).

7.5.2 Member Agreements

The case study agreements dealt with property contributed by members and the manner in which property would be distributed among the members. No person was forced to join any of the communities and no member was prevented from leaving.

7.5.2.1 19th Century Case Studies

Each member that joined one of the19th century case study communities was made aware of the community's requirements and committed to them as a term of membership. This commitment was made either in writing or verbally, and sometimes both. None of the 19th century case study member agreements separately accounted for intellectual property contributions which were considered part of the membership commitment to work for the benefit of the group.

A list of Shaker membership requirements included the requirement that each prospective member must join the group voluntarily and that "[n]o considerations of property are ever made use of by this Society to induce any person to join it, nor to prevent any person from leaving it" (Hinds, 1878, p. 90).

During the formal practice of the Law of Consecration, the Mormon bishop provided a written contract deeding the property to each individual. However, only the portion deeded to the individual was considered property that a departing member could keep – the portion given to the bishop would remain with the community of Mormons. (Smith, 1981) [29] During the informal practice of the Law, Mormon commitment was verbal and included the covenant to "devote both talent and material means" to the growth and benefit of the group (Talmage, rev ed. 1976).

The Oneida community agreement made clear that any work performed while a member of the Community was compensated through the benefit of the education and

---

[29] Section 51: 2-9. Wherefore, let my servant [bishop] Edward Partridge, and those whom he has chosen, in whom I am well pleased, appoint unto this people their portions, every man equal according to his family, according to his circumstances and his wants and needs. And let my servant Edward Partridge, when he shall appoint a man his portion, give unto him a writing that shall secure unto him his portion, that he shall hold it, even this right and this inheritance in the church, until he transgresses and is not accounted worthy by the voice of the church, according to the laws and covenants of the church, to belong to the church. And if he shall transgress and is not accounted worthy to belong to the church, he shall not have power to claim that portion which he has consecrated unto the bishop for the poor and needy of my church; therefore, he shall not retain the gift, but shall only have claim on that portion that is deeded unto him. (Smith, 1981, pp. 94-5)

care received while a member.[30] Members agreed that the benefits received during membership of the community were sufficient compensation if they ever decided to leave the community.

7.5.2.2 21st Century Case Studies

FOSS case study agreements, referred to as open source licenses (OSL), were much more detailed than the 19th century case study agreements. Although there are numerous different OSL agreements, the most commonly used is the General Public License or GPL which, as of 2005, was implemented by approximately 70% of FOSS projects (David & Tsur, 2005). The GPL ensures perpetual free access and distribution rights for the software by utilizing US copyright laws (David & Tsur, 2005). [31]

Not only are contributors of code subject to a strict licensing agreement, but also FOSS users who download the software are required to accept a licensing agreement

---

[30] If the member subsequently left the Community, the defector would be entitled to a “refund” of the contributed property or an “equivalent” amount. As a result of several legal actions, the practice of returning contributed property or other compensation to disaffected ex-members became a common practice among Utopian Socialists. (Rappites, Mormons, Amana and others.) A departing member would receive any real property, or its equivalent, with which he entered the Community. The Association maintained that it was doing this through generosity and not through obligation and no claim to anything other than the individual’s original belongings would be returned. When joining the Oneida Community, individuals would sign the following:

> On the admission of any member, all property belonging to him or her becomes the property of the Community. A record of the estimated amount will be kept, and in case of the subsequent withdrawal of the member, the Community, according to its practice heretofore, will refund the property or an equivalent amount. This practice, however, stands on the ground, not of obligation, but of expediency and liberality; and the time and manner of refunding must be trusted at the discretion of the Community. While a person remains a member, his subsistence and education in the Community are held to be just equivalents for his labor and no accounts are kept between him and the Community, and no claim of wages accrues to him in case of subsequent withdrawal. (Oneida Community, 1867, pp. 17-18)

[31] Because of the unusual use of copyright laws, GPL and other FOSS licenses are often referred to as “copyleft”. GPL is also referred to as a “viral” license because any other software that is released with code licensed under a GPL is also required to be licensed under the GPL (David & Tsur, 2005, pp. 7-8).

which gives the right to use and modify the software but restricts any attempt to limit the property rights through appropriation of the software (Lerner & Tirole, 2005).[32] FOSS case study members did not confer IP copyright of their contributions to the community but licensed their IP to each user which made it difficult for either the contributor or a third party to re-appropriate the IP (Benkler, 2004).

The Linux operating system was powered by the various programs developed in the GNU project and was itself licensed under the GNU General Public License (GPL) (Hasan, 2000).

> Torvalds initially distributed Linux under a licensing agreement that restricted any payment for the program, as well as requiring that all programs distributed or used with Linux be freely available. After half a year, however, he relaxed these restrictions. The number of users grew rapidly, from about one hundred in one year to half-a-million in 1994. (Lerner & Tirole, 2005, p. 209)

However, free access does not necessarily mean that the software is free in price (GNU License, Preamble), but rather that the freedom to access and redistribute the code and that contributors of code do no maintain legal rights (Wheeler, 2007). The Linux software is licensed under the GPL.

---

[32] That does not mean, however, that all OSL are the same. Some OSL are much more permissive in redistribution of the source code than is the GPL. The Berkeley Software Distributions (BSD) license is an early and well-known OSL which allows those who modify and add to the original source code to redistribute the resulting software without restrictions on the type of license. Based on the type of restrictions or permissions the kernel author wants to impose on the FOSS project will also likely determine the type of contributors to the project. Those who do not want to see their FOSS contribution potentially redistributed as proprietary software will be less likely to contribute to a project licensed under the BSD than the GPL (Lerner & Tirole, 2005, p. 108).

> Examples of cases where we would expect a restrictive license are projects geared for end users who are unlikely to appreciate the coding, such as computer games, or those sponsored by corporations, who potential contributors might fear would "hijack" the project and use the code for commercial ends. (Lerner & Tirole, 2005, p. 108)

The Apache Software license is similar in intent to the GPL in allowing users to "freely download and use" the software for personal or commercial purposes. The Apache license requires that each contributor grants a "perpetual, worldwide, non-exclusive, no-charge, royalty-free, irrevocable" license on the software (Licenses – The Apache Software Foundation, 2010, para. 2 and 3). However, unlike GPL projects the source code of proprietary or personal modifications to the Apache software do not need to be included in further free redistribution of the software (Apache license and distribution FAQ, 2011). GPL projects are not compatible with the Apache licensed projects and cannot be combined in Apache licensed projects because of the different license requirements (Apache license v2.0 and GPL compatibility, 2011). "Some licenses (e.g., BSD and its close cousin the Apache license) are relatively permissive, while others (e.g., GPL) force the user to distribute any changes or improvements (share them) if they distribute the software at all" (Lerner & Tirole, 2002, p. 229).

The Mozilla Public License 1.1 (Mozilla Public License Version 1.1, n.d., 2.2 Contributor Grant) states that "each Contributor hereby grants You [the user] a world-wide, royalty-free, non-exclusive license." Similar to GPL projects, code contributors must agree that their code will be freely available to redistribute and any modifications to the code are also subject to the terms of the original license (Mozilla Public License Version 1.1, n.d.). Initially, when Netscape was converting to FOSS the proposed license was to allow Netscape to "take pieces of the open source code and turn them back into a proprietary project again." Mozilla settled on the Mozilla Public License which specifies that Netscape cannot "regain proprietary rights to modifications of the code" (Lerner & Tirole, 2005, p. 108).

In summary, the case study groups share common organizational characteristics that provide a foundation for a communitarian innovation business model. The shared organizational structure is comprised of the following areas:

- leadership
    - motivational
    - shared
    - adaptable;

- socioeconomic design
    - property distribution
    - fundamental equality;

- organization of labor
    - self-selected, not compulsory
    - subgroup structure;

- internal communication
    - open communication
    - peer review; and

- member commitment
    - membership levels
    - member agreements.

CHAPTER 8

APPLICATION OF COMMUNIATARIAN BUSINESS MODEL TO BIOTECHNOLOGY

> An interesting question is whether the open source model can be transposed to other industries. … a number of ingredients of open source software are not specific to the software industry. Yet no other industry has yet produced anything quite like open source development. (Lerner and Tirole, 2000, p. 115)

While the academic community has focused efforts into understanding incentives, a broader question is whether the communitarian innovation business model can be successfully transported to other industries. Because of the lifesaving potential of more abundant food crops and medicine for neglected diseases combined with the high cost of research and development, biotechnology has received attention as a hopeful candidate for successful collaborative innovation. Several alternatives to the traditional business model have already been attempted including private-public partnerships and development prizes funded by governments (Orti, 2009). One area that provides hope of achieving societal goals of healthcare and food security is the communitarian innovation demonstrated by FOSS. A model of successful communitarian innovation groups is important to understand how biotechnology groups may benefit from communitarian innovation. According to Shulman and Schweik (2011, p. 162), the next step in the research is to

> … study the domains in detail where the OSS principles have been adopted and make case studies, then identify the similarities and differences, strengths and weaknesses in those approaches. This would finally lead to building analytic models that try to specify conditions that favor or hinder the experiments in open source.

In *Chapter 7*, I analyzed organizational characteristics common to cooperative innovation across six case study communities, three case studies from 19th century communitarian projects and three from 21st century FOSS communities. The purpose of this chapter is to apply these organizational characteristics to the biotechnology industry and determine the potential for success of communitarian innovation in this field. I have identified three cooperative biotechnology innovation communities for a case study analysis: CAMBIA, Tropical Disease Initiative (TDI), and Open Source Drug Discovery (OSDD). CAMBIA focuses on agricultural collaborative innovation while OSDD and TDI focus on collaborative innovation of drugs for neglected tropical diseases such as malaria, tuberculosis, schistosomiasis and leishmaniasis. These diseases receive little attention from the traditional patent-based research and development because of the relatively few people suffering from these diseases that could afford to pay for the patented drugs (Orti, 2009).

In ***Section 8.1*** of this chapter, I review the development of intellectual property rights in biotechnology and the impact on pharmaceutical and agriculture industries. The traditional structure drives the need for an alternative organizational structure to achieve broader societal goals than is currently motivated by the status quo. ***Section 8.2*** provides an overview of the three case study communities and in ***Section 8.3***, I compare the five structural characteristics discussed in *Chapter 7* to the three biotechnology case study organizations.

8.1 Impact of IPRs on Pharmaceutical and Agricultural Industries

The 1980 Supreme Court decision in Diamond v. Chakrabarty transformed the pharmaceutical and agricultural industries and launched the modern biotechnology industry.[33] (See Appendix C for further discussion on the pharmaceutical patent system.) This decision ruled in favor of patentability of "genetically engineered bacteria" and biological living organisms (Gallini, 2002; see also, Carrier, 2004). Since the 1980 Chakrabarty decision, the USPTO has granted patents for genes and gene fragments and other biological living organisms. To obtain a patent on a gene or gene fragment the USPTO requires that "inventors must (1) identify novel genetic sequences, (2) specify the sequence's product, (3) specify how the product functions …[and] (4) enable one skilled in the field to use the sequence for its stated purpose" (Human Genome Project information, Genetics and patenting, 2008, Patenting Genes, Gene Fragments). Biological organism patents were only recognized and enforceable in a few countries until the TRIPS agreement globalized IPRs to biotechnology organisms (Kothari & Anaruadha, 1999).

Controversy surrounded the relative ease of obtaining a patent on gene sequences and fragments and in 2001 the USPTO increased patent requirements to show "specific and substantial utility that is credible" (U.S. Human Genome Project Research Goals,

[33] Although patents have been awarded for centuries on mechanical inventions, ethical and philosophical concerns have delayed support for patent protection of living organisms until relatively recently (Iwasaka, 2000). It was not until the passage of the Plant Patent Act in 1930 that the USPTO ended this restriction by granting intellectual property protection to asexually derived plant varieties ("United States Patent and Trademark Office, n.d., What is a plant patent?). Currently, the USPTO grants monopoly rights for 20 years from the date of filing to "exclude others from asexually reproducing, selling or using the plant so reproduced." ("United States Patent and Trademark Office, n.d., What is a plant patent?). The patent law defines a plant "inventor" as a person who contributes to one of two steps: (1) the discovery of a new plant, and/or (2) the asexual reproduction of the plant ("United States Patent and Trademark Office, n.d., What is a plant patent?).

n.d., Genes and Gene Fragments; see also Masum, Schroeder, Khan, & Daar, 2011). The requirement for increased specificity was intended to better demonstrate how the inventions function in nature. Even so, patenting gene fragments put the patent holder in a position to act as a gatekeeper and “exercise undue control over the commercial fruits of genome research” (U.S. Human Genome Project research goals, n.d., Genes and Gene Fragments). As disease genes were identified, corresponding tests were developed and patented to screen for the disease (U.S. Human Genome Project research goals, n.d.). The patent holder then controls any use of the test and maintains a monopoly allowing the possibility of excluding other users from further research. As an example, in 1994 a University of Utah researcher identified and patented the genes responsible for hereditary breast cancer, BRCA1 and 2. The university licensed the gene discovery to Myriad Genetics which actively protects its monopoly by enforcing its patent through blocking other researchers in using the gene (Cukier, 2006).

Responding to the concerns of increased control by private organizations of patented biological genes, government and private organizations have created projects to identify and map the human genome in order to maintain the information in the public domain. The US Department of Energy and the National Institutes of Health initiated the Human Genome Project in 1990 in order to identify the genes in the human DNA and determine chemical pair sequences. With the participation of 18 countries, the human DNA sequence was completed in 2003 (Human Genome, 2010).

In 2002, scientists in Japan, UK, Canada, China, Nigeria and the US developed a project to create a haplotype map of the human genome called the International HapMap Project. The organization makes this information freely available for researchers and “is expected to be a key resource for researchers to use to find genes affecting health, disease, and responses to drugs and environmental factors" (HapMap Project, 2006, About the International HapMap Project; see also Human Genome, Genetics and patenting, 2010).

8.1.1 Open Source Biotechnology Research and Development

Although these collaborative gene identification projects provide open access to information, "[o]pen access to information by itself, while often the easiest step to take, may be of little value without the freedom and collaborators with which to apply such information to create solutions" (Masum et al., 2011, p. 66). Because biotechnology has become increasingly an "information-oriented science," there is hope that collaborative innovation can work with biotechnology as well as it has with software (Munos, 2006). Some of the first collaborative biotechnology innovation projects using open source as its model were bioinformatics software projects including Biojava, BioPerl, BioPython, and Generic Software Components for Model Organism Databases (GMOD). It is important to note, however, that while FOSS was privately funded, bioinformatics software has often been publically funded. This distinction is important because funding entities typically have the authority to determine the type of license for the software which is not always open source (Shulman and Schweik, 2010; see also Todd, 2007).

8.2 Three Biotechnology Case Study Communities

Although no biotechnology "open source" project has matured past its infancy, these three case studies were chosen based on the degree of organizational structure achieved to date and the available information on the community. My analysis reveals that two of the three case study communities, CAMBIA and TDI, have applied few of the organizational characteristics and as a result the communities have had a difficult time achieving the goals of the organization. OSDD shows an organizational structure very similar to the 19th century and FOSS case study communities. Chronologically, CAMBIA and TDI are an early attempt of cooperative biotechnology innovation while OSDD was organized much later and appears to have learned from the earlier communities and implemented an organizational structure that more closely matches the 19th century and FOSS case study communities.

8.2.1 CAMBIA

Richard Jefferson, trained as a molecular, cellular and developmental biologist, initiated CAMBIA as an international nonprofit organization based in Canberra Australia in 1991. With this organization, Jefferson intended to “up-end” the established biotechnology system of exclusion through patents (Mair, 2011). His theory was to charge only what each technology user could afford to pay – large commercial labs would pay a substantial amount while small research organizations might receive access to the same technology free of charge. Earlier in his career, Jefferson developed GUS which is “widely credited for enabling many breakthroughs in plant biotech” including Monsanto’s Roundup Ready soybeans (Dreyfuss, 2006, p. 31; see also BiOS, Executive staff, n.d.).

CAMBIA offers for license several technologies including, TransBacter which “can be used instead of the costly Agribacterium for genetically engineering plants”

(Singh, 2008, p. 201; see also Dreyfuss, 2006). Another technology offered is Diversity Arrays which is a genome diversity mapping technology (Singh, 2008, p. 201). According to CAMBIA's website, these technologies are research tools used for further biotechnology research and are available through the BiOS license, which is intended to make these technologies "open source" in order to "advance rapid development and debugging" of the technologies (What BiOS-compatible agreements are available, n.d.).

BiOS licenses provide that:

- "Ownership of technology stays with the owner
- "A world-wide, non-exclusive, royalty-free non-assertion covenant to make and use the technology and improvements.
- "Mechanisms for sharing information that is desirable to share, such as public safety information" (What BiOS-compatible agreements are available?, n.d., para.4)

CAMBIA founded BiOS (Biological Innovation for an Open Society) in 2006 to improve world nutrition and food security through collaborative innovation and making biotechnology research tools equally available to research groups within developed and developing economies (BiOS, Home, n.d.). CAMBIA's biotechnology resources are openly available to the research community through BiOS licensing agreements and a "protected commons approach which allows "users to access, improve, and modify enabling technologies without infringing on proprietary rights" (Masum, 2011; see also Hilgers, Muller-Seitz, & Piller, 2010). A user of the BiOS research tools is required to "grant-back any improvements and modifications into the [BiOS] open patent pool" (Penin, 2011, p 15-16). The grant-back requirement in the BiOS licensing agreement is often found in commercial licenses; however, in the BiOS license the grant-back allows other licensees to use the improvements of the innovation. ("Do BiOS agreements allow patenting of improvements?," n.d.)

Licensees are allowed to patent their improvements but "set aside" proprietary rights for others who have agreed to the BiOS license (How do BiOS Agreements encourage and ensure Access and Benefits-Sharing?, n.d.). However, innovation developed as a result of using the BiOS research tools is not subject to the viral license and licensees have the "liberty to individually control new strains of plants, through patents if so wished" (Penin, 2011, p. 16). This is because BiOs desires to keep the research tools free for members to use but does not want to impede the "commercial exploitation of their direct applications" (Penin, 2011, p. 16).

The BiOS website states that the CAMBIA technology is available at "no cost" but it is "costly to maintain an exchange of materials and improvements, and to serve up and maintain the information technology commons" (What is the cost of a BiOS agreement?, n.d., para. 1). Therefore, the BiOS agreement requires that "for-profit licensees" pay a flat rate fee based on the size of the organization. However, nonprofit organizations are not required to pay any fee for use of the technology, "other than cost recovery for materials handling (postage etc.)" (What is the cost of a BiOS agreement?, n.d., para. 3). The "capital-intensive and highly privatized biotechnology sector" has been reluctant to accept the BiOS licenses and there are relatively few licensees of the CAMBIA technology. Further, CAMBIA technology has attracted few licensees because they cannot mix CAMBIA technology with their already proprietary technology (Kloppenburg, 2008).

Another CAMBIA project, BioForge, hopes to return to practices in the "first few thousand years of agricultural development" by establishing a structure that encourages farmers and breeders to share their results of research and study. BioForge is an online organization developed to facilitate the open interaction between scientists (Porceddu & Jefferson, 2004; see also BiOS, Home, n.d.). Similar to SourceForge for FOSS, BioForge was intended to be a centralized location for community member contributions and peer review within a “protected commons” where members could discuss inventions and improvements without invalidating future patent applications or having the innovation misappropriated by nonmembers (CAMBIA, What is a ‘protected commons’?, n.d.). Within its first 2 months, BioForge attracted 2,000 participants but within a short time CAMBIA shut down BioForge as it was clear that online collaboration was not occurring. Differing protocols from one lab to another might be one reason for the failure of BioForge which was discontinued. Jefferson suggested that the failure of BioForge may be due to the lack of attribution to members’ contributions (Masum, 2011).

8.2.2 Tropical Disease Initiative

Five attorneys and scientists associated with Duke University, Berkeley, UCSF and Prince Felipe Research Center in Spain established The Tropical Disease Initiative (TDI) in 2004 (Tropical Disease Initiative, What, who, how and more…, 2008). The purpose of TDI is to develop drugs to treat neglected tropical diseases such as leishmaniasis, schistosomiasis, dengue fever and African sleeping sickness. The current market model fails to motivate pharmaceutical companies to invest in research and development for drugs in these diseases because of the small number of people who are able to pay patented-drug prices for the treatment (Shulman & Schweik, 2011).

TDI was funded in part by the Spanish Ministerio de Ciencia e Innovacion and the US National Institutes of Health. TDI does not plan to develop any resulting drugs from the collaborative project but rather will “act as a generator and steward of the kernel it has provided and hopes that others will develop the drug candidates that arise from this collaboration” (Goulding, 2009, p. 12). The TDI kernel is a group of possible drug development targets developed by a group of researchers. The contributors to TDI would determine drug leads, which ultimately would be sent to “Virtual Pharma” that would then choose which candidates to work on with corporate partners (Shulman & Schweik, 2010). The TDI kernel is available through the WordPress package which allows for “creation, storage and dissemination of each target entry” and allows for members to rate the potential success of each proposed target (The Tropical Disease Initiative, Methods, 2008).

TDI utilizes The Synaptic Leap (TSL) as its online collaboration website which, like CAMBIA’s BioForge, has been compared to SourceForge used for FOSS projects (Goulding, 2009; see also About the Synaptic Leap, 2006).[34] TSL incorporated in 2005 in order to “create an online community that could connect and collaborate on research efforts for neglected tropical diseases” (Singh, 2008, p. 202). TSL provides web access to those who want to contribute and allows members to start their own projects based on different ideas to develop drugs. Anyone can go to the TSL projects page and see contributions and add contributions to existing projects or start their own project. The TSL website under “Get involved with an open research project” (2006) on the Malaria Research Community states, “Go to our current projects page for a list of projects in process. You can comment directly or "add a child page" … to start something new (a

[34] Several founding members of TDI are also on the board of directors for TSL (About the Synaptic Leap, 2006).

"fork" in open source software development) and describe your own open research project for malaria."

TDI intends to reduce costs of drug development through volunteers who donate time and knowledge; through market competition rather than patent monopolies and allowing the company with the lowest bid to develop the drug candidate provided by TDI. TDI compares this off-patent drug development to the development of the polio vaccine which was sponsored by the March of Dimes. The March of Dimes then signed "guaranteed purchase contracts" with drug makers that were willing to produce the drug on a large scale (Maurer, Rai, & Sali, 2004, p. 184).

TDI has achieved some success through its research on schistosomiasis. The World Health Organization identified as a priority the development of a low priced "single enantiomer" which would make the current treatment for schistosomiasis, Praziquantel (PZQ), more accessible to administer to patients (Woelfle, Olliaro, & Todd, 2011). PZQ is difficult to administer due to size and taste of the pill. The WHO and the Austrian Government funded the initial process of establishing an online electronic lab notebook on which all data and experiments could be deposited. Work by TDI on the PZQ project led to a potentially successful outcome in identifying dibenzoyl tartaric acid as a "superior resolving agent" which was posted openly (Woelfle et al., 2011).

> Praziquantel… is a perfect example of where open source can really deliver. The iterative improvement of the route to a drug that is of great importance to underdeveloped countries is of little interest to for-profit companies, but neither is it a priority for academia. We see open source collaboration as the only way to make research challenges like this tractable. (Todd, 2007, Online Collaborative Research)

Since January of 2010 there have been approximately 100 comments in TSL regarding the TDI project and 60 of those were from outside contributors who were not involved in the kernel project. The majority of the outside comments came from industry rather than academic sources (Woelfle et al., 2011).

TDI implements computational “pipeline” programs, MODPIPE and AnnoLyze, to organize and make the target genome sequences available to the community. The software programs make the information easy to search protein models and predicted locations of binding sites (“The Tropical Disease Initiative, Methods, 2008).

TDI does not seek IPR protection but rather implements a Science Commons protocol for maintaining open access to all outcomes of the collaborative innovation. The license is based on the Creative Commons 3.0 License. The Science Commons protocol has no restrictions on how TDI data are used and, according to TDI, does not contain a “viral” condition requiring users to donate back any improvements or changes to the community but requires proper attribution based on “customary academic attribution norms” (Goulding, 2009; see also Orti, 2009). TDI, however, hopes that those implementing the information in any innovation will promise “not to seek patents of their own” (Orti et al., 2009; see also Shulman & Schweik, 2011, p. 176).

8.2.3 OSDD

In 2007, India’s Council of Scientific and Industrial Research (CSIR) under the direction of Samir Brahmachari initiated Open Source Drug Discovery in order to focus cooperative innovation efforts on neglected diseases such as tuberculosis and malaria.

The traditional pharmaceutical model of innovation invests very little in neglected tropical diseases due to high investment costs and relatively low potential profitability.

Although there is currently a drug to treat TB, the disease kills two people every 3 minutes in India and drug resistant strains of TB (Multiple Drug Resistant TB and Extensive Drug Resistant TB) have increased due to the long-term duration of the current therapy and tendency for patients to quit therapy before completion (Bhardwaj, 2011). The Indian government provided US $27 million to fund OSDD's first project of finding a better treatment for tuberculosis (TB).

OSDD also intends to pursue additional funding from public and private sources (Goulding, 2009; also see Masum, 2011). "The funds raised would be used for conducting Quality Control activities and tests. It would also be used to reward contributors and fund scholarships" (Open Source Drug Discovery, FAQs, n.d., Who is funding OSDD?). Current OSDD partners include universities, nonprofit organizations (including CAMBIA) and industry partners including Sun Microsystems, Infosys and AstraZeneca (Open Source Drug Discovery, FAQs, n.d., Who are OSDD partners?). As one of its long-term partners, Sun Microsystems manages OSDD's information technology (IT) systems and provides open source software for the project (Singh, 2008). Similar to FOSS, OSDD created a community of volunteers who contribute knowledge online. The community intends to discover new chemical entities (NCEs) that lead to effective drugs for TB and will make the innovation available to numerous drug manufacturing and marketing organizations in order to create affordable and available drugs similar to generic drug pricing and distribution.

OSDD members contribute research and knowledge through Sysborg 2.0, a web-based system that logs member contributions and peer review (“Open Source Drug Discovery, n.d., What is OSDD). Other web-based tools for collaborative innovation include Computational Resources for Drug Discovery (CRDD) which facilitates the interaction of drug research tools and also Open Access Archive which assists in disease-related research (Shulman & Schweik, 2010). OSDD also implements TBrowse, a resource that brings together nearly 50 different research resources into one format (Open Source Drug Discovery, FAQs, n.d.). OSDD’s online structure “provides bioinformatics tools, biological information, data on the pathogens, projects for participation in drug discovery, and discussion forums” (Masum, 2011, p. 65).

OSDD leadership breaks down the drug discovery process into “Work Packages” (WPs) and opens them up to all members of the community to contribute (Datta, 2009). Each WP sets forth the problem that must be solved and its connection to other WPs. WPs include target identification, screening, lead generation and break these complex problems into simpler and smaller projects with a defined scope of expected deliverables (Scaria, 2010; see also Shulman & Schweik, 2010). Contributions of WP solutions are peer reviewed before attribution to the contributor is awarded (Singh 2008). As of November 2011, OSDD reported more than 5,000 registered participants contributing to over 100 projects on its web portal (Open Source Drug Discovery, FAQs, n.d., After registration on OSDD, what I have to do?; see also OSDD crosses 5000 registered users, 2011).

OSDD created its TB kernel through collaborative re-annotation of the mycobacterium tuberculosis genome. Launched in December 2009, volunteer researchers were trained in annotation methods using web-based materials and completed the annotation in April of 2010 – an estimated 300 "man years" into 4 months (Munos, 2010). From this annotation, a "kernel" of 20 pairs of proteins and ligands was identified for OSDD's use in TB research (Anderson, 2010). OSDD is structured to follow its innovation model through the point of human drug testing which would then be outsourced to Contract Research Organizations (CROs) in countries like India that are already set up to carry out clinical trials on drugs for global pharmaceutical companies. These trials would be conducted with cooperation by governments and private industry which would "bring down the cost considerably." CSIR, OSDD's sponsoring organization, has experience taking drugs through clinical trials and bringing them to market and will be able to guide OSDD through these steps. (Open Source Drug Discovery, What is OSDD, n.d., OSDD Approach to Clinical Trials; see also Bhardwaj, 2011).

OSDD plans to limit the risks and individual expense of high-cost clinical trials by using public funding to obtain the necessary trial information and results. All data created during OSDD clinical trials will be openly available ("About Us", n.d.). This model of keeping all clinical results open to anyone provides the foundation of bypassing potential pharmaceutical monopolies moving the outcomes into the generic sector of the industry resulting in potentially lower-priced drugs (Open Source Drug Discovery, What is OSDD, n.d.). "To ensure affordability, the drugs that come out of the OSDD platform will be made available like a generic drug, without Intellectual Property encumbrances. OSDD thus relies on the already established business models of generic industry for delivery of drugs" (Open Source Drug Discovery, What is OSDD, n.d., OSDD Approach to Clinical Trials).

OSDD's license is similar to the FOSS GPL license which incorporates a "viral" clause that requires any improvement to be contributed back to the OSDD community (Shulman & Schweik, 2011). The OSDD license allows its information to be used commercially or noncommercially; however, users must "grant back an unencumbered worldwide nonexclusive right to OSDD for use of any IP rights acquired for their improvements or modifications" (Masum, 2011, p. 65).

8.3 Five Organizational Characteristics

Although none of these case study communities has yet replicated the success of the earlier communitarian innovation communities, it is worthwhile to examine the organizational structure of these communities in order to understand the potential for success of each community. In the following pages, I analyze each of the organizational structure categories discovered in *Chapter Six* as they relate to the biotechnology case study groups. These structural characteristics found in the 19th century and FOSS case study communities are:

- leadership
    - motivational
    - shared
    - adaptable;

- socioeconomic design
    - property distribution
    - fundamental equality;

- organization of labor
    - self-selected, not compulsory

  - subgroup structure;

- internal communication
  - open communication
  - peer review; and

- member commitment
  - membership levels
  - member agreements.

8.3.1 Leadership

Leadership motivates participation in the community activities by establishing the importance of the group's mission and by providing the innovative concept on which the community could improve and expand. "Enticing people to join is a challenge. A good website helps, but it's not enough. It takes a sustained effort to build trust with stakeholders. It also takes a leader who can connect with people, understand their motivation and foster trust" (Shulman & Schweik, 2011, p.177). ***Table 8.1*** summarizes the leadership attributes of each of the biotechnology case study communities.

8.3.1.1 Motivational Leadership

Within each of the biotechnology case study communities' leadership has worked diligently to promote its social agenda of freely accessible data within drug and agricultural development. Each has provided a type of "kernel" on which other contributors can improve upon or add to. Even so, the type of kernel is somewhat different in each of the biotechnology case study communities. CAMBIA leadership is active in promoting collaborative innovation and has used patented technologies as its

TABLE 8.1 – Leadership

	Motivational	***Adaptable***	***Shared***
CAMBIA	Active community leader and evidence of "kernel" contributed by leader	No evidence of adaptable leadership	Minimal shared leadership
TDI	Active community leader and evidence of "kernel" contributed by leader	Evidence of adaptable leadership with PZQ project	Minimal shared leadership
OSDD	Active community leader and evidence of "kernel" created by community	Evidence of adaptable leadership	Evidence of shared leadership

kernel. Since CAMBIA requires a license fee that increases to $500,000 depending on the size of the organization there has been little improvement on the existing technology that has been granted back to the community ("What BiOS-compatible agreements are available", n.d.). Although there are several individuals listed on the TDI board of directors, there is no clear leadership and there is little chance at leadership due to the fact that no one knows who exactly is working on any aspect of the TDI kernel (Anderson, 2010). TDI has posted what it identifies as a "kernel" on which contributors can work. The kernel is used to predict success of potential drug candidates and is comprised of 143 potential drug targets from ten pathogen genomes. The kernel is maintained in the public domain and contributors seek only traditional academic attribution under the Science Commons license (The Tropical Disease Initiative, Methods, 2008).

Samir Brahmachari, Director General of CSIR, leads the OSDD initiative for collaborative online innovation. He hopes to raise money from governments, NGOs and charities to fund the discovery of new drugs for TB and other neglected diseases (Singh, 2008). Through the OSDD leadership, the TB "kernel" was developed through collaborative online efforts. OSDD established its kernel through community participation by re-sequencing the mycobacterium tuberculosis genome (Munos, 2010).

8.3.1.2 Shared Leadership

Shared leadership, with a broad governance structure involving many community members, is implemented in varying degrees by the biotech case study communities. CAMBIA and TDI have several participants on their Boards of Directors but there is no evidence that either have implemented a broad leadership structure utilizing community members who share community responsibilities and decision making. OSDD, however, has in place a system that implements a shared leadership structure with mentors and others who lead different segments of the cooperative innovation. Also, OSDD has implemented a system to track the level of contribution and participation in the community by each member, which will put the most active members in a leadership position. OSDD has been more successful at establishing a structure which shares leadership with community members. Leadership of the collaborative innovation is shared through Principal Investigators and the Board of Mentors (Open Source Drug Discovery, FAQs, (n.d.) How is OSDD project managed?).

8.3.1.3 Adaptable Leadership

CAMBIA implements a fixed fee royalty license structure to access the community's kernel. Very few organizations have signed a license and CAMBIA has not adapted its structure to meet the needs and resources of potential community members. Additionally, BioForge was implemented to create an online community forum but instead of adapting to the needs of the community, BioForge was discontinued. TDI identified certain potential targets for an improved PZQ and changed course when a community member provided input on a different potential target, leading to publication. OSDD has demonstrated adaptability through its creation of the TB kernel, which was developed by the community and the leadership adopted the results.

8.3.2 Socioeconomic Design

Critical to the case study communities was a nontraditional socioeconomic structure which organized the community differently than that of the status quo. Within the 19th century and FOSS communities, fundamental equality and property distribution provided the new socioeconomic structure. Like software and other goods, the production of drugs is traditionally done through a hierarchical corporate structure with contributors meeting face-to-face. CAMBIA, TDI and OSDD have changed this aspect of traditional innovation model where contributors meet online and are dispersed throughout the world; however, some of the case study communities have not significantly changed other aspects of their socioeconomic design sufficiently to succeed at cooperative innovation. ***Table 8.2*** summarizes the socioeconomic design of each of the biotechnology case study communities.

8.3.2.1 Fundamental Equality and Property Distribution

CAMBIA has changed very little of the status quo with its current IP licensing structures which implements tiered lump sum royalty payments based on the size of the organization.

TABLE 8.2 – Socioeconomic Design

	Fundamental Equality	***Property Distribution***
CAMBIA	No evidence of fundamental equality	No evidence of equal property distribution
TDI	Contributions based on merit not position	Property distribution is not based on members' contributions
OSDD	Contributions based on merit not position	Property distribution is not based on members' contributions

The requirements imposed by the BiOS license are not comparable to the earlier communitarian requirements – CAMBIA requires a specified contribution prior to obtaining access to the technology. Although the lump sum royalty is defined by CAMBIA as a fee to cover costs of the organization, it has many of the same disadvantages of the existing IPR status quo – costs that must be passed on to the end user, and no evidence of distribution of the resources to the rest of the community. Unlike most royalty licenses, however, the CAMBIA royalty amount is not based on the potential for profit but rather the size of the organization. CAMBIA offers for "license" research tools that can help biotechnology research organizations discover agricultural innovations. This "grant-back" requirement is not uncommon in traditional licenses. However, the license also requires that any improvements or changes made by users of the research tools must be granted back to the community – but this applies only to improvements made to the licensed research tools and not to the innovations made using the licensed technology. The terms of the CAMBIA license do not meet the requirements of fundamental equality because it does not treat profit and non-profit organizations equally based on the same criterion of number of employees. Further, it is not clear how the lump sum royalty fee is distributed among the community members. There is no evidence of fundamentally equal property distribution among the community members.

TDI states that it does not require users of its technology to grant back the rights to any improvements; however, the Science Commons license that TDI uses for its technology does require the grant back of improvements. The distribution of property is available for any organization or person who would like to use the technology, similar to earlier cooperative communitarian innovations in that anyone could use the innovation regardless of contribution. The community practices fundamental equality and accepts contributions from all members based on merit of the contribution. The proposed changes to PZQ that resulted in a published paper was proposed by a member outside of the main Australian group indicating a structure based on merit rather than position (Woelfle et al., 2011). However, TDI does not plan to distribute the knowledge created by the community equally among its members. TDI states that its innovations will not be patented and that "sponsors" would be awarded development contracts based on the "company that offered the lowest bid" (The Tropical Disease Initiative, What, who, how, and more…2008).

OSDD has created a protected commons where community created innovation is protected from misappropriation and is kept available to all who want to use the technology within a licensed structure. The community practices fundamental equality among its members based on the level of contribution by each member. Members' contributions are involved in the community based on their own abilities. Each contribution is peer reviewed and accepted based on the merit of the contribution and not the position of the contributor.

8.3.3 Organization of Labor

Similar to the FOSS and 19th century case study communities, each of the biotechnology case study communities has organized in such a way that contributions are self selected and not compulsory. There is evidence that the communities have established online structures that allow each member to contribute in specific areas that allow individuals to organize into subgroups based on interest and skills. ***Table 8.3*** summarizes the organization of labor for each of the biotechnology case study communities.

8.3.3.1 Labor Self-Selected, not Compulsory and Subgroup structure

In each of the biotechnology case study communities contributions were determined by the community member and were not compulsory (see Table 8.3). Each of the communities has structured itself so that community members can select where to contribute. However, through its WPs, OSDD is the only biotechnology case study community that shows evidence of a formal subgroup structure allowing community members to work on limited and well-defined aspects of each project.

8.3.4 Peer Review and Open Communication

Peer review and open communication are attributes found in the earlier case study communities. ***Table 8.4*** summarizes the leadership attributes of each of the case study communities CAMBIA and TDI do not show evidence of a formal peer review process or open communication. There is no record of open business meetings within which

TABLE 8.3 – Organization of Labor

	Self-Selected, not Compulsory	***Subgroup structure***
CAMBIA	Members select areas of contribution	Website is broadly structured into targeted areas of research
TDI	Members select areas of contribution	Website is broadly structured into targeted areas of research
OSDD	Members select areas of contribution based on the WP structure	Organization is structured into specific WPs which help subgroups focus on specific tasks.

community members can voice their input. OSDD does have a formal peer review process in order for member contributions to complete WPs. Although there is significant amount of communication from OSDD to its members, I was unable to observe open communication where members freely contributed input into the organization's decision making process.

8.3.5 Member Commitment

The three biotechnology case study communities built their organizational structure in response to the existing IPR system that requires potentially expensive and time consuming patent filing rather than the automatic IPR protection of copyright which covers software code written by FOSS contributors. As a result, these communities have set up systems to avoid misappropriation of the cooperative innovation including the protected commons, open access or Science Commons licenses which have been implemented to work around the current IPR system.

Because biotechnology innovations are protected through patents rather than copyrights, the "copyleft" principle popular within FOSS "is not easily applicable to the

TABLE 8.4 – Peer Review and Open Communication

	Peer Evaluation	***Open Communication***
CAMBIA	No structural evidence of peer review	Difficult to locate open communication of organizational changes and progress on community website
TDI	No evidence of peer review beyond publication of academic paper	No evidence of open communication through which members can contribute to decision making process.
OSDD	Formal peer review process implemented for each contribution	No observation open communication through which members can contribute to decision making process.

biotechnological realm" (Hilgers, Muller-Seitz, & Piller, 2010, p. 9). The IPR system creates challenges for cooperative biotechnology communities because patents are expensive and require a lengthy approval process with the USPTO. "Obtaining copyrights on the code in an open source project does not add any time or cost to the project. Open source projects concerning biological material, on the other hand, are not as easily grounded in intellectual property" (Beck, 2010, p 201). ***Table 8.5*** shows membership commitment for each of the biotechnology case study communities.

In order to better allow collaborative innovation in biotechnology without the concerns of misappropriation, a derivative of the Creative Common license was developed for patentable projects called the Science Commons (Cukier, 2006). The Science Commons license keeps the innovation free from potential misappropriation and also requires users to grant back any improvements to the community. Another method of protecting cooperative communities' innovations is to create a "protected commons" where community members must agree to specific terms granting legal use of any contribution to the community and agreeing to not misappropriate the technology.

TABLE 8.5 – Member Commitment

	Membership Levels	***Member agreements***
CAMBIA	No evidence of specific membership levels	Member agreements for those that license the technology. No evidence of agreements for those who contribute to the community
TDI	No evidence of specific membership levels	No evidence of membership agreements
OSDD	Defined levels of membership based on levels of contribution	Members required to agree to a membership agreement

8.3.5.1 Member Agreements

CAMBIA requires written agreement (the BiOS license) for those community members who want to license the available technology. However, since BioForge is defunct there is no current evidence of membership agreements for those who contribute to the innovation without first licensing the existing CAMBIA technology. CAMBIA appears to have already patented its technology and is now licensing it with grant-back requirements. From The CAMBIA "Biological Open Source" (BiOS) License for Plant Enabling Technologies Version 1.5, paragraph B:

> It is the goal of the BIOS Initiative to ensure common access to the tools of innovation, to promote the development and improvement of these tools, and to make such developments and improvements freely accessible to both academic and commercial parties under substantially similar conditions… (BiOS PMET License Agreement 1.5, n.d.)

Licensees are not "prohibited" from patenting their inventions but are expected to provide the same "nonassertion" of IPR to community members as was provided to the licensee (FAQs - BiOS Agreements, n.d., Do BiOS agreements allow patenting of improvements?). This part of the BiOS agreement is ambiguous but appears to be an agreement structure with no enforcement of the "nonassertion" expectations of the community. BiOS licenses allow licensees to assert IPRs on derivative innovations of the CAMBIA technologies without a nonassertion obligation (Beck, 2010). The BiOS licenses do not "prohibit licensed technology from being used to develop downstream proprietary products" (Masum, 2011, p. 69). In other words, licensees are able to innovate new products using the licensed research tools under the BiOS licenses and can patent the innovations without concern for sharing the technology with other BiOS members.

TDI (through its partnership with TSL) apparently does not require any written agreement from those who contribute to the community projects. TDI states that its innovations are subject to the Science Commons license but it is not clear how the innovations are protected from misappropriation since there is no evidence of a protected commons. TDI does not intend to patent any collaborative discovery but rather "could" award a contract to the low bidder for further development (Gould, 2009). Further, TDI recognizes that there is no reason why any researcher should share findings with TDI. One of TDI's founders stated that he has no idea who is working on TDI's projects (Anderson, 2010).

OSDD requires written agreements for those who become members in the community. OSDD has created a protected commons within which community members can contribute. OSDD's license states that "[a]nyone accessing the Protected Collective Information has an obligation to contribute any addition or improvements made to or using such Protected Collective Information or any research result or proprietary rights generated out of the Protected Collective Information…" This applies whether the information is patented or not and if it was used only partly for the invention (Open Source Drug Discovery, FAQs, 2011, Proprietary Rights).

8.3.5.2 Membership Levels

Although each of the three biotechnology case study communities has users and developers, only OSDD shows evidence of different membership levels within the innovation community. OSDD has four levels of contributor membership based on the activity of each contributor. Anyone can contribute to OSDD and contributions include laboratory access, computing bandwidth, datasets, as well as, ideas and intellectual property. Different from TDI and CAMBIA, OSDD has implemented an attribution system that tracks all member contributions and level of involvement in the community. OSDD divides the process of drug discovery into specific, individual problems which are then solved by the community members and peer reviewed. "Credit points" are then awarded after the peer review for correctly solving the problem (Open Source Drug Discovery, FAQs, 2011, What can be contributed?). Points are given for each contribution based on type of contribution. Each member begins as a "blue" member and is upgraded to either a "silver," "gold," or "platinum" member depending on the contributions made. Each of these membership levels come with "rights, privileges and responsibilities in the entire process" (Shulman & Schweik, 2010, p. 172; see also Bhardwaj, 2011). Some contributions are financially rewarded and the payment is determined on "a case-by-case" basis ("Open Source Drug Discovery, FAQs", 2011, Will I be paid if I contribute?).

CAMBIA's and TDI's community structure did not include several of the five organizational characteristics (as shown in gray in ***Table 8.6***) found in the earlier case study communities. OSDD's community structure is much more closely aligned to the characteristics found in the 19th century and FOSS case study communities. OSDD has implemented nearly all of the five organizational attributes of the earlier case study communities. My analysis of the biotechnology industry and the three case study communities reveals a progressive application of the communitarian innovation business model. The early biotechnology projects were structured to organize and develop research tools including gene sequencing and haplotype mapping. Beyond open access databases other projects formed around bioinformatics software tools. These projects created research and communication tools which were made available to researchers and commercial entities.

Because of lengthy physical testing and costly regulatory compliance required for pharmaceutical development, some have argued that "open source" drug research and development cannot progress beyond the point of providing research tools (Shulman & Schweik, 2010; see also Srinivas, 2006).[35] However, as online biotechnology tools have become more powerful and more accessible, the next generation of cooperative biotechnology communities, CAMBIA and TDI, utilized BioForge and The Synaptic Leap web portals, respectively, to organize online contributions and discussions for targeted research projects. Innovation was based on a kernel of knowledge to which

[35] The "rule-based" portion of drug discovery includes Good Laboratory Practices, Good Clinical Practice, Good Manufacturing Practice, as well as, FDA approval (Munos, 2006). Regulatory oversight not only increases costs but also delays time to market and returns on investment for pharmaceutical innovations. Additionally, contributions to the pharmaceutical R&D process that are sloppy and inaccurate could "compromise years of work costing tens of millions of dollars" (Shulman and Schweik, 2010, p. 169).

TABLE 8.6 - Summary of Organizational Structure for Biotechnology Case Study Communities

	CAMBIA	***TDI***	***OSDD***
Leadership: motivational	Active community leader and evidence of kernel contributed by leader	Somewhat active Board of Directors and evidence of kernel	Active community leader and evidence of kernel created by community cooperation
Leadership: adaptable	No evidence of adaptable leadership	Some evidence of adaptable leadership with the PZQ project	Evidence of adaptable leadership
Leadership: shared	No evidence of shared leadership outside of main leadership group	No evidence of shared leadership outside of main leadership group	Evidence of shared leadership with community members
Socioeconomic Design: Property Distribution	No evidence of fundamental equality	Some evidence of contributions based on merit	Contributions based on merit, not position.
Socioeconomic Design: Fundamental Equality	No evidence of equal property distribution	Property distribution is not based on members' contributions	Property distribution is not based on members' contributions
Organization of Labor: Self Selected, not Compulsory	Members self-select areas of contribution	Members self-select areas of contribution	Members self-select areas of contribution based on WP structure
Organization of Labor: Subgroup structure	Community is broadly structured into targeted areas of research	Community is broadly structured into targeted areas of research	Community is structured into specific WPs which help subgroups focus on defined tasks within broader targeted areas of research
Peer Review	No structural evidence of peer review	No evidence of peer review beyond publication of academic papers	Formal peer review process implemented for each contribution
Open Communication	No evidence of open communication and members' contributions to decision making process	No evidence of open communication and members' contributions to decision making process	No observation of open communication and members' contributions to decision making process

TABLE 8.6 – Continued

	CAMBIA	***TDI***	***OSDD***
Member Commitment: Membership Levels	No evidence of specific membership levels	No evidence of specific membership levels	Defined levels of membership based on contributions
Member Commitment: Member agreements	Member agreements for those who license CAMBIA technology. No evidence of agreement requirements for those who contribute to cooperative innovation	No evidence of membership agreements.	Members are required to accept a membership agreement

community members were to contribute additional improvement and innovation. The innovation results were protected through either traditional patent rights or through a protected commons approach which encouraged users to contribute improvements back to the community. However, at this stage of biotechnology communitarian development, CAMBIA's and TDI's community structure did not include several of the five organizational characteristics (as shown in gray in *Table 8.6*) found in the earlier case study communities.

The current stage of cooperative biotechnology, as manifest in OSDD, provides community members with a business structure much closer to the characteristics found in the 19th century and FOSS case study communities. OSDD has implemented nearly all of the five organizational attributes of the earlier case study communities. While it is still too early to determine whether OSDD will be successful in its projects, observation of its future performance will help determine the accuracy of the communitarian business model introduced in Chapter 5.

8.4 Conclusions

In this dissertation I develop a communitarian innovation business model in order to extend the communitarian innovation method to other industries. "Forming [a] viable business model is of paramount importance for the sustenance of any activity, and open source is no exception" (Shulman & Schweik, 2011, p 181).

The next stage of communitarian innovation in biotechnological is to apply this business model through clinical trials. In order to succeed at the next stage of communitarian innovation, there will need to be better online tools to coordinate lab experiments. This stage of biotechnology communitarian innovation requires financing of the costly lab experiments and clinical trials, as well as, the development and promotion of the final product. To do this, it is necessary to encourage the communities' commercial motivation. As discussed in earlier chapters, there are several incentives that motivate contributions to communitarian innovation; one of these is the commercial potential of the innovation. Commercial motivation was a key factor for the 19th century and FOSS case study groups. For example, the Shaker and Oneida communities supported and sustained their communities through sales of products based on their communitarian innovation. The Mormons utilized the mileage results from the roadometer for commercial purposes. Likewise, FOSS case study communities were commercially motivated or had commercially motivated supporters and partners.

Although a nonprofit 501c-3 corporation, The Linux Foundation was formed initially as the Open Source Development Labs (OSDL) by a consortium of commercial ventures including IBM, Hewlett-Packard, Intel, AMD, RedHat, Novell (The Linux Foundation Staff, 2011, "Fellows").[36] These corporations earn significant revenues from the use of FOSS with Linux-related revenue estimated to reach $4.8 billion dollars in 2011(The Linux Foundation, VMware Joins The Linux Foundation, 2011).

OSDD's current plan for bringing pharmaceutical targets to market is to outsource to generic corporations. This may not solve the problem of the millions of individuals afflicted with TB or neglected tropical diseases such as leishmaniasis and schistosomiasis. For the poorest individuals even a generically priced drug would be too costly.

[36] In 2007 OSDL merged with The Free Standards Group and became The Linux Foundation (The Linux Foundation Staff, 2011, Fellows).

One solution to this problem is to apply the communitarian innovation business model to the clinical trial, regulatory approval and marketing stages of the innovation process. To finance these additional stages of product development and marketing, the community would emphasize contributors' commercial incentives. Similar to Linux, cooperative biotechnology innovation could be funded and sponsored by corporations who encourage employees to contribute to the communitarian innovation project. Each company benefits separately and jointly because risk of development is spread over many companies and the cost is greatly reduced through spreading the production over many contributors, some of whom are volunteer and others employees of the commercial corporation.

Another approach to solving the problem of extending the communitarian business model to the marketing stage is similar to the for-profit commercial motive seen in the Shaker, Oneida Perfectionist and Mozilla communities. The communitarian innovation was sold or licensed for profit to support the communities. Similar to Mozilla, in order to fund advanced stages of pharmaceutical development a biotechnology community could license the innovation to commercial entities. Governments and NGOs will be able to license the product at low or no costs in order to distribute to clinics and organizations that serve the poorest populations. This does not violate the business model requirements of equal distribution and fundamental equality because these entities would not be part of the community but, like those who purchased Oneida traps or paid Firefox royalties, are payments by nonparticipants to the community for use of the innovation. As with the earlier communitarian groups, these payments support the continuing existence and success of the community. Another method of financing the social agenda for communitarian innovation is for the biotechnology innovation communities to encourage the development of pharmaceutical products that have a market in the developed world and can be licensed for higher royalties which in turn could finance the projects for neglected tropical diseases. The communitarian innovation communities must be structured so that profit maximization is not the sole incentive but rather the profit incentive is used for advancing a common social agenda.

Economists often assume that the "momentum for change must come from outside the situation" and ignore the creativity of those personally involved to adequately "restructure their own patterns of interaction" (Ostrom, 2010). Individuals may be more capable of handling a perceived "perverse situation" than any "external officials" such as the government. Ostrom (2010, p. 3) quotes Richard Sugden's (1986) commentary on the "distorted view" that the government must respond to and resolve collective problems.

> ...The government is supposed to have the responsibility, the will and the power to restructure society in whatever way maximizes social welfare; like the US Cavalry in a good Western, the government stands ready to rush to the rescue whenever the market "fails," and the economist's job is to advise it on when and how to do so. Private individuals, in contrast, are credited with little or no ability to solve collective problems among themselves. This makes for a distorted view of some important economic and political issues.

In this dissertation I provide a business model that functions within the market economy to achieve social goals such as drug discovery for neglected tropical diseases. This communitarian innovation business model can potentially be utilized to achieve other societal goals, such as education for the poor that are currently neglected by existing traditional business structures.

In *Chapter 2* I looked at existing incentive structure of patent monopoly and discussed the literature on patents and the impact on innovation; I also discuss the literature on cooperative innovation. *Chapter 3* briefly delves into the progression of private property rights and the devolution in some communities to a communitarian property structure. *Chapters 4 and 5* provide details on the 19^{th} century and FOSS case study innovations, respectively; and *Chapter 6* connects the incentives to participate in communitarian innovation for the 19^{th} century and FOSS case study communities. *Chapter 7* analyzes five categories of organizational structure of communitarian innovation discovered through analysis of the case study communities. This analysis creates the foundation of a business model for communitarian innovation which I applied to biotechnology communitarian innovation case study groups in *Chapter 8*.

APPENDIX A

GLOBAL HARMONIZATION OF IPRs

The World Trade Organization (WTO) agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is an attempt to "strike a balance between the long term social objective of providing incentives for future inventions and creation, and the short term objective of allowing people to use existing inventions and creations." (World Trade Organization, 2006, Philosophy: TRIPS attempts to strike a balance). According to the WTO (2006), this balance works in three ways:

1) Protection of intellectual property and encouragement to develop more -- 'private rights also bring social benefits'
2) Disclosure of patented knowledge benefits other who study the new technology
3) TRIPS provides flexibility for governments to 'fine tune the protection granted in order to meet social goals'

Under TRIPS, member nations of the WTO must "provide patent protection for any invention, whether a product (such as a medicine) or a process (such as a method of producing the chemical ingredients for a medicine), while allowing certain exceptions." (World Trade Organization, 2006, Obligations and exceptions). There are certain requirements to be met in order to qualify for patent protection. In return for the patent, details of the invention must be made public in the form of the patent application; thusly, the knowledge is made available to the world, but also granted a legally protected monopoly status (World Trade Organization, 2006, Obligations and exceptions).[37] A major aspect of the TRIPS Agreement is Article 30, which states:

> Members may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties. (World Trade Organization, 2006, Obligations and exceptions)

A thoughtful reading of the above WTO Article yields many questions and concerns regarding the role of intellectual property in world health, and especially in resolving various epidemics of the developing world. It is the stated role of the WTO to balance the rights of the patent holders along with the human desire for health and progress. In very broad terms the WTO declares that governments can prevent patent owners from "abusing intellectual property rights, 'unreasonably' restraining trade, or hampering the international transfer of technology" (World Trade Organization, 2006, Developing countries' transition period). Under this agenda, the WTO conference in Doha (called the Doha Declaration) created refinements and clarification to TRIPS regarding patent rights and healthcare concerns.

Not surprisingly, developed countries produce the majority of patents. As much as 86% of all patent applications occur in developed countries, as well as, 97% of worldwide earnings for royalties and licensing fees (UNDP, 2000). These numbers, however, do not mean that the poor developing countries do not create advances in innovation; however, they are frequently on a small scale and not likely to be formalized through the legal infrastructure of IP. Poorer nations do not have the required

---

[37] Under Article 27 of the TRIPS agreement, exceptions to patentability include diagnostic, therapeutic and surgical methods for the treatment of humans or animals. Also, excluded from patentability under this Article is any invention's commercial exploitation that would jeopardize "human, animal or plant life or health . . ." (World Trade Organization, 2006, Obligations and exceptions).

infrastructure with which to create a strong IPR system. Only a very small fraction of worldwide patents are issued in developing nations which makes a strong patent system a poor return on a high investment. Similarly, patented products from developed countries also receive weak patent protection in developing countries.

Many less developed countries rely heavily on knowledge passed down from generations and disseminated within the community for all to benefit. Modern pharmaceutical and biotechnology researchers are interested in the potential of TK and a few have appropriated this heretofore commonly-held knowledge through patent protection. This so called biopiracy includes the unauthorized and uncompensated taking of traditional knowledge, as well as the unauthorized use of any biological resource contained in rain forests, jungles, and areas within the geographical scope of indigenous peoples, whether or not such use or knowledge had been previously understood. The International Convention on Biological Diversity (CBD) established a complex set of guidelines in an attempt to overcome the rising concerns of traditional knowledge piracy. Under these guidelines, pharmaceutical companies, universities, and indigenous groups have entered into several contracts and licensing agreements. One supporting group of the CBD, the International Cooperative of Biodiversity Groups (ICBG), sponsored a license agreement between the pharmaceutical corporation Searle, Washington University, and the Aguarana people of the Andean region. Even though the license was not made public, it was nonetheless acquired and published by an NGO, Rural Advancement Foundation International (RAFI). It is RAFI's position that the royalty amount agreed upon in the ICBD sponsored license is inadequate to compensate the

Aguaruna people for their traditional knowledge and comparable to biopiracy (Greene, 2004).

A case that has been much discussed and reported in the media involves an Amazonian rainforest plant called Ayahuasca which has traditionally been used in religious and curative ceremonies by the indigenous tribes of that area for at least 500 years (Fecteau, 2001). The plant is a potent psychotropic providing strong hallucinogenic and purgative responses in its users. Loren Miller visited the Cofan tribe in Ecuador and was introduced to the ayahuasca plant which apparently was of a different strain than otherwise grown in the Amazonian region. Miller owned a small pharmaceutical lab in California and upon returning to the US, he processed the necessary paperwork to patent the Ayahausca plant in 1986 (Fecteau, 2001).[38] The US patent office, not having any prior art in the plant, granted the patent. Upon discovery of this alleged biopiracy, the indigenous organization COICA (Coordinadora de las Organizaciones Indigenas de la Cuenca Amazonica) proceeded to fight against the monopoly protection issued by the US Patent and Trade Organization on the ayahuasca vine and through its efforts helped motivate the USPTO to overturn the patent in 1999.

Groups of farmers, scientists and NGOs are working to protect TK and allow access to valuable knowledge for developing countries.

> Farmers in many countries have warned corporations and governments not to establish IPRs for crop varieties, and have opted to openly violate such IPRs, even if it means being jailed. Indigenous peoples everywhere are acquiring a deeper

[38] While Intellectual Property Rights (IPR) protection has been available for centuries in the US, it wasn't until 1930 that the US Plant Patent Act was passed protecting intellectual property of asexually derived plant varieties. In 1961 an International Convention for the Protection of New Varieties of Plants was signed by mostly industrialized countries – a Union for the Protection of New Varieties of Plants (UPOV) was also formed and the treaty came into force in 1968. In a 1980 Supreme Court decision it was held that people could patent biological living organisms. Since that decision biopiracy has "been on the rise" (Fecteau, 2001).

> understanding of IPR regimes, and ways of challenging them when they impinge on their human or resource rights. (Kothari & Anaruadha, section 5.3)

TRIPS induced power imbalances have caused concerns to developing nations including the problem of actually developing and funding an effective patent system, as well as the concern that TRIPS does not adequately address biopiracy and traditional knowledge (Ragavan, 2001). Global harmonization of a US style patent system is increasingly criticized as an inhibitor to dissemination of knowledge and innovation. One of the main problems with imposing a strong patent requirement on less developed economies is the ability, or desire, of the governments of those countries to enforce the IPR laws (Maskus, 2006).

APPENDIX B

THREE SHORT-LIVED 19TH CENTURY COMMUNITARIAN GROUPS

B.1 Owenites

Robert Owen first established his reformist ideas in New Lanark, Scotland where, as manager and partner of a mill, he attempted to improve working conditions and raise moral character. However, his attempts were, at first, rebuffed by his partners as well as the workers. His partners refused a shorter working day and the workers were suspicious of any so called attempt to help them. Owen persisted and established an incentive system to motivate workers to stay sober and work diligently (Loubere, 1974).

His management system involved a spindle painted a different color on each of its four sides hanging by each worker. At the end of each day, every worker's spindle was turned to indicate the level of worker performance for that day (Tour Guide, Harmony Scotland, October 2010). Unlike the more brutal management style of the day, Owen's simple device motivated his workers to produce without the physical abuse of some of his colleagues. Owen also insisted that children should be educated until at least the age of 10 and built schools for the mill worker's children -- a radical idea for that time. These, along with other managerial and social reforms, produced high productivity among the workers and large profits for Owen (Loubere, 1974).

Pleased at the economic and social outcomes of his reforms, Owen determined to create a “new moral world” and began proselytizing other capitalists to implement his system. Few were convinced that his reforms would translate into higher profits for themselves and were not willing to implement his system into their mills and factories. He did, however, receive intellectual support from William Thompson and John Stuart Mill (Loubere, 1974).

Finally, Owen decided to take his own wealth and begin a new society that would prove the effectiveness of his ideas to the world. To achieve success as quickly as possible, in1825 Owen purchased an existing community established by the Rappites in Harmonie, Indiana.[39] Harmonie had been a successfully operating communitarian society and it seemed success could be achieved quickly and easily from this foundation. Based on a letter from his son who was in the US preparing for the community, Owen was made aware of one of the major problems of intentional communities – attracting the wrong kind of participant. Owen received a letter from his son who was to help establish and administer the new community. The letter illustrates one of the biggest concerns of an intentional community of that era:

> Although I do not perceive opposition to your plans in any quarter & although there is often an appearance of interest excited for a time, yet the character of the people is so little enthusiastic & parties have been so long accustomed to be dilatory in business & to be thinking only of overreaching others & acting an

[39] Founded as a religious group in Germany by George Rapp, the Rappites fled persecution in Germany to the New World. Originally organized in Pennsylvania, in 1815 they claimed land in Indiana and established their community of Harmonie [sic]. The group desired only to be able to practice their religion without outside interference. Few members of the group had contact with the outside world and practically no one learned the English language. They did not proselytize or allow outsiders (even other Germans) to join their group. This communitarian effort seemed a very practical response to a hostile environment and society. At its peak, Harmonie was a well-organized operation with the largest population in Indiana. Jealous neighbors took advantage of their situation and the Rappites gave up their new community and returned to Pennsylvania after selling off their property to Robert Owen (Loubere, 1974).

> insincere part, that an entire change must be effected in order to make them valuable members… I have seen only one or two persons, who as they are, I should consider desirable associates. I certainly look forward with more favorable expectations to those, who come from Europe. (Bestor, 1953, p. 508)

Calling the location New Harmony, Owen proceeded with his plan and encouraged all types of individuals to join the community. Owen continued to travel and promote his new social order while leaving his son in charge of New Harmony. As one of the communitarian experiments not based on religious or moral like mindedness, and without a strong motivational leader present at the community, some problems quickly developed in the system (Harrison, 1969).

Owen's original communitarian plan called for four classes of society with distinct amounts of property and consumption. However, by the time New Harmony was established he professed more egalitarian ideas (Loubere, 1974). Although he preached an equal division in New Harmony, he and others of the upper class contributors never practiced it nor hid their higher living standards from the rest of the group. There was extreme distinction between those who came to the project with large amounts of money and those who did not. Confusion and envy reigned in the 2 years, 1825-27, that the Owenites occupied New Harmony (Loubere, 1974).

'Class' structure in a so called egalitarian society did not strike Owen as ironic or implausible. In fact, it was not the class structure as much as the family unit that, in Owens opinion, caused lack of community. He felt the family was the basis for private ownership of property and selfish behavior in general. Owen attacked the family and refused to see class division as a primary problem. In his view, society should be one large family -- but class evidently did not seem to matter (Harrison, 1969).

Further cause for contention at New Harmony came from Owen's application of the labor theory of value. Owen, accepting the theoretical underpinnings of this theory of value, attempted to put it into active practice. However, the subjective nature of the pricing method as practiced in New Harmony led to a great deal of disagreement as to the "real" value of goods (Loubere, 1974, p. 84). Additionally, Owen's theories expounded mechanized production but his New Harmony experiment never matched the mechanization or success of the New Lanark mills. The main source of production at New Harmony was agrarian output. In an address to U.S. House of Representatives on February 25, 1825, Owen testified regarding the social order he brought to America:

> In the new system, union and co-operation will supersede individual interest, and the universal counteraction of each other's objects; and, by the change, the powers of one man will obtain for him the advantages of many, and all will become as rich as they will desire. … We cannot fail to be alive to the superiority of combined over individual efforts. (Johnson, 1970, p. 45)

However, these high moral ideals were not sufficient to keep New Harmony alive for more than 2 years (Loubere, 1974).

B.2 Fourierists

It was not until Francois Fourier died that his communitarian ideas were put into practice. As a social reformer, and one who had inherited an annual pension, he was able to write prolifically on the specific details of how a new social order should be structured. More than any other utopian socialist, Fourier created an elaborate theoretical system of detailed instructions and anticipated potential problems and their solution. Fourier did not limit himself to the mere economic reform of society, but as with many other Social Utopian communities of that time (most notably, Oneida Perfectionists, Shakers and

Mormons), he attempted to reform and restructure social relations at many levels including gender and marital roles. Unlike his economic ideas, Fourier considered some of his other ideas (involving sexual relations, as well as, the afterlife) as too radical for publication at the time.

Early followers of Fourier were among the many in France looking for social reform during the first half of the 19th century. However, throughout his life, Fourier searched without success for a wealthy patron to finance his phalanstery -- the name given to the physical application of his socialist theories. Fourier's economic ideas were not practiced until Victor Considerant became an advocate and missionary for the cause, and Albert Brisbane decided to adopt Fourierist ideas in America (Taylor, 1982).

Phalansteries (or phalanxes as they were called in America) were the common buildings central to the Fourierist community. Every detail was specified including the dimensions and the number of individuals to be included in each phalanx. The phalanx would house sixteen to eighteen hundred persons on three square miles of land. The land was to be divided for field crops, orchards and gardens. The living quarters were formed into groups of at least seven individuals representing 'ascending and descending tastes and abilities' (Taylor, 1982).

Like Owen, Fourier addressed the issue of 'unpleasant work' and decided that a battalion of junior workers would be in charge of cleaning and would learn to make it 'fun.' Each phalanx would have a concert hall, library, community dining chambers, nurseries and schools, as well as, the workshops and warehouses necessary for production (Rexroth, 1974).

The movement was not completely egalitarian. Shares were sold, but not all members were required to own shares. Further, the profits of the phalanx were divided five-twelfths to labor, four-twelfths to capital and three-twelfths to skill. Eleven-twelfths of the members would be farmers and mechanics and the remainder were to be artists, scientists and capitalists (Rexroth, 1974). Many individuals tested the Fourier principals but typically only for a short period. The already existing Brook Farm community, established by prominent intellectuals prior to the popularity of Fourierism, converted to the Fourierist program but soon failed and disassembled. The few Fourierist experiments that worked, organized a more practical communal arrangement than prescribed by Fourier. The North American phalanx in New Jersey was probably the most successful experiment of Fourierism. The members modified the exact specifications of Fourier and created a strict policy of not allowing more members than what the system could support and then only after a rigid screening and probationary period (Rexroth, 1974).

Not strictly socialist or egalitarian, Fourierism was a popular movement for a short period. Some thought Fourier to be mad. Aside from his economic reforms, he believed the earth would reach a state of perfect communalism, men would grow long tails with eyeballs at the end, and the oceans would turn to lemonade. Upon death, the body would turn into cosmic perfume. Although Fourier considered his social system as a perfect balance, he was unable to advance his more radical ideas -- ideas of free love among all genders and ages to indicate love and friendship. Fourier claimed these radical ideas would need to be introduced very slowly and only after re-education of the people (Taylor, 1982).

B.3 Icarians

Along with Fourier, Etienne Cabet was another product of the French revolutionary movement. He was exiled to England (Belgium refused asylum) in 1834 due to his advocacy of workers' rights and forceful revolution. While in exile Cabet met Robert Owen and other radical social reformers. Greatly influenced by Thomas Moore's *Utopia*, he wrote his own utopian novel, *Journey to Icaria*, published in 1840.

> You are right if you think that the city is perfectly illuminated, as well as Paris and London, even much better, because the source of light is not absorbed by the shops, since there are none, or by the factories, since nobody works at night. Illumination is then concentrated on the streets and public monuments; and not only is the gas odorless because means have been found to purify it, but the illumination combines to the highest degree the pleasing and the useful, through the elegant and varied forms of the street lamps and the thousand shapes and colors which they give the light. I have seen fine illumination in London in some streets on certain holidays; but in Icara the illumination is always magnificent, and sometimes it creates a veritable fairy-land. (Cabet, 1842/1946, What follows is the text…)

His efforts from that time forth were to establish an 'Icarian' movement that would practice the principles of utopian socialism as he saw it. Along with this emphasis on practical application, he wrote a work describing Christianity's connection to communitarian thinking. "He placed increasing emphasis during the 1840s on communism as a new Christian doctrine…[s]uch a suggestion was hardly original, yet it did much to reinforce the image of Icarianism as a perfectly respectable movement" (Taylor, 1982, pp. 162-63).

Even so, it became clear that the French government would not allow an Icarian community to ever be established in France. In 1847, Cabet announced to his followers that they would move to the United States and establish an Icarian community. At that time, the Icarian movement had between 10-20 thousand members and was established as a communist organization for the working class in France. Cabet had earlier attacked the ideas of Owen and Fourier as too small scale – Cabet originally fought for a whole nation of communism. The decision to move to America and attempt a small scale socialist community undoubtedly cost Cabet many followers. However, a larger problem for the Icarian movement and its American experiment was that shortly after setting sail for the US, the French revolution successfully overthrew the monarchy and many of Cabet's followers left the Icarian movement to influence the new French government (Taylor, 1982).

In order to succeed at his communitarian project, Cabet contacted Robert Owen for ideas on property location in the U.S. and other practical application of communitarian socialism. After a failed attempt in Texas without Cabet present, Cabet came to the U.S. in 1849 and the Icarians reconvened in Nauvoo, Illinois, previously abandoned by the Mormons fleeing to the arid west (Taylor, 1982).

The Icarians legally incorporated in Illinois and issued capital stock. A company was established with six directors and a General Assembly (comprised only of adult males.) No person was allowed to own more than one share, thus keeping a form of equality as part of the movement. Along with these practical requirements, Cabet required love for each other and organization and discipline from the members. Further, there was a requirement to know the appropriate Icarian texts and abstain from tobacco and strong alcohol and to allow the community to control the education of the children (Taylor, 1982).

As to the productive efforts of the community, few details are known aside from the funding that continued from Paris through 1863 either from wealthy philanthropists or contributions from the mass of sympathetic workers to the communist ideal (Taylor, 1982). The implication of this funding is that the communitarian production was not sufficient to meet the needs or wants of the group. As with other experiments in social equality, it was understood that the first generation may have a difficult time changing their old thinking. This was the case with the Icarian community, but it also seemed the youth growing up in the utopian culture failed to receive the appropriate education to change their ways and make Icarian community stronger and more productive. Much of the idealism was just that -- there were few practical ways to motivate members to want to work and contribute to the success of the community. Cabet solved the problem in theory by assuming machines would perform the most unpleasant tasks -- in practice, however he found no solution.

Another problem with the Icarian society was its governance. The position of President, which Cabet held continuously between 1850 and 1855, was a completely authoritarian post. As Cabet became increasingly despotic over the years, there was mounting opposition to his authoritarian style of governance and a significant group of dissidents left the main community (Taylor, 1982). Gradually, the numbers who remained with Cabet diminished until his death in 1857 when there were less than 200 followers. The remaining Icarians attempted to continue a style of Icarian community but failed to agree on how it should be carried out. Faction after faction left the body until the Icarian movement finally died out (Taylor, 1982). Finally, in 1863 the last of the Icarians dissolved -- the young men rebelled against the old and the common property reverted to private ownership (Taylor, 1982).

APPENDIX C

PHARMACEUTICAL PATENTS

Within the pharmaceutical industry, increased government oversight during the 20th century drove up the costs of innovation and simultaneously decreased the term of IP protection. In 1938, prompted by the disastrous effect of sulfanilamide that killed 107 individuals, government regulators passed the Food, Drug and Cosmetic (FDC) Act which required new drugs to be proven safe prior to marketing. This Act charged the Food and Drug Administration (FDA) to provide safety standards to the public but did not distinguish between those drugs that must be dispensed with a prescription and those that could be sold over-the-counter (OTC) – this distinction was left to the manufacturers' discretion (Kaplan, 1995). In 1951 the Durham-Humphrey Amendment entrusted to the FDA to determine if a prescription was necessary based on whether the drug presented risks "beyond the ability of laymen to safely assume," or whether it was intended to treat a condition that was "beyond the layman's capacity to recognize and treat" (Kaplan, 1995, pp. 179-196). It wasn't until 1962 and the devastation of Thalidomide on infants that the FDA was required to approve new drug safety and efficacy.[40]

[40] An additional change to the pharmaceutical industry from this same 1962 Act provided the opportunity for generic manufacturers to obtain FDA approval through a 'paper' New Drug Application (NDA.) This paper NDA meant that a manufacturing firm could receive approval "based solely on published scientific or

FDA approval increased costs pharmaceuticals length of time to market which often exceeded 10 years. (Congressional Budget Office, July 1998, section 6.) Extended FDA oversight also increased cost of development and reduced the effective length of patent protection due to the necessity of obtaining patent protection on the pharmaceutical invention prior to initiating the FDA approval process. In 1978, the Carter administration reviewed domestic policy on industrial innovation and recommended "term restoration of pharmaceuticals and any other product that required regulatory review – to compensate for, or restore to the term of the patents, the time lost in regulatory review" (Mossinghoff, 1999, p. 187). This recommendation provided momentum for the Hatch Waxman Act which combined patent term restoration along with increased generic drug competition and was passed into law in 1984 (Congressional Budget Office, 1998, section 6; see also Mossinghoff, 1999). The patent extension aspect of the Hatch-Waxman Act restored some of the time pharmaceutical patents lost while in the FDA approval process. The extension length varies based on the length of time for FDA approval but cannot exceed 5 years nor can it extend the patent beyond 14 years after product approval (Congressional Budget Office, July 1998, section 6).[41]

medical literature; a generic manufacturer could get its drug approved by showing that learned articles had been written about the chemical demonstrating that it was safe" (Mossinghoff, 1999, p. 187).

[41] For 43 drugs approved between 1992 and 1995 that applied for an extension under Hatch-Waxman, the average extension was 3 years (Congressional Budget Office, 1998, section 6).

REFERENCES

About the Synaptic Leap. (2006). Retrieved from http://www.thesynapticleap.org/about

Adelman, D. E. (2006, February). Patent metrics: The mismeasure of innovation in the biotech patent debate. *Arizona Legal Studies*, *Discussion Paper No.*, *06-10*.

Alexander, E. C., & Keep, W. W. (1995). Innovativeness and Shaker society. *7th Marketing History Conference Proceedings, VII*, 363-373.

Anderson, T. (2010, March). Open source: the way forward in the search for new treatments for the infectious diseases of poverty?. Retrieved from http://www.tropika.net/svc/news/20100317/ Anderson-20100317-News-OpenSource

Andrews, E. D., & Andrews, F. (1974). *Work and worship among the Shakers*. Retrieved from http://books.google.com/books?hl=en&lr=&id=Yh18lhH-ytwC

Apache license and distribution FAQ. (2011). Retrieved from http://apache.org/foundation/license-faq.html#WhatDoesItMEAN

Apache license v2.0 and GPL compatibility. (2011). Retrieved from http://www.apache.org/licenses/GPL-compatibility.html

Apache, HTTP server project. (2011). Retrieved from http://httpd.apache.org/ABOUT_APACHE.html

Arrington, L. J. (1976). *Building the city of God, community and cooperation among the Mormons*. Salt Lake City, UT: Deseret Book Company.

Ash, A., & Roberts, J. (2008). *Community, economic creativity, and organization* . Oxford, UK: Oxford University Press.

Bates, J., Lakhani, K. R., & Wolf, B. (2002, July). The Boston Consulting Group Hacker Survey. *O'Reilly Open Source Conference,*1-43. Retrieved from http://ftp3.au.freebsd.org/pub/linux.conf.au/2003/papers/Hemos/ Hemos.pdf

Beck, R. (2010, May). Farmers' rights and open source licensing. Arizona Journal of Environmental Law & Policy, 1(2), 167 – 218. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1601574

Becksvoort, C., & Sheldon, J. (2000). *Shaker legacy*. Retrieved from http://books.google.com/books?id=SvNd-yJUDW0C

Beggs, A. W. (2001, April). Queues and hierarchies. *The Review of Economic Studies, 68*(2), 297-322. Retrieved from http://www.jstor.org/stable/2695930

Benkler, Y. (2004, November). Sharing nicely: On shareable goods and the emergence of sharing as a modality of economic production . *The Yale Law Journal, 114*(2), 273-358. Retrieved from http://www.jstor.org/stable/4135731

Bestor, A. E. (1953, April). Patent-office models of the good society: some relationships between social reform and westward expansion. *The American Historical Review, 58*(3), 505-526. Retrieved from http://www.jstor.org/stable/1843945

Bhardwaj, A., Scaria, V., & Patra, D. (2011, January-February). Open source drug discovery: A global collaborative drug discovery model for tuberculosis. *Science and Culture, 77*(1-2), 22-26. Retrieved from http://www.scienceandculture-isna.org/jan2011/04%20Anshu%20Bhardwaj.pdf

BiOS - Executive staff. (n.d.). Retrieved from http://www.bios.net/daisy/bios/2518.html

BiOS PMET License Agreement 1.5. (n.d.). Retrieved from http://www.cambia.org/daisy/bios/3530/version/default/part/AttachmentData/data/BiOS%20License%20and%20Tech%20Support%20Agreement%20version%201_5.pdf

BiOS, Home. (n.d.). Retrieved from http://www.patentlens.net/daisy/bios/home.html

Blinn, H. C. (1884). *The manifesto, volumes 14-15*. Retrieved from http://books.google.com/books?id=pAhbAAAAMAAJ.

Boyd, R., & Richerson, P.J. (1985). *Culture and the evolutionary process*. Chicago, IL: University of Chicago Press.

Boyle, J. (2004). *James Boyle: Give me liberty and give me death?*. Retrieved from http://www.law.duke.edu/boylesite/liberty.html

Brandes, P. A., & Kropotkin, G. (1899/2009). *Memoirs of a Revolutionist*. Retrieved from http://books.google.com/books?id=9nvlvlXnMSkC&printsec=frontcover&dq=Pyotr+Alexeyevich+Kropotkin+%28and+Georg+Brandes%29+Memoirs+of+a+Revolutionist&hl=en&sa=X&ei=QDf- TuGjNoiYiAKqncCACA&ved=0CDYQ6AEwAA#v=onepage&q&f=false.

Bratspies, R. M. (2006/2007). The new discovery doctrine: Some thoughts on property rights and traditional knowledge. *American Indian Law Review, 31(2), 315-340*. Retrieved from http://www.jstor.org/stable/20070790

Brown, J. S., & Duguid, P. (1991, March). Organizational learning and communities-of-practice: Toward a unified view of working. *Organization Science, 2*(1), 0-57. Retrieved from http://www.jstor.org/stable/2634938.

Brown, S.L. (2002). *Intentional community, an anthropological perspective*. New York, NY: State University of New York Press.

Brumann, C. (2003, April). All the flesh kindred that ever I see: a reconsideration of family and kinship in utopian communes. *Comparative Studies in Society and History, 45*(2), 395-421. Retrieved from http://www.jstor.org/stable/3879322

Buckingham, D. A. (1877, August). Epitomic history of the Watervliet Shakers. *The Shaker, 7:8*(4), 59. Retrieved from http://dlib.hamilton.edu/dl-sha/

Cabet, E. (1842 /1946). *Voyage en Icarie* (5th ed.). Retrieved from http://www.marxists.org/subject/utopian/cabet/icarus.htm.

CAMBIA, What is a ‘protected commons’?. (n.d.). Retrieved from http://www.cambia.org/daisy/cambia/404.html

Carrier, M. A. (2004, October). Cabining intellectual property through a property paradigm. *Duke Law Journal, 54*(1), 1-145. Retrieved from http://www.jstor.org/stable/40040481

Carson, P. P., Lanier, P. A., & Carson, K. D. (2000). An historical examination of early "Believers" in the quality managements movement: The Shaker example. *The TQM Magazine*, *12*(1), 37-52.

Carter, C. L., & Geores, M. E. (2006). Heaven on earth: the Shakers and their space. *Geographies of Religions and Belief Systems*, *1*(1), 5-27. Retrieved from http://gorabs.org/journal/issues/2006/GOR01_01_carter.pdf

Clayton, W. (1921). *William Clayton's journal, A daily record of the journey of the original company of “Mormon” pioneers from Nauvoo, Illinois, to the valley of the Great Salt Lake*. Salt Lake City, UT: The Deseret News.

Cole, D. H., & Grossman, P. Z. (2002, August). The meaning of property rights: law versus economics?. *Land Economics, 78*(3), 317-330. Retrieved from http://www.jstor.org/stable/3146892

Cole, R.E., & Lee, G.K. (2003, November/December). From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organization Science, 14*(6), 633-649. JSTOR.

Congressional Budget Office. (1998, July). How increased competition from generic drugs has affected prices and returns in the pharmaceutical industry. Retrieved from http://www.cbo.gov/ftpdocs/6xx/doc655/pharm.pdf

Cook, L. W. (1985). *Joseph Smith and the Law of Consecration*. Provo, UT: Grandin Book Company.

Cooper, M. (1987, January). Relations of modes of production in nineteenth century America: the Shakers and Oneida. *Ethnology, 26*(1), 1-16.
Retrieved from http://www.jstor.org/stable/3773412

Corbato, F.J. & Vyssotsky, V. A. (1965). Introduction and overview of the Multics System. 1965 Fall Joint Computer Conference. Retrieved from http://www.multicians.org/fjcc1.html

Corbet, J. (2008). *How to participate in the Linux community*. Retrieved from http://www.linux.com/learn/whitepapers/doc/3/raw

Corbet, J., Kroah-Hartman, G., & McPherson, A. (2010, December). Linux kernel development, How fast it is going, who is doing it, what they are doing, and who is sponsoring it. *The Linux Foundation*. Retrieved from https://www.linuxfoundation.org/sites/main/files/lf_linux_kernel_development_2010.pdf

Correa, C. M. (2001, November). Traditional Knowledge and Intellectual Property, Issues and options surrounding the protection of traditional knowledge. *Quaker United Nations Office (QUNO).*
Retrieved from http://www.quno.org/geneva/pdf/economic/Discussion/Traditional-Knowledge-IP-English.pdf

Cosgel, M. M., Miceli, T. J., & Murray, J. E. (1997, April). Organization and distributional equality in a network of communes: the Shakers. *American Journal of Economics and Sociology*, *56*(2), 129-144.
Retrieved from http://www.jstor.org/stable/3487250

Crain, W.C., (2000). *Theories of development, concepts and applications* (4th ed.), New Jersey, Prentice Hall

Crawley, P. (2005). *A descriptive bibliography of the Mormon church, volume two 1848-1852*. Retrieved from Digital Collections at BYU.

Crawley, P. (2005). *A descriptive bibliography of the Mormon church, volume two 1848-1852*. Retrieved from http://relarchive.byu.edu/MPNC/descriptions/emigrants.html

Cukier, K. N. (2006, March). Navigating the future(s) of biotech intellectual property. *Nature Biotechnology, 24*(3), 249-251. doi:10.1038/nbt0306-249

Datta, S. (2008-09, December-January). Ayurveda to OSDD – India's Unbroken Tradition of Affordable Healthcare. Everyman's Science, XLIII (5), 308- 312. Retrieved from http://sciencecongress.nic.in/html/pdf/Dec08_Jan09.pdf

David, S., & Tsur, M. (2005, April). A license to kill (innovation)? Open source licenses and their implications for innovation. Retrieved from http://ssrn.com/abstract=858104.

Demsetz, H. (2002, June). Toward a theory of property rights II: the competition between private and collective ownership. *The Journal of Legal Studies*, 31(2), S653-S672. Retrieved from http://www.jstor.org/stable/3592064

Dougherty, R. J. (2003, Fall). Catholicism and the economy: Augustine and Aquinas on property ownership. *Journal of Markets & Morality*, 6(2), 479-495.

Dreyfuss, Joel, ed. (2006, April). Open Source. Red Herring , 30-36. Retrieved from http://www.patentlens.net/daisy/patentlens/2296/version/default/part/AttachmentData/data/Red%20Herring%20-%20April%2017,%202006.pdf

Duffy, J. (2004, Spring). Rethinking the prospect theory of patents. *University of Chicago Law Review, 71*(2), 439-510. Retrieved from http://www.jstor.org/stable/1600673

Egan, H. (1917). *Pioneering the west, 1846 to 1878; Major Howard Egans' diary*. Salt Lake City, UT: Skelton Publishing.

Endowed from on high: Temple preparation seminar teacher's manual. (2003). Retrieved from http://lds.org/manual/endowed-from-on-high-temple-preparation-seminar-teachers-manual/lesson-4-receiving-temple-ordinances-and-covenants?lang=eng&query=temple+covenant

Epstein, R., & Kuhlik, B. N. (2004, March). Navigating the anticommons for pharmaceutical partners: Steady the course on Hatch-Waxman. *Chicago Working Paper Series*, (No. 209). Retrieved from http://www.law.uchicago.edu/Lawecon/index.html

Estlake, A. (1900). *The Oneida Community and American Socialism*. Retrieved from http://books.google.com/books?id=X6spAAAAYAAJ

Evans, F. W. (1888). *Autobiography of a Shaker: and revelation of the apocalypse*. Retrieved from http://books.google.com/books?hl=en&lr=&id=gOUKAAAAYAAJ

FAQs - BiOS Agreements. (n.d.). Retrieved from http://www.bios.net/daisy/bios/1249.html

Fecteau, L. (2001, January). The Ayahuasca patent revocation: Raising questions about current US patent policy. *Boston College Third World Law Journal, 21*(1), 69-104. Retrieved from http://lawdigitalcommons.bc.edu/twlj/vol21/iss1/4

Fehr, E., & Schmidt, K. (1999, August). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics, 114*(3), 817-868.

Firefox. (2010). Retrieved from http://www.mozilla.com/en-US/firefox/ie.html

Foley, J. P. ed. (1900). *The Jeffersonian cyclopedia: a comprehensive collection of the views of Thomas Jefferson* . Retrieved from http://books.google.com/books?id=ZTIoAAAAYAAJ&pg=PA433&dq=%E2%80%9C

Freedman, D. H. (2007, February). Mitchell Baker and the Firefox paradox. *Inc.*, Retrieved from http://www.inc.com/magazine/20070201/features-firefox.html

Gallini, N. T. (2002, Spring). The economics of patents: lessons from recent US patent reform. *The Journal of Economic Perspectives* , *16*(2), 131-154. Retrieved from http://links.jstor.org/sici?sici=0895-3309%28200221%2916%3A2%3C131%3ATEOPLF%3E2.0.CO%3B2-M

Gardner, H. (1917, May). Cooperation among the Mormons. *The Quarterly Journal of Economics, 31*(3), 461-499. Retrieved from http://www.jstor.org/stable/1883385

Gardner, H. (1922, November). Communism among the Mormons. *The Quarterly Journal of Economics, 37*(1), 134-174. Retrieved from http://www.jstor.org/stable/1885911.

Garrouste, p., & Saussier, S. (2005, August). Looking for a theory of the firm: Future challenges. *Journal of Economic Behavior & Organization*, *58*, 178-199. doi:10.1016/j.jebo.2004.09.008

Gaudeul, A. (2007, June). Do open source developers respond to competition? The (LA)TEX case study. *Review of Network Economics, 69*(2), 239-263. Retrieved from http://www.bepress.com/cgi/viewcontent.cgi?article=1119&context=rne&sei-redir=1&referer=http%3A%2F%2Fscholar.google.com%2Fscholar%3Fhl%3Den%26q%3DDo%2BOpen%2BSource%2BDevelopers%2BRespond%2Bto%2BCompetition%253F%253A%

2BThe%2BLATEX%2BCase%2BStudy%26btnG%3DSearch%26as_sdt%3D0%252C45%26as_ylo%3D%26as_vis%3D0#search=%22Do%20Open%20Source%20Developers%20Respond%20Competition%3F%3A%20LATEX%20Case%20Study%22

Gay, J., editor, (2002). *Free software, free society: Selected essays of Richard M. Stallman*. Retrieved from http://www.gnu.org/philosophy/fsfs/rms-essays.pdf.

Gerloff, K. (2010). *Free software and standardization*. Retrieved from http://ec.europa.eu/enterprise/sectors/ict/files/ict-policies/13_gerloff_en.pdf

Get involved with Mozilla. (2011). Retrieved from http://www.mozilla.org/contribute/

Gloor, P. A. (2006). *Swarm creativity: competitive advantage through collaborative innovation networks*. Oxford, UK: Oxford University Press.

GNU Operating System, GNU General Public License, Version 2. (1991). Retrieved from http://www.gnu.org/licenses/gpl-2.0.html

Gosepath, S. (2009). *Stanford Encyclopedia of Philosophy*. Retrieved from http://plato.stanford.edu/archives/win2009/entries/equality/

Goulding, R. (2009, June). Open source and neglected disease drug discovery. *OHI Deliverables,* (#4), 1-16. Retrieved from http://isis.sauder.ubc.ca/files/2010/06/goulding_os_and_nd_drug_discovery_p4_briefing_.pdf

Greene, S. (2004, April). Indigenous people incorporated. *Current Anthropology, 45*(2), 211-237. Retrieved from http://www.ibcperu.org/doc/isis/2822.pdf

Griliches, Z. ed. (1984). *R&D, patents, and productivity*. Retrieved from http://www.nber.org/books/gril84-1

Hafstein, V. T. (2004). The politics of origins: Collective creation revisited. *Journal of American Folklore*, *117*(465), 300-315.
Retrieved from http://hi.academia.edu/ValdimarHafstein/Papers/961670/The_politics_of_origins_Collective_creation_revisited

Harrison, J.F.C. (1969). *Quest for a new moral world*. New York, NY: Charles Scribner.

Hasan, R. (2005). *History of Linux*. Retrieved from https://netfiles.uiuc.edu/rhasan/linux

Herbsleb, J. D., & Mockus, A. (2002, July). Two Case Studies of Open Source Software Development: Apache and Mozilla. *ACM Transactions on Software Engineering and Methodology,, 11*(3), 309-346. Retrieved from http://herbsleb.org/web-pubs/pdfs/mockus-two-2002.pdf

Hess, C., & Ostrom, E. (2003, Winter-Spring). Ideas, artifacts, and facilities: information as a common-pool resource. *Law and Contemporary Problems, 66*(1/2), 11-145. Retrieved from http://www.jstor.org/stable/20059174

Hilgers, D., Muller-Seitz, G., & Piller, F. T. (2010). Benkler revisited - venturing beyond open source software arena?. *ICIS 2010 Proceedings, Paper 97*(), 1-16. Retrieved from http://aisel.aisnet.org/icis2010_submissions/97/

Hinds, W. A. (1878). *American communities: brief sketches of Economy, Zoar, Bethel, Aurora, Amana, Icaria, The Shakers, Oneida, Wallingford, and The Brotherhood of the New Life*. Retrieved from http://books.google.com/books?hl=en&lr=&id=jzJJAAAAIAAJ

History of the Mozilla project. (1998-2010). Retrieved from http://www.mozill.org/aout/history.html

How do BiOS agreements encourage and ensure access and benefits-sharing. (n.d.). Retrieved from http://www.patentlens.net/daisy/bios/3596.html

How the ASF works. (2011). Retrieved from http://apache.org/foundation/how-it-works.html#developers

How to participate in the Linux.com. (2011). Retrieved from https://www.linux.com/tour http://www.cambia.org/daisy/cambia/4790/version/default/part/AttachmentData/data/Q&A.v5.pdf

Hughes, J. (1988, December Day). The philosophy of intellectual property. . Retrieved from http://www.justinhughes.net/docs/a-ip01.pdf

Human Genome. (n.d.). Retrieved from http://www.ornl.gov/sci/techresources/Human_Genome/project/about.shtml

Human Genome Project information, Genetics and patenting. (2008) Retrieved from http://www.ornl.gov/sci/techresources/Human_Genome/elsi/patents.shtml

Hunt, E.K. (2002). *History of economic thought, A critical perspective* (2nd ed.). NY, NY: M.E. Sharpe.

International Cooperative Biodiversity Groups (ICBG). (2002, October). Retrieved from http://www.icbg.org/pub/documents/finalreport_20021017.pdf

International HapMap Project. (2006) Retrieved from http://hapmap.ncbi.nlm.nih.gov/abouthapmap.html

Iwasaka, R. M. (2000, April). From Chakrabarty to chimeras: The growing need for evolutionary biology in patent law. *The Yale Law Journal, 109*(6), 1505-1534. Retrieved from http://links.jstor.org/ sici?sici=0044-0094%28200004%29109%3A6%3C1505%3AFCTCTG% 3E2.0.CO%3B2-6

Johnson, O. C. (1970). *Robert Owen in the United States*. New York, NY: Humanities Press.

Jostedt, E. (2009). *The Mozilla blog*. Retrieved from http://blog.mozilla.com/blog/2010/11/09/happy-6th-birthday-firefox/

Kahn, A. E. (1940, September). Fundamental deficiencies of the American patent law. *The American Economic Review*, 30(3), 475-491. Retrieved from http://www.jstor.org/stable/1807576.

Kaplan, A. H. (1995). Fifty years of drug amendments revisited: In easy-to-swallow capsule form. *Food & Drug Law Journal, 179*. Retrieved from http://heinonline.org/HOL/LandingPage?collection=journals& handle=hein.journals/foodlj50&div=76&id=&page=

Katz, C. J. (1997, June). Private property versus markets: democratic and communitarian critiques of capitalism. *The American Political Science Review, 91*(2), 277-289. Retrieved from http://www.jstor.org/stable/2952356

Kloppenburg, J. (2008, November). Seeds, Sovereignty, and the Via Campesina: Plants, Property, and the Promise of Open Source Biology. Workshop on Food Sovereignty: Theory, Praxis and Power, 1-34. Retrieved from http://www.drs.wisc.edu/documents/articles/kloppenburg/ 2008%20Seeds%20and%20Sovereignty.pdf

Knous, M. (2011). *Mozilla Developers Network*. Retrieved from https://developer.mozilla.org/en/Code_Review_FAQ

Kothari, A., & Anaruadha, R. V. (1999). Biodiversity and intellectual property rights: can the two co-exist?. *Journal of international Wildlife and Policy, 2*(2), . Retrieved from http://www.jiwlp.com/contents/ashish.pdf

Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. Retrieved from http://books.google.com/books?id=CAVIOrW3vYAC&dq=situated+learning+ legitimate+peripheral+participation&lr=&source=gbs_navlinks_s

Lee, P. (2004, December). Patents, Paradigm Shifts, and Progress in Biomedical Science. *The Yale Law Journal*, Vol. 114 (3), 670.

Lerner, J., & Tirole, J. (2002, June). Some simple economics of open source. *The Journal of Industrial Economics, 50*(2), 197-234. Retrieved from http://www.jstor.org/stable/3569837

Lerner, J., & Tirole, J. (2005, Spring). The economics of technology sharing: Open source and beyond. *Journal of Economic Perspectives,* 19(2), 99-120. Retrieved from http://www.jstor.org/stable/4134939.

Levine, R. (2005, Summer). Law, endowments and property rights. *Journal of Economic Perspectives*, 19(3), 61-88. Retrieved from http://www.jstor.org/stable/4134973.

Levmore, S. (2002, June). Two stories about the evolution of property rights. *The Journal of Legal Studies*, 31(2), S421-S451. Retrieved from http://www.jstor.org/stable/3592057

Licenses - The Apache Software Foundation. (2010). Retrieved from http://wwww.apache.org/licenses/

Lipartito, K., & Sicilia, D.B. (2004). *Constructing corporate America, History, politics, culture*. Oxford Scholarship Online. doi:10.1093/acprof:oso/9780199251902.001.0001

Long, P. (1991, October). Invention, authorship, "intellectual property," and the origin of patents: Notes toward a conceptual history. *Technology and Culture, 32*(4), 846-884. Retrieved from http://www.jstor.org/stable/3106154

Loubere, L. (1974). *Utopian Socialism, It's history since 1800*. Cambridge, MA: Schenkman Publishing.

Love, J. (2005). Pharmaceutical research and development and the patent system. International Journal of Health Services Planning Administration Evaluation, 35 (2), 257-263. Retrieved from http://www.mendeley.com/research/ pharmaceutical-research-development-patent-system/

Lowenthal, E. (1927, February). The labor policy of the Oneida Community, Ltd.. *The Journal of Political Economy*, 35(1), 114-126. Retrieved from http://www.jstor.org/stable/1821791.

Mair, J. (2011, Spring). Q&A: Richard Jefferson. Stanford Social Innovation Review, 13-15. Retrieved from http://www.cambia.org/daisy/cambia/4790/version/default/part/AttachmentData/data/Q&A.v5.pdf

Malone, T. W., Laubacher, R., & Dellarocas, C. (2009, February). Harnessing crowds: Mapping the genome of collective intelligence. *MIT Center for Collective*

Intelligence, Working Paper No. 2009-001. Retrieved from http://cci.mit.edu/publications/CCIwp2009-01.pdf

Marasco, S., & Boyer, K. (2001). *The stock market returns to disaggregated intangible investments*. Michigan State University. ProQuest Dissertations and Theses. Retrieved from http://search.proquest.com.ezproxy.apollolibrary.com/pqdtft/docview/304703168/abstract/1340CAA02F06C7A0DC2/1?accountid=35812

March 2010 Web Server Survey - Netcraft. (2010). Retrieved from http://news.netcraft.com/archives/2010/03/17/march_2010_web_server_survey.html

Marx, K. (translated 1953). *Grundrisse der kritik der politischen okonomie*. Retrieved from http://www.marxists.org/archive/marx/works/1857/grundrisse/

Maskus, K. E. (2006, November). Reforming US patent policy: Getting the incentives right. Retrieved from http://www.asiaing.com/reforming-u-s-patent-policy-getting-the-incentives-right.htm

Masum, H., Schroeder, K., & Khan, M., Daar, A. (2011, Spring). Open source biotechnology platforms for global health and development. *Information Technologies & International Development, 7*(1), 61-69. Retrieved from http://itidjournal.org/itid/article/viewFile/697/295

Maurer, S. M., & Scotchmer, S. (2002, November). The independent invention devence in intellectual property. *Economica, 69*(276), 535-547. Retrieved from http://www.jstor.org/stable/3549014

Maurer, S. M., Rai, A., & Sali, A. (2004). Finding cures for tropical diseases: Is open source an answer?. PLoS Med 1(3) e56. doi:10.1371/journal.pmed.0010056

Mill, J.S., (1879, reprint 1987). On Socialism. Buffalo, NY: Promethius Books.
Modules and Module Owners. (2011). Retrieved from http://www.mozilla.org/hacking/module-ownership.html

Moser, P. (2005, July). Do patent laws help diffuse innovation? Evidence from the geographic localization of innovation and production in 19th-century England. *unpublished*,1-35. Retrieved from http://web.mit.edu/moser/www/loc507nber.pdf

Mossinghoff, G. J. (1999). Overview of the Hatch-Waxman Act and its impact on the drug development process. *Food and Drug Law Journal, 54*, 187-194. Retrieved from http://www.regulatorypro.com/FDLI%20-%20Overview%20of%20Hatch-Waxman%20Act%201984.pdf

Mossoff, A. (2007). Who cares what Thomas Jefferson thought about patents? Reevaluating the patent "privilege" in historical context. *Cornell Law Review*, *92*(953), 953-1012. Retrieved from http://www.lawschool.cornell.edu/research/cornell-law-review/upload/CRN502Mossoff.pdf

Mozilla awards. (n.d.). Retrieved from http://www.mozilla.org/en-US/press/awards.html

Mozilla Foundation and subsidiaries, December 31, 2010 and 2009, independent auditors' Report and consolidated financial statements. (2010). Retrieved from http://static.mozilla.com/moco/enUS/pdf/Mozilla%20Foundation%20and%20Subsidiaries%202010%20Audited%20Financial%20Statement.pdf

Mozilla metrics report Q1 2010. (2010). Retrieved from https://wiki.mozilla.org/images/e/ed/Analyst_report_Q1_2010.pdf

Mozilla Public License Version 1.1. (n.d.). Retrieved from http://www.mozilla.org/MPL/MPL-1.1.html

Mozilla roles and leadership. (2011). Retrieved from http://www.mozilla.org/about/roles.html

Munos, B. (2006, August). Can open-source R&D reinvigorate drug research?. *Nature Reviews Drug Discover*. doi:10.1038/nrd2131

n.a., . (1895, March 7). A loss of $80,000,000. *St. Paul Daily Globe*. Retrieved from http://chroniclingamerica.loc.gov/lccn/sn90059522/1895-03-07/ed-1/seq-6.pdf

n.a., . (1905, March 12). Their large colonies dwindling away, the remnants growing old and feeble. *St. Paul Globe*. Retrieved from http://chroniclingamerica.loc.gov/lccn/sn90059523/1905-03-12/ed-1/seq-10/

National Cyber Alert System, Cyber Security Alert SA04-184.A. (2004). Retrieved from http://www.us-cert.gov/cas/alerts/SA04-184A.html

Newhouse, S. (1865). *The trapper's guide a treatise on the capture of fur-bearing animals*. Retrieved from http://books.google.com/books?hl=en&lr=&id=8BNIAAAAIAAJ

Olin, S. C. (1980, September). The Oneida Community and the instability of charismatic authority. *The Journal of American History*, *67*(2), 285-300. Retrieved from http://www.jstor.org/stable/1890409

Oneida Association. (1849). *First annual report of Oneida Association: exhibiting its history, principles, and transactions to Jan. 1, 1849*. Retrieved from http://libwww.syr.edu/digital/collections/f/FirstAnnualReportOfTheOneidaAssociation/.

Oneida Community. (1867). Hand-book of the Oneida Community. Retrieved from http://libwww.syr.edu/digital/collections/h/Hand-bookOfTheOneidaCommunity/

Oneida Community. (1876). Mutual criticism, Pamphlet published by the Oneida Community in 1876. Retrieved from http://libwww.syr.edu/digital/collections/j/JohnHumphreyNoyes,ThePutneyCommunity/chapter12/.

Open Source Drug Discovery, FAQs. (n.d.). Retrieved from http://www.osdd.net/faqs

Open Source Drug Discovery, What is OSDD. (n.d.). Retrieved from http://www.osdd.net/about-us

Orti, L., Carbajo, R.J., & Pieper, U., Eswar, N., Maurer, S. M., Rai, A. K., Taylor, G., Todd, M. H., Pineda-Lucena, A., Sali, A., & Marti-Renom, M. A. (2009, April). A kernel for open source drug discovery in tropical diseases. *PLoS Neglected Tropical Diseases, 3*(4), e418. doi:10.1371/journal.pntd.0000418

OSDD crosses 5000 registered users. (2011). Retrieved from http://www.osdd.net/new-updates/osddcrosses5000registeredusers

Osterloh, M., & Rota, S. G. (2004, March). Open source software development - just another case of collective invention?
Retrieved from http://papers.ssrn.com/sol13/papers.cfm?abstract=561744

Osterloh, M., & Rota, S. G. (2007). Open source software development - just another case of collective invention?. *Research Policy,* 36(2), 157-171.

Ostrom, E. (1990). *Governing the commons: the evolution of institutions for collective action* (15th ed.). Cambridge, UK: Cambridge University Press.

Ostrom, E. (2010, June). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review*, 100(3), 1-33.

Penin, J. (2011, April). Open source innovation: Towards a generalization of hte open source model beyond software. *DIME Final Conference*, 1-23.
Retrieved from http://final.dime-eu.org/files/Penin_D7.pdf

Phipps, S. (2010). *Computer World UK: Apache's lesson in radical transparency*. Retrieved from http://blogs.computerworlduk.com/simon-says/2010/05/apaches-lesson-in-radical-transparency/index.htm#

Porceddu, M. C., & Jefferson, R. (2004, November). Fostering democratic innovation as a means of reducing the 10/90 gap in health. *Global Forum for Health Research*,

1-13.
Retrieved from http://www.patentlens.net/daisy/patentlens/1259/version/default/part/AttachmentData/data/(2004)%20Fostering%20Democratic%20Innovation.pdf

Radner, R. (1992, September). Hierarchy: the economics of managing. *Journal of Economic Literature, 30*(3), 1382-1415.
Retrieved from http://www.jstor.org/stable/2728063

Ragavan, S. (2001). Protection of traditional knowledge. *Minnesota Intellectual Property Law Review, 2*(2).
Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=310680

Raymond, E. S. (2002). *The Cathedral and the Bazaar*. Retrieved from http://www.catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/

Rexroth, K. (1974). *Communalism, from its origins to the 20th century*. Retrieved from http://www.bopsecrets.org/rexroth/communalism.htm

Richardson, G., & McBride, M. (2008, May). Religion, longevity, and cooperation: the case of the craft guild. *NBER Working Paper,* (no. 14004).
Retrieved from http://www.nber.org/papers/w14004

Romney, M. G. (1966). *Is socialism the United Order?*. Retrieved from http://members.tripod.com/~runwin/socialism.html

Rosenzweig, S. A. (2009, March). The false connection between strong patent rights and global inequity: A response to professor Stiglitz. *The Progress and Freedom Foundation*, 16(8).

Rothschild, J., editor. (1981). *Women's Studies International Quarterly*. Oxford, UK: Pergamon Press Ltd.

Samuel, W. J. (1961, February). The Physiocratic theory of property and state. *The Quarterly Journal of Economics*, 75(1), 96-111. Retrieved from http://www.jstor.org/stable/1883206.

Scaria, V. (2010, December). The Open Source Drug Discovery. *OSDD Update, 1*(1), 1-12. Retrieved from https://docs.google.com/viewer?a=v&pid=sites&srcid=b3NkZC5uZXR8d3d3fGd4OjFmNGRhOGE0M2M5ZDQyMTc

Schumpeter, J. A., (1934 (2004)). *The theory of economic development, an inquiry into profits, capital, credit, interest, and the business cycle* (10th ed.). Retrieved from http://books.google.com/books?id=-OZwWcOGeOwC&printsec.

Schweik, C. M., & Shulman, S. (2010, May). Politics of open source. *2nd Annual Journal of Information Technology & Politics Thematic Conference*. Retrieved from http://scholarworks.umass.edu/cgi/viewcontent.cgi?article= 1000&context=jitpc2010&sei-redir=1&referer=http%3A%2F% 2Fscholar.google.com%2Fscholar%3Fhl%3Den%26q%3Dexpanding% 2Bdomains%2Bkumar%2Bjha%26as_sdt%3D0%252C3%26as_ylo% 3D%26as_vis%3D0#search=%22expanding%20domains%20kumar%20jha%22

Security Soft - Web server survey. (2011). Retrieved from http://www.securityspace.com/s_survey/data/201012/index.html

Shapiro, C., & Varian, H. R. (2003, December 1). Linux adoption in the public sector: an economic analysis. Retrieved from http://www.ivanexcobar.ort/ linux-adoption-in-the-public-sector.pdf

Singh, S. (2008, April). India Takes an Open Source Approach to Drug Discovery. Cell, 133(2), 201-203. Retrieved from http://www.cambia.org/daisy/cambia/4208/version/default/part/AttachmentData/ data/India_Takes_an_Open_Source_Approach_to_Drug_Discovery.pdf

Smith, G. (1897). *Essays on questions of the day* (2nd ed.). Retrieved from http://books.google.com/books?id=tUQtAAAAYAAJ

Smith, J. (1981). *Doctrine and covenants*. Salt Lake City, UT: The Church of Jesus Christ of Latter-day Saints.

Sourceforge. Most downloads over all time. (2011). Retrieved from http://sourceforge.net/topalltime/

Sourceforge. About. (2011). Retrieved from http://sourceforge.net/about.

Spolsky, J. (2002). *Strategy letter V, Joel on software*. Retrieved from http://www.joelonsoftware.com/articles/StrategyLetterV.html

Staff Correspondent. (1881, August 1). Among the shakers. *New York Daily Tribune*. Retrieved from http://chroniclingamerica.loc.gov/lccn/sn83030214/1881-08-01/ ed-1/seq-5.pdf

Taft, D.K. (2010). *Apache web server turns 15*. Retrieved from http://www.eweek.com/c/a/Search-Engines/ Apache-Web-Server-Turns-15-702912/#user_comments

Taylor, K. (1982). *The political ideas of the Utopian Socialists*. London, England: Frank Cass & Co.

Taylor, P. (1996). Computer typesetting or electronic publishing New trends in scientific publication. *TUGboat*, 17(4), 367-381. Retrieved from http://tug2.tug.org/TUGboat/tb17-4/tb53tayl.pdf

Ten years ago today: Netscape launches mozilla.org. (2008). Retrieved from http://www.mozillazine.org/talkback.html?article =23022

The Linux Foundation staff. (2011). Retrieved from http://www.linuxfoundation.org/about/staff

The Linux Foundation, VMware Joins The Linux Foundation. (2011). Retrieved from http://www.linuxfoundation.org/news-media/announcements/2008/08/ vmware-joins-linux-foundation

The Synaptic Leap, Malaria Research Community. (2006). Retrieved from http://www.thesynapticleap.org/malaria/community

The Tropical Disease Initiative, Methods. (2008). Retrieved from http://tropicaldisease.org/kernel/methods/

Todd, M. H. (2007, February). Open source and open access in chemistry. *Chemistry Central Journal, 1*(3). doi:10.1186/1752-153X-1-3

Tropical Disease Initiative, What, who, how, and more… (2008). Retrieved from http://tropicaldisease.org/?page_id=2

Tysver, D.A. (1996-2008). *The history of software patents: from Benson and Diehr to State Street and Bilski*. Retrieved from http://www.bitlaw.com/ software-patent/history.html

United Nations Development Programme. (2000). Human development report 2000. Retrieved from http://hdr.undp.org/en/reports/global/hdr2000/

United States House of Representatives Committee on the Judiciary. (2011). Retrieved from http://judiciary.house.gov/issues/issues_patentreformact2011.html

UNIX Operating System. (2003). In *Encyclopedia of Computer Science*. Retrieved from http://www.credoreference.com/entry/encyccs/unix_operating_system

US Human Genome Project research goals. (n.d.). Retrieved from http://www.ornl.gov/sci/techresources/Human_Genome/hg5yp/

USPTO patent full-text and image database. (1995). Retrieved from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p= 1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1= AND&d=PTXT&s1=5443036.PN.&OS=PN/5443036&ftxRS=PN/5443036

USPTO patent full-text and image database. (1999). Retrieved from http://patft.uspto.gov/netacgi/nph-arser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=%22bird+diaper%22.ABTX.&OS=ABST/

von Hippel, E. (2002, June). Open source projects as horizontal innovation networks - by and for users. *MIT Sloan School of Management*, *Working Paper 436602*. Retrieved from http://ssrn.com/abstract_id=328900

von Hippel, E. (2007, May). Horizontal innovation networks - by and for users. *Industrial and Corporate Change*, *16*(2), 293-315. doi:10.1093/icc/dtm005

von Hippel, E., & von Krogh, G. (2009, March). Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science. *MIT Sloan School Working Paper 4739-09*, 1-31. Retrieved from http://ssrn.com/abstract=1410789

Waldron, J. (1995, November). The wisdom of the multitude: some reflections on book 3, chapter 11 of Aristotle's Politics. *Political Theory*, *23*(4), 563-584. Retrieved from http://www.jstor.org/stable/191901

Weber, S. (2004). *The success of open source*. Cambridge, MA: Harvard College.

What BiOS-compatible agreements are available? (n.d.). Retrieved from http://www.patentlens.net/daisy/bios/2534.html

What is the cost of a BiOS agreement?. (n.d.). Retrieved from http://www.patentlens.net/daisy/bios/2535.html

Wheeler, D. A. (2007). *Why open source software/free software (OSS?FS, FOSS, or FLOSS)? Look at the numbers!*. Retrieved from http://www.dwheeler.com/oss_fs_why.html

White, A., & Taylor, L.S. (1904). *Shakerism, its meaning and message: embracing an historical account, statement of belief and spiritual experience of the church from its rise to the present day*. Retrieved from http://books.google.com/books?id=j4MuAAAAYAAJ

Wilde, A. (1891). *The soul of man under socialism*. Retrieved from http://generation.feedbooks.com/userbook/11610.pdf

WIPO Resources. (2011). Retrieved from http://www.wipo.int/ipstats/en/statistics/patents/

Woelfle, M., Olliaro, P., & Todd, M. H. (2011, September). Open science is a research accelerator. *Nature Chemistry, 3*, 745-748. doi:10.1038/nchem.1149

Wonderley, A. (n.d.). The most utopian industry: making Oneida’s animal traps, 1852-1925. (Unpublished article). Oneida Community Mansion House, Oneida, NY.

World Trade Organization fact sheet. (2006). Retrieved from http://www.wto.org/english/tratop_e/trips_e/factsheet_pharm02_e.htm

World Trade Organization. (2006). Fact sheet: TRIPS and pharmaceutical patents. Retrieved from http://www.wto.org/english/tratop_e/trips_e/factsheet_pharm01_e.htm

World Trade Organization. (2011). Retrieved from http://www.wto.org/english/tratop_e/trips_e/factsheet_pharm02_e.htm

Wright, N. E. (1997-98). The Mormon pioneer odometers. *BYU Studies*, 37(1), 83-115.

Wu, T. (2006, March). Intellectual property, innovation, and decentralized decisions. *Virginia Law Review, 92*(1), 123-147. Retrieved from http://www.jstor.org/stable/4144999