



**From Medieval Guilds to Open Source Software:
Informal Norms, Appropriability Institutions, and
Innovation**

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Abstract

This essay draws on recent scholarship concerning the nature and function of medieval guilds. I argue that certain features of these guilds appear in modern institutions that further collective invention (“appropriability institutions”): patent pools, industry-wide standard-setting organizations, informal knowledge exchange among academic scientists, and (in a more limited way) open source software development . In particular, guilds and modern institutions share three features: (1) an “appropriability structure” that makes it profitable for individual entities to develop new technologies and sometimes share them; (2) reliance on group norms, as opposed to formal legal enactments, as an enforcement mechanism; and (3) a balance of competition and cooperation which determines what information is to be shared with the group, and what (if any) individual-proprietary information is not. The current trend toward greater dispersal and atomization of economic activity may increase the importance of such interfirm appropriability institutions.

“A working society means relationships which must be kept in some minimum balance, and requires fulfillment of some minimum functions of reciprocity and mutual restraint. The order which law helps create and keep is not a static condition. It is a moving equilibrium, product of continuous adjustment to diverse pressures and to the constant press of changed circumstances.”

J. Willard Hurst, *Law and Economic Growth: The Legal History of the Lumber Industry in Wisconsin, 1836-1915* (1964), at 427.

“There are many other organizations besides the government and the firm. But all of them, whether political party or revolutionary movement, university or church, share the common characteristics of the need for collective action and the allocation of resources through nonmarket methods.”

– Kenneth Arrow, *The Limits of Organization* (1974), p. 26.

1. Introduction

Legal scholars from the “law and economics” school have long been interested in various aspects of economic history. Much of the attention has been selective however, with particular emphasis on a few “canonical” episodes in history, such as the emergence of property rights in certain specific settings,¹ or the British “enclosure movement.”² If legal historian Ron Harris is right, this may be changing; he detects a more sustained interest in more aspects of history among law and economics scholars.³ It is in the spirit of this newfound, broad-based interest in economic history that I offer this essay.

My topic is the medieval guild. I focus on one feature of this literature, namely that guilds played an important role in generating and diffusing new techniques and information. If there is anything original in the essay, it stems from my scholarly orientation as a student of intellectual property law: I see guilds as one example of a larger set of informal institutions that facilitate innovation by virtue of shared norms. Sometimes these norms take the form of reciprocity: an understanding that all members of a circle have the right of access to at least some common techniques and information, including in some cases original additions to the body of technological knowledge. At

¹ Harold Demsetz, “Toward a Theory of Property Rights.”

² Posner, “Economic Analysis of Law”; Boyle, “Enclosure Movement.”

³ Ron Harris, “The Uses of History in Law and Economics.”

other times, they take the form of limited exclusivity: recognizing the right of individual members of the circle to exclusive use and possession of self-generated information.

To be effective, I argue that these institutions typically require at least two things: (1) some way to differentiate insiders from outsiders, i.e., some way to “draw the circle,” and (2) some shared norms or rules about what insiders (or “members”) must share with other members. To further differentiate these groups from the more general category of a social group or “occupational culture,”⁴ I also stress the importance of some sense of “proprietaryness” concerning technical information.

Guilds may have been the first such institutions, but they were by no means the last. Other examples from history include the famous case of steel technology, which Robert C. Allen called “collective invention,” a topic recently reprised with respect to second-generation steam engine technology for well pumps. The late nineteenth century saw the emergence of the patent pool, a mechanism employed by a large (and still growing) number of industries to break patent-related bottlenecks, which in some cases evolved into cooperative interfirm innovation mechanisms. A similar multifirm institution is the standard-setting organization (SSO), which brings together competing firms to set a technology standard that can be used and shared by all members of the industry.⁵ There was also an interesting effort among fashion designers in the 1930s to create an industry code of conduct regarding credit and exclusivity for designs – one example of what I have called elsewhere “private intellectual property systems.”⁶ The contemporary entertainment industry, which relies heavily on industry-wide norms and informal (non-state-backed) enforcement mechanisms such as arbitration, is another excellent example of this phenomenon. Eric von Hippel has documented a practice of “informal know-how sharing” among engineers working in the steel “minimill” industry in the 1980s. In addition, the norms of research scientists, permitting exclusive patents but requiring in some cases reciprocity in the sharing of laboratory research results, demonstrate some of the features of these institutions as well.⁷ Finally, some have argued that, despite the lack of any mechanism of exclusion or apparent economic reward, the open source software movement depends in part on reciprocity and other informal norms, which I would argue makes it a contemporary variant on these institutions.

In some ways, then, the open source movement represents a sort of “virtual guild.” And if some recent theorizing by prominent economists and economic historians is correct, it may be the vanguard of a larger resurgence of guild-like communities. Naomi Lamoreaux, Daniel Raff and Peter Temin,⁸ joined by Richard Langlois,⁹ have noted the emerging dominance of the “post-Chandlerian” economy – an economy characterized by a great diversity of industry structures including many small, specialized

⁴ See, e.g., Alexandra von Meier, “Cultural Conflict.” For discussions of the distinctive culture of engineers and other technically trained workers, see

⁵ See, e.g., Urs von Burg, “The Triumph of Ethernet: Technological Communities and the Battle for the LAN Standard.”

⁶ See below, section 3.

⁷ Robert P. Merges, “Property Rights Theory and the Commons: The Case of Scientific Research.”

⁸ Naomi R. Lamoreaux, Daniel M.G. Raff and Peter Temin, “Beyond Markets and Hierarchies.”

⁹ Richard N. Langlois, “Chandler in a Larger Frame.”

firms. Such an economy will tend to disperse engineers, scientists and technicians into smaller “modularized” units than ever before. Under such conditions, we might speculate that technological communities will emerge to mediate these atomizing forces. It may even happen that among technical employees, affiliation to a technological community will vie for supremacy with affiliation to the firm, coming close to a true renaissance of the guild.

1.1 Brief Roadmap

The remainder of this essay proceeds as follows. Section 2 takes an “intellectual property” (IP) perspective on the economic function of medieval guilds. Section 3 builds on the themes of the Introduction. A special effort is made to connect these ideas with recent legal scholarship on the importance of social norms as “bottom up law,” in contrast to formal “top down law.” Section 4 describes the open source movement as a “virtual guild,” in the manner described in the introduction, and speculates about the growing importance of appropriability institutions in an increasingly modularized, “post-Chandlerian” economy.

2.0 Economic Function of the Guilds: An IP Perspective

From the perspective of an intellectual property scholar, the medieval guilds served two primary functions: (1) they protected investments in training new members, a human capital formation function typically associated with modern “trade secret” law; and (2) they certified minimum quality standards among producers within a group, a function now performed by collective trademarks of “certification marks.” This section describes each function and relates it to modern IP protection mechanisms.

2.1 How Guilds Protected Trade Secrets

Two important determinants for economic growth are human capital investment and employee mobility. Two factors must be traded off to achieve balanced policies in this area: (1) incentives to train new employees, including safeguards making it rational to pass along information of potential value to industry entrants or competitors; and (2) freedom of movement, whereby individual employees can seek out and find their highest-valued employment. Many of the medieval guilds did an admirable job striking this balance for many years. When in later years restrictions on labor entry proved inefficient in the face of new technologies, rival systems of manufacture emerged, effectively bypassing the power of guilds and ending their period of effective domination of craft production. In this brief section, however, we focus on the “heyday” of the guilds, which many trace to the 11th-14th centuries.¹⁰

¹⁰ Sylvia Thrupp, “The Gilds.”

Guilds protected trade secrets by providing an enforcement structure for apprenticeship systems,¹¹ and by protecting information adequately enough at the communal level to promote innovation. Stephan R. Epstein has provided important evidence on the economic structure of labor contracts within guilds.¹² Epstein examined a broad cross-section of guild regulations and other historical evidence and discovered a number of general patterns. According to Epstein, guilds:

- Protected against apprentice opportunism, or inefficient labor mobility, by providing an enforcement mechanism for apprenticeship contracts, in the form of “compulsory membership, blackballing, and boycott”,¹³
- Protected against employer (master) opportunism, by specifying minimum training requirements (i.e., a floor on the master’s investment in skills training) and providing for transfer to another master if the first one died;¹⁴ and
- Despite a reputation for conservatism, fostered numerous technological innovations, particularly with respect to process technologies.¹⁵

Through these regulations, guild structure fostered the generation of technological innovation, by permitting at least modest appropriation of investment in new information and techniques. Again according to Professor Epstein,

The existence of strong externalities in many industries defined an environment characterized by low appropriability. Low appropriability will in principle reduce incentives for innovation within individual firms, and would help explain the craft guilds’ reputation for technological conservatism. Nonetheless, empirical evidence of guild conservatism is weak and there is good evidence to the contrary, even though innovation that drew prevalently on craft knowledge is hard to quantify The craft guild also enabled individual members to capture a share of consumer surplus from their invention, by forbidding the poaching of skilled labor employed by the inventor, and by raising the costs of exit for other members through a combination of penalties and club goods. The interval between invention and copying provided inventors with a first-mover advantage and a reasonable rate of return.¹⁶

Similar evidence comes from a study of the Venetian glass industry:

The skills to make quality glass constituted a form of intellectual property. Knowledge was, as it is in today’s information age, a valuable commodity. In the

¹¹ See, e.g., Dyer, 2002, at 315 (“The ordinances of the Bristol cobblers were drawn up by eighteen named masters of the craft in 1364. . . . Masters were forbidden to poach workers from other members of the craft.”).

¹² Stephan R. Epstein, “Craft Guilds, Apprenticeship, and Technological Change.”

¹³ Stephan R. Epstein, “Craft Guilds, Apprenticeship, and Technological Change,” at p. 691.

¹⁴ Stephan R. Epstein, “Craft Guilds, Apprenticeship, and Technological Change,” at p. 692.

¹⁵ Stephan R. Epstein, “Craft Guilds, Apprenticeship, and Technological Change,” at p. 694.

¹⁶ Stephan R. Epstein, “Invention and Institutions of Intellectual Property in Historical Perspective,” at 3-4.

community of Murano, where practically everyone's livelihood depended on glassmaking to some degree, the knowledge associated with the glass craft was "communal property." Failure to protect or maintain this property was to the detriment of the community, the guild, and the Venetian state. Artisan skills and processes, especially in technical and complex crafts, were an intangible commodity with a tangible commercial potential.¹⁷

A related argument is presented by economist Bo Gustaffson, who ties minimum training standards to the high labor turnover he says prevailed in the early years of the guilds.¹⁸ As we will see in the next section, apprenticeship training served the interests of consumers as well; it was one of the many ways guilds assured minimum quality standards for craft goods.

2.2 Quality Assurance: Proto-trademarks

Guilds appear to have coevolved along with urban centers beginning in late antiquity and extending into the Middle Ages. They were an organizational innovation that arose in large part to address new needs and concerns stemming from urbanization. In a pre-urban economy, commerce is limited to a small circle of acquaintances. In this setting, buyers can usually be sure they are getting what they pay for. If they do not – if a piece of crockery breaks immediately, or a horseshoe wears down far too quickly – recourse is close to hand: they can confront the seller, or at least spread the word among the close-knit community that the seller is not to be trusted. One of the earmarks of urbanization is the beginning of more "anonymous" commerce. There are numerous producers, more consumers, and larger markets that bring both together. In such a setting, something was needed to replace traditional mechanisms for assuring buyers that they were getting goods of the kind and quality they paid for. Guilds were the answer.

It is clear from the records left by guilds that they were vitally interested in matters of "quality control" and quality assurance.¹⁹ The exclusive right of the guilds to sell certain goods in certain markets, coupled with quality standards written into the guild regulations, assured buyers that all goods under the guild's jurisdiction would be of a certain quality. The guild "imprimatur," in other words, took the place of the reputation of individual craftsman as a quality assurance device. This fact explains two important

¹⁷ W. Patrick McCray, "Glassmaking in Renaissance Venice," at p. 150.

¹⁸ Bo Gustaffson, "The Rise and Economic Behaviour of Medieval Craft Guilds," at 6:

"[Because of the great turnover of people in towns,] we cannot take for granted that relations between sellers and buyers were very stable. On the contrary, they were characterized by frequent changes, while the inflow of less professional peasant craftsmen tended to increase the variation of professional skills and by this also of product quality"

¹⁹ See, e.g., Christopher Dyer, "Making a Living," at 315:

The influence of the Bristol merchants is readily apparent in the dyers' rules of 1407, which were focused on the problem of shoddy workmanship and the lack of proper training among the dyers' craft. The regulations allowed for inspection of dyed cloths by two masters approved by the mayor, and the exclusion from work of those who lacked the right skills. . . .

points about guilds that have commanded consensus in the literature: the prevalence of quality standard issues in the text of the many written guild regulations that survive, and evidence of resistance to them, in the form of non-guild (typically rural) competition for craft products, and to a lesser extent conflict among guild members over quality standards.²⁰

Economist Bo Gustaffson stresses quality control as a key organizing principle of medieval guilds. He writes:

Anyone who wanted to sell something in repeated exchange transactions, as was the case with the growing stratum of town artisans, had to reckon with considerable costs of the transaction and close scrutiny of the quality of the products by the buyers. This was especially important in the case of craft products as their quality was to a large extent conditioned by the individual craftsman's skill. This would be changed only with the industrial revolution, when the quality of products were to be determined by machines and hence given a more uniform and homogenous character.²¹

These conditions created what Gustaffson refers to as “the quality problem.”²² Guilds solved this problem. In addition to training, Gustaffson discusses at length the many direct quality control measures employed by guilds, including: (1) scrutiny of raw materials, (2) scrutiny and regulation of production processes, and (3) standards and compliance inspections for end products. In the weaver's guild in Memmingen, southern Germany, for example, Gustaffson notes that there were inspections before and after each stage of production, and “[a]n enormous number of marks were applied to the cloth to indicate the specific quality.”²³ One interesting source of evidence about ongoing quality control comes in the form of guildmembers' conflicts over the setting of quality standards. While some resistance might be explained by honest differences of opinion over how best to make a certain article, or perhaps just contrariness at being told what to do, it seems clear that at least some manufactures preferred to pursue to a “low quality” product strategy, and the guilds sought to prevent this.²⁴

It should be added that quality standards contributed to market segmentation, and might have formed part of a conscious strategy of product differentiation. Guild-produced items came from the urban center, were generally of higher quality, and usually cost more. Non-guild-produced items often competed, though product features, transport costs, and other local conditions affected the degree of price competition that competing goods effectively engendered.

²⁰ For insight into the resolution of conflict among guild members, as well as some interesting evidence on the related issue of municipal resolution of disputes between guilds and rival producers (including other guilds as well as non-guild producers), see Carlo Poni, “Norms and Disputes.”

²¹ Bo Gustaffson, “The Rise and Economic Behavior of Medieval Craft Guilds,” at p. 5.

²² Bo Gustaffson, “The Rise and Economic Behavior of Medieval Craft Guilds,” at p. 21.

²³ *Id.*

²⁴ See, e.g., Christopher Dyer, “making a Living,” at 315 (Among Bristol dyers, quality control “rules were clearly being imposed against the will of some of the masters . . .”).

2.3 Comparison to Modern IP Protection

2.3.1 Trade Secret Law

The modern law of trade secrets strives to balance the same forces that presented problems for the medieval guilds. Consider for example the guilds' restrictions on "poaching" employees. Today courts police employee exit issues on a regular basis.²⁵ In general, employees cannot be prevented from leaving for a new employer along with their "general knowledge and skill." On the other hand, information or techniques that are specific to the ex-employer cannot be taken. The line between general skill and specific information is of course a delicate one, which is one reason why this is one of the most-litigated issues in the pantheon of intellectual property disputes. And even though bilateral contracts often govern aspects of the employment relationship, courts review very closely contractual provisions preventing employees from going into business to compete with an ex-employer. These "covenants not to compete" form an important analogue to the body of trade secret law proper.

As sovereign governments learned in the era of the guilds and later, it is very difficult to prevent acquired information from diffusing outward during the course of employee mobility. This was well understood by the state powers in Venice, for example, who fought a long and inevitably unsuccessful battle to prevent Venetian glassmaking knowledge from moving to other parts of Europe. Even in the contemporary U.S., where formal legal strictures define a much tighter appropriability regime for intellectual property, it is very difficult to prevent employees from taking good ideas with them when they move to other employers or establish new firms of their own.²⁶

Naturally, the power to control entry and mobility carries with it the potential for anticompetitive behavior. This was a major theme of the literature on guilds until fairly recently. Modern trade secret law reflects an awareness of these issues as well. That is why courts review covenants not to compete so carefully, even in relatively "pro-employer" states: there is always the fear that such agreements can easily be used as a disguise for agreements to explicitly restrain trade. In historical settings, of course, there were often no effective court systems to prevent such a result. According to some historians, this helps explain the rise of rural "putting-out" systems of manufacture and other examples of "proto-industrialization," which were said to arise partly in response to the restrictions on commerce that had come to be embodied in urban guild regulations.²⁷

2.3.2 Trademarks

²⁵ Robert P. Merges, et al., "Intellectual Property in the New Technological Age," pp. 72-91.

²⁶ Robert P. Merges, "The Law and Economics of Employee Inventions."

²⁷ Peter Kriedte, "Industrialization Before Industrialization."

Collective trademarks and certification marks today perform many of the same functions as guild certification. (Indeed, legal historians specifically cite guild marks as an early form of trademark.)²⁸ A certification mark is generally used by a trade association to identify a particular type or class of good, to certify that it complies with a standard or meets certain qualifications. It can be used in addition to a more distinctive trademark that identifies a particular seller of that type of goods – e.g., an individual company. A classic example is a “kosher” food certification, granted by one of several competing organizations applying various standards of traditional Jewish food purity and preparation.²⁹ The obvious parallel here with the medieval guilds is that the guilds permitted, in some cases at least, individual artisans to identify themselves as the “author” of particular craft guilds, while the guild mark certified compliance with more generic guild standards.

A “collective mark” is a mark used by members of a cooperative, association or other collective group to show membership in the group or to identify goods or services as originating with members of the group. Advertising membership in the “Better Business Bureau” would be an example. Again, individual sellers can identify themselves further through their own distinctive trademarks, but the collective mark serves as a guarantee of certain firm or product attributes, or in some cases minimum safety or quality assurances.

The modern organizational form of the franchise often makes use of certification and collective marks. The use of a similar quality assurance device points out some similarities between guilds and franchises. Both are solutions to problems of product quality verification by consumers. Guilds arose, as we have seen, in part as a response to the absence of adequate reputational devices in the burgeoning urban markets of the early medieval period. Franchises were a response to the growing mobility of western, particularly American, consumers, during the twentieth century. Local reputation and word of mouth were no longer possible where products were manufactured in large central plants and distributed throughout the breadth of the United States.³⁰ National advertising and the birth of “national branding” were natural responses to these developments, and trademark law played a crucial role in solving the information problems created by the new market realities.³¹ But for some goods and services, it was soon discovered that complete vertical integration was less efficient than a combination of centralized production and localized delivery and support. The monitoring costs associated with a national chain of centrally-owned restaurants, for example, were daunting. So a new organizational form mixing national production of inputs with local ownership and delivery was devised – and thus was born the franchise. One of the most important assets of the national franchisor (e.g., MacDonald’s, or Pizza Hut) is its portfolio of trademarks, which often includes a collective mark. In exchange for the right to place the national trademarks on locally-delivered products, the franchisee agrees to

²⁸ Robert P. Merges, et al., “Intellectual Property in the New Technological Age,” p. 544 (citing historical research).

²⁹ Robert P. Merges, et al., “Intellectual Property in the New Technological Age,” pp. 544-545.

³⁰ Alfred Chandler, “Scale and Scope.”

³¹ Robert P. Merges, “One Hundred Years of Solicitude,” at pp. XX.

keep up certain minimum quality standards. Selective monitoring of quality by the national franchisor is an important part of most franchise arrangements. Notice the parallels with the guilds, where quality-checking inspections were quite common. In each instance, incentives are balanced by permitting individual production under the umbrella of a centrally-controlled quality indicator. Compliance inspections and other policing devices are put in place to prevent opportunism.

In the guilds, exploitation by the “center,” the guild hierarchy, was guarded against by voting rules and other participatory devices that gave each producer at least some voice in the conduct of the organization. Interestingly, a parallel device is in place in many franchise situations; groups of powerful franchisees often come together to give voice to the interests of the franchisee as against the large national office of the franchisor.

2.4 A Note on Guilds and Patents

In the historical introduction to the first edition of my casebook on Patent Law, I drew a sharp contrast between patents and guilds. In keeping with what I had learned, I said that patents arose in the early Renaissance as an expression of the force of progress and innovation, as opposed to medieval guilds which were essentially cartels and therefore characteristic of the technological stagnation of the Middle Ages. The simple view I put forth was that guilds were old and static, patents new and dynamic.

I could write a separate paper listing all the many ways I was wrong. But here I would like to emphasize one aspect in particular: my failure to understand the significance of the fact that patents and guilds coexisted for many years. I was not wrong to see the importance of the emergence of patents as a new instrument of economic policy in the fifteenth through seventeenth centuries. This did indeed represent a new initiative on the part of Europe’s nascent states to directly encourage and promote new technologies. But where I went wrong was in not seeing that guilds could and did in many cases serve the same goal, and not infrequently, that the same states that began granting patents also ratified and enforced guild regulations that in some cases at least fostered innovation.

To see this in action, we must revisit the case of Venice. For Venice not only saw the emergence of perhaps the best-known guild system in Europe, but also the enactment of the first patent law, in 1447. The famous case of the Venetian glass industry will be explored in the following section, but one salient feature of that discussion deserves mention here as well: the fact that the artisanal secrets of glass were fairly difficult to glean from the finished product itself. So glass production techniques were well susceptible of protection through secrecy. This was not the case with many of the earliest inventions for which patents were sought, which tended to be large, open, inherently public devices. Filippo Brunelleschi’s harbor dredge and cargo boat designs are good examples.

So what did the creative polity of Renaissance Venice do? It authorized the granting of patents for devices such as Brunelleschi's barge hoist (for transporting marble), which was in fact the subject of the first patent under the Venetian statute. The text of this first patent act may be read to imply that it was directed at inventions in the form of publicly accessible structures, as opposed to craft processes; it speaks of a reward to "every person who shall build any new and ingenious device in this City," the reward to attach when proof is made that it can be "operated," forbidding anyone else from "make[ing] any device conforming with and similar to said one," with penalties for "anybody [who] builds it in violation hereof."³²

I do not mean to suggest that the likelihood of what we would today term "reverse engineering" strictly determined what was patentable subject matter. Clearly there were other considerations. Chief among these was whether the inventor was a local resident or not. Typically, patents were used during this early period to induce foreign artisans to transplant a technology or skill which a sovereign government wanted to establish in its own jurisdiction. Elizabeth I under William Cecil, Lord Burghley, used patents as an inducement to encourage the transfer of technologies from the Continent; ironically, in light of the Venetian origins of patents, one of the earliest of these British proto-patents was granted to a glassmaker from Venice.

Nor were patents and guilds identical insofar as their formal legal status is concerned. Guild statutes were ratified by the state, not created by the state. Guilds originated as autonomous artisan collectives, and their regulations began as *internal* rules applying to members only and backed only by the authority of the guild itself. The power of state enforcement came later. It gave the guilds more clout (though often at the cost of diluting some of the focus of the guilds and therefore their effectiveness), and perhaps helped to prevent defection from guild norms. But these norms were in the first instance generated by the members in response to the needs and demands of specific technologies and industries. In this sense they were "bottom-up" norms, which later came to be backed by state power.³³ Patents were quite different. They were "top-down" prerogatives, planned out and granted by the sovereign state authority in each jurisdiction. They represent the very type of state-backed "right to exclude" that forms the cornerstone of modern property rights.

To summarize, patents were "invented" to encourage innovations that would be difficult to keep secret or which were associated with non-resident "outsiders." This is in contrast to guilds, which in addition to being inherently local institutions appear to have fostered innovation in primarily "process" industries (in addition to the other functions they served). Yet despite their differences, both of these institutions could be and at times were employed to serve the same end – encouragement of technical progress. Here is where I really went wrong in my patent casebook, mentioned earlier: I did not see guilds, and government promotion and ratification of them, as serving the goal of technological innovation in the same way as patents. In this I now believe I was wrong. At least in some places, and at some times, guilds did serve this function. And indeed, their

³² Quoted in Robert P. Merges and John F. Duffy, "Patent Law and Policy" at 4.

³³ See generally Eric Posner, "Law and Social Norms."

successors continue to exist as an integral part of innovation systems, along with formal property rights in some cases. Just how the guilds operated, and what this might mean for contemporary innovation, are the topics I turn to next.

3.0 Guilds and Other Appropriability Institutions

While it is evident that guilds served some of the same functions as the modern intellectual property system, what is really most interesting about them from a contemporary perspective is the distinctive way they performed this function. To revert to a distinction introduced earlier, they were “bottom-up” institutions: norm-based groups which developed their own internal governance rules. State backing of guild regulations took the form of ex post ratification. This is in obvious contrast to “top-down” systems of formal legal rules, for example, patents and other formal intellectual property rights. The most salient feature of guilds for my purposes in this essay is that this “bottom-up” structure effectively promoted the generation and sharing of information and techniques. What held the guilds together, provided their “social glue,” was the fact of a shared set of craft practices and values – a distinctive culture organized around the work they did and the things they made. Each guild represented a community having a shared occupational culture.

In this they presage well-documented instances of “collective invention” and certain other norm-based institutions. The key attribute of these institutions is free exchange of existing techniques and information, which created incentives for generating new information. As I will argue later in Part 4, the contemporary significance of these institutions is that they provide an example of how informal social norms can mediate individual claims to techniques and information, and in some sense therefore *in effect* modify formal legal relations.

3.1 The Social Mechanisms of Guilds

Guilds and other “appropriability institutions” have often had a strong geographic component. In many cases, in fact, such an institution is coextensive with a region or neighborhood – this is the well-known phenomenon of the “industrial district.” As Stephan Epstein writes in describing this aspect of guild organization,

Much premodern craft and engineering knowledge appears to have been shared or ‘distributed’ within industrial districts. . . . Sharing was more likely in ship- and edifice-building, mining and metalworking, and in the production of clocks and scientific instruments, which displayed strong division of labor and advanced levels of coordination and where cooperation provided clear economies of scale and scope – sectors that are also notable for having played the most technologically innovative role in the Industrial Revolution.³⁴

³⁴ Stephan R. Epstein, “Invention and Institutions of Intellectual Property in Historical Perspective,” at 3.

Beyond the geographic, however, there are certain other features important to the organization of guilds, and hence of potential contemporary interest. Indeed, guilds appear to share many features with other “network” forms of economic organization, including modern professional and trade groups.³⁵ To see these features in action, we turn to a case study.

3.1.1 Venice Glassmaking: A Case Study of an Appropriability Institution

The glassmaking guild of Venice was famed for its innovativeness. According to W. Patrick McCray, “Beginning in the XVth century, the glassmakers of Venice, in response to changing patterns of demand and consumption, developed new glass designs and novel compositions. These were desired and imitated throughout Europe and the Near East.”³⁶ These were a product, he states, of the “technical skill and knowledge” of the owners and masters who were members of the glassmaking guild, the *fieroli*. Given that it had a strong guild culture, and was geographically isolated on the island off Murano in the Venetian lagoon, there is little doubt that glassmakers constituted a distinctive community.

But was it something more – was it an “appropriability institution” with common norms supporting the generation of new information and techniques? There is reason to think so. Although the evidence is less than robust, there are indications that, against a backdrop of common technical skill in the glassmaking art, certain novel techniques were permitted by the guild to remain exclusive to their creators. This suggests a norm that differentiated generic guild-level information from specific, individual contributions. According to Professor Stephan Epstein, all successful guilds created at least the potential to foster innovation, because they “supplied incentives to invention that the [premodern] patent system did not by enforcing temporary property rights over members’ innovations.”³⁷

The argument here is that guilds operated as early versions of “private intellectual systems.” To support this, claim, I make two points in this section: (1) there was a shared body of generic information common to all members of the guild; and (2) there were specific pieces of novel information that the guild members *tacitly* permitted to be kept proprietary, out of the hands of the general guild membership. These bottom-up (non-state-imposed) norms helped form an innovation environment in this important early industry.

Evidence of a distinctive body of generic craft information in the Venetian guild is not difficult to find. A collective body of craft knowledge is widely understood to have played a key role in the dominance of the industry, particularly from about 1450 until

³⁵ See Luke Pittaway, Maxine Robertson, Kamal Munir, David Denyer, and Andrew D. Neely, “Networking and Innovation: A Systematic Review of the Evidence,” 5-6 International Journal of Management Reviews 137-168 (2004).

³⁶ W. Patrick McCray, “Creating Networks of Skill,” at 305.

³⁷ Stephan R. Epstein, Invention and Institutions of Intellectual Property in Historical Perspective,” p. 9.

roughly the late seventeenth century.³⁸ The many recipe books which were written to transmit craft knowledge to newcomers, as well as chemical similarities in surviving glass objects, all bear witness to the existence of generic knowledge. In addition, the regulations of the guild reflect an awareness of the existence and importance of a shared body of knowledge. Finally, detailed restrictions and fines intended to prevent the diffusion of craft knowledge via migration of skilled artisans attest to the fact that each individual craftsman was understood to possess a valuable body of knowledge, simply by dint of membership in the guild.

Experts in the history of glassmaking identify a number of crucial similarities among glass specimens that survive from the period of the *fieroli*'s dominance. The inclusion of small but significant ingredients such as lime and magnesia are characteristic of the famous *cristallo* (crystal-like) glass of post-1450 Venetian guild production.³⁹ Likewise, extant specimens reveal levels of purification of ingredients that are unknown to other glass manufacturing centers. In addition, some technical treatises, known to have been widely available to the public, have survived, suggesting that at least by the fifteenth century glassmaking techniques had become so "generic" they could no longer be effectively kept within the guild. (An alternative explanation is that disclosures in these treatises was inadequate enough, or excluded enough valuable, recent information that they were not a threat to the guild.)⁴⁰ One important treatise in this genre was that of Antonio Neri in 1612.⁴¹

Guild regulations also show that everyone concerned understood that there was a generic body of guild knowledge that was to be kept within the guild. There was the oath required of apprentices, for example.⁴² In addition, from an early date, the Venetian government required all glassmaking to take place on the island of Murano – to maintain secrecy as well as to prevent fires in the city.⁴³ These and other regulations make clear that everyone involved understood that the guild generated and contained a distinctive body of secret knowledge, shared by its members.

Finally, the government of Venice was involved at the highest level (the "Council of Ten") in maintaining the Venetian monopoly over high-value (and high-prestige) glass production. The Council backed a steady stream of ever-increasing penalties for guild members who took their skills to other cities. These penalties express the notion of the guild's craft knowledge as a distinctly *communal* asset that was in some sense embodied

³⁸ It is well known that "[E]ach trade and each craft [in the premodern economy] had different traditions and social practices, a different identity and status in society, and a different culture of work." Carlo Poni, "Norms and Disputes," at 80-81.

³⁹ Gay Turner, "*Allume Catina*," at 120.

⁴⁰ Scientific analysis of Venetian glass specimens from this era reveals that they embody techniques not codified in any of these publicly available glassmaking treatises. As one historian put it, "certain techniques remained secret"; they could not be gleaned with available technology of the era. Gay Turner, "*Allume Catina*," at 120.

⁴¹ Pamela Long, "Openness, Secrecy, Authorship."

⁴² W. Patrick McCray, "Creating Networks of Skill," at 309 ("Workes also took an oath not to practice the craft outside the city [of Venice].")

⁴³ Gay Turner, "*Allume Catina*," at 116.

in every member of the guild – i.e., truly generic knowledge. According to glass historian W. Patrick McCray:

The skills of Muranese glassmakers represent a form of communal property which had been refined and developed for the benefit of the city and for the glassmaking community as a whole. . . . The efforts of the Venetian state and glassmakers' guild to restrict the migration of glassmakers via the threat of fines and prison sentences certainly suggests that their skills and abilities were both desirable and guarded domestically. At the same time, because their products were in demand, Venetian glassmakers were constantly tempted to leave Venice and take their skills with them.⁴⁴

Despite a shared body of generic knowledge, it is also apparent that some family- and workshop-specific knowledge was not shared. The implications of this are spelled out in the next section.

3.1.2 Competition Within Cooperation

Guilds did not coerce members to share *all* techniques with other group members. Guild members often kept certain specific techniques within their families. Thus while the guild encouraged development and sharing of relatively generic information within the ranks of members, certain (presumably valuable) techniques which could be kept secret were permitted to remain as private information (what would today be termed “trade secrets” or “proprietary knowhow”).⁴⁵ Indeed, some scholars, noting that the primary function of most guilds was to serve as “social networks” for members, conclude that overall guilds likely contributed more to rent seeking than economic efficiency.⁴⁶

A case study can be found in a dispute over a secret glassmaking technique described by scholar Pamela Long. She recounts the story of a Venetian guild member who had developed a new process for making high-quality glass. The glassmaker entrusted the formula to only one family member, his daughter. But an ambitious suitor stole the formula. He later married another woman whose father (also a glassmaker) had agreed to set him up with a glass furnace to take advantage of the stolen formula. Long takes note not only of the apparent acceptance of such “family secrets” in the guild, but also the sense that the episode reveals a breach of accepted ethical norms. From this she surmises that family-specific trade secrets were an accepted part of the Venetian glassmaking guild.

⁴⁴ W. Patrick McCray, “Creating Networks of Skill,” at 316.

⁴⁵ Stephan R. Epstein, “Craft Guilds, Apprenticeship, and Technological Change,” at 694 (documenting the acceptance of competing process technologies, and noting an apprentice’s guild oath requiring nondisclosure of the *master’s* “secrets”).

⁴⁶ Sheilagh Ogilvie, “Guilds, Efficiency and Social Capital.” CESifo Working Paper No. 820, www.cesifo.de

According to Professor Stephan Epstein, this was not unique to the glassmakers. “[Knowledge] [s]haring was probably less common in industries like glassmaking and in some of the luxury goods sectors, where chemical processes whose scientific basis [were] poorly understood gave industrial craftsmen a competitive edge.”⁴⁷

The presence of non-generic, quasi-proprietary knowledge is also evident from the many glass recipe books that were written by guild members, the first in 1446. These were practical “shop manuals,” aimed at apprentices and others in individual shops. Historian W. Patrick McCray describes one such “recipe collection”:

[T]he recipe collection of the Darduin family [for example] may be viewed as a tool used in the Venetian glasshouse, in much the same manner as a furnace or blowpipe. . . . In contrast to the [publicly available treatises such as Neri’s] . . . , collection such as this, because of their primarily private nature, did not directly distribute glassmaking knowledge outside of Venice.⁴⁸

To summarize, in the glassmaking guild of Venice, members tolerated– and may have even promoted – a special category of family- or workshop-specific information, kept from the generic pool of knowledge passed on to all apprentices. This raises an important point. Just because a subset of a family or shop’s techniques were not shared does not by itself indicate the absence of a norm requiring at least some sharing. As in other contexts (for example, patent pools, standards organizations, and data sharing among modern research scientists – described briefly below), sharing norms can be very fine-grained. They can provide that certain (generic) technology must be shared, while excluding self-generated, newer, or higher-value technology from this general norm. In this way, even those technological communities that have evolved reciprocal sharing norms can still permit a category of secret or proprietary information.

3.3 Episodes of Collective Invention

To connect guilds to more modern organizations, we will begin by taking a brief look at some well-documented cases of “collective invention.”

In his article “Collective Invention,” Robert Allen first described a technological community explicitly committed to the sharing of a new technology.⁴⁹ Allen studied the development of iron furnace technology in the Cleveland (UK) area during the mid-nineteenth century:

[I]f a firm constructed a new plant of novel design and that plant proved to have lower costs than other plants, these facts were made available to other firms in the industry and to potential entrants. The next firms constructing a new plant build on the experience of the first by introducing and extending the design change that

⁴⁷ Id.

⁴⁸ W. Patrick McCray, “Creating Networks of Skill,” at 319.

⁴⁹ Robert C. Allen, “Collective Invention.”

had proved profitable. The operating characteristics of the second plant would then also be made available to potential investors. In this way fruitful lines of technical advance were identified and pursued.⁵⁰

Alessandra Nuvolari identifies a similar phenomenon in the case of the Cornish pumping engine in the early nineteenth century.⁵¹ Nuvolari documents the activities of a technological community operating after the expiration of the burdensome patents held by James Watt. This community established a publication dedicated to the rapid diffusion of new and effective information on the design and operation of steam engines for pumping water from mines. A subsidiary goal was to promote competition among engineers, by publicizing successful design innovations. The newsletter and the culture behind it resulted, according to Nuvolari, in a rapid acceleration in technical advance in the industry.

Eric von Hippel has documented similar sharing norms among steel “minimill” operators in the 1970s and 80s.⁵² Von Hippel describes reciprocity norms in this technological community, particularly with respect to operating parameters and other “know-how” related to steel production. He also argues that the events recounted by Robert Allen followed the same pattern.

3.4 Other “Appropriability Institutions” Through Time

Although the guilds withered with changing economic conditions in the seventeenth and eighteenth centuries, certain features survived in later institutions. This section attempts a brief synopsis of some of these. What follows is a brief list of the “appropriability institutions” that share at least some of the pro-innovation features of certain guilds at certain times.

- ***Exchange of research results and materials by academic scientists.*** This practice shares some features of the guilds. I have documented elsewhere how scientists exchange information under reciprocity norms with peer researchers, while seeking patents to assert against “outsider” commercial entities. This balancing of sharing with insiders, coupled with community norms about who constitutes insiders and outsiders, is reminiscent of some aspects of the guilds. In addition, some research results are considered too recent or too important to be subject to the sharing norm, which resembles the keeping of family or workshop-exclusive trade secrets in the Venetian glassmaking guild;⁵³
- ***Patent Pools.*** Multiple firms holding mutually complementary or blocking patents often come together to form “patent pools.” The rules that define these pools differentiate insiders (pool members) from outsiders. There are also rules and norms about which patents must be shared within the pool and which may be kept

⁵⁰ Id., at 2.

⁵¹ Alessandro Nuvolari, “Collective Invention During the British Industrial Revolution.”

⁵² Eric von Hippel, *The Sources of Invention*, pp. 76-92.

⁵³ Merges, “Property Rights Theory and the Commons.” On the reward systems of science and industry, see Partha Dasgupta and Paul A. David, “Toward a New Economics of Science.”

as strictly exclusive rights. The negotiations and agreements required to aggregate technology and intellectual property from multiple firms sources in some ways mirror certain features of the guilds.⁵⁴

- ***Standard-setting organizations.*** In some ways similar to patent pools, these organizations involve technical personnel from firms and other institutions, who come together to define protocols and other common technical features to be shared by industry members. The rules governing whether aspects of the standard may be the subject of patents held by the individual firms, and if so under what conditions they may or must be licensed, can be complex. The combination of generic and firm-specific technology that these institutions define is also reminiscent of some aspects of the guilds.
- ***The “Fashion Originators Guild of the 1930s.”*** In 1932, fifteen U.S. manufacturers of expensive women's dresses organized the Fashion Originators' Guild of America. Guild members agreed to register original designs, which were (and are) not protected by patent or copyright law, with the Guild's “registration bureau,” and to refrain from copying other members' designs.⁵⁵ This “private intellectual property system” also shares some common features with the guilds, insofar as industry norms were employed as a substitute for formal legal property rights.
- ***The Entertainment Industry.*** Many aspects of the U.S. entertainment industry are subject to similar “private law” systems⁵⁶ – e.g., the procedure for registering film scripts with the writers' union prior to submission to studios, and the administrative mechanism for registering potential film titles with a movie industry trade group, the Moving Picture Association of America.

4. Appropriability Institutions Go Virtual: The Open Source Movement

Open source software – a model of software development where individuals are held together not by ties to a common employer-firm, but by shared professional norms and practices⁵⁷ – offers some intriguing parallels with guilds as well. This type of software refers to software developed by a loose body of volunteer programmers and disseminated without restrictive proprietary claims. Most open source software involves contributions by many farflung programmers, some of whom contribute on their own time and others of whom contribute at the behest of their employers. Individual contributions are evaluated and integrated by a central organization or informal group entrusted with maintaining and authorizing “official” versions of the software. Economists and others have argued about the motives of contributors, but for commercial

⁵⁴ On patent pools, see Robert P. Merges, “Contracting into Liability Rules.” On standard-setting organizations, see Urs von Burg, “The Triumph of Ethernet” and Mark Lemley, “Intellectual Property Rights and Standard-Setting Organizations.”

⁵⁵ Robert P. Merges, “Contracting into Liability Rules.”

⁵⁶ Id.

⁵⁷ Eric von Hippel and Georg Krogh, “Open Source Software and the Private-Collective Innovation Model.”

entities at least there can be clear benefits. For our purposes, what is important is that open source projects involve norms of proprietariness that create conditions for innovation – they are institutions that facilitate innovation, just as the guilds were.

Open source norms are different from those that operated in the guilds, however. This can be explained at least partly by the nature of the software. Writing a complex program is a collaborative enterprise. Each piece of code must work with the preexisting code. Because intellectual property law (in particular, copyright) permits a contributor to claim rights in works that build on preexisting public domain works, open source contributors need to restrict property claims of downstream contributors. They accomplish this through various “open source license agreements.” As explained in an article by Yochai Benkler:

In [open source] software, the risk of defection through . . . appropriation is deemed a central threat to the viability of the enterprise, and the [standard open source license agreement] is designed precisely to prevent one person from taking from the commons, appropriating the software, and excluding others from it.”⁵⁸

In other words, by agreeing on a norm eschewing property rights,⁵⁹ a large number of independent contributors can create and integrate components into a single, useable asset with minimal transaction costs.

How are open source projects like guilds? There are two primary ways: (1) they both depend on shared norms within communities of specialists in particular technologists; and (2) these norms include understandings about what can and cannot be claimed as proprietary by members of the community. Especially as described in the scholarship of Professor Stephan Epstein, guilds arose as institutions responding to the difficult appropriability landscape of the medieval economy. The same is true of the open source movement. Although the content of the norms differs across the two institutions, they share common “bottom-up” origins, both arising in response to arguably inefficient appropriability conditions in the surrounding economy. Despite the fact that guilds originated in what was largely a vacuum with respect to formal property rights, whereas open source originated as a response to what some see as an overly-proprietary environment, they both represent norm-based institutions that fundamentally alter prevailing appropriability conditions.

In my mind at least, these similarities in origin suggest something interesting and important about appropriability regimes. Many scholars – and particularly legal scholars – have tended to have a state-centric, if not legal-centric, view of appropriability. This “top-down” view must give way to a different conception: one where bottom-up institutions of all kinds contribute importantly to appropriability conditions. This view is in

⁵⁸ Yochai Benkler, “Coase’s Penguin” at p. 441 (citing Free Software Found, GNU General Public License)

⁵⁹ Or, more accurately, by adopting a “restrictively open” property rights model. For the sake of accuracy, it should be pointed out that technically, open source software is subject to full copyright protection; the difference is that all contributors agree by contract to forego full enforcement of property rights in their contributions.

keeping with the recent trend in law and economics scholarship toward a discussion of social norms in conjunction with formal law.⁶⁰

4.1 Appropriability Institutions and Property Rights

If I am right that these modern-day practices emulate certain features of guilds, some interesting conclusions regarding property rights follow suit. First, we will have yet another revision to the influential early view associated with Demsetz (1967) that property rights evolve along with the value of underlying assets. This has normally been interpreted in what might be termed a “linear property rights” view: as an economy develops, property rights are ever more closely specified, and ever more aggressively enforced. The revival of guild-like organizations in the modern economy shows that this view is an oversimplification. These organizations demonstrate that under modern conditions, institutions for collective innovation – what I call appropriability institutions – may emerge *in the presence of property rights*, and not simply in their absence. Indeed, in some cases, guild-like organizations have emerged precisely because of the presence of overlapping and blocking intellectual property rights (pools and standards), or in direct response to what are seen as the strictures and constraints that property rights impose on free exchange (scientific norms and open source software).

In the contemporary economy, therefore, the resulting fabric of innovation institutions is much richer than in the stylized world of Demsetz. Yet the Demsetzian thesis can be rehabilitated, by placing it in a larger frame. The emergence of collective organizations in a property rights-rich environment demonstrates that not just property rights, but institutions generally, appear to evolve in response to changes in asset values, *including* increased value in the aggregation of assets. Thus, early Demsetz demonstrated the logic behind property rights as a solution to the commons problem; and contemporary, guild-like institutions can be seen as a response to the proliferation of property rights held by disparate firms and individuals – i.e., the “anticommons”.⁶¹ The overall point is that there are similarities between historically important organizational forms and emergent institutions in the modern economy.

5. Conclusion

Some of the features that make guilds interesting may be becoming more important. Naomi Lamoreaux, Daniel Raff and Peter Temin,⁶² joined by Richard Langlois,⁶³ have noted the emerging dominance of the “post-Chandlerian” economy – an economy characterized by a great diversity of industry structures including many small, specialized firms. Such an economy will tend to disperse engineers, scientists and technicians into smaller units than ever before, as the integrated, hierarchical Chandlerian

⁶⁰ See, e.g., Eric Posner, *Law and Social Norms*; Terry L. Anderson, and Peter J. Hill, “The Not So Wild, Wild West.”

⁶¹ Michael Heller, “Anticommons.”

⁶² Naomi R. Lamoreaux, Daniel M.G. Raff and Peter Temin, “Beyond Markets and Hierarchies.”

⁶³ Richard N. Langlois, “Chandler in a Larger Frame.”

firm gives way to a greater diversity of viable organizational forms. Richard N. Langlois in a related vein speaks of the increasing “modularization” of economic activity: as population and economy grow, and communication and transport cost drop, functions that were previously better performed in a hierarchical setting are spun out into discrete firms.⁶⁴ Under such conditions, we might speculate that appropriability institutions will emerge with increasing frequency to mediate these atomizing forces.

Simply put, as economic forces disperse the basic units of innovation, informal institutions regulating the norms of information sharing become more important. And so I believe guilds – prototypical “appropriability institutions” – deserve to become of interest to a wider range of scholars.

* * *

My goal here has been to present evidence of historical continuity. I realize full well that I have generalized well beyond the conventional bounds of the historical literature. I have overlooked exceptions, failed to note nuance, and generally made a mockery of much accepted historical practice. This of course is the prerogative of the non-specialist – and I have made full use of it here.

However I hope there is something to be gained in the exercise. I hope that somewhere in the generalizations of this brief article I have put my finger on some identifiable lines of continuity running outward from the medieval guild, through the industrial revolution, and into the contemporary era. I at least have been struck by the recurrence of groups of technologists in which the work of individuals has been amplified by sharing and combination with others in the group. The fascination that the medieval guilds have always held for me is that they seem such clear embodiments of this collective spirit. It always seemed to me that there was perhaps something beyond coincidence to explain the emergence of patents in fifteenth century Venice, a republic rarely if ever matched for the prominence of technologically innovative guilds. As I have tried to make clear, I believe that guilds – or more accurately, the technological communities they represented – were the source of an innovation strategy that supplements the role of formal state-backed property rights (such as patents) in important ways. As we can see from subsequent episodes of collective invention, extending all the way to the modern open source movement, elements of complementarity continue today in the coevolution of property rights and appropriability institutions. As a plausible rationale for continuing study of these fascinating institutions (not to mention a return trip or two to Venice!), we need look no further than this.

⁶⁴ Id., at 20-21.

Sources

Robert C. Allen, "Collective Invention," *J. Econ. Beh. Org.* 4 (1983), pp. 1-24.

Allen, Thomas J. "Managing the Flow of Technology," The Massachusetts Institute of Technology, 1977.

Anderson, Terry L., and Peter J. Hill. "The Not So Wild, Wild West," Stanford University Press, 2004.

Yochai Benkler, "Coase's Penguin, or, Linux and the Nature of the Firm," *Yale L. J.*: 112 (2002), p. 369.

Boyle, James, "The Second Enclosure Movement and the Construction of the Public Domain," *L. & Contemp. Probs.* 66 (2001), p. 33.

Bucciarelli, Louis L. "Designing Engineers," Massachusetts Institute of Technology, 1994.

Bugbee, Bruce W., *Genesis of American Patent and Copyright Law* (1967).

Cornia, Giovanni Andrea, and Vladimir Popov. "Transitions and Institutions," Oxford University Press, 2001.

Dasgupta, Partha, and Paul A. David, "Toward a New Economics of Science," *Research Policy* 23 (1994), pp. 487-521.

Demsetz, Harold. "Toward a Theory of Property Rights," *Am. Econ. Rev. Papers & Proc.* 57 (1967): 347.

Dyer, Christopher. *Making a Living in the Middle Ages: The People of Britain, 850-1520* (New Haven, CT: Yale Univ. Press, 2002).

Epstein, S.R. "Craft, Guilds, Apprenticeship, and Technological Change in Preindustrial Europe." *The Journal of Economic History*, vol. 58 no. 3 (1998): 684-712.

Epstein, Stephen R. "Property Rights to Technical Knowledge in Premodern Europe, c.1300-c.1800." Unpublished manuscript presented at American Economics Association Annual Meeting, Jan. 3, 2004.

Gustafson, Bo. "The Rise and Economic Behaviour of Medieval Craft Guilds An Economic-Theoretical Interpretation." *The Scandinavian Economic History Review and Economy and History*, vol. 35, no. 5 (1987): 1-40.

Hickson, Charles R., and Earl A. Thompson. "Essays in Exploration: A New Theory of Guilds and European Economic Development." *Exploration in Economic History* 28 (1991): 127-168.

Harris, Ron, "The Uses of History in Law and Economics," *Theoretical Inquiries in Law*: 4 No. 2 (July, 2003), Article No. 9.

Heller, Michael. "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets," *Harv. L. Rev.* 111 (1998): 621-688.

Kriedte, Peter, Hans Medick and Jurgen Schlumbohm, *Industrialization Before Industrialization*, Cambridge, England: Cambridge University Press 1981 (Beate Schemp, trans.)

Naomi R. Lamoreaux, Daniel M.G. Raff and Peter Temin, "Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History," NBER Working Paper 9029 (July 2002).

Langlois, Richard N. "Chandler in a Larger Frame: Markets, Transaction Costs, and Organizational Form in History." Unpublished manuscript, 3rd Draft, Jan. 2004.

Lemley, Mark A., "Intellectual Property Rights and Standard-Setting Organizations," *California Law Review*: 90 (2002): p. 1889.

Long, Pamela O. "Openness, Secrecy, Authorship," The John Hopkins University Press, 2001.

Marshall, T.H. "Capitalism and the Decline of the English Gilds." *The Cambridge Historical Journal*, vol. 3, no. 1 (1929): 23-33.

McCray, W. Patrick. *Glassmaking in Renaissance Venice: The Fragile Craft* (Aldershot, UK: Ashgate Publishing, 1999).

McCray, W. Patrick. "Creating Networks of Skill: Technology Transfer and the Glass Industry of Venice." *The Journal of European Economic History*, vol. 28, no. 2 (1999): 301-333.

Merges, Robert P., "Property Rights Theory and the Commons: The Case of Scientific Research," 13 *Soc. Phil. & Pol'y*: 13 (1996), pp. 145-167.

Merges, Robert P. "The Law and Economics of Employee Inventions," *Harv. L. & Tech. J.*: 13 No. 1: p. 1 (1999).

Merges, Robert P. and John F. Duffy, *Patent Law and Policy: Cases and Materials* (3rd ed.) (New York: LexisNexis Publishing 2002).

Merges, Robert P., Peter S. Menell and Mark Lemley, *Intellectual Property in the New Technological Age* (3rd ed.) (New York: Aspen Law and Business Publishing 2003).

Nuvolari, Alessandro, "Collective Invention During the British Industrial Revolution," *Cambridge J. Econ.* (forthcoming).

Ogilvie, Sheilagh, "Guilds, Efficiency and Social Capital." CESifo Working Paper No. 820, 2002, avail. at www.cesifo.de.

Ogilvie, Sheilagh C., and Markus Cerman. "European Proto-Industrialization," Cambridge University Press, 2001.

Poni, Carlo. "Norms and Disputes: The Shoemakers' Guild in Eighteenth Century Bologna," *Past and Present* no. 123 (May, 1989), pp. 80-108.

Posner, Eric A. "Law and Social Norms," Harvard University Press, 2000.

Thrupp, Sylvia, "The Gilds," in Postan, M. M., and E.E. Rich, and Edward Miller, eds., *The Cambridge Economic History of Europe* (Cambridge, UK: Cambridge University Press, 1965), pp. 230-280.

Von Burg, Urs. "The Triumph of Ethernet: Technological Communities and the Battle for the LAN Standard," Stanford University Press, 2001.

Von Hippel, Eric. "The Sources of Innovation," Oxford University Press, 1988.

_____ and Georg von Krogh, "Open Source Software and the Private-Collective Innovation Model: Issues for Organization Science," working paper, 2002, avail. at <http://web.mit.edu/evhippel/www/PrivateCollectiveWP.pdf>.

von Meier, Alexandra. "Cultural Conflict as a Challenge to Technological Innovation," *IEEE Transactions on Engineering Management*, Vol. 46, No.1, Feb. 1999.