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Craft Guilds, Apprenticeship, and Technological Change in Preindustrial Europe

S. R. EPSTEIN

This article argues that medieval craft guilds emerged in order to provide transferable skills through apprenticeship. They prospered for more than half a millennium because they sustained interregional specialized labor markets and contributed to technological invention by stimulating technical diffusion through migrant labor and by providing inventors with temporary monopoly rents. They played a leading role in preindustrial manufacture because their main competitor, rural putting out, was a net consumer rather than producer of technological innovation. They finally disappeared not through adaptive failure but because national states abolished them by decree.

Technological invention and innovation in the preindustrial economy are still poorly understood. This is partly because of the difficulty in identifying the small-scale and anonymous innovations that dominated technical progress at the time. However, the problem is compounded by several long-standing assumptions about premodern manufacture, in particular by the view that from the fifteenth century onwards craft guilds—which provided European urban manufacture with its main institutional framework for over 600 years—were organized rent-seekers that systematically opposed technical innovation.

This article suggests that the prevailing view of craft guilds misrepresents their principal function and their technological consequences. It begins by analyzing the guild structure from the point of view of individual producers and suggests that the primary purpose of craft guilds was to provide adequate skills training through formal apprenticeship. It then argues, from evidence of innovation and resistance to it, that technological invention and innovation were a significant, albeit mostly unintended effect of the crafts' support for investment in skills. It concludes by briefly addressing the counterfactual question implied by the guilds' critics: if craft guilds were technologically regressive, why was guild-based craft production not out-competed by its major contemporary rival, rural protoindustry?

Rather than provide a detailed study of an individual craft or of a constellation of guilds in one town, the focus will be on the broad outlines of a sys-

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tem that remained fundamentally unchanged for more than half a millennium.[1] A distinction is drawn between the general structure and purposes of the manufacturing guild and individual guild practice under changing historical circumstances. The purpose of the distinction is twofold. First, it provides a set of parameters for the way craft guilds, markets in skilled labor, and technological innovation interacted in premodern Europe. Second, it draws attention to two aspects of guild behavior that are often confused. These are, on the one hand, the technological spillovers of craft activities, which were largely unintentional, unavoidable, and economically beneficial; on the other hand, the crafts' oligopolistic controls over output, which were deliberate and had essentially negative effects, but were neither universal, nor permanent, nor easily enforced. This article focuses on the former and touches more briefly on the latter. It is concerned strictly with manufacturing guilds; I do not discuss guilds associated with the service sector whose strategies and effects may have been quite different.[2]

WHAT WERE CRAFT GUILDS FOR?

The craft guild was a formal association of specialized artisans, the masters, whose authority was backed by superior political sanction; apprentices and journeymen came under guild jurisdiction but lacked membership rights. Economic explanations of the craft guild assume that it performed one or more of the following functions: it acted as a cartel, both as buyer of raw materials and as seller of its products; it enforced quality standards which lowered asymmetries in information, particularly outside the local marketplace where the products were little known; it provided members with intertemporal transfers of income in highly unstable markets, smoothing the trade cycle and removing the issue of compensation from the arena of partisan politics, and it served as a bargaining unit in narrow markets in which agents held market power; it supplied cheap credit in underdeveloped financial markets with high information costs; it operated as a political and administrative unit that protected its members from expropriation by opportunistic urban elites, who in exchange demanded that it collect capital tax and tie apprentices so as to provide cities with a ready military force; or finally and

[1] See Farr, "On the Shop Floor" for a recent defense of this approach. There were nonetheless significant regional differences both in the number and in certain formal characteristics of the guilds. For example, quality controls were particularly extensive in the Germanic world, where political fragmentation gave a foreign trade orientation to much artisan output (Hickson and Thompson, "New Theory," p. 155). On the other hand, French and Spanish guilds were less pervasive and more loosely organized (Turnau, "Organization," pp. 586–95). Although I do not address such regional differences systematically, the article shows how a meaningful regional typology of guilds can be constructed.

[2] Manufacturing guilds were subject to far greater competitive pressures than guilds in the service sector, which also appear to have been more litigious and protectionist; see Deceulaer, "Guilds," for early modern Antwerp.

most noxiously, it was a rent-seeking organization that lobbied for economic privilege from the state.[3]

None of these explanations alone seems to account wholly for the range and typology of premodern manufacturing guilds. The most pervasive view, according to which craft guilds were primarily rent-seeking institutions, takes their regulations at face value and assumes that they acted as monopolists in political markets. In fact, the powers of craft guilds were frequently illusory. In the first place, guild privileges were contingent upon competing political interests. This meant that privileged income streams could be revoked at any time, as Charles V's abolition of the guilds' political privileges in 27 German free imperial cities between 1548 and 1552 proved to good effect.[4] Second, the interests of the more conservative small-scale craftsmen were generally at odds with those of the wealthier masters, and the guilds as a whole were often at odds with the merchant corporations, who were usually better represented in local government. Cumulatively, these rivalries undermined the more conservative smaller craftsmen's concerns. Third, guilds in larger cities mostly lacked the powers and resources to effectively police their precincts. Fourth, the claim that craft guilds were primarily rent-seeking coalitions is belied by widespread evidence of craftsmen deliberately *avoiding* guild membership. I return to these points in more detail.

We must also ask whether some of the more positive functions credited to guilds could not have been exercised as well and more cheaply by other means. It is true that the guilds could help reduce asymmetries of information and promote sales through quality controls. However, in small-scale markets, less formal arrangements could be just as effective. Thus, the *bazaar*-like bunching together of shops in the same street that was one of the more salient features of urban manufacture in this period allowed local customers to compare wares and prices on the spot.[5] Equally, where industries served foreign markets in which it was crucial to establish and uphold a reputation by signalling the product's origin, those assurances could be provided just as effectively by city authorities or merchant associations, as the examples of late medieval Douai and Milan attest.[6] Similarly, it was possible to smooth fluctuations in life-cycle income or provide members with cheap credit by means of other readily available institutions like religious fratern-

[3] See Mickwitz, *Kartellfunktionen* (cartelization); Gustafsson, *Rise*; and Richardson, "Brand Names" (enforcement of quality standards); Persson, *Pre-Industrial Economic Growth* (bargaining and welfare functions); Pfister, "Craft Guilds" (credit provision); Hickson and Thompson, "New Theory" (administrative and fiscal functions); and Ogilvie, *State Corporatism* (rent seeking).

[4] Friedrichs, *Early Modern City*, p. 56.

[5] The suggestion below, note 66 that the agglomeration of crafts in the same location was a consequence of the development of an apprenticeship system implies that quality control emerged as an unforeseen benefit of clustering.

[6] Howell, "Achieving""; and Mainoni, *Economia*, pp. 207–28.

ities, kinship networks, urban provisioning structures, "poor laws," and the like. The comparative advantage of guilds in these respects is not immediately apparent.

Arguments based on the welfare-enhancing functions of guilds face the same difficulty that claims about rent-seeking do, which is to explain why craft guilds enforced compulsory membership to avoid free-riding by external beneficiaries of its activities. Since the externalities of cheap credit or improved average consumption were, if anything, negative, guilds whose main purpose was to provide these services should have been faced with an oversupply rather than a dearth of applicants.[7] The view that guilds aimed to protect their members against capital expropriation raises similar objections.[8]

Although it would be wrong to deny that craft guilds took on these capacities (including the distribution to members of politically determined rent streams), quality enforcement, credit provision, and welfare support seem insufficient reasons for the guilds to emerge and to survive for such an extraordinary length of time. Although those welfare-enhancing capacities increased greatly as early modern state regulation expanded, they are best understood as subsidiary "non-collective social benefits" which raised the cost for members of free-riding or of defecting with technical secrets.[9] They helped the craftsmen as a group to retain their members' skilled labor and to avoid the costs of dispersal: guilds sought rents if they were there for the taking, but they were not invented nor did they survive for that purpose.

The main objective of an individual master was to make the most efficient use of family and outside skilled labor in the workshop. Hence, relations with apprentices and journeymen who did not formally belong to the guild were just as important as those with the guild membership. The first hypothesis to be addressed is that, from the point of view of the individual artisan, the primary function of the craft association was to enforce contractual norms that reduced opportunism by masters and apprentices.[10] Put somewhat differently, the main purpose of the craft guild was to share out the

[7] Nonmembers of a group that aimed to provide cheap credit would have to pay higher interest rates because of information asymmetries. Moreover, if the guilds' primary function (see below, note 10) was the provision of credit, one would expect to find guild density to be inversely correlated with the development of efficient credit markets; in fact, guilds emerged first in Italy where sophisticated credit markets were also the first to develop.

[8] Hickson and Thompson, "New Theory."

[9] Olson, *Logic*, pp. 72–75.

[10] The primary function is defined here as one that is both necessary and sufficient for guilds to emerge and survive over time. The earliest references to craft guilds invariably concern contracts of apprenticeship (Epstein, *Wage Labor*). Conversely, the decline of guild influence in late eighteenth-century England is strongly correlated with a rise in the number of incomplete apprenticeships (Snell, *Annals*, pp. 253–54; see also below, note 82). A mainly skills-enhancing function of guilds might also explain why female guilds were so unusual. Women were mostly restricted to activities learned informally at home and formally in female religious houses and orphanages; exceptions were granted to relatives of master craftsmen and journeymen (ibidem, chap.6; Hafter, *European Women*; and Farr, "On the Shop Floor", pp. 42–47).

unattributed costs and benefits of training among its members. Guilds were cost sharing rather than price-fixing cartels.[11]

APPRENTICESHIP AND THE PROVISION OF SKILLS

Ever since Adam Smith's attack on apprenticing laws as a means of restricting access to the labor market, the economics of preindustrial apprenticeship has been virtually ignored. Because the formal length of training that was imposed (which in Smith's England was for many crafts still seven years) seemed out of proportion to the requisite skills, its purpose could only be to exclude competition. Smith's argument that apprenticeship served to maintain a labor market monopsony seemed at first blush unassailable; since then, it has become akin to an article of faith.[12]

The argument has both an epistemological and an institutional component. Smith's epistemological claim is that tacit, embodied skills which cannot be formulated explicitly or symbolically through the written or the spoken word can nonetheless be transmitted at virtually no cost. In modern terminology, Smith assumes that all skills are general. This clearly underestimates both the existence and complexity of specific or transferable skills in preindustrial crafts and the difficulties in transmitting expertise. The question to be addressed is not whether training in skills was costless or unnecessary (it was neither), but which institution could best overcome the three principal hurdles of technical transmission. These were how to *teach* skills; how to *allocate* costs to provide teachers and pupils with adequate incentives; and how to *monitor* the labor market to avoid major imbalances between supply and demand for skilled labor. In the absence in premodern societies of compulsory schooling and of efficient bureaucracies, the best available solution on all counts was arguably a system of training contracts enforced by specialized craft associations.[13]

Smith's institutional critique of apprenticeship raises the objection that, although he implied that apprenticeship would only persist where corporations could enforce their laws strictly, there is strong evidence that informal

[11] The guilds' general lack of concern with fixing price was probably due to the high enforcement costs involved; where price controls were applied, they established price maxima and quality minima rather than price minima and quality maxima (Hickson and Thompson, "New Theory"), possibly as a way of maximizing exports. Competition on price within the guild was therefore allowed.

[12] Smith, *Wealth of Nations*, pp. 133, 136–37. However, the seven-year rule did not apply to any craft that arose after the Statute of Artificers was approved in 1563.

[13] See Rothschild, "Adam Smith," pp. 13–15. Trainees needed to learn not only about a range of different production methods and technologies, but about markets, competitive standards, and negotiation with other artisans, laborers, and merchants. Even modern schooling provides insufficient instruction for learning a craft or profession, for the simple reason that it does not impart tacit skills in them. Thus machine tool producers, lawyers, doctors, and microbiologists must all undergo some kind of nonverbal craft-like training. On the cognitive difficulties of knowledge transmission, see Bloch, "Language." For transferable skills see below, note 25.

rules of apprenticeship applied also where craft guilds were not legally sanctioned.[14] It is also the case that the combined vigilance of town authorities and merchant corporations, and competition between craft members and between separate crafts, made statutory restrictions on apprentice numbers easy to flout. The labor market was oligopsonistic rather than monopsonistic.[15] Thus, more able apprentices could rise to journeyman status before their contract expired.[16] Governments lifted guilds' entry requirements if epidemics or other events reduced the supply of craftsmen.[17] The significant differences in the length of apprenticeships between similar crafts suggest moreover that statutory length was an arbitrary and negotiable benchmark, set because the guilds were unable to legislate on the teaching itself.[18] Even the apparently uncompromising norms of the Statute of Artificers of 1563 gave English J.P.s discretion in applying apprenticeship rules.[19] Labor market restrictions were further weakened by town councils, which frequently allowed masters to practise without enrolling in the corporation and gave tacit approval to a vast number of skilled journeymen and de facto masters, "false workers" and women who set up business in the expanding town suburbs beyond guild jurisdiction. In Vienna in 1736 only 32 percent out of over 10,000 master artisans were enrolled in guilds.[20]

[14] Epstein, *Wage Labor*, pp. 77–78; Howell, "Achieving"; Gay Davies, *Enforcement*, pp. 1, 11, 125, 263–67; Sewell, *Work*, pp. 38–9; Sonenscher, *Hatters*, pp. 48–67; and Hudson, *Genesis*, p. 31. The existence of set-up costs established a minimum viable size for guilds, below which less specialized institutions (village or small town courts) or informal face-to-face arrangements could be expected to enforce implicit contracts. Para-guild structures such as fraternities arose where craft organizations were formally banned by the state and merchant associations were particularly powerful, as in fourteenth-century Milan (Mainoni, *Economia*, pp. 207–28) and late medieval Douai (Howell, "Achieving"). However, the question of what arrangements replaced guilds where these lacked political backing has still to be systematically examined.

[15] Thus, the English Statute of Artificers did not restrict the number of apprentices that could be employed. In general, "guild officials and courts were not easily inclined to prosecute employers [who] flouted apprenticeship clauses" (Lis and Soly, "Irresistible Phalanx," pp. 22–23, 41–42; also Swanson, *Medieval Artisans*, p. 114; and Lipson, *Economic History*, vol. 2, pp. 39–40). For flouting of restrictions on journeymen see Safley, "Production," p. 129; and Farr, *Hands*, pp. 63–64. The association between apprenticeship and imperfectly competitive labor markets is demonstrated by Stevens, "Theoretical Model," who shows how under such circumstances oligopsonistic structures may emerge from a competitive system of firms.

[16] Epstein, *Wage Labor*, pp. 107, 109, 110.

[17] See Heller, *Labor*, p. 96; Rapp, *Industry*, p. 20; and Berlin, "Broken," p. 78.

[18] Degrassi, *Economia*, pp. 54–55, 58–60; Thrupp, "Gilds," p. 264; Hirshler, "Medieval Economic Competition," p. 57 fn. 29; and Rappaport, "Reconsidering."

[19] Gay Davies, *Enforcement*, p. 2; and Degrassi, *Economia*, p. 53. The seven-year term set by the Statute of Apprentices codified the custom of London, but "its observance was primarily a matter of local custom" (Lipson, *Economic History*, vol. 3, p. 283).

[20] Ehmer, "Worlds," pp. 177–78. In Antwerp the enforcement of guild membership was the third most important source of litigation, after the defence of guild privilege and demarcation conflicts between crafts (Deceulaer, "Guilds", p. 197, table 6). See also Thrupp, "Gilds," pp. 246, 255–58; Walker, *German Home Towns*, pp. 24, 90–92; Davids, "Beginning Entrepreneurs"; Rappaport, *Worlds*, pp. 104–05; and Farr, *Hands*, pp. 44–55. For suburban production, see Thrupp, "Gilds," p. 280; Farr, "On the Shop Floor", pp. 39–42, 47–49; Rappaport, *Worlds*, p. 111; Heller, *Labor*, pp. 49–50; Sonenscher, *Work*; and Kaplan, "Lutte."

The legal confusion underlying claims to "monopoly," which caused friction over the demarcation of tasks, made the regulation of labor even harder.[21] Whereas struggles to control new industrial processes are often decried for their coercive aspects and legal costs, they also expressed guild competition and widespread evasion of rules; similarly, the frequent wrangles when new crafts broke away from old undermined the parent craft's control. In some cities, like Florence and London, crafts were grouped in huge "umbrella" denominations, which took the sting out of demarcation issues and made it easier for craftsmen to move between different sectors.[22] Changes in craft descriptions brought about by periodic fissure, abolition and creation are further proof of their capacity to adapt to changing technical processes and tastes.[23] Finally, members of the same household practicing different crafts also weakened the hold of guild jurisdiction.[24] Generally speaking, urban labor markets were far more flexible than the letter of the law seems to allow.

Guild coercion was instead essential as a means of enforcing apprenticeship rules in the presence of training externalities in transferable skills.[25] Before the introduction of mass schooling, a degree of formal training was needed to iron out initial differences in skills among children and to socialize adolescents into adulthood; artisans required skilled labor to produce goods to a standard quality and to raise output.[26] Masters could reclaim their investment costs (which included time spent on training, wasted materials,

[21] For a detailed study of guild conflicts in Antwerp over two centuries, see Deceulaer, "Guilds," with extensive references.

[22] In theory, demarcation conflicts could produce technological bottlenecks; in practice their effects are less clear cut. See Mokyr, "Innovation," p. 21 fn. 48, citing Heller, *Labor*, pp. 95–96 for resistance by Parisian armourers to an innovation in military helmets, which was however overruled by Charles IX; see also below, note 43. In Antwerp demarcation conflicts were concentrated in the service sector; industrial and luxury crafts did little to regulate members or to exclude outsiders (Deceulaer, "Guilds," pp. 191–95, 200 with references to similar conditions elsewhere in the southern Netherlands). Hirshler, "Medieval Economic Competition," pp. 53–54, views conflict between guilds and guild separations as evidence of strong competition.

[23] See Berlin, "Broken," pp. 77–78, for the effects of some 27 new incorporations in London between 1600 and 1640. As the total number of craft descriptions in Dijon increased from 81 to 102 between 1464 and 1750, 67 new descriptions appeared and 45 vanished, presumably owing to technological innovation (Farr, "On the Shop Floor", p. 34). In 1570 the cloth guilds in Amiens were reorganized in order to produce a cloth with the properties of both says and woolens (Heller, *Labor*, p. 120). By contrast, in 1726 the Amiens merchants blocked an attempt to consolidate two cloth guilds because they feared to lose the profits from brokering thread (Bossenga, "Protecting Merchants," p. 701).

[24] Swanson, *Medieval Artisans*, p. 117.

[25] Transferable skills are neither entirely general (applicable across a competitive labor market) nor entirely specific to one firm, but are valued by a small group of oligopolistic firms, and require apprenticeship contracts to avoid poaching (Stevens, "Theoretical Model"). The oligopolistic structure of craft industry was the result of increasing returns to scale and, in particular, of gains from learning-by-doing, which lowered marginal costs over time as productivity per worker increased.

[26] For socialization see Smith, "London Apprentices"; and Lipson, *Economic History*, vol. 1, pp. 313–14. Sabel and Zeitlin, "Historical Alternatives," pp. 152–55, suggest that in areas with high concentrations of specific industries, most skills were acquired informally, but they also note the existence of formal apprenticeships.

and maintenance) by requiring that the apprentice work for below market wages after gaining a set level of skills. Conversely, in the absence of credible bans against apprentice opportunism which took the shape of early departure and of poaching by rival masters who could offer higher wages because they had no training costs to recover, training would have been less than optimal and would have constrained output. A lack of rules would also have reduced the masters' incentives to develop their own talents. More highly skilled masters stood a better chance of attracting good apprentices at lower cost; the effort of teaching could also help develop the master's talents.[27] Guilds enforced compliance through statutory penalties backed up with a combination of compulsory membership, blackballing and boycott.[28]

In order to restrain apprentices' opportunism, masters also demanded rights over the apprentice's labor through long-term training agreements upheld by formal or informal sanction. For instance, it was customary for masters to be vested with the legal prerogatives of fathers, which included rights of ownership.[29] They raised the trainee's cost of default by demanding entry fees, by setting apprentices' wages on a rising scale for the contract's duration, and by promising a pay-off upon completion.[30] They addressed problems of adverse selection by stipulating entrance requirements that signaled the laborer's quality or provided surety against misbehavior, such as place of residence, family income, or the father's occupation.[31] Analogously, the entry fee to the guild was a mortgage on trust, which was used to deter lesser-known masters from exploiting the guild for short-term advantage; and which accounts for the nearly universal practice of fixing low or non-existent fees for masters' next of kin.[32] In some highly specialized and cyclical industries, like Alpine mining, iron-making, ship building and high-quality masonry, skills were often kept within closely knit kin networks; rather than a sign of restrictive practice, however, this is more likely to be because the higher risks of those industries restricted the supply of apprentices.

Equally, apprentices needed to be protected against the opportunism of their masters. They were liable to be exploited as cheap labor, which could be discharged before gaining the agreed skills. Because apprentices learned

[27] Examples of poaching in Lis and Soly, "Irresistible Phalanx," p. 41; and Coulet, "Confréries," p. 70.

[28] Rappaport, *Worlds*, pp. 234–36. Guilds obviously also helped settle other forms of dispute (Lipson, *Economic History*, vol. 1, pp. 343–44).

[29] Steinfeld, *Invention*; see also Lipson, *Economic History*, vol. 1, pp. 312–13.

[30] Degrassi, *Economia*, pp. 55–56; Snell, *Annals*, pp. 256–57; and Gay Davies, *Enforcement*, p. 10. Since the opportunity costs of default were higher for older trainees and the costs of socialization were lower, the length of apprenticeship declined with age at entry (Rappaport, *Worlds*, p. 321). Such restrictions did not apply to younger members of the craftsman's family, for whom no formal contract was required; the weight of paternal authority was sanction enough (Epstein, *Wage Labor*, pp. 104–05).

[31] For entrance requirements, see for example, Gay Davies, *Enforcement*, pp. 1, 5, 9.

[32] Farr, *Hands*, pp. 22–23.

craft-specific skills within oligopsonistic labor markets, they suffered serious loss if they were discharged early or were poorly trained. Guilds therefore passed rules to enforce adequate training.[33] Like masters, apprentices had to be vested with appropriate rights (including a guarantee of proficiency and security of employment over at least one economic cycle) in order to invest in capabilities. To comply with these obligations guilds placed apprentices with a new master if the first one died. In sum, opportunism by both parties explains both why the contracts appear to be excessively long, and why the relation between length and requisite skills is seldom straightforward.[34]

In order to allocate skilled labor efficiently, masters required mechanisms for screening job applicants and trained apprentices (journeymen) required information about the labor market. Both conditions were easily met in small-scale labor markets with low rates of in- and out-migration, and by the later Middle Ages local markets for partly trained apprentices were making the task easier.[35] As commodity markets increased in size and supply shocks intensified, however, more sophisticated arrangements to pool information and improve labor mobility emerged. Innovations of this kind seem to have occurred mainly during two phases. The first phase coincided with the sharp demographic downturn and the localized but virulent epidemics following the Black Death of 1348 to 1350 and with the ensuing reorganization of regional markets. A second phase of integration occurred during the seventeenth century, again at a time of demographic stagnation when many European regional economies were being restructured into fledgling supra-regional and national markets.[36]

Skilled workers in scarce supply established regional and later national associations to pool information and devised training credentials that were recognized by craft masters across a broad area. Both innovations appeared

[33] See Lipson, *Economic History*, vol. 1, pp. 310–11. Nonetheless, apprentices could be cheated by the craft guild acting in concert, as occurred in Paris in 1514 when the master dyers collectively agreed to hire cheaper non–Parisian labor (Heller, *Labor*, pp. 47–48).

[34] On this account, which complements standard human capital theory (Becker, *Theory*), length of apprenticeship would be a function of physical and human asset specificity within a craft; see Williamson, *Economic Organization*, pp. 178, 187; Demsetz, "Theory," pp. 169–72; and Pagano, "Property Rights." The existence of a significant positive link between length of apprenticeship and requisite skills could be tested by using wage dispersion as a proxy for skills.

[35] Degrassi, *Economia*, pp. 56–57.

[36] For late medieval regional integration, see Epstein, "Cities" and "Regional Fairs"; for seventeenth-century integration, see Reed, "Transactions Costs." For the chronology of journeymen associations, see Sonenscher, *Work*, chap.9; and Lis and Soly, "Irresistible Phalanx," pp. 24–28. Informal networks of skilled laborers had probably existed since the thirteenth century in the highly specialized and seasonal building, shipping and mining industries (Vergani and Ludwig, "Mobilità"); before 1350 only journeymen weavers in German and Swiss towns had autonomous associations (Lis and Soly, "Irresistible Phalanx," p. 19). In central and northern Italy, the religious movement of the *Umiliati* was associated in the thirteenth and early fourteenth centuries with highly mobile, technically skilled woolen weavers (Epstein, *Wage Labor*, pp. 93–98). It thus combined the skills-enhancing features of guilds and the security-enhancing features of journeymen's associations.

in strength during the late medieval phase of labor-market integration, at which time it became common to provide certificates of apprenticeship making journeymen employable across firms.[37] Organizations of journeymen spanning several regions or associations of towns were recorded in Switzerland, Germany, England, France, and the southern Low Countries. Significantly, such associations were less present in the more highly urbanized regions of Europe (north and central Italy, Flanders and the northern Netherlands, and northern France), where information flows were more intensive. During the second, seventeenth-century phase of integration, these arrangements expanded into interregional and international networks of *compagnonnages* and other semisecret journeymen associations. Although such developments benefitted masters, they also gave journeymen leverage to restrict the numbers of apprentices. Masters therefore consistently opposed such associations, at first by establishing countervailing interurban alliances of guilds that organized coordinated lockouts, and subsequently by resorting to state-backed repression.[38]

DID CRAFTS OPPOSE TECHNOLOGICAL CHANGE?

The argument that the main purpose of the craft guilds was to transmit skills raises the question of their relation to technological innovation, particularly in view of the crafts' formidable reputation for technical conservatism.[39] This reputation rests on the assertion that guilds produced no endogenous innovation (mainly because they enforced strict manufacturing procedures by means of official "searches" of members' premises) and that they refused to adopt innovations from outside.

Evidence that guilds set rigid technical standards that stifled innovation is far from compelling. On the one hand, it seems reasonable to assume that the factors that made it hard to regulate the labor market applied just as strongly to technology. Because of administrative limitations and disagreements within the guilds themselves, in the larger cities—where the number of wealthier masters who were more likely to favor technical innovation was proportionally greater—officials only visited a small proportion of shops on predefined dates and routes.[40] It is in any case far from clear that the main

[37] Gay Davies, *Enforcement*, p. 264 fn. 9; Truant, *Rites*, chap.2; and Thrupp, "Gilds," p. 280. Rising labor mobility may also account for the greater use from the late Middle Ages of the masterpiece to assess skills; see Cahn, *Masterpieces*, chap. 1; and Unger, *Dutch Shipbuilding*, p. 76.

[38] Lis and Soly, "Irresistible Phalanx," pp. 22–35. For the chronology of journeymen associations see also Truant, *Rites*; and Leeson, *Travelling Brothers*.

[39] See for example Kula, *Theory*, p. 78: "changes in production techniques—and therefore changes in labour productivity—are not possible in the corporate system". Similar statements by Pirenne, Cipolla and Kellenbenz are cited by Mokyr, "Urbanization," pp. 14–15.

[40] Farr, *Hands*, p. 37; and Rappaport, *Worlds*, p. 111. In the seventeenth century, when London was approaching half a million inhabitants, the Coopers visited no more than 30 workplaces every three months; examinations were necessarily selective (Berlin, "Broken," p. 80).

purpose of searches was to enforce technical standards to maintain reputation in outside markets, since controls of this kind were made in any case by the guild officers or the merchants who sealed the goods for export, and craftsmen resented searches that could breach their trade secrets. For all these reasons, searches were rather unusual.[41] Where they did apply, they are better understood as a symbolic means of reassuring the poorer craftsmen who had the most to loose from technological innovation, while also maintaining the artisans' assent to the corporate hierarchy.[42]

On the other hand, technological innovation was not easily controlled. Technical infringements were far harder to monitor than the use of illegal workers because guild "searchers" could only establish deviations from stipulated standards by observing the final product. It was therefore possible to introduce process innovations without incurring sanctions.[43] Craft guilds seem in any case to have accepted the existence of competing processes and techniques—an attitude that the mercantilist policies of governments and town administrations reinforced, as we shall see later. Thus, the standard oath sworn by an early modern London apprentice stipulated that he "his said master faithfully his *secrets* keep."[44] Even on the evidence of guild statutes, which exaggerate craft conservatism, statutory technical restrictions seem to have declined after the later Middle Ages, suggesting that innovation was becoming more accepted in the face of expanding markets and competition.[45]

The claim that guilds tended spontaneously to oppose outside innovations is also problematic. One reason is that it is excessively generic. If it is meant to say that guilds never innovated, it is demonstrably false; if it is meant to say that guilds would at some point become technically conservative, it loses any predictive value. The argument is also methodologically naive. Al-

[41] For the reputational purposes of searches, see Richardson, "Brand Names." For the incidence of searches see Thrupp, "Gilds," p. 256; Lipson, *Economic History*, vol. 3, pp. 335, 340, 343; Ward, *Metropolitan Communities*, pp. 126–43; and Deceulaer, "Guilds," pp. 178–79. For strong resistance to searches see ibid., p. 178 and fn. 25. A major purpose of searches was to verify the quality and status of apprentices, and in England this seems to have become their main function from the late seventeenth century (Berlin, "Broken," p. 86).

[42] Ibid., p. 83.

[43] The difficulty in monitoring the manufacturing process explains why guild demarcations were based on product, not process (Marshall, "Capitalism," p. 24). For similar reasons, guilds never specified the content of apprentices' teaching, since their proficiency could only be evaluated *ex post*.

[44] Rappaport, *Worlds*, p. 234; my emphasis. Searchers from the guild of gold and silver wire-drawers in seventeenth-century London agreed to keep officers who were also potential competitors out of a member's work room because he feared losing his trade secrets (Berlin, "Broken," p. 82). In the Venetian glass industry, craftsmen recorded their technical innovations in secret "recipe books," several hundreds of which survive (Trivellato, "Was Technology"). In 1574 the town council of Memmingen interviewed four linen masters on the techniques of bleaching, revealing extreme variation in what were closely guarded secrets (Safley, "Production," pp. 130–31). See also below, notes 76–79.

[45] For a systematic analysis of this point for early modern Italy, whose guilds are claimed to have been particularly conservative, see Lanaro, "Statuti." See also Hatcher and Barker, *History*, pp. 142–44.

though it assumes that all applications that were refused were better than current practice, in practice the record seldom reveals whether guild opposition was driven by rent-seeking or by an objective assessment of the innovation's merits. For example, in 1543 in Amiens the city council agreed to pay the inventor of a more efficient furnace for dyeing, but only if it proved to be useful.[46] In the case of the widespread refusal in the late thirteenth century by high-quality cloth makers to adopt the fulling mill, which is often cited as proof of guild obscurantism, we now know that the early mills were resisted because they damaged better quality fabrics, and opposition melted away once the machine had been improved.[47] What is more, there is surprisingly little evidence to support the implied suggestion that technological obstruction had disastrous consequences for individual guilds or for entire towns. While it is generally the case that innovative regions or cities showed symptoms of technological stagnation over time, the precise role of guilds in this process is not at all clear, as we shall see. Finally, the argument reifies the guild, by postulating a degree of internal homogeneity and a communality of interests over technological change that is quite misleading.

Individual instances of resistance to change tell us little about relations between the guilds and technological progress in general. A theory of guild innovation must identify both the *technical* and the *political* criteria that dictated the choice of technology and established a given technological path. The outlines of such a theory can be sketched as follows. The preceding discussion has indicated that craft-based innovation would generally aim to save capital and enhance skills. The reasons for this preference become clear if one examines the two hypothetical alternatives open to master artisans, the use of unskilled labor on the one hand, and of capital-intensive machinery on the other. When craft guilds were first established between the twelfth and the thirteenth centuries, craft shops were unable to draw on unskilled labor because of underdeveloped spot labor markets and the seasonal character of the rural labor supply. Subsequently, they resisted a move that would have exposed them to major diseconomies of scale in monitoring compared with protoindustry and factory production. Crafts avoided investing in capital-intensive machinery for similar reasons. Initially, they did so because of the lack of spot markets in capital goods, and because the use of firm-specific capital stock within highly unstable markets exposed producers to excessive risk.[48] Subsequently, they avoided capital-intensive innovations because these devalued investments in current skills and reduced incentives to invest in new ones.

[46] Heller, *Labour*, p. 25.

[47] Malanima, *Piedi*, chap.4.

[48] Millward, "Emergence," p. 33. Even if high-cost machinery had been available for lease, master artisans would still have faced higher costs than capitalists because they had weaker incentives to maintain the equipment in good shape.

In principle, therefore, one would expect the crafts to prefer technology that privileged skill-enhancing, capital-saving factors. Despite a lack of systematic research, evidence from patent records indicates that this was precisely the kind of innovation that prevailed in England before the mid- to late eighteenth century, when the country's guilds were still very active. Between 1660 and 1799, labor-saving innovations accounted for less than 20 percent of the total, whereas innovations aimed at saving capital (especially working capital) and at quality improvements accounted for more than 60 percent. There is no reason to believe that patterns elsewhere in Europe were very different.[49]

On the other hand, we might expect that craftsmen would oppose capital-intensive and labor-saving innovations that tended to substitute transferable with generic wage labor, or that raised fixed capital costs in the industry and thereby shifted control over the production process from the owners of skills to the owners of capital.[50] In practice, the reaction of individual crafts was the outcome of factors that were defined primarily by political rather than by market forces. There was a fundamental difference in outlook between the poorer craftsmen, who had low capital investments and drew their main source of livelihood from their skills, and who therefore (frequently in alliance with the journeymen) opposed capital-intensive and labor-saving innovations, and the wealthier artisans who looked on such changes more favourably. For example, in sixteenth-century Liège, the small drapers opposed improved looms fearing that they would advantage the larger producers, whereas in seventeenth-century London, ribbon-making Dutch or engine looms up to eight times as productive as the traditional hand loom were introduced by "silkmen, wholesalers and master weavers" against fierce opposition by the "rank and file [of the Weavers' Company] ... small masters and journeymen." The balance of power between the two major interest groups within guilds was therefore crucial for successful innovation. Thus if, as is often claimed, manufacturing became more concentrated during the early modern period, one would expect to find increased corporate disunity to be associated with higher rates of technological change.[51]

The decision to innovate was also affected by relations between the guilds' constituencies and the state. On the one hand, the wealthier and more innovative masters were more likely to influence government policy, and under normal circumstances authorities seem to have allowed them to cir-

[49] MacLeod, *Inventing*, chap.9. In the textile industry, nonlabor saving innovations accounted for 70 percent of the total before 1770 (Griffiths, Hunt, and O'Brien, "Activity," pp. 892–95).

[50] On resistance to deskilling, see Rule, "Property"; and Lis and Soly, "Irresistible Phalanx," pp. 16–28.

[51] Quotations from Berlin, "Broken," pp. 84–85; see also Ward, *Metropolitan Communities*, chap.6. For Liège see Thrupp, "Gilds," p. 273. See also ibid., pp. 255, 256, 257; Friedrichs, *Early Modern City*, p. 97; and Lis and Soly, "Irresistible Phalanx," pp. 33, 37, 39–48.

cumvent guild regulations. On the other hand, city councils were more willing to meet the small masters' concerns if labor-saving innovations coincided with a serious economic downturn, both to ensure social and political stability and to restrain unemployed craftsmen from leaving the town.[52] In other words, guilds were most likely to act as "recession cartels" when economic circumstances took a turn for the worse, but they still required political support to enforce cartel restrictions successfully against free riders and competing guilds. Thus, Dutch guilds began to resort systematically to restrictive policies when the country entered a long phase of stagnation after the mid-seventeenth century—but only after obtaining municipal approval.[53]

Relations between guilds and the state could also influence innovation in the opposite direction. In Ancien Regime France, for example, rather than the craft guilds it was frequently the state, in alliance with local political and mercantile elites, which developed the vast system of quality regulation over exported goods decried by economic historians. Moreover, following a pattern that we shall see at work also in Venice and Milan, it was frequently an alliance between the mercantilist state and the great merchants that actually stifled artisan innovation aimed at lowering costs. Thus, the invention of a new silk loom in seventeenth-century Lyon was rejected not by the local silk guild (which did not exist at this time), but by the Italian importers of manufactured silk who put pressure on their clients to oppose it. In 1728, new machinery similar to the gig-mill devised by artisans in Languedoc was destroyed by the state cloth inspectors; in 1732, the latter opposed a device "remarkably similar to the flying shuttle, 'invented' one year later in England."[54]

Since the consequences of both internal and external factors were defined by institutional, social, and economic conditions that were mostly beyond the guilds' control, the latter's response to technological change varied considerably with circumstances. Here we can usefully distinguish between "one-off" and systemic protectionism. One-off protectionism by individual guilds did occur, although the records inflate both its incidence (crackpot inventors were never in short supply) and its effects (what one guild refused another was likely to adopt).[55] By contrast, systemic protectionism was the effect of

[52] A Venetian decree of 1631 attempted to recall forty glassmakers of Murano who had fled the city during the plague of 1630–1631 (Francesca Trivellato, personal communication).

[53] de Vries and van der Woude, *First Modern Economy*, pp. 294 (for the silk industry), 340–41, 582; and Unger, *Dutch Shipbuilding*, chap.5. Deceulaer, "Guilds," pp. 194–95, 197 also finds that litigation in Antwerp increased at times of economic contraction. However, there is little hard evidence that technological obstruction increased significantly as a consequence of economic stagnation; see Davids, "Shifts," pp. 349–53.

[54] See Heller, *Labour*, pp. 180–81 for Lyon; Thompson, *Clermont*, pp. 336–37 for Languedoc. See also above, note 23.

[55] Florence's first recorded patent was awarded in 1421 to Filippo Brunelleschi for a revolutionary new ship that would haul loads more cheaply to the city. The machine was "a technical fiasco that

broader, politically enforced competitive restrictions, which led or sometimes forced guilds to adopt more restrictive behavior. I have already remarked upon the conservative role played on occasion by merchants and government elites in premodern France. It has been argued similarly that the Dutch Republic's relative manufacturing decline and the southern Netherlands' continued industrial strength after the mid-seventeenth century were due to the different balance of power between merchants and craftsmen in the two regions. Whereas in Holland, Dutch merchants restrained industrial developments that threatened the import trade and were frequently able to dismantle guild regulations entirely, in Flanders craftsmen had greater freedom to continue a centuries-long tradition of innovation. If ever guild conservatism assumed systemic proportions, it appears to have been more effect than cause of its society's economic ills.[56]

Developments in England reinforce this conclusion. The most distinctive feature of English guilds compared to most of their Continental peers was not so much a generic weakness, as is often assumed, for they continued to be the main source of specialized training up to at least the third quarter of the eighteenth century. Rather, it was the relative decline in their political links with the state and with merchant corporations after the English Civil War, at the same time that such links were being either maintained or strengthened on the Continent. The preceding discussion suggests that this institutional decoupling, which made restrictive legislation increasingly hard to enforce but maintained the technological benefits of the guild system after the 1660s, may have given post-Restoration England the technological edge over the Continent. Significantly, the English—who had previously always been net technological importers—began to worry about exporting technical secrets from around 1715.[57] The key to the different performance by craft guilds in different European countries lies in the institutional and political framework in which they were embedded.

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failed to carry a single load to Florence" (Long, "Invention," pp. 878–89). An example of an innovation surviving localized opposition was the ribbon loom: repressed in Danzig around 1579, it was patented in Holland in 1604 (Mokyr, *Lever*, p. 179) and was introduced in London around 1614 (Ward, *Metropolitan Communities*, p. 128).

[56] Lis and Soly, "Different Paths." For the suggestion that Dutch guilds declined from the third quarter of the seventeenth century following strong political attacks, see Hickson and Thompson, "New Theory," pp. 132–33. For the negative effects on guild attitudes of the conservative turn of an entire society see instead Walker, *German Home Towns*, pp. 89–92; Chicco, "Innovazione"; and below, for Venice and Milan.

[57] On the more liberal turn in domestic policy after the English Civil War, which undermined the guilds' privileges but did not affect their role in training, see Lipson, *Economic History*, vol. 3, pp. 265, 280–81, 286–89, 324–27, 342. However, eighteenth-century English guilds were far from a spent political force; for example, they lobbied strongly against attempts to raise excise on manufactured products (Brewer, *Sinews*, pp. 231–49). On the balance of trade in technology see Harris, "First British Measures."

DID CRAFTS INNOVATE?

Craft innovation was the outcome of small-scale and incremental practical experiment and of random variation.[58] Crafts had no wish to publicize innovation; most guild "secrets" appear in the records only after they had been illicitly transferred. Inasmuch as corporate supervision had any effect, it tried to ensure that an individual's discovery was kept within the guild membership. Because craft innovation is less apparent than outright opposition, identifying the origins of an innovation (as distinct from its purveyors) is rather like finding the inventor of a joke. Jokes typically have no author.[59]

Even so, evidence of anonymous improvements within guilds is readily available, although their impact is hard to quantify. In a rare estimate of the gains from craft innovation, Walter Endrei has suggested that labor productivity in the high-quality woollen industry under guild control increased by about 240 percent between the late thirteenth and the seventeenth centuries; productivity gains in weaving were over 300 percent. Gains in labor productivity of the order of 750 percent were achieved in the heavily gilded book industry in Lyon between c.1500 and 1572; but the precise manner by which this was done is unknown. Harder to quantify but equally significant gains in the volume and sophistication of production of that most intellectually demanding machine, the mechanical clock, occurred after it became organized in formal crafts in early sixteenth-century south Germany.[60] Further references to equally nameless improvements, including instances of deliberate experimentation, are found scattered across the literature.[61]

[58] Discussing the possibility that God's mind was *not* perfect and had therefore not created the best of all possible worlds, David Hume came up with the following description of preindustrial technological change as a stochastic process: "If we survey a ship, what an exalted idea must we form of the ingenuity of the carpenter, who framed so complicated useful and beautiful a machine? And what surprise must we entertain, when we find him [God] a stupid mechanic, who imitated others, and copied an art, which, through a long succession of ages, after multiplied trials, mistakes, corrections, deliberations, and controversies, had been gradually improving? Many worlds might have been botched and bungled, throughout an eternity, ere this system was struck out: Much labor lost: Many fruitless trials made; And a slow, but continued improvement carried on during infinite ages in the art of world-making" (*Dialogues*, p. 77).

[59] Epstein, *Wage Labor*, p. 140. Dennet, *Darwin's Dangerous Idea*, p. 99, draws an analogy between speciation and the invention and transmission of jokes, but his point applies equally well to preindustrial technology. On patents and guilds, see MacLeod, *Inventing*, p. 83. For guild "secrets" see notes 44, 76–79.

[60] Endrei, "Changements"; Zemon Davis, "Trade Union," p. 53 fn. 3; and Mayr, *Authority*, pp. 8–9.

[61] Wire-makers in Nürnberg, who experimented from 1390 on the invention of automatic machines, devised a wire-drawing bench operated by water power around 1410 (Ashtor, "Factors," p. 33); Murano glassmakers kept secret recipe books with experimental data (Trivellato, "Was Technology"). For innovations see Endrei, "Rouet", pp. 74, 79 (pedal-actioned loom in late eleventh-century Flanders; spinning wheel in Tortosa in the 1450s); Irigoin, "Origines" (rag paper invented in late thirteenth-century Fabriano); Hirshler, "Medieval Economic Competition," p. 55 (a new wheel combining the twisting and spinning of silk yarn in Cologne, 1397); de Vries and van der Woude, *First Modern Economy*, p. 276 (innovations by Dutch beer brewers in the late fifteenth and early sixteenth centuries); Malanima,

An apparent lack of innovation can also disguise a far more complex situation. Although most commentators claim that guild conservatism caused the Italian economy to stagnate after the mid-seventeenth century, the most frequently cited example of guild-induced sclerosis, Venice, has only recently been tested against the records.[62] It is now apparent that seventeenth-century Venetian guilds—whose technical leadership in glass making, dyeing, mirror making, cloth-of-gold weaving, soap production and high-quality printing had been gradually eroded over the preceding two centuries by European competitors—did in fact respond innovatively to competition. However, the authorities frequently frustrated their activities. Attempts by craftsmen in dyeing and wool weaving and in the shipbuilding industry to lower fixed capital costs were systematically opposed by the regulatory agencies of the Venetian state. Venice's failure to adapt to cheaper foreign competition was due not to the sclerosis of its guilds, but to its merchant oligarchy's desire to preserve the quality standards that upheld the city's industrial reputation.[63] A similar response by merchants may have caused the decline of manufacturing in Milan; elsewhere in Italy also recent scholarship has tended to exonerate the guilds from responsibility for the country's plight after 1650.[64]

An equally striking reversal of conventional wisdom has occurred regarding the Dutch Republic's Golden Age between c.1580 and 1680, which was believed to be the result of strong technical innovation associated with liberal institutional arrangements, including unusually weak craft guilds. Recent scholarship has shown instead that corporations pervaded Dutch

Decadenza, pp. 151–52, 238–43 (sixteenth-century innovations in Tuscan silk, wool and linen cloth production); Safley, "Production," pp. 122–23 (sixteenth-century invention of cheaper linen thread in the Upper Swabian linen industry); Heller, *Labour*, pp. 25, 180–81 (a machine for rolling satin in Amiens in 1543, and a new silk loom in seventeenth-century Lyon); Thompson, "Variations," p. 71 (new Dutch- and Seau-style wool cloth introduced by the Clermont-de-Lodève cloth guild in the 1650s); Thompson, *Clermont*, pp. 331–32, 336–38 (innovations in clothmaking in 1748, including the use of the flying shuttle); Hafter, "Programmed Brocade Loom", p. 54 (guildsmen invent the precursor of the Jacquard loom in late eighteenth-century Lyon to save on female labor); Sabel and Zeitlin, "Historical Alternatives", p. 168 and fn. 85 (innovations by the eighteenth-century ribbon weavers of Saint-Etienne). See also below, notes 63, 65.

[62] Cipolla, "Decline."

[63] For innovations see Trivellato, "Was Technology" (Murano glass industry); Rapp, *Industry*, p. 108 (silk-stocking making); and Della Valentina, "Artigiani" (silk cloth industry). For stalled innovations in the cloth and dyeing industries, see Rapp, *Industry*, pp. 112–16; for a proposal in 1665 by a local craftsman to build a ship on a Dutch model "of a quality not seen here for 35 years," which was ignored by the authorities, see Davis, *Shipbuilders*, p. 43 and fn. 139, with further examples in the same footnote. For innovations at an earlier date, see Lane, *Venice*, pp. 320–21.

[64] In the mid-seventeenth century the Milanese woolen producers listed six reasons why rural manufacturers to the north of the city made cloth more cheaply: they paid lower excise on oil and wool, and paid no taxes to the merchant guild in Milan; property rents were lower; they dealt directly with the spinners and thus employed the best; and they did not have to employ more expensive Milanese weavers. In fact, according to Beonio Brocchieri, "Piazza universale," pp. 300–01, who reports this document, Milanese manufacturers had no difficulty employing cheaper weavers in the hinterland. Thus, the only source of higher costs attributed to craft guilds did not in fact apply. See Vigo, *Uno stato*, p. 75 for Milan; and Sella, *Italy*, pp. 35–41.

society—well over one-fifth of seventeenth-century Amsterdam's population belonged to a craft—and that the majority of guilds arose precisely during the boom years of 1610 to 1670. Dutch craft guilds—including those associated with the two industrial sectors in which the Dutch excelled, shipbuilding and windmill technology—were at the forefront of technological innovation, both through inventions within their ranks and in their adoption of novelties from abroad. Jan de Vries and Ad van der Woude have followed up on these discoveries by suggesting that Dutch economic success was in part a *consequence* of the country's high number of guilds, which ensured a correspondingly high level of investment in human capital.[65]

There is thus clear evidence both that guilds produced and adopted innovations and that under certain circumstances (including economic recession, the dominance of production by small-scale producers, and merchant and state regulation for export) guilds opposed them. However, innovation was not just a consequence of random institutional variation. Craft guilds increased the supply of technology systematically in three ways: by establishing a favorable environment for technical change; by promoting technical specialization through training and technical recombination through artisan mobility; and by providing inventors with monopoly rents.

The first source of innovation was an unintended consequence of the apprenticeship system itself. Artisans could only monitor apprenticeship rules effectively if they located their shops in the same area.[66] Clustering, which was a typical feature of premodern crafts, was likely in turn to produce positive organizational and technological externalities. Thus, Bologna maintained its leadership in silk throwing for two centuries because ties of kin and neighborhood sustained collaboration between firms, the circulation of apprentices between firms ensured that innovations were diffused, and control over the raw silk inputs from the countryside gave rise to economies of scale and specialization.[67] Nonetheless, marginal innovations of the kind most likely to be fostered by individual craft districts would tend to run into diminishing returns as the costs of breaking out of the prevailing technologi-

[65] Unger, *Dutch Shipbuilding*, chap.5; Davids, "Technological Change", pp. 89–91, 94 (on the lack of guild opposition to innovations), 96; and de Vries and van der Woude, *First Modern Economy*, pp. 275–76, 296–98, 344–45, 694–95 (on the role of guilds in human capital formation). Dutch urban cloth industries eagerly adopted innovations like the fulling mill, twining mills, hot presses for pressing serges, and the ribbon frame (patented in 1604 and exported a few years later to England; see above, note 55).

[66] Even if a common system of training did not emerge, clustered firms would benefit from the supply of more specialized intermediate goods and from any technological spillovers through random innovation. Nonetheless, labor pooling would provide additional dynamic gains, and the need to enforce an apprenticeship system can explain how clustering first arose.

[67] Poni, "Per la storia". Analogously, the concentration of Venetian glassmakers along one street of the small island of Murano fostered intense competition (Trivellato, "Was Technology"). The link between "industrial districts" and small-scale production is discussed also by Sabel and Zeitlin, "Historical Alternatives", pp. 142, 144, 146–48.

cal pattern increased.[68] Although in premodern, unintegrated markets QWERTY phenomena were less likely to prevail because the sunk costs and externalities of individual technologies were smaller, path-dependency and inbreeding were unavoidable in the long run if distinct technological pools did not interact. In preindustrial economies, technological cross-fertilization occurred overwhelmingly through artisan migration.

Technological transfer took place through the permanent emigration of master artisans and the temporary migration of journeymen. The former was analogous to the breakaway under industrial capitalism of small firms from larger ones; both were a functional consequence of the guild system, which imparted skills that increased the masters' and journeymen's mobility.

Masters offered their services to competitors either voluntarily or to escape religious persecution, economic hardship or warfare.[69] Although guilds might object to integrating alien craftsmen bearing new techniques, opposition seems to have been neither frequent nor very effective. Competition between states fostered technological diffusion. Particularly after the post-Reformation confessionalization of politics, European rulers made it a point to attract displaced craftsmen from enemy lands. The Huguenot migrations to Geneva and England and the wholesale transfer of artisan skills from Brabant to the Netherlands after the sacking of Antwerp in 1585 are just three threads in an intricate web of politically driven technical diffusion.[70] Alternatively, artisans were lured from the most technologically advanced cities with financial and legal inducements and, if necessary, protection from guild obstruction; in this way a Murano glassmaker was brought to England in the 1630s by paying him five to ten times his earnings in Venice.[71]

Guilds responded by banning artisan emigration, but weak administrations and state competition made restrictions hard to enforce.[72] The only fail-safe way to stop members departing was to offer them stronger inducements to stay. Crafts could do this through rent streams and "club benefits," such as a guild's brand name which raised demand for its products, or a personal reputation for skills which attracted better apprentices.[73] As it was, most artisan migrants ended up being incorporated in another guild. This was not

[68] Mokyr, "Urbanization."

[69] For voluntary transfers see Fennell Mazzaoui, "Artisan Migration"; Unger, *Ship*, pp. 270–76; Cavaciocchi, *Le migrazioni*; and notes 70–71.

[70] Schilling, "Innovation"; Heller, *Labour*, chap.5; Scoville, "Huguenots" and *Persecution*, chap.10; and Cavaciocchi, *Le migrazioni*.

[71] Rapp, *Industry*, p. 109 fn. 6. Towns competed for skilled labor even within the Dutch state (de Vries and van der Woude, *First Modern Economy*, p. 340).

[72] Long, "Invention," pp. 873–74; Cipolla, *Before the Industrial Revolution*, p. 157; and Harriss, "First British Measures."

[73] Since the dangers of competition through dissemination of a guild secret were greatest for high value-added, export-led industries, one would expect guilds in such industries to provide proportionately more benefits than guilds engaged in low value-added, localized product markets. See also above, note 34.

just because it made technical sense (since only other trained workers could interpret the new information effectively), but also because the host guild often saw integration as a way of controlling alien competitors.[74]

Technological transfer through traveling journeymen was an equally inescapable consequence of the craft guild system. Although innovation of this kind has attracted less attention, the greater scale and regularity of journeyman tramping compared with permanent artisan migration suggests that its effects may have been proportionally stronger.[75] The fears of corporate espionage that journeymen raised among masters, the existence of "clandestine," nongilded, journeymen competitors, and the fact that the most technically advanced sectors (mining, shipbuilding, building, luxury textile production and printing) also had the most mobile labor force, reveal the journeymen's role in transferring technology.[76] The main qualitative difference between the two sources of technical diffusion was probably the fact that forced migration helped transfer technology across linguistic and national boundaries, whereas journeymen's travels were mostly restricted to areas that were institutionally and culturally more homogeneous.

The third source of guild support for technological innovation originated with the inventors themselves. Deliberate inventions will not be forthcoming if the inventor cannot claim more than his proportional share of the gains. Of the three possible solutions to this problem (state support for primary research, patent rights to discovery, and secrecy and the transmission of secrets through training), only the last two were available in our period. However, despite the fact that the patent was a late medieval invention and

[74] The statutes of the Florentine silk guild stipulated that foreign inventors be encouraged to settle (Ashtor, "Factors," pp. 26–27); see also Hirshler, "Medieval Economic Competition," p. 53. English statutes passed in 1523 and 1529 forbade foreign artisans from employing other strangers as apprentices, and foreigners working in London and its suburbs were placed under the control of the London companies (Esser, "Germans," p. 24). In 1684–1688 Huguenot innovations were allowed by the London Weavers' guild conditional upon the use of English weavers and upon integration into the craft (Macleod, *Inventing*, pp. 83–84).

[75] See Reith, "Arbeitsmigration." Although precise numbers of traveling journeymen are unavailable, the most recent overview states that "tramping [was] a characteristic feature of the social constitution of the crafts in Central Europe and very common in England and France" (Lis and Soly, "Irresistible Phalanx," p. 18). In Vienna in 1742, less than a quarter of the more than 4,000 master artisans had been born in the city. The rest, together with the tramping journeymen, came from "the entirety of German-speaking Europe," with a core area measuring 700 km across from the Upper Rhine to the Danube (Ehmer, "Worlds," p. 179–80). In eighteenth-century France, fewer than a fifth of the journeymen employed in the building, furnishing, clothing, and victualling trades appear to have been born in the towns in which they worked (Sonenscher, *Work*, p. 295).

[76] For corporate espionage see Simon, "Labor Relations," p. 141; Poni, "Per la storia," p. 103; Davids, "Openness"; and Davidson, "Northern Italy," p. 160. The Württemberg Black Forest worsted guild attempted to prevent journeymen from exporting their technical secrets in the late seventeenth century (Ogilvie, *State Corporatism*, p. 358). For nongilded craftsmen see above, note 20. In 1459 master and journeymen masons involved in building major churches across Central Europe met at Regensburg to discuss craft questions and to stipulate that no one should be taught for money—with the implication that technical information was to be freely shared (Black, *Guilds*, p. 9).

was frequently applied during the early modern period, the current use of patents is in essence a nineteenth-century development.[77] The most significant premodern incentive for invention was thus the capacity to capture the rents provided by a technical secret; and the most effective source of these rents was the craft guild—which significantly was known originally as *misterium* or, as in England, craft "mystery" as opposed to religious "fraternity."[78]

In the absence of specific research on the topic, one can only speculate as to how an inventor and his craft guild would react to a discovery. In principle, it is unlikely that craft guilds could extort a "secret" from its inventor by force. Only a willing teacher could transmit the kind of trial-and-error discoveries that dominated craft innovation, and a badly treated artisan could easily defect. In any case, although technical secrets were often kept within the craftsman's family, it is unlikely that significant breakthroughs could withstand a guild's scrutiny for long.[79] On the other hand, an inventor had to weigh the guild's offer of a temporary quasi-monopoly rent against the possibility of obtaining a one-off royalty (net of migration costs) from a rival craft or government. Although the costs of emigration were not negligible, the fact that most trades faced low capital barriers to entry increased the competitive value of technical secrets. Ceteris paribus, the larger the market and the higher the potential super-profits, the greater the probability that technological recombination would occur through migration.

Craft-based invention and the multicentered, competitive institutional setting in which it was embedded came close to resembling an ideal market structure for innovation. Thus, technological diffusion seems to have been constrained less by guild coercion than by the lack of efficient channels of information about the gains to be reaped from migration. The guilds' contri-

[77] Long, "Invention," pp. 875, 879–81; and MacLeod, "Paradoxes," pp. 894–909. Davids, "Technological Change", pp. 95–96 emphasizes the role of patenting for technical innovation during the Dutch Golden Age; for a more skeptical view see de Vries and van der Woude, *First Modern Economy*, p. 345. One reason why patented innovation was less likely to work was cognitive: under circumstances in which technological knowledge was preeminently an embodied practice, only tried and tested innovations were likely to succeed. This fact was recognized but misunderstood by William Petty, who lamented that inventors were scorned by "the generality of men" if the "new practices have not been thoroughly tried" (Petty, *Treatise*, p. 53, cited by Mokyr, "Innovation," p. 2).

[78] See Long, "Invention," pp. 859–60, who suggests that the first proprietary approach to invention evolved within medieval guilds. She also draws the useful distinction between secrets as "techniques" that could only be learned through practice, and "intentionally concealed" knowledge, which was new.

[79] In early modern Holland, some guilds seem to have devised a system of sharing innovations during compulsory annual meetings; see Unger, *Dutch Shipbuilding*, p. 80. The arrangement was presumably based on a combination of prizes for inventors and credible punishments meted out to free riders. The London clockmakers also argued that their craft developed through "small improvements, freely exchanged among craftsmen" (MacLeod, *Inventing*, pp. 83, 188). See also above, notes 74, 76. For the curious case of an employee who stole his Venetian master's secret recipes for glass-making, sold them to a rival whose daughter he then married, and set up his own furnace with the proceeds, see Long, "Invention," p. 874.

bution to technological progress was nevertheless largely involuntary, in two distinct senses of the term: because it was most likely to be an unforeseen consequence of everyday practice rather than of systematic experimentation, and because it was an undesirable side effect of artisan and journeyman migration. It was this inherent contradiction between the tendency to devise innovations that could be a source of quasi-monopoly rents, and the need for supra-local, competitive markets for skilled labor that supported technical diffusion, which imparted to the premodern craft system its main source of technical dynamism.

WHY DID CRAFT GUILDS PERSIST?

The view of the craft guilds as rent-seekers assumes that they operated in markets with very high economic and political barriers to entry. On the evidence we have reviewed, these obstacles have been exaggerated. Competitive markets were ubiquitous and hard to avoid. Powerful competitive pressures in manufacturing and between states meant that it was possible to delay an innovation locally, but it was much harder to stop it in its tracks. The prevailing emphasis on what the guilds *chose* to do, and the related stress on their resistance to technical innovation, may therefore be doubly misplaced. On the one hand, the ubiquity of free riding, of rule evasion, and of a mobile labor force together with the competitive policies of towns and sovereign states systematically undermined the guilds' powers of coercion. On the other hand, if technological innovation was for the most part a consequence of mechanisms beyond the guilds' control, we should be focusing on what the craft guilds and their members were *compelled* to do by market and institutional pressures, rather than on what they sometimes attempted to impose.

The broader implications of these claims for the course of premodern technology can only be touched upon briefly. If premodern markets were sufficiently competitive to make technological conservatism self-defeating, the question why craft guilds were able to survive as a mode of industrial organization for more than half a millennium is cast in a new light. In recent debates on protoindustrialisation and on the rise of the centralized factory it has been suggested that both systems won out over craft-based production because they were technologically more dynamic and enjoyed significant economies of scale. What this argument does not explain, however, is the coexistence for several centuries of several alternative modes of organization under the undisputed technological *leadership* of guild-based production.

Although centralized "factories" existed no later than the fourteenth century, they were never of more than marginal importance before the nineteenth. Thus, the main preindustrial competitor of craft-based production was the rural putting-out system known as protoindustry. However, because

of protoindustry's lack of formal training and the dispersed character of production, which substantially raised monitoring costs, it seems to have been technologically sluggish and to have delivered little endogenous innovation.[80] Moreover, rural industry found it difficult to incorporate exogenous innovation without undergoing structural change. Because major technical change caused either labor skilling or capital intensification, protoindustry displayed a tendency to move either "back" into craft production, "forwards" into factory industrialism, or "sideways" into sweatshops.[81] Comparison with its organizational competitors therefore suggests that it was the technological edge provided by institutionalized apprenticeship, by its associated specialized labor markets, and by the quasi-monopoly rents over innovation that underpinned the craft guild's long-term survival. For centuries, alternative arrangements were out-competed, restricted to low-skill manufactures like protoindustry, or forced to inhabit institutional niches like centralized manufactories.[82]

[80] See Sokoloff and Dollar, "Agricultural Seasonality," pp. 316–17, for a recent restatement of this point. The argument cannot easily be tested, because urban craftsmen and rural cottagers tended to engage in different activities. However, it would seem that whereas craft innovations were adopted by rural manufactures, the opposite was unlikely to occur. In Holland, the transfer after 1600 of the shipbuilding industry from the towns to the rural Zaan region was followed by a "striking" decline in technological innovation (de Vries and van der Woude, *First Modern Economy*, pp. 297–98). The example suggests that the static gains of rural production in terms of cost were offset by a loss in dynamic gains from urban innovation. But urban technology did not always flow very swiftly to the countryside. The Dutch loom, patented in Holland in 1604 and recorded in London around 1614, was adopted by the Lancashire cloth industry only at the beginning of the following century (Walton, *Lancashire*, p. 64).

[81] On the incorporation of new technology see Coleman, "Textile Growth"; MacLeod, *Inventing*, p. 102; Magnusson, "From *Verlag*," p. 202; Gullickson, "Agriculture"; Millward, "Emergence," pp. 22–23; Ogilvie, *State Corporatism*, p. 27; and Jones, "Organization," pp. 134–35. On structural change see Liu, *Weaver's Knot*; Randall, *Before the Luddites*, chaps.1–3; Hudson, *Genesis*; Ogilvie and Cerman, *European Proto-Industrialization*, chaps.4, 5, 9; and Berg, "On the Origins," p. 181.

[82] The preceding argument raises the question why guilds eventually failed. The short answer is that they did not. In every instance they were abolished by a forcible act of legislation (in 1791 in France, in 1835 in England, in 1869 in Germany), and their training functions were taken up by unions, workers' and professional associations, and other public (municipal, regional or state) organizations. Nonetheless, it is clear that traditional forms of guild organization were threatened by the rapid expansion of wage labor and by the shift in numerical balance from skilled to unskilled labor, which significantly increased the enforcement costs of apprenticeship. Thus, in England during the second half of the eighteenth century, even as the absolute number of apprenticed individuals increased they were ever less likely to conclude a full apprenticeship (Snell, *Annals*, pp. 241–43). Apprentices appear to have become more mobile in part because the demand for semiskilled labor was increasing faster than for skilled, and in part because improved means of transport made it harder to restrain the apprentices' opportunism. Because the guilds' narrow territorial jurisdiction restricted their coercive powers, it seems likely that under these new conditions they would have had to fuse into regional or national craft organizations to survive. To do so, however, meant successfully facing down the state. Although the state's attack on the guilds was often justified in economic terms, it is more accurately understood as part of a broader strategy to extend its sovereignty and the associated institutions of citizenship and equality before the law. The guilds, which represented the most deep-rooted and legally quasi-autonomous corporate bodies of the Ancien Régime, posed the main challenge to the modern state's claim to sovereign power; they therefore had to be destroyed. The extinction of the guilds occurred because of the institutional equivalent of an asteroid from outer space. See Black, *Guilds*, chaps.12–14 for the intellectual antecedents and consequences of this process.

Given the frequent assertion that skilled craftsmen and innovators played a crucial role in initiating the Industrial Revolution, there is surely some value in enquiring how this pool of skilled labor was created.[83] This is all the more the case because according to one estimate, in the late sixteenth and seventeenth centuries roughly two-thirds of the English male labor force had at one time or another been apprenticed in one of the greater cities, primarily London.[84]On this and the other evidence we have examined, the customary dismissal of the role played by craft-based apprenticeship and innovation in British and Continental industrialization may need to be revised.

[83] Mokyr, "New Economic History," pp. 34–36.

[84] London was a "vocational training centre for a national economy" (Rappaport, *Worlds*, pp. 77, 314). See idem, "Reconsidering," for the numerical estimate. Paris and a few other great cities may have performed a similar function in France, where most towns lacked incorporated guilds. An edict by Henri III in 1581 admitted that the majority of artisans in the kingdom worked outside the control of the guilds; he described them however as *compagnons*, in other words trained craftsmen, presumably because they had learned their trade under a guild (Heller, *Labor*, p. 51).

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