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S.R. Epstein

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S.R. Epstein

Economic History Department,
London School of Economics.

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S.R. Epstein,
Department of Economic History
London School of Economics,
Houghton Street,
London.WC2A 2AE.
United Kingdom.

Telephone: +44 (0)171 955 7046
Fax: +44 (0)171 955 7730

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CRAFT GUILDS, APPRENTICESHIP AND TECHNOLOGICAL CHANGE IN PRE-MODERN EUROPE[1]

The origins and nature of technological invention and innovation in the pre-modern economy are still very much a 'black box'. In some respects this is because, compared with heroic 'macro-inventions' (Mokyr 1990), it is far harder to identify the kind of piecemeal, small-scale, anonymous innovations at the margin which dominated technological progress in this period (Coleman 1973; Kellenbenz 1974). However, the difficulty is compounded by certain long-standing assumptions about pre-modern manufacture, and in particular by the view that craft guilds were a major obstacle, possibly the main obstacle, to technological advance. Scholars trained by institutional neo-Darwinism to rationalize an economic institution that survives as *eo ipso* 'efficient', still state categorically that craft guilds -- which provided the main institutional framework for European urban manufacture for seven hundred years or more -- were simply organized interest groups bent on redistributive rent-seeking, and thus reactionary opponents to technological progress (e.g.Mokyr 1990: 77, 178-9, 191, 258-9, 298).

In this, of course, they are simply echoing a line of thought that reaches back through Adam Smith to the thirteenth century. Yet such a reassuring portrait of pre-modern obscurantism is not without its problems. Although critics accept that craft guilds only turned sour during the late Middle Ages, the sixteenth or even the seventeenth century (Mokyr 1990: 259 n.19), following two, three or perhaps four centuries during which they appear to have been associated with uninhibited economic growth, it is hard to

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[1] This paper was first discussed at the Colloquium on History and economics: skills and training at King's College, Cambridge in July 1994; my thanks to Paul Ryan for inviting me to take part, and to Michael Sonenscher in his role as discussant. I have also received valuable comments from Francesco Galassi, Mary Morgan, Gunnar Persson, Maarten Prak, and Keith Snell.

explain why it should have taken so long for their fundamental drawbacks to stand revealed. I shall argue in this paper that the accepted view of craft guilds misunderstands their main purpose and effects. In the first part, I analyze the guild structure as a firm and argue that the primary goal of craft guilds was to provide adequate skills training through apprenticeship. In the second part, I suggest that a significant albeit unintended effect of the craft guild's investment in skills was to promote technological invention and diffusion. In the third and final part, I take some recent advances in the theory of the firm as a structure of governance, which indicate how different property rights interact with different forms of technology to establish long-run organizational equilibria associated with distinct paths of technological invention and innovation, to suggest that guilds favoured kinds of technology which reinforced the specific property rights of the craft shop, and opposed technology which undermined those rights. In support of these claims, I briefly compare the technological preferences of guild-based manufacture with those of proto-industry and centralized factory production, and suggest reasons why proto-industry was effectively a technological 'dead end'.[2]

I

Most economic explanations of the guild assume that it performed one or more of the following functions: it acted as a monopolistic cartel, both as buyer of raw materials and as seller of its products (Mickwitz 1936); it enforced quality standards, particularly outside its community where its products were little or not at all known; it provided stable incomes and social security in highly unstable markets (Gustafsson 1991); it acted as a bargaining force in narrow markets in which agents normally held market power (Persson 1988: 53); and it worked as a political and administrative unit,

[2] We know very little about the distinctive regional and national traits in craft organization which began to be defined during the late fourteenth and fifteenth centuries (Turnau 1988); lacking modern comparative studies, the 'craft guild' discussed below is something of an ideal type.

protecting its members from expropriation by opportunistic urban elites, which in exchange demanded that it collect capital tax and tie apprentices for abnormally long periods of time so as to provide their city with an ever ready supply of military manpower (Hickson & Thompson 1991).

The only views among these which contrast specifically with our hypothesis are that craft guilds exerted monopoly power and that apprenticeship served to provide towns with soldiers. The interpretation of guilds as monopolists, stated forcefully by Mickwitz in 1936 and firmly embedded in the subsequent literature (Cipolla 1963: 411-14, 415-16, 426-9; Thrupp 1963: 253; Gustaffson 1991, who also draws an analogy between guilds and producer cooperatives) does not withstand closer scrutiny. Where cartels must fix output quotas to achieve their goals, it can be shown that guild regulations setting output quotas were seldom enforced and where cartels must set price *minima* and quality *maxima*, we find that pre-modern guilds and urban regulations were invariably concerned with establishing price *maxima* and quality *minima*. This of course *encouraged* competition through improved quality and reduced input costs (Hickson and Thompson 1991; see also Hirshler 1954; Thrupp 1963: 231, 246-7, 252, 263, 275; Epstein S. 1991: 100).[3]

[3] As I discuss below, barriers to entry for trained masters were generally low, and urban governments were willing to allow master artisans to practice without taking up guild membership, thus further undercutting any cartelization of supply. This made it very hard for forms of oligopoly and attendant cartelization to emerge and persist for long periods of time; a significant exception seems to have been constituted by guilds which had a technological edge (a 'secret', as discussed below) that gave them supra-normal profits (see the discussion of the Bolognese silk industry by Poni 1990). Lacking significant technological advantages, guild-based cartelization might emerge as a short-run phenomenon, but it cannot explain the guilds' long-term survival.

The view that apprenticeship was a non-economic, defence supplying feature of craft guilds also fails, when we observe that urban crafts in highly corporatist medieval and early modern Italy never possessed military functions (Sestan 1966); conversely, in several parts of Europe (such as Spain and southern France) craft guilds were not *formally* established before the fifteenth or even the sixteenth centuries (Zemon Davis 1966: 50), several centuries after towns had to establish specialized militia to defend themselves.[4]

Through a process of elimination we seem to have been left with the view that craft guilds were set up to enforce quality control and to provide social welfare for their members. These seem weak foundations to raise a general theory of craft guilds upon. Institutionalized quality control may have been needed to reduce assymmetries of information between buyers and sellers of durable consumer goods and promote sales,[5] and guilds would have made it easier to monitor standards (Persson 1988: 52-3); however, cartelization of this kind was best suited for export markets attended by merchant middlemen, for in domestic, small-scale markets quality could be monitored more cheaply through less formal arrangements, like the *bazaar*-like bunching together of shops in the same street that was such a salient feature of urban manufacture in our period. The enforcement of product quality alone does not adequately explain why

[4] The late emergence of guilds in some parts of Europe also undermines Hickson's and Thompson's main claim that guilds served to protect their artisan members from capital expropriation by urban elites.

[5] Information assymmetries arise for goods whose quality can only be established *ex post*. This applies both to commodities in export markets (where quality control helps to establish producers' and merchants' reputation) and to common consumer goods produced for local markets like shoes, metalware, pottery etc.

guilds also proliferated in trades catering mainly to local markets.[6] Similarly, welfare support to act as a buffer against rapid market fluctuations and changes in life-cycle income could have been provided by other, equally or more effective institutions like religious fraternities, urban provisioning structures, kinship networks and the like.[7]

This is not to argue that medieval and early modern guilds did not *also* take on these functions. It will become apparent below, however, that quality enforcement and welfare support were necessary but not sufficient conditions for the guilds' emergence and survival; their purpose was to provide subsidiary 'non-collective social benefits' (Olson 1965: 67), which raised the cost to guild members of defaulting on their duties and of free-riding on their privileges in the *main* sphere of guild activity. In other words, these and other roles (including political, military or fiscal functions) may well have aided individual guilds to solve the free-rider problem; but they cannot have been the reason for setting up craft guilds in the first place, nor can they explain why guilds dominated European manufacture for the half millennium preceding industrialization.

The primary function[8] of craft associations becomes apparent if we focus on the main technical and organizational elements shared by their constituent members. Guilds and workshops are usually discussed separately, the guild as a form of union or cartel, the

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[6] Adam Smith's view that consumer pressure was the only form of necessary control seems too optimistic (1976: 144-5; see e.g. Hirschman 1970: 23).

[7] Once a guild had been established, on the other hand, it might have been more effective than other welfare-providing institutions in monitoring free riding on benefits, since its normal economic activities would have given it a more accurate knowledge of conditions among its membership.

[8] By which I mean a function that was both necessary and sufficient for guilds to emerge and survive over time. I discuss the *reasons* why guilds may have emerged in the first place in section VI below.

workshop as a family-based, self-contained unit of production, the link between the two being a postulated 'pre-capitalist' egalitarian ethos expressed in statutory limitations on the size of the workshop. No-one to date has connected the specific technical and organizational characteristics of the craft shop with the purpose and rationale of guilds.[9]

I suggest instead that the pre-modern artisan workshop should be understood as a governance structure similar to the modern firm, whose main purpose was to make the most efficient use of family and outside skilled labour. On this view, the apprenticeship contract and the craft guild are to be understood as interdependent solutions to the problem of opportunistic behaviour by masters and apprentices. The advantage of this explanation over current alternatives is that it provides a simple rationale both for craft apprenticeship and for the emergence and survival of craft guilds as non-monopolistic organizations providing a collective good, namely training in skills.[10]

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[9] A theoretical emphasis on the size of the workshop rather than on its technology explains the literature's fascination with large-scale urban workshops ('manufactures'). These are seen as a major institutional departure from the family-based craft unit of production (see e.g. Howell 1986; Wiesner 1986), even though in strictly technological and organizational terms they were similar: Sonenscher (1987, 1989) makes this point with his concept of a 'core' of large shops and a 'periphery' of sub-contractors within eighteenth-century French trades.

[10] This argument does not require the existence of *formally structured* guilds. It does however imply that past a certain technical threshold of specialization, producers will organize *informally* to establish collective rules of apprenticeship and repress free-riding. Gay Davies (1956: 1), for example, suggests that the English Statute of Apprentices unified under a single code both the formal rulings of incorporated boroughs and towns and the informal practices of unincorporated centres and the

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Since Adam Smith's attack on apprenticeship laws as a means of restricting access to the labour market (Smith 1976: 133, 136-7), the economics of pre-modern apprenticeship has been virtually ignored. The length of training required (which in Smith's England was still fixed by the 1563 Statute of Artificers at seven years)[11] appearing to be out of all proportion to the skills required for even the most complex trade, its purpose could only be to exclude competition. Never mind that Smith got carried away and underestimated the complexity of transmitting what are essentially tacit, 'embodied' skills which cannot be formulated explicitly or symbolically, through either the written or the spoken word (Bloch 1991);[12] his argument that apprenticeship served to maintain a monopsony over labour seems at first blush unassailable and has since become widely accepted.

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countryside. See also Epstein S. 1991: 77-8. The medieval religious movement of the *Umiliati*, which was associated in the thirteenth and early fourteenth centuries with highly mobile, technically skilled woollen weavers (*ibidem*: 93-8), seems to have combined the skills-enhancing properties of the guild and the security-enhancing properties of journeymen's associations (discussed below), by means of a loose network of urban monasteries to which the workers were attached.

[11] The choice of a national norm of seven years was dictated by London custom, which was established during the fourteenth century; however, the Statute of Artificers was unable to stamp out local variations entirely (Dunlop 1912: 73, 83, 92, 134-5).

[12] It is clear that there was no feasible alternative to apprenticeship for transmitting practical, non verbal knowledge, including how to run a small business; even today's formal schooling is not an effective substitute. The contention that the most difficult craft of all, agricultural husbandry, required no formal training (Smith 1976: 141-2) is disputed by Mitch 1994.

Smith's indictment does not, however, explain why apprenticeship laws evoked so little hostility from the public at large, and indeed why town governments (which tended to legislate against producers and in favour of consumers, including the merchants who bought the crafts' output for sale abroad, and which were willing to undercut guild controls over entry in other areas) seem never to have acted against such restrictions. Smith also implied that apprenticeship would only survive where corporations could enforce their laws strictly; yet there is evidence that similar, albeit informal rules of apprenticeship applied where guilds did not formally exist.[13] Thus, it would seem that apprenticeship fulfilled positive requirements which were recognized as such, and accepted, both by master and apprentice and by the wider public.[14]

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[13] Gay Davies 1956: 11, 125, 263-7; Sonenscher 1987: 48 ff. See also above, n.5.

[14] Although pre-industrial apprenticeship was invariably very long, the duration varied enormously across trades and was clearly not just a function of the level of required skills. An alternative explanation based on human capital theory could be that the length of apprenticeship varied on the basis of expected future earnings, discounted for the costs of training. Assuming that the loss in potential earnings at the present level of skills during apprenticeship was less than the gains in lifetime earnings from having higher skills, the length of the apprenticeship would vary in proportion to the difference between present and expected future earnings. The higher that expected difference in income, the longer an apprentice would be willing to wait, i.e. work for a sub-standard wage for the master (this used to be the explanation for embarking on a Ph.D.). Since expected earnings would be high both in high skill crafts in competitive markets and in low skill crafts in uncompetitive markets, we would expect apprenticeship to be longer there; it would be shorter in a craft requiring low skills and working in competitive markets, in which expected lifetime earnings were low or declining (this is the explanation given by Snell 1985: ch.5 for the declining length of apprenticeship in eighteenth-century England). The model however does not explain

Apprenticeship in uncompetitive markets might well be a conspiracy against the public, as Smith averred. But just as guilds were incapable of enforcing cartel-like agreements over production, they seem to have been unable to impose restricted entry of unskilled labour into the trade. The evidence suggests that statutory restrictions on the number of apprentices a master could accept could be broken with relative ease (Hirshler 1954: 57; Thrupp 1963: 246, 264; Epstein S. 1991: 106); what is more, the rules seem to have allowed a degree of flexibility or discretion that enabled apprentices to be promoted to journeyman status before their contract had formally expired (Epstein S. 1991: 107, 109, 110).[15] Guild control over the labour market was weakened further by town governments, who frequently allowed masters to practise without having to enrol in the local corporation (Hirshler 1954: 57; Thrupp 1963: 246; Goldthwaite 1980: 259-60), and by trained artisans' ability to set up their trade outside the guilds' jurisdiction (Thrupp 1963: 280).

If apprenticeship had been purely a means to restrict access to the guild, and at the same time guild rules were so easily evaded, it would be hard to explain why the institution survived. In fact, contracts of apprenticeship met two central and related needs: the master's requirement to employ specialized labour and to be insured against the apprentice's opportunism, and the apprentice's need to be insured against the master's opportunism before embarking on the risks of specialization. The first precondition implies that the master would teach an apprentice only if he was reasonably secured against the latter's premature departure. A master had to be sure that he could reclaim his investment costs (that is, the time spent on training, on

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why guild requirements for the *same* trade could apparently vary between one and eight years (e.g. Goldthwaite 1980: 260), or why by contrast the English Statute of Artificers set a fixed term of seven years irrespective of the apprentice's craft.

[15] This is surely why English J.P.s were granted discretion in applying the rule of compulsory apprenticeship up to the age of 21 (Gay Davies 1956: 2).

wasted materials and on daily maintenance, since most apprentices doubled as live-in servants) by requiring the apprentice to work for sub-market wages *after* formal training had ceased. But at that point an apprentice might well wish to leave, since he could earn higher wages with another master who had no training costs to recover; this is the well-known externality problem of training. In the absence of rules forbidding opportunism of this kind, no master would have willingly engaged an apprentice. Being unable to pass on his skills, the master would have been unable to expand his output and, perhaps just as importantly, would have had less incentive to develop his own talents.[16]

The problem of opportunism arose because apprentices possessed *general* skills[17] which could be employed in other workshops within the same craft and which masters could not control. In order to reduce this kind of opportunism, the masters required *rights* over the apprentices' labour, which they achieved by demanding long-term training agreements upheld by formal or informal sanction (Berengo 1965: 77-8). They frequently reinforced their claims by demanding entry fees (Gay Davies 1956: 10), by increasing apprentices' wages during the last years of the contract, or by promising a pay-off to set up in the trade upon completion (Lipson 1945: 309-10; Berengo 1965: 79; Snell 1985: 256-7), all of which raised the trainee's cost of defaulting, or by

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[16] Assuming that a more highly skilled master had a better chance of attracting and retaining good apprentices. Conversely, an unintended consequence of apprenticeship may have been to develop the master's skills by way of demonstration: teaching is the most effective way of improving the clarity and quality of one's thought.

[17] *General* skills are acquired through training for a specific profession but are not specific to one firm; by contrast, *generic* skills are untutored and are neither craft- nor firm-specific. Training in general skills allowed journeymen to move between shops which specialized to different processes within the same, broadly defined craft. These issues are discussed in greater detail below.

enforcing criteria of eligibility to apprenticeship status based upon residence, the level of income or the father's occupation (Gay Davies 1956: 1, 5, 9).[18]

Conversely, apprentices were also liable to opportunistic behaviour by their masters. They could be exploited as cheap labour to be discharged at the first dip in demand, without having gained the promised skills or an attestation of proficiency that would enable them to become journeymen and aspiring masters. The nature of apprenticeship made the costs of such behaviour particularly high. Because apprentices learned what were essentially tacit and craft-specific skills that could not be transferred through speech or writing, the costs of switching to a different profession or of being fired before achieving full proficiency were unusually high.[19] Similarly to masters, therefore, prospective apprentices had to be given appropriate rights and incentives in order to invest in skills: namely, guaranteed employment for a sufficiently long period of time (enough to include at least one industrial cycle), prospective entry into the guild, and perhaps the hope of marrying into the master's family and ultimately of

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[18] A similar rationale would explain the virtually universal practice of fixing low or non-existent entry costs for the masters' close kin. On this view, the entry fee to the guild would be a mortgage on trust, used to deter lesser known masters from exploiting the guild for short term advantage, e.g. for stealing a guild's 'secrets'.

[19] See Winter 1989: 219-20 for a similar argument about technology and the firm. This can explain why the length of apprenticeship tended to decline with age of entry, since older trainees would have faced higher opportunity costs for defaulting. The costs were not simply financial. Apprentices who reached the age of legal responsibility (generally fourteen) were required to swear an oath; having thus bound themselves in spirit, they got better conditions of service, often being paid some kind of wage (Epstein S. 1991: 104). The best apprentice was a younger member of the craftsman's family for whom no formal contract was required; the weight of paternal authority was sanction enough (*ibidem*: 104-5).

inheriting the shop. Lacking such rights and opportunities, no worker would willingly develop his skills and capabilities.

We are now able to understand both the seemingly inordinate length of apprenticeship contracts and why the relation between that length and the required degree of skills is so seldom straightforward.[20] Insofar as all guild-based production was based on craft-specific, general skills, apprenticeship contracts had to guarantee an adequate return to the master *and* a degree of security to the apprentice.[21,22] Apprenticeship contracts were therefore a device to protect both parties' investments in skills from expropriation.[23,24]

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[20] See above, n.14.

[21] The additional length of apprenticeship above the minimum threshold required to engage in skills training would be determined by the current state of the labour market, as discussed in n.14 above.

[22] A lengthy apprenticeship also served to 'socialize' the candidate into the adult, professional and wage-earning world (Epstein S. 1991: 111, 124, 188), thereby reducing the chances of opportunistic or 'irrational' behaviour by young apprentices.

[23] Conversely, when apprenticeship laws began to break down, master-apprentice opportunism increased sharply. For eighteenth-century England see Snell 1985: 253-8 and Figure 5.8.

[24] It might be argued that the purpose of lengthy apprenticeship was to establish relations of trust. Trust however cannot explain the solution to the initial problem, which was how to get master and apprentice to agree; trust is merely a possible *outcome* of an existing relationship. This is not to say that the long-term survival of a firm did not also depend on relationships of trust, friendship and even kinship; the absence of trust within a craft shop would make monitoring costs impossibly high. For the view that the modern firm is a non-market institution *devised* to establish relations

The first references to craft guilds, which invariably concern contracts of apprenticeship (Epstein S. 1991: 69, 75, 101 and *passim*), do in fact indicate that the institution's primary purpose was to provide its members with a pool of trained labour by monitoring the apprenticeship system.[25] The fear that craftsmen outside the guild could engage in 'poaching' on the skilled labour market that others had trained, explains why corporations were so concerned with drawing up written contracts of apprenticeship (Epstein S. 1991: 76) and with establishing compulsory membership (Thrupp 1963: 263-4).[26] The externalities of training and widespread free-riding would threaten investment in skills and jeopardize the very livelihood of the craftsmen. This explains why, notwithstanding individual exceptions, the general rule of compulsory membership of the guild was not challenged by the political authorities. As long as the number of non-guilded artisans stayed below a certain threshold the craft guild -- or rather, investment in skills -- would not be seriously threatened, since association members would still have possessed enough critical mass to sanction deviant behaviour effectively.[27]

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of trust, see Hodgson 1988: 206-11.

[25] The same argument explains why *female* guilds were so unusual in pre-industrial Europe. With few exceptions, women were restricted to activities which exploited 'female' skills connected with housework (spinning, weaving, needlework, brewing etc.), that were learned through the informal apprenticeship of hearth and home; see e.g. Hafter 1985, with references. See also below, n.33.

[26] The view that guilds aimed to protect their members against capital expropriation (Hickson & Thompson 1991) fails to explain why guilds spent much of their time enforcing compulsory membership. Our own explanation solves the problem.

[27] The elaborate codes and rituals of guild behaviour, which symbolically reinforced the sense of membership and allegiance, further reduced the probability of opportunistic behaviour.

III

As most academics know to their cost, specialization increases expected wages but restricts the range of jobs one can make a living from. Craft trainees faced a similar dilemma: if skills gained in one shop could not be used elsewhere, training would reduce rather than enhance future earnings. Masters would also be unwilling to train an apprentice if they could not easily find a replacement, and they would face uncertainty on the labour market if they had no means of checking the labour force's quality or credentials (Gustafsson 1991: 74, 85). The second main function of apprenticeship laws was therefore to coordinate demand and supply of trained labour in order to reduce market uncertainty.

By creating a pool of interchangeable skilled labour, apprenticeship buffered potential trainees from the risk of unemployment following random shocks to individual firms,[28] and provided masters with a trained workforce to which they could resort in case of sudden increases in demand. This was achieved by providing certificates of apprenticeship which made journeymen employable across firms (Thrupp 1963: 280; Gay Davies 1956: 264 n.9), and by guaranteeing employers a sufficiently homogeneous labour force from which the largest initial differences in natural skills and ability had been ironed out.

As commodity and labour markets increased in size and therefore also in the scale of risk, institutions were devised for pooling labour skills across greater distances. Informal networks of skilled labourers had probably existed since the thirteenth century, particularly within itinerant trades like the building, shipping and mining

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[28] In sectors with a relatively high elasticity of demand, guilds tended to be controlled by merchants, who were 'inclined towards drawing labour in freely while business was good, forcing masters to train it as fast as possible, and letting wage-workers and the small masters look for some other occupation when business was poor' (Thrupp 1963: 267).

industries. In other trades, however, more structured organizations of journeymen spanning several regions or large associations of towns emerged in Germany and France only after the mid-fourteenth century (Geremek 1975: 118; Schulz 1987); inter-urban networks of masters' guilds also appeared at the same time (Thrupp 1963: 254, 256-7).

These changes[29] were arguably a response to the sharp demographic downturn and the localized but virulent epidemics brought on by the Black Death of 1348-50, and to the reorganization and integration of regional markets that ensued (Epstein S.R. 1991 and 1994). A similar phenomenon, albeit on a somewhat larger scale, of integration within the specialized labour market occurred in seventeenth-century France (Sonenscher 1989: ch.9), again at a time of demographic depression when regional economies were being reorganized into a fledgling national market. In both instances, systemic economic and demographic shocks caused large and unpredictable variations in local demand for skilled labour, and a significant increase in the latter's mobility. In both instances, the efficient pooling of information over large distances on local conditions of supply and demand became a matter of pressing concern, particularly for skilled workers who were in especially scarce supply. Lastly, in both instances new interregional and 'national' journeymen organizations, *compagnonnages* and confraternities emerged as institutional means of absorbing the effects of increased fluctuations in local employment which threatened craft specific, skilled labour. Particularly in the late Middle Ages, these organizations transcended political

[29] It is not clear whether such agreements and organizations arose in late medieval England. However, the Statute of Artificers of 1563 and the Settlement Acts of 1662, which restricted apprentice and journeyman mobility, would have made such arrangements well nigh impossible.

frontiers; just as significantly, they seldom overcame the boundaries of a common culture and language.[30]

The tendency to focus on the trade union functions of journeymen's associations (e.g.Zemon Davis 1966) has rather obscured the fact that those functions were a consequence of a far more pressing concern, the need to find work in highly unstable labour markets. While it may be the case that in the (very!) long run, the union aspect of journeymen's associations would become more significant, before the industrial revolution they seem to have functioned mainly to pool information, to provide support in times of need, and to lower search costs for their employers. They helped to distribute a smaller number of workers over a larger territory more efficiently than would otherwise have been possible;[31] paradoxically, they made it easier for labour than for most commodities to cross the Ancien Regime's innumerable jurisdictional boundaries. Last but far from least, they contributed to technological progress by disseminating technical skills.

IV

Pre-modern guilds contributed to technological progress through training, specialization, diffusion and invention. We have already discussed how apprenticeship and journeymen's associations promoted training and worker specialization by lowering the transaction costs and uncertainty involved. We will now see how guilds promoted technical diffusion by establishing a system of circulating labour, and promoted inventiveness by providing inventors with monopoly rents. This claim seems

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[30] An interesting exception was the large-scale late medieval migration of German-speaking workers to northern and central Italy (Doren 1903).

[31] See *contra* Smith 1976: 150-1: the Statute of Artificers 'obstructs the free circulation of labour from one employment to another, even in the same place'.

hard to square with the guilds' reputation for technological conservatism;[32] yet for every episode of Luddite reaction (e.g. Thrupp 1963: 272-3; MacLeod 1988: 161; Mokyr 1990: 178-9, 258-9), there are dozens of examples of technological diffusion through *artisan migration*.

Artisans, like servants, were constantly on the move.[33] For journeymen it was a way of life; for master artisans it could easily become so. The Huguenot migration to England and the wholesale transfer of artisan skills from Brabant to the Netherlands in response to sixteenth-century warfare are just two better known threads of an intricate web of technological diffusion which covered the whole of early modern Europe and beyond (see e.g. Thrupp 1963: 270; Scoville 1952; Barbour 1950: 19-20; Mathias 1975; Rapp 1975: 505; Hammersley 1981; Hale 1985: 229; MacLeod 1988: 26,28,31,33,37,82,208; Ashtor 1989; Magnusson 1991: 210). Yet to state that these men embodied progressive forces that 'undermined' guild obscurantism (Mokyr 1990: 233, 298) misunderstands the fact that the migration of skilled workforce was a structural consequence of the guild system itself.

The reason why technological diffusion before the nineteenth century occurred overwhelmingly by means of artisan migration was, of course, the *embodied* nature of pre-modern technical skills. Although fundamental inventions could be published and made easily available, the printed word had negligible effects (Cipolla 1972). Technical knowledge had to be transferred, so to speak, in the flesh. It is no coincidence that the technologically most advanced sectors in the pre-modern economy

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[32] See e.g. Kula 1976: 78: 'changes in production techniques -- and therefore changes in labour productivity -- are not possible in the corporate system'.

[33] Persson 1988: 69 notes how the institution of servanthood helped propagate agricultural technique. Snell 1985: 256-7 also draws attention to parallels between apprenticeship and farm service.

(the mining, building, shipbuilding and textile industries) also had the most mobile workforce (Ashtor 1989). However, causation ran both ways. The high level of skills involved in these sectors restricted the number of qualified workers, who were forced to move between production centres in response to local economic cycles.[34] The 'tacit', embodied character of technical knowledge meant also that industrial espionage for rival manufacturers' 'secrets', process and other technological inventions which gave their owners the 'super-profits' we associate with patented inventions, could only be achieved by luring away an expert capable of conveying his prized knowledge by personal example (MacLeod 1991: 894).

A characteristic feature of medieval and Ancien Regime Europe made this kind of technological transfer easier than it might be today. The extreme political and jurisdictional fragmentation of the continent and the competition this engendered between territorial powers, meant that most craft guilds could seldom enforce their 'secrets' beyond the town walls. Most importantly, they could do little to stop members from moving elsewhere, since if a guild refused to adopt an innovation it would be quite simple to offer it to another, more receptive jurisdiction (Hirshler 1954: 55-6; Ashtor 1989: 20-1).[35] Whereas patents aimed in principle to protect the grantee's rights within the boundaries of a grantor state, most pre-modern industrial 'secrets' could rely virtually only on the legal and physical safeguards set up by the

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[34] These industries may also have been more subject to cyclical fluctuations than ones in more protected markets less subject to exogenous shocks, e.g. warfare or unitive taxation. These higher risks may have contributed to restrict the supply of willing apprentices.

[35] Throughout this argument we are assuming that technology transfer could only occur between individuals with a basic training in 'general skills' as defined above, n.17.

manufacturer, that is, the guild itself: and these, as we have just seen, were weak indeed.

Although the issue must still be examined systematically, it therefore seems inherently unlikely that guild secrecy played a significant part in delaying the dissemination of technical knowledge in pre-modern Europe. Generally moderate fixed capital requirements (e.g. Berengo 1965: 66-7 for Lucchese silk masters) meant that skilled artisans faced low entry costs to most manufactures, which in turn raised the value of owning a technical 'secret' to maintain a competitive edge; the larger the market and the higher the potential profits, the greater the incentives for technological innovation *and* for an opportunistic artisan to transfer his secret burden of knowledge to a more appreciative environment.[36] The best way of avoiding members' defection was thus to provide them with a sufficient number of exclusive 'social benefits' to raise exit costs above the perceived benefits of migration; we already saw that this is the most likely explanation for the guilds' willingness to take on a wide variety of social and political functions which could have been provided equally or more efficiently by other kinds of organisation.[37] Describing the eighteenth-century silk industry in Bologna, Carlo Poni has recently suggested that placing restrictions on the size of members'

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[36] It was common practice among guilds to name officers who routinely (up to once a week) visited their members' workshops to check the quality of the output. This would have ensured that master specific inventions became common patrimony of the whole guild over a relatively short period of time. See below, n.36.

[37] Since the dangers of competition through dissemination of a guild 'secret' were highest for high value-added, export-oriented industries, we would expect guilds in such industries to provide proportionately greater 'non-collective social benefits' (e.g. forms of political representation, tax and social security benefits etc.) than guilds engaged in low value-added, localized product markets. It would therefore also be less costly for artisans trained in the latter to defect from their guilds.

workshops (that is, on the number of apprentices and journeymen they could take on) could be a further means of avoiding dissemination of trade secrets through migration of unemployed workers (Poni 1990: 103); we saw previously, however, that these restrictions were seldom strictly enforced.[38]

This mode of propagating technical knowledge quite certainly increased after the mid-fourteenth century, as interregional and international movements in commodities, people and ideas expanded. Indeed, improved lines of communication may well explain why early modern technological progress was achieved mostly through the development of small-scale 'micro-inventions' and the diffusion of 'best practice', rather than through revolutionary but isolated technical breakthroughs (Mokyr 1990).

The widespread evidence of technology transfers can be taken as proof that guilds were not inherently averse to technical innovation, indeed that they welcomed it under certain conditions to be discussed.[39] To understand this, we must shift our focus from diffusion to invention, and raise the question of how *deliberate* technological progress through invention could be achieved. The problem is well known: new discoveries will not be forthcoming if the inventor cannot claim more than his proportional share of the gains. Systematic invention therefore has to be promoted through non-market

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[38] Another cause of artisan migration was indebtedness; this is said to have been the reason why Ugolino Menzoni, a silk master from Bologna, carried the secret of the city's silk-throwing mill with him to Modena (Poni 1990: 121).

[39] Most artisans who decided to leave their town of origin ended up being integrated into a new guild (Hirshler 1954: 53). This would make technical sense, since only other trained workers would be able to *interpret* the new information correctly and efficiently; 'proto-industrial' workers with generic skills would be less technically receptive, whatever their attitude towards new technology. I discuss proto-industrial technology further below.

institutions. Only three solutions are available: state support for primary research, patent rights to discovery, and 'secrecy' and the transmission of secrets through training (Dasgupta & David 1988: 9, 26). But although patent rights were invented in the early fifteenth century, patents in their modern guise are an eighteenth- or even nineteenth-century invention (MacLeod 1991); this is even more the case for public support for basic research. This means that the *only* significant incentive for invention before the eighteenth century was the capacity to control and transmit a technical secret, and to capture the rent that secret provided. The most effective defender of rents from secrecy was, of course, the craft guild -- which incidentally was originally known as *misterium* (Long 1991: 859-60).[40]

The demonstration that guilds could monopolize *existing* knowledge by hindering technological diffusion and that they were willing to adopt 'secrets' garnered elsewhere does not of course prove that they were a major source of, or indeed capable of producing, *new* technical knowledge. Unfortunately, whereas the adoption of 'secrets' imported from elsewhere is sufficiently well documented, the production of new technology *within* a guild is extremely hard to observe. On the one hand, the kinds of innovation that guilds preferred, namely process and capital saving devices and investment in skills (I discuss the reasons for this in the next section), are inherently harder to identify than the labour saving inventions more commonly

[40] The concept of 'secrecy' misleadingly implies that the technology *could* be transmitted as formalized knowledge. However, since most pre-industrial technology could only be propagated by personal example, one could argue that secrecy was a *conditio sine qua non* rather than a privileged or unusual condition. See Mathias 1975: 111-13. A similar consideration applies to much scientific technology today (I owe the latter point to Mary Morgan).

associated with industrialization.[41] On the other hand, guilds did not advertise their technological advances; most 'secrets' came into the competitors' domain and appear in the documentary records only after they had been 'stolen' or transferred (see Long 1991: 858-9). Although the patent was an institutional offshoot of the guilds' 'invention' of technology as a distinct sphere of human practice (Long 1991), guilds had no desire to make their discoveries public as the patent must do. Nor did they have to: corporate supervision ensured that an individual's discovery would spread to the only 'public' that mattered, the membership of the guild itself (Epstein S. 1991: 140).[42,43] From there the invention could take other paths, but that was no more than an undesired, albeit inevitable side-effect of the guild's limited powers of coercion.

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[41] Even so, the size of the gains from this kind of innovation could be striking. Labour productivity in the Lyonnais book industry increased by *c.*750 per cent between *c.*1500 and 1572, an annual rate of growth of 3 per cent. The journeymen did not complain (Zemon Davis 1966: 53 n.3).

[42] 'Patents ... undermined [the guilds'] ethic of unrestricted communication of trade secrets between the freemen of a company' (MacLeod 1988: 83). The importance of patenting was inversely proportional to the strength of guilds: the intensity of patenting in England increased sharply after 1720 as guild membership began to collapse (*ibidem*: 84, 88, 113). Nonetheless, some types of invention typically associated with crafts, such as improvements in technique, could not be patented at all (*ibidem*: 97-8).

[43] This was true so long as patents were viewed as a discretionary privilege to be granted by the state. Only when the concept of invention as a natural human right emerged in the late eighteenth century did guilds lose the ability to protect their rights and 'secrets' as a corporate body (see Hilaire-Pérez 1991, and more broadly Sonenscher 1989).

Invention was most likely achieved through unintended, random change or through economies of practice or 'learning by doing';[44] it was probably less frequently the result of a deliberate search for technical advantage (Persson 1988: 7; but see Sonenscher 1987: 62-6). What is clear, however, is that investment in skills and apprenticeship training provided a pool of constantly renewed talent which ensured a higher than average *potential* for technical invention. Improvements of this kind drew on what I have called 'embodied', rather than formalized knowledge.

By contrast with the patent, which constituted a deliberate attempt by the state to foster inventiveness (and perhaps to an equal degree, rent-seeking), the diffusion of 'secrets' through the craft guild system relied upon a process of bidding by the invention's potential beneficiaries, including most importantly the breakaway artisan himself. Craft innovation was thus a *by-product* of the guild acting as a collective 'firm of firms'. Even so, craft-based invention and the multi-centred, competitive institutional setting in which it was embedded came close to resembling an 'ideal' market structure for efficient innovation (Kamien & Schwartz 1982: 218-19).[45]

V

Both the debate on proto-industrialization and that on the rise of the centralized factory draw upon claims about relative technological efficiency. Both proto-industry and factory industry are said to have 'won out' over craft-based production because they

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[44] Since most journeymen tended to be employed on short-term contracts, the probability of making gains from economies of practice and random experimentation must have been greatest among long-term apprentices.

[45] The optimal institutional balance may in fact be a system which promises property rights over inventions but is unable to enforce these effectively, such as the seventeenth-century English patent system described by Thirsk 1978, and the guild system as described here.

were (in several senses) cheaper ways of organizing manufacture. Yet claims based on inherent superiority cannot easily explain why the most significant feature of pre-modern manufacture was the *co-existence* over several centuries of different modes of organization under the hegemony of craft-based production (Berg 1991).

By contrast with prevailing stage-theories of technological progress, I propose to analyze different organizations of manufacture as distinct kinds of 'firm', each of which was competitive within its own, specific technical and organizational matrix, and each of which, therefore, maintained a specific technological equilibrium. Following recent work by Pagano and others, I assume that each type of 'firm' responded to two distinct institutional and organizational pressures: to the problem of efficiency (resulting from the costs of monitoring the production process) on the one hand, and to the problem of governance (resulting from different property rights over capital and labour) on the other. Each type of 'firm' tended to *adopt* technology which reinforced its basic property rights, and to *refuse* innovations which undermined those rights. Each type of 'firm' therefore also *promoted* invention in directions that reinforced its existing governance structure or set of rights (Pagano 1991a and 1991b; Pagano & Rowthorn 1994).

The scheme draws a basic distinction between owners of capital (K) and labour (L). The concept of 'asset specificity' (Williamson 1986) gives us a further distinction between '(asset) specific' and 'generic' capital (K_s, K_g) and labour (L_s, L_g) respectively. A third major distinction can be made on the basis of monitoring costs (which are a function of opportunism), between easy to monitor and hard to monitor labour (L_e and L_h).[46] These categories produce eight possible permutations, of which seven seem to have existed in practice (Table 1).

[46] Monitoring costs and asset specificity are homologous for K.

Table 1. ***Property rights and technology in pre-modern manufacture***

Labour	Capital: K_g	Capital: K_e
L_g embedded	household production	factory
L_e embedded	proto-industry	
L_g disembedded	'buying-up' system (Kaufsystem)	centralized manufacture
L_e disembedded	craft manufacture (guilds)	joint ownership

Table 1 summarizes the distinctive features of the two[47] main types of pre-modern 'firm' (craft production and proto-industry) along these lines. Let us take craft production first. Artisan fixed capital (craft machinery) was generic and could be acquired at relatively low cost; apprentices and journeymen could usually expect to set up their own shop with a few years' savings. Since the machinery could be quite easily replaced, owners of capital could not engage effectively in opportunistic behaviour, e.g. by withdrawing from the market. The production process was thus controlled by skilled labour. Opportunism among trainees took the form of flight; opportunism among journeymen took the form of strikes, walkouts and especially boycotts. In both cases, the worker's opportunism was tempered by the *rights* that apprenticeship provided: the right not to be fired in the case of apprentices, and the right to have one's skills recognized through certificates of training in the case of journeymen.

Proto-industry occupied a more ambiguous position than craft production in this scheme. On the one hand, although the two shared hard to monitor labour, proto-industrial workers based their opportunism on organizational rather than technical factors. Instead of withdrawing their skills, which were generic and thus easily substituted,[48] proto-industrial workers exploited the dispersed character of production

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[47] Some organizational aspects of centralized manufacture are discussed by Cerman 1994; joint ownership companies like those formed in the Yorkshire woollen industry were even more uncommon (Berg 1991: 189). The 'buying-up' and the strictly proto-industrial or 'putting-out' systems are distinguished by who controls access to the raw material; this is in the worker's hands in the former, in the merchant's hands in the latter case.

[48] This is not to signify that the skills involved were inconsiderable (Berg 1991: 177), but rather that they were part of the standard 'in-house training' and socialization of European rural society. See above, n.21.

in order to embezzle the raw materials they received from the capitalist 'putter-out' (Magnusson 1991: 206-10, 212-15).[49] On the other hand, proto-industrial capitalists could *also* (and, historically, for the first time) engage in opportunistic behaviour, on the basis not of their control over the machinery (which was usually owned by the workers themselves) but of their superior *organizational* skills. Although on balance the latter gave capital control over labour, the equilibrium was highly unstable, since entrepreneurial proto-industrial workers could become capitalist putters-out simply by mastering the requisite organizational skills (Berg 1991: 180).

From this perspective, factory industry emerges as a combination of the centralized and machine-based features of craft-shop organization, and the generic and unskilled features of proto-industrial labour. To these it makes two unique contributions: it introduces specialized, firm-specific machinery, and it shifts the 'balance of opportunism' decisively in the capitalist's favour. Neither withdrawal nor embezzlement are any longer a strategic option for unorganized factory workers; the focus of their opportunism now shifts to the *use* of the factory's specialized (e.g. difficult to substitute) *machinery*, be it through Luddite destruction or strikes. By contrast, for the first time withdrawal by the capitalist threatens the very livelihood of the worker.

The main conclusion to be drawn from our discussion is that the balance between skills-intensive and capital-intensive production was a function of the prevailing

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[49] Interestingly, just as apprenticeship aimed to reduce worker opportunism by providing him with rights to his skills, proto-industrial capitalists often responded to widespread embezzlement by tacitly recognizing it as a right (Magnusson 1991: 219); this helped internalize the costs of monitoring proto-industrial labour. Of course, the problem then became one of drawing the line between 'legitimate' and 'excessive' pilfering.

property rights to labour and capital.[50] Following the opening remarks in this section, we should therefore also expect to find that each governance structure was biased towards a specific kind of invention and innovation. With respect to craft production, we should find technological choice directed towards easy to monitor capital and hard to monitor skills: that is, towards capital-saving, skills-enhancing, and process and technique innovation. This is precisely the kind of innovation which prevailed in England before the mid-late eighteenth century: before, that is, the country's guild structure collapsed (MacLeod 1988; Snell 1985: ch.5; Griffiths, Hunt and O'Brien 1992). The English evidence (which it seems reasonable to assume is similar in pattern if not in detail to that of its Continental neighbours) suggests two conclusions in support of our claims. First, invention and innovation favoured techniques which prevailing property rights in manufacture made it feasible to accept; and second, patentees of such inventions would have been most frequently of artisan extraction, since those were the technological paths along which their training tended to direct them.

The reasons for this become clearer if we examine the two hypothetical alternatives open to master artisans, the use of unskilled labour on the one hand, or of capital-intensive machinery on the other. Craft shops could not base production on unskilled labour for two reasons: initially (between the eleventh and the thirteenth centuries), because the lack of efficient spot markets for unskilled wage labour exposed them to excessive risk (Grantham 1993); subsequently, because to do so would have subjected them to huge diseconomies of scale in comparison both with proto-industry and with factory production. Craft shops could not invest in capital-intensive machinery for similar reasons: initially, because medieval and early modern spot markets in capital

[50] This discussion implies that the concept of 'human capital' is an oxymoron: the reduction of 'labour' to 'capital' belies their very different (indeed, historically alternative) organizational requirements.

goods did not exist,[51] and because the use of firm-specific capital stock within highly unstable markets exposed producers to excessive risk; subsequently, because capital-intensive innovations would have devalued investments in existing skills and destroyed any incentive to invest in new ones. Craftsmen and their guilds opposed capital-intensive innovations and investments not as a matter of principle, but only where these risked devaluing skills, whether directly by substituting general with generic wage labour, or indirectly by raising fixed capital costs in the industry and by shifting control from the owners of skills to the owners of capital (Zemon Davis 1966: 53; DuPlessis & Howell 1982: 68-70, 71, 79). This in turn suggests that medieval and early modern artisans' notorious 'attachment to democratic equality or independence' (Thrupp 1963: 272-3) and aversion to developments that would raise *fixed capital* costs of entry to the trade were grounded first and foremost in technological, rather than in ideological concerns.

Although it has been claimed that proto-industry promoted technological invention and innovation, our analysis points to the opposite conclusion. Balancing as it were half way between skills-intensive craft production and capital-intensive factory production, proto-industry seems to have been a dead end for technical invention (Coleman 1973; MacLeod 1988: 102; Magnusson 1991: 202). Proto-industry also found it difficult (albeit not impossible) to incorporate innovation from outside while remaining unchanged: since major technical innovation caused either labour skilling or capital intensification, proto-industry had a spontaneous tendency to move either 'back' into craft production, 'forwards' into factory industrialism, or 'sideways' into sweat-shops

[51] Even if high cost machinery had been available for lease, master artisans would still have faced higher costs than capitalists for reasons of moral hazard: artisans would have had fewer incentives than capitalists to maintain the capital equipment in good shape.

(Berg 1991: 181).[52] This *technologically-induced* disequilibrium of the proto-industrial governance structure provides a simple explanation to the long-standing puzzle, why proto-industry so seldom spawned factory industry proper and why it just as easily transformed into craft-based production (Reddy 1984: 49-50; Berg 1991: 181). The single area in which proto-industry may have developed innovative skills among its practitioners was, as indicated above, that of industrial organization.[53]

VI

Ancient prejudice notwithstanding, the governance structure of craft production and of its handmaiden, the guild, was not technologically inefficient. Once it had passed the threshold of simple household production, pre-modern manufacture was forced to resort to a specialized workforce; urban guilds and apprenticeship emerged jointly in the eleventh or twelfth century to solve the moral hazard involved in training skilled labour.

As for the historical origins of guilds and apprenticeship we need be no more specific. We need not assume that these institutions were the outcome of conscious choice; craft guilds could easily have been 'selected' randomly and then reproduced once their positive welfare effects had been (vaguely) recognized.[54] On the other hand, I have argued that the long-term *survival* of craft guilds was a result of their favourable

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[52] Organizational instability would explain why proto-industrial workers could be averse to technological innovation (Mokyr 1990: 257).

[53] This may have been due to the ability of proto-industrial production to respond flexibly to large short-term fluctuations in demand, which was also its most significant organizational advantage over craftsmanship and factory production.

[54] A neo-Darwinian model would better explain why craft guilds of the kind I have described seem to have developed only in medieval Europe.

technological consequences, due in particular to the institution of apprenticeship.[55] For centuries, arrangements that could not provide equivalent or superior technology were either 'selected out' by craft-based guild production, specialized like proto-industry to low-skill manufactures in which they could maintain an unstable comparative advantage (Persson 1988: 57-8), or were forced like centralized manufacture to inhabit technologically sophisticated but institutionally restricted niches (Cerman 1994).[56]

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[55] It is notable that the capitalist-style woollen cloth manufactures which briefly emerged in early fourteenth-century Florence and Flanders did not survive the wave of worker revolts and the demographic collapse of that century, but were 'downsized' into a combination of small-scale workshops and dispersed rural putting-out (proto-industry). Merchants of early modern Leiden and Lille supported skills-intensive crafts against the development of proto-industrial or 'capitalist-style' manufacture (DuPlessis & Howell 1982) for similar reasons: capital-intensive factory production was still not a feasible technological equilibrium.

[56] This argument does not require that guilds be initially aware of the beneficial technological side-effects of apprenticeship. However, increasing artisan and journeyman mobility would have raised members' awareness of technological progress. The invention of the patent, which for the first time established the intellectual distinctiveness of technical knowledge, was a logical development of this process (Long 1991).

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