

# The Economics of Apprenticeship

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## Introduction

The subject of apprenticeship, one of the more enduring of all economic arrangements, has received more attention from economic historians and the economics profession at large in recent years. Yet, compared, say, with issues such as the economics of slave labor or the rise of formal human capital and literacy, apprenticeship — the mechanism through which practical skills were transferred from generation to generation — has not been the subject of much research until the last decades. Even in the literature that has revised and criticized the old view of the guilds as a pure redistributive institution and an impediment to efficiency and technological progress, apprenticeship was often mentioned but was eclipsed by other issues such as exclusionary rent-seeking and allocative efficiency. There were some exceptions in specific cases, but in proportion to its importance and prevalence, the institution remained strangely under-researched until recently.<sup>1</sup> This is now changing, in large part through the pioneering work of a number of scholars on apprenticeship in Canada and Europe such as Gillian Hamilton, Bert De Munck, and Patrick Wallis, among others.<sup>2</sup>

The new research has been directed primarily at economic and social historians; the important implications of apprenticeship for issues in economic growth, the economics of innovation and technological diffusion, labor economics, and the new institutional economics, need to be spelled out in some detail, which is what this essay will attempt to do. As the essays in this volume amply attest, a great deal of new information has been unearthed in recent years about the actual workings of apprenticeship in the past. At the same time, economics provides a set of analytical tools that provide a theoretical framework to interpret the new data. These tools are both micro-economic and macro-economic. In terms of micro-economics, one issue concerns contracts, that is, analyzing the transaction between the supplier of training (the master) and the customer (the apprentice and his family). Other micro-economic themes of interest connect directly to the organization of the industry and the use of apprenticeship as a barrier to entry and the structure of pre-modern urban

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<sup>1</sup>Dunlop, “Some Aspects”; Ibid., *English Apprenticeship*; Elbaum, “Why Apprenticeship Persisted”; Lane, *Apprenticeship in England*; Hamilton, “Enforcement.” Ibid., “The Decline.”

<sup>2</sup>De Munck, *Technologies of Learning*; Ibid., “From Brotherhood”; Ibid., “Corpses”; Wallis, “Apprenticeship and Training.” Ibid., “Labor, Law and Training.” Economists, too, are gradually recognizing its importance, e.g., Smits and Stromback, *The Economics*; De la Croix, Doepke and Mokyr, “Clans, Guilds, and Markets.”

labor markets, as apprentices and journeymen were a form of *ur*proletariat before the Industrial Revolution.

Human capital theory suggests that investment in education is one of the most important human activities that determines life-time outcomes on the micro-economic level and the economic performance of society on the macro level. An analysis of apprenticeship involves the intergenerational transmission of technical skills. These skills constituted a special form of human capital, a set of recipes often referred to as the “secrets of the trade,” a *savoir faire* that determined how goods and services were to be produced and who would be allowed to engage in it. The economics of knowledge stresses the important distinction between codifiable and tacit knowledge.<sup>3</sup> Much of the knowledge imparted to apprentices was *tacit* knowledge, that could not be obtained from textbooks or encyclopedias, and was not taught in schools. The only way for a young lad to become a barber, a cooper, or a cabinetmaker was through direct contact with and imitation of people who already possessed the requisite competence and were willing and able to teach it.<sup>4</sup> In terms of more aggregative analysis, apprenticeship was a major factor in the determination of the rate and quality of human capital formation. Beyond that, masters acted *in loco parentis* and apprenticeship was a major part of socialization and the intergenerational transmission of culture and norms, a topic that has recently become quite interesting to economists.<sup>5</sup> Here the interests of the two disciplines clearly form a confluence.<sup>6</sup>

Moreover, apprenticeship should also be analyzed through the prism of the new institutional economics pioneered by Douglass North. The market for apprenticeship, like all markets, depended on a set of institutions that determined how the contracts were enforced, how effective the training was, whether innovation was encouraged, and what it implied for the status of masters and

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<sup>3</sup>Foray, *Economics of Knowledge*, especially pp. 71-90.

<sup>4</sup>John R. Harris, *Skills, Coal and British Industry*, p. 33 called the tacit knowledge in the iron industries “unanalyzable pieces of expertise” and “the knacks of the trade,” but it was equally true in many service industries (see Farr, *Artisans*, p. 34).

<sup>5</sup>Bisin and Verdier, “The Economics.”

<sup>6</sup>De Munck believes that masters transmitted to their apprentices both skills and “values, mores and cultural codes” and served as “surrogate fathers.” De Munck, *Technologies of Learning*, pp. 4-5.

apprentices. The institutions governing apprenticeship thus represent a prime example of a set of Northian “rules of the game” that determined economic outcomes. In its regulation, formal (that is to say, government) institutions coexisted and overlapped with private arrangements and corporate bodies and underlay pre-modern non-agricultural labor markets.

Finally, I will turn to the issue of economic growth and the Industrial Revolution, and argue that the work of economists implies a central role for apprenticeship in the great questions regarding the sources of the “Great Enrichment” in Europe. An obvious reason for its significance in the growth literature is the observed differences in technological capabilities in different economies, with far-reaching consequences for economic performance. In the case of the British Industrial Revolution, for instance, it has been argued that the level of skills of British workers was higher than elsewhere largely due to its superior and flexible institutions of training youngsters.<sup>7</sup>

The Industrial Revolution did not lead to the end of apprenticeship. In many economies one-on-one training is still very widely practiced. Despite the abolition of the English Statute of Apprentices and Artificers in 1814, apprenticeship remained of central importance in the British textile engineering sector, one of the high-tech sectors of the day.<sup>8</sup> Moreover, while in our time apprenticeship has been partially supplanted by formal instruction in vocational and professional schools, the personal one-to-one transmission of knowledge and hands-on experience is still felt to be of substantial importance, complementing rather than replacing more formal forms of instruction.<sup>9</sup>

### **Tacit knowledge and Personal Teaching**

One way to look at apprenticeship is as a personal and direct way of passing tacit skills and competence from master to pupil. Skills have been described by Michael Polanyi in his classic work

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<sup>7</sup>Kelly, Mokyr and Ó Gráda, “Precocious Albion”; Humphries, “English Apprenticeships”; Ben Zeev, Mokyr and Van Der Beek, “Flexible Supply.”

<sup>8</sup>Cookson, *Age of Machinery*, p. 236. As late as 1925, there were 315,000 apprentices and 110,000 “learners” in Great Britain. See Smits and Stromback, *The Economics*, p. 20.

<sup>9</sup>In Germany today almost 60 percent of young people train as apprentices, compared with less than 5 percent in the US. Apprenticeship occurs not just in manufacturing but in banking, IT, and hospitality. In experimental sciences, postdoctoral training — a form of apprenticeship — is still required (e.g., Jacoby, “Why Germany”).

on the topic as “the observance of a set of rules not known to the person following them.”<sup>10</sup> Tacit knowledge of any kind is likely to be transmitted through personal contact: by observation, memorization, and imitation. Hence, Polanyi argued, “An art which cannot be specified in detail cannot be transmitted by prescription, since no prescription for it exists. It can be passed on only by example from master to apprentice. This restricts the range of diffusion to that of personal contacts, and accordingly craftsmanship tends to survive in closely circumscribed local traditions”.<sup>11</sup> One corollary is that many high-skilled crafts were located in urban areas; rural manufacturing — while widespread — was mostly low-skill.<sup>12</sup> In the modern age, it is common to think of codified and tacit knowledge as complements in which a hands-on personal relation supplements formal course work. Not so before the Industrial Revolution: formal instruction in the majority of trades and occupations was rare. Only in law, medicine, and religion was there a formal training in schools and universities.<sup>13</sup> Artisans, both in manufacturing and in services, were taught the secrets of the trade by associating with a master with whom they spent their adolescent years.

How, exactly, the transmission of knowledge took place is not always easy to establish and was likely to depend on the idiosyncratic characteristics of individual masters and the special characteristics of the techniques taught. Most studies concede that little is known regarding the actual learning process, but Schalk speaks for the consensus when he surmises that skills were picked up primarily through imitation and learning by doing.<sup>14</sup> The costs were the master’s time as well as the raw materials used up in the less-than-successful products produced by the apprentice. An interesting formulation is suggested by Steffens suggesting that skill-transmission took place through

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<sup>10</sup>Polanyi, *Personal Knowledge*, p. 49.

<sup>11</sup>Polanyi, *Personal Knowledge*, p. 53.

<sup>12</sup>Desrochers in “Geographical Proximity,” p. 26 points out that “the geographical concentration of economic activities, by allowing certain individuals better opportunities to tap into tacit knowledge than individuals located elsewhere, can provide an economical advantage.” While his data are all for our time, his argument holds *a fortiori* for medieval and early modern Europe.

<sup>13</sup>The first medical school was established in Salerno in the 8<sup>th</sup> century, and others such as Bologna and Paris followed in the high Middle Ages. Legal training in universities have been recently shown to have had a major impact on the growth of commerce and markets (see Cantoni and Yuchtman, “Medieval Universities”). Yet it remains true that French notaries were almost entirely trained through an informal apprenticeship with masters.

<sup>14</sup>Schalk, “Craft Apprenticeships,” p. 12.

apprentices “stealing with their eyes” – meaning that they learned mostly through emulation, observation, and experimentation.<sup>15</sup> Apprentices learned by being “inserted into the production process” from the start and in the absence of any serious epistemic base of the techniques in use, learning by doing and emulation were clearly central in the process.<sup>16</sup> The tasks to which apprentices were put at first, insofar that they can be documented at all, seem to have consisted of menial assignments such as making deliveries, cleaning, and guarding the shop. Only at a later stage would an apprentice be trusted with more sensitive tasks involving valued customers and expensive raw materials.<sup>17</sup>

### **Contracts and the Nature of Apprenticeship**

To start an apprenticeship, some kind of agreement had to be made between the two parties. In the absence of any formal and detailed description of what and how the youngster would be taught, the contract between him and his guardian on one side and the master on the other, must be regarded as an archetypal incomplete contract. Unlike the standard incomplete contract model in economics in which the main issue is the inability to specify all contingencies *ex ante*, in the case of apprentice indentures even the exact nature of the service to be exchanged was vague. Even when some contracts were written by public notaries and contained details of the mutual expectations, the full details could not be specified *ex ante*, nor could they be observed with much accuracy *ex post*.<sup>18</sup> Both the diligence and motivation of the pupil and the effort put in by the master were matters of discretion. The parents and guardians had to trust the master that he would teach properly — without such trust, the contract could not be viable. Moreover, the contract was normally concluded and signed by the parents, and when a tuition fee or “premium” was paid, this normally came out of their

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<sup>15</sup>Steffens, “Le métier volé,” p. 131. Goody, “Learning,” p. 289, thinks that most learning in this set-up comes from “monitored participation,” a form of learning by doing in which the apprentice was allowed to carry out increasingly more complex tasks. In larger workshops, much of the earning of novices came from more advanced apprentices and journeymen.

<sup>16</sup>De Munck, *Technologies of Learning*, pp. 4, 9.

<sup>17</sup> Lane, *Apprenticeship in England*, p. 77.

<sup>18</sup>De Munck, *Technologies of Learning*, p. 42

funds. Hence there was another agency problem, in that the main subject of the contract, the youngster himself, was usually not a party to the negotiation. In that regard an indenture contract between an apprentice and a master in early modern Europe was similar to the implicit contract between a student and a college in our time. The difference is that each apprentice-master relation was a non-repeated, personal, and unique interaction. Furthermore, the number of apprentices per master was small, so the informational difficulties were amplified and the possibility for opportunistic behavior on either side was considerable.

Most of the economics literature on incomplete contracts is of little help here, since the solutions proposed there, such as the integration of firms to resolve hold-up situations or an ownership assignment that may incentivize both sides, seem irrelevant to this particular question. What is more, the information about the realized transaction was asymmetric in two ways. First, even if the two sides could observe the outcome perfectly themselves, it may have been impossible to convey this information to third parties asked to adjudicate disputes, that is, “incompleteness arises because states of the world, quality and actions are observable (to the contractual parties) but not verifiable (to outsiders)” — such as courts.<sup>19</sup> But in this case one of the sides to the contract — the apprentice — was *by definition* underinformed about the material to be taught (and his parent or guardian, often the signatory on the contract, absent from the scene), the incompleteness was compounded by an informational asymmetry between the contracting parties.<sup>20</sup> To make things worse, the apprenticeship contract was non-repeatable and had a clear-cut termination date after which the relationship was resolved, which made opportunistic behavior especially attractive as the contract came to an end.

The contract between master and apprentice was subject to what is known as the credible commitment problem, which occurs widely in contract theory and political economy.<sup>21</sup> The issue is basically this: if the apprentice or his guardian could advance the full cost of his training at the

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<sup>19</sup>Hart, “Incomplete Contracts.”

<sup>20</sup>For this point, see Smits and Stromback, *The Economics*, pp. 41-42.

<sup>21</sup>Commitment problems are present in all aspects of social life and all contracts, as economists have long realized. For a good summary, see Acemoglu and Robinson, *Economic Origins*, pp. 133-36.

outset, this would be obviously desirable for the master. But when the apprentice was impecunious, and credit markets unavailable for this purpose, the best way to cover the master's cost was to have the apprentice commit to work for him when the training had advanced, thus securing a flow of cheap skilled labor for the master in compensation for his teaching efforts.<sup>22</sup> From the point of view of incentivizing the master to teach properly, this makes sense: the productivity of the apprentice as employee depended on how skilled he was when the time came. The commitment problem, however, meant that while the apprentice or his guardian could promise from the outset to supply this work, when the time came he had no incentive to do so, and instead might shirk in his work or abscond carrying in his head the human capital he had accumulated.<sup>23</sup> As the master knew this, the apprentice could not credibly commit to provide the work and the entire apprenticeship system might unravel. The contract was therefore not self-enforcing.<sup>24</sup>

The exchange between master and apprentice typically thus involved two bundles: the master taught the apprentice the skills and secrets of the trade, which involved his time and the time of his employees, as well as the tools and raw materials that were used up in the instruction process. Moreover, in most documented cases, the apprentice was provided room and board by the master and in many cases he was socialized in other subjects, such as piety, literacy and good manners.<sup>25</sup> As in most educational markets, the training involved not just the actual transmission of knowledge but also a formal stamp of approval at the end of the training that permitted the trainee to practice the trade, hopefully eventually as a master himself. It was thus a complex transaction on both sides, and it is easy to see what could go wrong.

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<sup>22</sup>In many cases, if a premium was paid upfront the mandated length of training was shorter, indicating that masters drew their compensation in the form of labor from the apprentice in the final stages of the training period. See e.g., Epstein, *Labor Markets*, pp. 143-44.

<sup>23</sup>The hard-to-observe effort exerted by the apprentice working for his master is at the core of the principal-agent models that analyze such contracts, as Adam Smith already noted (*Wealth of Nations*, pt. I, p. 137).

<sup>24</sup>The reverse has been argued by Smits and Stromback, *The Economics*, p. 77, yet in the end they concede that neither the effort exerted by the apprentice nor the quality of instruction were contractable, and so the credible commitment problem remains (pp. 88-89).

<sup>25</sup>For examples on the demand of apprentices for literacy skills, see Davies and Saunders *History of Merchant Taylors*, p. 109.



An example from mid thirteenth century France serves as an illustrative example. In one, from Arras, a mother (probably a widow) to a weaver for four years and basically guaranteed the good behavior of her son.

*Be it known to present and future aldermen that Ouede Ferconne apprentices Michael, her son, to Matthew Haimart on security of her house, her person, and her chattels, and the share that Michael ought to have in them, so that Matthew Haimart will teach him to weave in four years, and that he (Michael) will have shelter, and learn his trade there without board. And if there should be reason within two years for Michael to default she will return him, and Ouede Ferconne, his mother, guarantees this on the security of her person and goods. And if she should wish to purchase his freedom for the last two years she may do so for thirty-three solidi, and will pledge for that all that has been stated. And if he should not free himself of the last two years let him return, and Ouede Ferconne, his mother, pledges this with her person and her goods. And the said Ouede pledges that if Matthew Haimart suffers either loss or damage through Michael, her son, she will restore the loss and damage on the security of herself and all her goods, should Michael do wrong.<sup>26</sup>*

This example may create a mistaken idea of uniformity; in fact there was great variety in the nature of these contracts. In fourteenth century Montpellier, for example, out of 126 surviving contracts, 48 were signed by the apprentice himself, so that nobody could vouchsafe or place a bond for their good behavior and ability to learn the trade.<sup>27</sup> In some cases, the apprentice had to pay a premium and separately for his room and board; in others, the money flowed in the other direction and he received a wage. In a way, the apprenticeship market resembled the marriage market: depending on the economic circumstances, traditions, and the way the matching operated, money could flow from the bride side to the groom side or the reverse.<sup>28</sup>

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<sup>26</sup>Espinas and Pirenne, *Recueil de Documents*, Vol. 1, p. 121. These kind of contracts go back to antiquity, for some examples, see Hawkins, *Roman Artisans*, pp. 109-10.

<sup>27</sup>As Reyerson, “The Adolescent Apprentice,” p. 358 points out, in some cases family friends or business colleagues might have served in this capacity. *Fideiussores* (sureties) could be invoked to guarantee an arrangement from friends or colleagues of deceased parents, yet it is also clear that in some cases no such guarantor existed and yet contracts were signed.

<sup>28</sup>Hamilton, “The Market,” pp. 505-07 has emphasized the importance of a good “match” between master and apprentice, and that uncertainty made the likelihood of a bad match higher. She finds that in Montreal around 1800, a third of all apprentice contracts were preceded by a “probationary” period, which may have reduced the uncertainty somewhat.

From a purely theoretical point of view, it might thus have been logical for apprenticeship to take place within families, in which fathers taught their sons. The agency and enforcement problems would have been much reduced. In fact, in agriculture — that is, the majority of workers in pre-Industrial Revolution Europe — this was predominantly the case, and formal apprenticeship was rare (although teenage farms servants must have had some similar characteristics to apprentices). In urban occupations — both artisanal and commercial — fathers teaching their sons was fairly unusual, Alessandro Scarlatti, Johann Sebastian Bach, and Leopold Mozart notwithstanding.<sup>29</sup> By the seventeenth century, apprentices trained by relatives were a distinct minority, estimated in London to be somewhere between 7 and 28 percent.<sup>30</sup> Training within the extended family or clan was less common in Europe, because the nuclear family had become the norm from the early Middle Ages on, although relatives remained an option.<sup>31</sup> It can be shown that if apprentices could select from a wide array of unrelated masters, technological progress was faster than if he was limited to family members.<sup>32</sup>

Given that the contractual relation between master and apprentice can thus be seen as the mother of all incomplete contracts, one wonders how various past societies solved the threat of opportunistic behavior on both sides. There were countless margins at which things could go wrong, and they often did. The incentives simply did not line up. Even a competent teacher might skimp on

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<sup>29</sup>Reyerson, “The Adolescent Apprentice,” p. 357 finds that in her fourteenth century contracts only eleven out of 208 contracts followed the same occupation as their father. It should be noted, however, that in the cases in which sons were trained by their fathers, no formal contract would be necessary so that our sources are biased against finding such relations.

<sup>30</sup>Leunig, Minns and Wallis, “Networks,” p. 42; Prak, “Megastructures,” p.153 has calculated that in the bricklaying industry, fewer than ten percent continued their fathers’ trades. The same phenomenon is observed for many modern societies, see Goody, “Learning,” p. 239. Fragmentary evidence for the Roman period indicates the likelihood that even in antiquity artisans commonly sent their sons to be trained with others. Cf. Hawkins, *Roman Artisans*, pp. 198-202.

<sup>31</sup>In medieval Bologna, most of the blacksmith apprentices trained with people to whom they were related. Cf. Epstein, *Wage Labor*, p. 105-06.

<sup>32</sup>Doepke, De la Croix and Mokyr, “Clans, Guilds, and Markets.”

the board and room, or humiliate and beat up his pupil.<sup>33</sup> The apprentice, as noted, might learn the secrets of the trade quickly and then abscond, or he might learn very slowly and thus be an unproductive worker. The relationship was by its nature asymmetric, but it was becoming progressively more symmetric as the apprentice acquires the skills of the trade.<sup>34</sup> Yet it was in the interest of the master to keep the asymmetry as long as possible, since it was this asymmetry that allowed him to control his worker and thus draw rents from the apprentice's labor. It also delayed the appearance of another potential competitor in the local market.

### **Institutions and Apprenticeship**

It is thus perhaps surprising to the economist that apprenticeship worked *at all*, let alone its longevity and ubiquity. *Some* kind of institution was needed to enforce the contract between master and apprentice. In the absence of such an institution, opportunistic behavior would doom apprenticeship and limit it to the nuclear family. Over time, implicit and formal local institutions evolved that created conditions in which contractual relations for training could be carried out in an effective matter and resolve the threats of moral hazard and opportunistic behavior. Local governance was usually involved. After all, there was a collective interest at stake, since external economies and economies of agglomeration meant that the entire community had an interest in the preservation of certain specialized skills and the reputational rents that came with it.<sup>35</sup> However, this collective need does not, by itself, explain why certain institutions arose that made the institution work. Indeed,

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<sup>33</sup>The printer's apprentice in Paris in the later 1730s described in Darnton, *Great Cat Massacre*, p. 75 may be an extreme example: "Life as an apprentice was hard ... They slept in a filthy, freezing room, rose before dawn, ran errands all day while dodging insults from the journeymen and abuse from the master, and received nothing but slops to eat. They found the food especially galling. Instead of dining at the master's table, they had to eat scraps from his plate in the kitchen. Worse still, the cook secretly sold the leftovers and gave the boys cat food—old, rotten bits of meat that they could not stomach and so passed on to the cats, who refused it."

<sup>34</sup>Buechler, "Apprenticeship and Transmission," p. 44. One form of the asymmetry was the *ius corrigendi*, the right of the master to inflict corporal punishment on apprentices.

<sup>35</sup>As Reyerson, "The Adolescent Apprentice," p. 360 noted perceptively, "The master provided service to his profession in training new personnel. To enable the perpetuation of skilled labor in various trades, it was necessary for the training process to be well organized. Skills were passed on from one generation to the next... Thus, the traditions of a town in a particular type of artisanal industrial activity could be sustained over time."

in the United States the absence of a guild tradition and high mobility made third party enforcement of apprenticeship contracts impracticable and the “market for apprenticeship” virtually disappeared.<sup>36</sup>

Three types of institutions emerged that carried out the task of enforcing and supervising the apprentice-master relationship and made it work. Perhaps the most important one is the hardest to observe: personal reputation. In an urban environment, in which transactions were repeated and in which people knew one another through a variety of channels, maintaining one’s reputation as a honorable and trustworthy person was extraordinarily valuable. The economics of such network relations are well-understood.<sup>37</sup> The idea is fairly simple: Suppose two agents face one another in two spheres, for instance a master training an apprentice, whose father served with the master in a local institution or was socially connected to his customers. If the master cheated the apprentice by shirking in his teaching duties or mistreated him, it could entail reputational damage and thus punishment in the other spheres. Thus, the possibility of punishment in one game may be used to induce cooperation in the other. Knowing this, the master would be incentivized to refrain from opportunistic behavior. What was true for the master would be equally true for the apprentice: misbehavior might threaten to damage his reputation as a trustworthy person as well as lead to sanctions on his family.

This insight is an application of how trust emerged through social networking and its effect on the efficiency of the apprenticeship market. When trust can be transferred from a social relationship into an economic one it can sustain cooperative outcomes in which exchange can take place and disputes are resolved even without the strict contract enforcement by a third party such as courts or arbiters.<sup>38</sup> It is this kind of environment, whether or not one wants to refer to it as “social capital,” that created the possibility of cooperation even when standard behavior in finite games would suggest that opportunism and dishonest behavior might have been a dominant strategy. To work effectively, however, the environment should be stable and fairly limited in size and mobility

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<sup>36</sup>Elbaum “Why Apprenticeship Persisted”; Elbaum and Singh “Economic Rationale.”

<sup>37</sup>Spagnolo, “Social Relations.”

<sup>38</sup>See for example, Posner, *Law and Social Norms*.

should be low, so that information networks could operate effectively. The more dynamic and sophisticated the economy, the less these conditions obtained.<sup>39</sup>

For that reason, more formal institutions involving third-party enforcement were needed to supervise the training and arbitrate between master and apprentice when disputes arose. There were many variations on the basic theme that some respectable local third party such as a Justice of the Peace was needed to arbitrate and settle out of court the frequent disputes that arose between master and apprentice.<sup>40</sup> Going to a formal court of law was possible in many countries, but given the cost and uncertainty of the outcome and the long duration of lawsuits, it must have been a *pis aller* (though some courts employed speedier and less costly arbitration and reconciliation procedures). Much of the negotiation between the master and his apprentice and his family must have taken place in the “shadow of the law.”<sup>41</sup> In many cases, then, the combination of the fear of reputational damage and the possibility of legal action were often enough to make the apprenticeship system work. In some cases special organizations set up by city government regulated the trade, including apprenticeship.<sup>42</sup> In other cases, the masters set up a number of clever contractual devices that made it less attractive for apprentices to abscond before fully serving their term. The up-front premium that

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<sup>39</sup>The rapid growth of Montreal after 1815 due to a high level of immigration disrupted the conditions that maintained apprenticeship in the late eighteenth century, and the it started a rather rapid decline. The same may well have been true for the United States, although there is no decisive evidence to support it. Cf. Hamilton, “Decline,” especially pp. 650-56.

<sup>40</sup>Davies, *The Enforcement*, pp. 207-08.

<sup>41</sup>The idea of bargaining in the shadow of the law was proposed by scholars working in Law and Economics, see Cooter, Marks and Mnookin, “Bargaining.” What this meant in practice was well-expressed by Rushton, *The Matter in Variance*, p. 102: “Thus the courts provided the reality of justice to some, though they promised it to all...The young were bound to society through the institutions which gave them justice... The paradox was, that in guaranteeing them their rights, the courts also reinforced their dependence on their elders. Thus justice for the few achieved the otherwise impossible: integration of the majority of the young into early modern society.”

<sup>42</sup>One example is the Dutch *neringen*, organizations sponsored and controlled by local municipal authorities, which played an important role in regulating and controlling the rapidly growing textile industry during the Golden Age. Unlike guilds, they were inclusive, and as such probably did not lead to excessive rent-seeking by incumbent manufacturers. See Davids, *Rise and Decline*, Vol. 2, p. 385.

would be forfeited and a promise of a cash payment upon completion were some of the contractual devices used to prevent the premature ending of the contract.<sup>43</sup>

The third type of institution to make apprenticeship work is the best-known: the craft guild. The history of apprenticeship and the history of the craft guild are intertwined and overlapping. Yet they are conceptually quite separate, and apprenticeship, being the more universal of the two, should be in a different category. While craft guilds of some kind existed all over the world, many — but not all — European guilds actively regulated and controlled apprenticeship.<sup>44</sup> More recent work casts some doubt on how widely guilds were engaged in explicitly enforcing the terms of the contract. In a conflict between a master (and thus a member of the guild) and an apprentice (who was not), it was unlikely that the apprentice would prevail if the guild was called to arbitrate.<sup>45</sup> This asymmetry would explain why eventually local officials and courts became increasingly involved in contract enforcement, creating conditions in which the market for apprenticeship could operate relatively freely and effectively. In a study of eighteenth-century northern England conflicts between masters and apprentices and servants, it was found that in the cases that went before the courts, the apprentice was usually the plaintiff, whereas “while the companies (guilds) offered the masters sufficient scope for correcting their apprentices, the latter had to appeal to the mercy of the more public forum of the quarter sessions to obtain justice.”<sup>46</sup>

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<sup>43</sup>Hamilton, “Enforcement.” In late eighteenth century Montreal, third-party enforcement was buttressed by the apprentices having “sponsors’ who would be held responsible if they absconded, although as she points out, the (fairly small) city “was divided into two smaller, closely knit areas, allowing information about workers to disseminate quickly within (but perhaps not across) the groups” (p. 564). End-loaded payments (either bonds posted or premia paid) that would be forfeited if the worker absconded, were also used. Yet the risk of a premature departure was only one of the many risks that the master faced.

<sup>44</sup>The canonical statement is by S.R. Epstein, “Transferring,” pp. 31-32, who states that the details of the apprenticeship contract had to be enforced through the craft guilds, which “overcame the externalities in human capital formation” by punishing both masters and apprentices who violated their contracts. As late as the eighteenth century, for French bakers, “the guild made the rules for apprenticeship and mediated relations between masters and apprentices . . . it sought to impose a common discipline and code of conduct on masters as well as apprentices to ensure good order” (Kaplan, *The Bakers*, p. 199). The radical Jean Paul Marat, no friend of the ancien régime, worried in 1791 after the abolition of the guilds that apprenticeship would disappear and lead to a decline in the quality of artisanal products. By 1803, the French state had taken control of apprenticeship, which they preferred to restoring the guilds (Fitzsimmons, *From Artisan*, pp. 46, 144-46).

<sup>45</sup>Summarized by Prak and Wallis, “Introduction.”

<sup>46</sup>Rushton, “The Matter in Variance,” p. 92.

Yet there is too much evidence pointing to the guilds being closely associated with regulating apprenticeship to dismiss altogether their role in making the institution work properly. This was especially true when the effective power of local government, to say nothing of “the state,” was limited.<sup>47</sup> In many cases, apprentices had to pay a special fee (known as *lichtgeld* in Germany) to the guild to start their term, and it stands to reason that this fee was for the supervisory functions that the guild exerted.<sup>48</sup> A stylized version of the evolution of apprenticeship suggest that guilds were central in creating the institution in the first place in medieval Europe, and eventually the “market” (backed up by the enforcement power of courts and similar third-party enforcement institutions) took over. In reality, the two systems overlapped, cooperated, and reinforced one another.<sup>49</sup>

European guilds were a classic example of a “corporation” (which is the term used for guild in French) in that it consisted of people who shared a common economic interest and occupation, but who were typically not related.<sup>50</sup> Precisely because they were a form of “social capital,” in which people met and exchanged information, guilds created the networks that supported reputation mechanisms that may have been the most effective way in which most contracts were enforced. As in many models of collective action, each Master had a strong incentive to free-ride and “renege,” unless a penalty was likely. A master who systematically exploited and mistreated his apprentices might gain an advantage on his competitors. The same would be true for a master who poached the trained apprentices from a colleague before they had fully repaid their training cost. The craft guild was one institution that curbed such opportunistic behavior. The many social and professional joint activities bound up in the guild created the kind of phenomenon captured in Spagnolo’s model — the costs of opportunistic behavior could come from a very different corner than where the benefits were.<sup>51</sup>

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<sup>47</sup>As Reith (“Apprentices in the German,” p. 181) put it, “the apprenticeship contract and the guild are ... interdependent solution to the problem of conflicting interests of the parties to the contract.”

<sup>48</sup>Reith, “Apprentices in the German,” p. 182. Schalk, “Craft Apprenticeships,” p. 7.

<sup>49</sup>For example, Bellavitis, Cella and Colavizza “Apprentices in Early Modern,” p. 9 point out that in Venice the guilds monitored apprenticeships but needed the *Giustizia Vecchia* magistracy to enforce their regulations.

<sup>50</sup>Greif, “Family Structure.”

<sup>51</sup>Court records analyzed by Rushton, “The Matter in Variance,” which inevitably recorded the atypical cases of opportunistic behavior, provide a long list of ways in which the master could renege on the contract, including physical abuse, failure to instruct, non-payment of owed wages, the disappearance of the master or his death (and replacement

### **Guilds, Apprentices, and Markets**

Did the role of craft guilds in regulating apprenticeship affect efficiency and the pace of innovation? The debate between those scholars who on balance see craft guilds as a positive force in the intergenerational transmission and accumulation of skills and those who see them primarily as an encumbrance to the development of human capital and well-functioning markets will not easily be decided. It involves a three-dimensional complex phenomenon that stretched along many centuries, a large number of different occupations, and countless localities.

As argued above, guilds were not the only mechanism to enforce and arbitrate apprenticeship contracts; and guilds, moreover, had many other functions unrelated to training. A guild system was thus neither necessary nor sufficient for the emergence of effective apprenticeship institutions.<sup>52</sup> When other methods of contract enforcement were effective, apprenticeship could function without them.<sup>53</sup> Nonetheless, the guilds were an institution that could help overcome some inherent market-failures that might have led to less and lower-quality human capital accumulation than was possible. They set rules to minimize the incentives for apprentices to engage in opportunistic practices. Perhaps the most obvious way was by solving the apprentice's commitment problem discussed above. With the power and authority of the guild behind him, the master could feel that the chances of opportunistic behavior were much lower, since an apprentice who departed before fulfilling the terms of his contract could be denied becoming a master or even employment altogether, or otherwise punished. The guilds had the power to enforce compliance with the contract through a variety of sanctions they could impose on wayward apprentices, including "compulsory membership, blackballing, and boycott."<sup>54</sup> Yet at the same time, guilds used limitations on apprenticeship as a way of

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by his widow).

<sup>52</sup>Ogilvie, *European Guilds*, ch. 7. See also, Hamilton, "The Market," p. 498.

<sup>53</sup>Moreover, even having completed a guild-mandated apprenticeship did not guarantee that after completing his term the apprentice would automatically attain the status of free journeyman or master (De Munck, *Technologies of Learning*, p. 41).

<sup>54</sup>Epstein, "Craft Guilds," p. 61.



generating rents for their members.<sup>55</sup> One complaint is that the uniform length of the apprenticeship term imposed by guilds was an inefficient one-size-fits-all kind of measure, and may have served more as a barrier to entry than as an efficient way of teaching youngsters.<sup>56</sup> That said, the specified duration of the term varied from skill to skill and were a way of ensuring that the master could expect some labor services at the later stages of the apprentice's term. After all, educational institutions have imposed some kind of uniform duration standard on students, including modern universities.

The advantages of a guild-enforced contract system was above all in supporting a system in which kinship was not the chief organizing principle of intergenerational transmission of skills. For one thing, innate abilities differed from father to son, and it seems obviously desirable that the son of a carpenter could become a notary and vice versa. More generally, however, what a non-kinship based system implies is that apprentices could choose a master able to teach them the best techniques extant, and that in principle they could learn from more than one master. De Munck refers to the custom of apprentices to roam from one workshop to the other as “shopping.”<sup>57</sup> A number of the papers in this volume provide evidence of apprentices changing masters, and while it probably was not a very common phenomenon, it may have played a disproportionate role in diffusing best-practice techniques. In many documented cases apprentices were “turned over” to another master—by some calculation this was true of 22% of all apprentices who did not complete their term in England.<sup>58</sup> Estimates for tailors' apprentices in late medieval England who did not complete their

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<sup>55</sup>Adam Smith, no friend of the guilds, noted that the bylaws of the guilds regulate both the number of apprentices that masters were allowed to have and the number of years that each was supposed to serve. “The intention of both regulations is to restrain the competition to a much smaller number than might otherwise be disposed to enter the trade.” Smith, *Wealth of Nations*, pt. I, p. 133. Pfister, “Craft Guilds,” p. 27 has asserted that the exclusionary rents generated by guilds was necessary to correct for the underinvestment in human capital implied by the market failures in human capital formation.

<sup>56</sup>Ogilvie, *The European Guilds*, ch. 7.

<sup>57</sup>De Munck, *Technologies of Learning*, p. 50.

<sup>58</sup>Wallis, “Apprenticeship and Training,” pp. 842–43.

terms have gone as high as two thirds.<sup>59</sup> There could be many reasons for this, of course, including the master falling sick or becoming otherwise indisposed. But at least some apprentices might also have discovered midway of their training that their master did not teach them best practice techniques or that the trade they were learning was not as suitable to them or as remunerative as some other and switched to a different master.<sup>60</sup>

Within the formal stipulations, however, apprenticeship systems could show surprising flexibility.<sup>61</sup> In England, the formal length of the contract (stipulated by the 1563 Statute) was perhaps more of a guideline than a binding constraint.<sup>62</sup> The flexibility of the guild system varied considerably across Europe, but nowhere in Europe was the institution as rigid as the written record suggests.<sup>63</sup> Still, it is no accident that economies in which such flexibility was more pronounced and in which apprenticeship was regarded as a “market” in which the terms between master and apprentice were negotiable were more dynamic and experienced more growth in productivity.

The archetypical example for this kind of flexibility were the Northern Netherlands. In his authoritative work on Dutch technological progress, Karel Davids acknowledges that guilds

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<sup>59</sup>Davies and Saunders, *History of the Merchant*, p. 55. De Munck and Soly, “Learning on the Shop-floor,” pp. 9-10) point out the odd paradox that in many occupations at the end of the ancien regime drop-out rates were exceedingly high (30 percent in France; 20-57 percent in Vienna) and yet their sources indicate that the “overwhelming majority” completed their service. By the eighteenth century the need for flexibility was felt all the more acutely; moreover, the sources may be biased toward cases in which a contract was violated (and a complaint filed) whereas the “normal” state in which an apprentice completed his term may have been less recorded.

<sup>60</sup>In the late eighteenth century when information flows and mobility were of course much higher, such switching and studying with multiple masters was increasingly common (Schalk, “From Orphan,” p. 737). Antwerp apprentices to gold- and silversmiths learned part of the occupation from one master and then switched masters to learn the other parts (De Munck, *Technologies of Learning*, p. 47).

<sup>61</sup>For instance, if an impecunious apprentice could not afford the require upfront premium, he had the option of committing to a longer indenture, as was the case in seventeenth-century Vienna (Steidl, “Silk Weaver,” 143). In eighteenth-century Augsburg a telling example is that apprentices with poor parents who could not afford the premium would end up being trained by a master who did inferior work, and that a “big strong man was often taken on without having to pay any apprenticeship premium, whereas a small weak man would have to pay more ” reflecting the value of anticipated labor that the apprentice could supply (Reith, “Apprentices in the German,” p. 183).

<sup>62</sup>Wallis, “Apprenticeship.”

<sup>63</sup>Prak and Wallis, “Introduction.” De Munck, *Technologies of Learning*, pp. 62-63, illustrates the contract flexibility in the case of Antwerp by showing how the length of the indenture period covaried with the complexity of the trade learned.

“supplied facilities for the training and education of skilled workers.”<sup>64</sup> Yet he shows convincingly that many of the formal restrictions that guilds imposed on apprentices were enforced with a wink and a nod. An example is the “master piece,” a kind of proof of competence that apprentices who had completed their term were supposed to submit. These tests of competence, in Davids’s words, “were characterized by a certain ‘open-endedness,’ which left room for innovation within the margins of a broad, liberal formula”.<sup>65</sup> Moreover, some of the craft guilds could force youngsters to take formal classes in drawing or mathematics if this was deemed a necessary complement to their proper training.<sup>66</sup>

### **Apprenticeship, Labor Markets, and the Distribution of Income**

Pre-Industrial Revolution economies differed from modern ones in many crucial ways, not least of them the way income was distributed between labor and non-labor and the blurry lines between firms and households. While in much of Europe land rents accrued largely to a well-defined class of landowners of whom few worked, in the non-agricultural economy the typical “firm” was a self-employed artisan in a workshop, often in or adjacent to his home. The distinction between household and firm, so fundamental to modern economics, was thus far from sharp. The main reason that so many of the apprentices received room and board was that it was natural for them to become part of the master’s production unit that coincided with the household.

Master artisans produced two products jointly: the goods or services that he supplied, and the human capital of the youngsters created while being trained in his workshop. Training apprentices meant that the master artisan was producing his own replacement but also possibly his own future competitors.<sup>67</sup> In a large competitive industry, these direct effects are very small (since the apprentices one single master trained competed with all craftsmen in that product line in the area), but he

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<sup>64</sup>Davids, *The Rise and Decline*, Vol. 2, p. 423.

<sup>65</sup> A similar flexibility was observed by De Munck, *Technologies of Learning*, pp. 78-79 in Antwerp, where the master piece was to create a formal distinction between approved masters and “unfree” journeymen.

<sup>66</sup>Davids, *The Rise and Decline*, Vol. 2, pp. 382, 486.

<sup>67</sup>At times, contracts were written to preclude such competition, and the apprentice had to commit not to practice in the same location as the master who trained him (see Epstein, *Wage Labor*, p. 109).

produced an externality for the entire industry. To be sure, as long as a master just replaced himself, the number of artisans remained the same. But given that the average apprenticeship length was perhaps four years plus two more years of journeymanhood, each artisan had the potential to train far more apprentices than was needed for his replacement even if he just had one at a time.<sup>68</sup> The much maligned restriction on the number of apprentices that each artisan was allowed to take, which could be seen as a mechanism to prevent such a collective action outcome.<sup>69</sup>

In some instances, such as the case of Utrecht documented by Schalk, only a small percentage of apprentices became masters, so that the threat of more competition was dealt with in other ways.<sup>70</sup> What happened to those apprentices who did not become masters? Given urban mortality rates, it is certain that many of them died. Others never attained master status and found employment as long-term free journeymen, basically skilled laborers. Given that apprenticeship was an urban institution, it also seems plausible that urban training supplied some artisans to the countryside, where people could work in their trades without the restrictions — guild-driven or otherwise— that urban institutions imposed on them. In times of economic boom, masters had a strong incentive to take on a number of apprentices and journeymen.

Indeed, much evidence suggests that the work that apprentices and journeymen carried out for their master was not a corollary of a transaction in which the main exchange was the acquisition of human capital, but in many cases an indispensable source of wage labor in the artisanal economies of pre-Industrial Revolution European manufacturing. In large part this must have been because other forms of wage labor in much of urban Europe were hard to come by.<sup>71</sup> The obvious smoking guns here are that in many cases apprentices were paid in cash in addition to receiving instruction, room

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<sup>68</sup>Ogilvie, *European Guilds*, Tables 7.4 and 7.5.

<sup>69</sup>Reyerson, “The Adolescent Apprentice,” p. 360 suggests a *positive externality* when she writes that “the master provided service to his profession in training new personnel. To enable the perpetuation of skilled labor in various trades it was necessary for training to be well organized...thus the traditions of a town in a particular type of artisanal industrial activity could be sustained.”

<sup>70</sup>Schalk, “Craft Apprentices.” A similar phenomenon is reported by Humphries, *Childhood*, p. 286.

<sup>71</sup>The pioneering paper that focused on apprenticeship as a labor market relation is Reith, “Apprentices in the German.”

and board. Moreover, in the early fourteenth century, when labor supply had increased due to population growth, masters were able to demand more from their trainees and give them less.<sup>72</sup>

In terms of economic analysis, the apprenticeship contract can be depicted as a continuum in the flows of resources between master and apprentice: on the one extreme it was purely a transaction involving the transmission of human capital, in which the master taught and the apprentice learned; in such cases a premium would be paid, or the equivalent in labor services. On the other extreme, apprenticeship could be a pure wage-labor contract under a different name.<sup>73</sup> In the latter cases, the worker learned little or nothing, and expected to be paid. Every apprentice in Europe found himself somewhere on this scale — most of course somewhere between the two extremes, when they learned and worked simultaneously, with the weights shifting toward the latter as the contract reached the end of the term. How important was the labor-market relation relative to knowledge-transfer? Again, Ogilvie’s compilation of scores of disparate sources can be used to document this phenomenon. In a survey of sources taken from all over Europe, spanning over half a millennium, she shows that over half of all apprentices were paid a wage and that the phenomenon was widespread.<sup>74</sup> The bargaining position of apprentices and their chances of finding employment in their occupation in the same location varied over time depending on the conditions of demand and supply in the labor market.<sup>75</sup>

In a competitive model, with well-informed agents, an equilibrium condition would be that both master and apprentice broke even, and that the condition of zero excess profit obtained. This kind of model is deployed by Hamilton for Montreal, but the assumptions she has to make for it to

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<sup>72</sup>Epstein, *Labor Markets*, pp. 216-20.

<sup>73</sup>In Venice a substantial share of apprentices never expected to enter the occupation and Bellavitis et al., “Apprenticeship in Early Venice,” p. 14 suggest outright that it is possible that masters were using apprenticeships as a form of labor contract.

<sup>74</sup>Ogilvie, *European Guilds*, Table 7.10. Specific cases confirm this, such as the orphans documented by Schalk, “Craft Apprenticeships,” in the Dutch cities of Leiden and Utrecht. Humphries, *Childhood*, p. 235, pp. 276-77 also finds that apprentices were paid (if understandably less than free labor), and that their wages rose over the duration of the contract as they became more productive, thus reducing their incentive to run away before their term was up, as noted also by Hamilton, “Enforcement.”

<sup>75</sup>In sixteenth century Zurich stonemasons were often married and the ban on marriage turned out unenforceable; two centuries later this had changed dramatically and married apprentices were very rare. See Reith, “Apprentices in the German,” p. 189.

hold are rather strong, including free exit and entry into a market in which one side only bought the service once, and the other a small number of times. Still, the conditions imply that term length should have varied positively with the net payment to the apprentice (wages plus payment in kind) and training costs across contracts and negatively with the expected quality of the apprentice, which is what her empirical results show.<sup>76</sup> This labor market was affected by the growing division of labor: the finer the division of labor, the simpler the tasks and the easier it would be to get an untrained beginner to be productive (even though the master himself had to acquire supervisory and managerial skills).<sup>77</sup> As markets expanded, the division of labor became finer and the demand for unskilled labor increased even if the workers were termed “apprentices.” The closer the relationship was to one of pure wage labor as opposed to training, the less reluctant the master was to take on more apprentices.

On the labor-supply side, it is worth pointing to the growth in the demand for market-purchased products associated with the Industrious Revolution in early modern Europe; while not much has been made of the growth of teenage labor in the seventeenth and eighteenth centuries in this literature, it stands to reason that once the emphasis shifts from individual income to household income, the demand for market-purchased goods created an impetus by parents to send their children to work and bring home their wages. In half the households surveyed in late eighteenth century England, children contributed to income.<sup>78</sup> This meant that in the process they acquired useful skills, through learning-by-doing and socialization by employers. For the textile workers who came under pressure due to mechanization, children often ended up as pauper apprentices, which may still have given them a chance to acquire valuable skills.<sup>79</sup>

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<sup>76</sup>Hamilton, “The Market.”

<sup>77</sup>A similar idea is suggested in the context of Venice by Bellavitis, Cella, and Colavizza, “Apprenticeship in Early Venice.” An example of a fine division of labor in a high-precision and high-skill industry is the Lancashire watchmaking industry. See Kelly and Ó Gráda, “Adam Smith.”

<sup>78</sup>De Vries, *Industrious Revolution*, p. 217.

<sup>79</sup>Humphries, *Childhood*, pp. 45-46; Horrell, Humphries and Voth, “Destined for Deprivation,” pp. 358-60.

## Apprenticeship, Skills and the Great Enrichment

Human capital stories have not been central in the literature on the Great Divergence or the Great Enrichment.<sup>80</sup> In large part that is because much of the historical literature has focused on two indicators of human capital: literacy and years of schooling. Yet before 1750, it is far from clear how valuable literacy was in the artisanal workplace outside some obvious service occupations such as clerks, notaries, teachers, and priests.<sup>81</sup> It is therefore not all that surprising that Britain could be the technological leader in the Industrial Revolution even when it scores somewhat in the middle of the pack as far as literacy is concerned.<sup>82</sup> A more recent work on the Great Divergence surveys the literature and tends to be skeptical of most human capital measures that explain the difference between West and East.<sup>83</sup> All the same, many scholars have not only made that connection, but argued that artisanal competence was the main factor that drove the Great Enrichment. Epstein goes so far as to shrug off all formal learning as largely irrelevant before the Industrial Revolution and sees improvements in artisanal skills and their successful dissemination as the key to technological progress.<sup>84</sup>

Skills and technological competence were crucial to economic progress. That does not mean that nothing else was; history does not live by one-line explanations. Artisans *by themselves* were limited in how much and how radically they could innovate, as they were taught a set of skills by

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<sup>80</sup>The notable exception is the economist Oded Galor, *Unified Growth*, pp. 30-46, who actually places human capital accumulation at the core of his model of the Industrial Revolution — through remarkably he has nothing to say about apprenticeship. Economics has often identified human capital with formal schooling and literacy, and failed to appreciate the importance of tacit knowledge and the one-to-one transmission of skills. For an introduction to this literature, see Mokyr, “Human Capital.”

<sup>81</sup>Economists have suggested that it was the commercial rather than the manufacturing aspect of artisanal work that required literacy and numeracy. See for instance, Kelly and Ó Gráda, “Artisanal Skills.”

<sup>82</sup>Mitch, “The Role of Education”; Mitch, *The Rise*.

<sup>83</sup>Davids, *Religion, Technology*, pp. 60-74. Needless to say, Davids recognizes the importance of apprenticeship, but he does not draw a direct connection between the difference in the institutions that regulated training and the technological gap that opened up at some point between West and East.

<sup>84</sup>Epstein, “Transferring,” especially pp. 53, 67. Deirdre McCloskey, *Bourgeois Dignity*, pp. 355-365; 2016, pp. 505-506) also dismisses formal science as a major factor in economic growth before 1900. Maxine Berg, “The Genesis,” does not dismiss formal knowledge as Epstein does, but clearly feels that by stressing concepts like the Industrial Enlightenment, my *Gifts of Athena* did not show a full appreciation for the role that artisanal knowledge played in bringing about the expansion of useful knowledge, and how the mobility of tacit knowledge through traveling craftsmen led to continuous improvement.

their masters. Artisans were trained to make things that they had not invented and did not usually design, reproducing a given design over and over. Was innovation possible in such a system? In many cases the rules of the guilds or other ways in which resistance to innovation could show up imposed obstacles to craftsmen who thought out of the box. And yet many of the great inventors of the Industrial Revolution were trained as craftsmen and in some sectors learning by doing and a growing division of labor could lead to sustained productivity growth. Yet without a growing understanding of the natural laws and regularities that underlay the techniques (the epistemic base), the trial-and-error methods of artisanal innovation would inexorably have run into diminishing returns.<sup>85</sup> As early as the eighteenth century, scientific knowledge and methods were crucial to technological progress in a substantial number of areas.<sup>86</sup> The root of Europe's rapid technological progress was neither artisanal skills alone nor scientific advances by themselves, but the synergistic complementarity of the two.

In terms of artisanal skills, Asia in 1500 was still in many ways ahead of Europe, and it was the fine work of Asian craftsmen that made Europeans desire Chinese ceramics, Indian cotton goods, Persian carpets, and similar high-end goods. Yet in the centuries that followed, European skills caught up, and they learned to make the Asian goods they desired, and then learned to make them better and cheaper than the Asians ever could. Without a flexible and open apprenticeship system that responded to demand and in which the high mobility of workers was normal, such a growth in prescriptive useful knowledge would not have happened. Footloose young apprentices and journeymen played an important role not only by disseminating best-practice techniques but also by creating a competitive environment in which creative artisans whose ideas were not welcome at home could move elsewhere.<sup>87</sup> In contrast, technology in Asia, with some exceptions, seemed to have been stuck in place, if often at a high level, and lacked the dynamism of Europe. Flexibility was a key: "skilled" workers who were experts in the old technology would do little for a Watt, a Smeaton, or a Fairbairn, because innovation implied that the old competences were often outdated.

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<sup>85</sup>Mokyr, *Gifts of Athena*, pp. 31-32.

<sup>86</sup>Wootton, *The Invention*, pp. 476-508; Mokyr, *Culture of Growth*, pp. 270-73.

<sup>87</sup>Belfanti, "Guilds, Patents"; Berg, "The Genesis."



New skills, or new combinations of old skills, were needed, and a rigid system of one-master-one-apprentice teaching unchanging old and tried methods would not do. Successful entrepreneurs, such as the Yorkshire textile machine makers were hiring well-trained artisans, and were able to make them do things they never did before.<sup>88</sup>

What was it that led up to the Industrial Revolution and allowed it to become the starting point of sustained technological progress and economic growth instead of just another efflorescence? The cheek-by-jowl growth in *both* the competence of European artisans and insights of *savants* studying natural philosophy that laid out the rules and regularities that made their techniques work was key to Europe's success. Brilliant technical ideas without the workmanship and materials to build them from blueprints would suffer the fate of Leonardo's sketches. The apprenticeship system provided Europe with the mechanics, metalworkers, carpenters, instrument makers, and engineers that could execute and scale up the novel designs and turn them into reality. Mechanics trained as metalworkers, millwrights, carpenters, wheelwrights, and clockmakers were in high demand in the textile machinery sector during the Industrial Revolution (even if the skills did not always carry over easily). Skills acquired through apprenticeship in one industry were of great use elsewhere as long as the workers had the mental agility to continue on-the-job learning after their apprenticeship was completed and to adapt to the needs of the new techniques.<sup>89</sup> The competitive and open system in Britain was more suited to such needs than the more rigid systems elsewhere.<sup>90</sup>

Economies that had developed a flexible, mobile, and well-functioning system of apprenticeship could thus count on a higher quality of skill-supply and experience greater technological dynamism. This was the case in seventeenth-century Netherlands, where in a host of industries, the Dutch developed technological leadership based on their widely-acknowledged expertise.<sup>91</sup> By the

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<sup>88</sup>Cookson, *The Age of Machinery*.

<sup>89</sup>Cookson, *The Age of Machinery*, p. 227 cites the great engineer James Nasmyth dismissive attitude to apprenticeship when Nasmyth pointed out that the great engineers Brindley, Smeaton and Watt owed little to their apprenticeship and everything to their innate genius. That may well be, notes Cookson, but engineering's fundamental needs was for skilled workers capable of quickly learning new shopfloor duties.

<sup>90</sup>Ben Zeev, Mokyr, and Van der Beek, "Flexible Supply."

<sup>91</sup>Dauids, "Guilds, Guildmen"; Id., "Apprenticeship and Guild Control."

eighteenth century, the advantage had shifted to Britain. The French chemist and politician, Jean-Antoine Chaptal was one of many who recognized the importance of tacit knowledge in Britain's precociousness when he pointed out that a central part of British know-how was what he called *tours de main* (tricks) and habits that were the soul of industry. Neither he nor his economist compatriot Jean-Baptiste Say ever spelled out how and why it was that Britain could count on the "superiority of its workmen" (as Say put it).<sup>92</sup> But skills were learned, not transmitted genetically, and as Jane Humphries has emphasized in her seminal paper on the topic, without a better recognition of the efficiency of the system that produced these skills, we will not fully understand Britain's leadership.<sup>93</sup>

Can the difference between Britain and the Continent be generalized to the difference between Europe and Asia? We know all too little how apprenticeship was organized in the East. Most of what we know supports the argument that elsewhere in the world the family still played a much larger role than it did in Europe.<sup>94</sup> One of Europe's unsung advantages recently stressed by economists was that professional and local corporations and organizations replaced kin-based cooperation.<sup>95</sup> There were guilds in China, but much more than in Europe they were dominated by common ancestry. Chinese guild regulations often specifically postulated that only family members could learn the trade.<sup>96</sup> In contrast with Europe, the ancient tradition of a close association between kinship (common origin) and training remained intact. In early twentieth century southern China it was reported that "not only were the elders of the town the heads of the clan but the entire industry was organized and monopolized by the clan."<sup>97</sup> Even fewer details are known about India, though

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<sup>92</sup>Chaptal, *De l'Industrie*, Vol. 2, p. 430. Say, *A Treatise*, Vol. 1, pp. 32-33. Darnton (1984, pp. 114-15) had described Montpellier in the mid eighteenth century as a place in which the products and the scale of production had been static for two centuries. "Despite the expansion of the mid-century years, the economy remained underdeveloped—an economy of tinkers banging on pots in doorways, of tailors sitting cross-legged in shop windows, and of merchants weighing coin in counting houses." This may not be a fair description of the more progressive parts of France, but France depended on British technicians whenever it wanted to introduce any kind of machinery in its industry — mostly at the initiative of the government.

<sup>93</sup>Humphries, "English Apprenticeships," p. 74.

<sup>94</sup>Van Zanden, *The Long Road*, p. 165; Van Zanden and Prak, "Technology and Human Capital," p. 15.

<sup>95</sup>Greif, "Family Structure"; Greif and Tabellini, "The Clan and the Corporation."

<sup>96</sup>Moll-Murata, "Guilds and Apprenticeship," p. 234; Morse, *Gilds of China*, p. 33.

<sup>97</sup>Macgowan, "Chinese Guilds," p. 181; Burgess *Guilds of Peking*, p. 71.

one scholar assures us that “with few exceptions, the apprentices were members of the household and that the family was the main vehicle of training.”<sup>98</sup> While there was a noticeable gap between Britain and much of the continent in the eighteenth century, this gap proved fairly easy to close in the years after 1815. The gap between western Europe and the rest of the world was much larger.

The main institutional advantages that explain the Great Divergence was not only that the European state became somehow more inclusive or open-access, that a bourgeois ethics arose, or the rise of the Republic of Letters.<sup>99</sup> What should not be left out is that a mixture of private-order and local government institutions were able to set up a system of professional training that provided the flexibility and the open-ness to new ideas that allowed Europe to develop a cadre of high quality craftsmen who could turn blueprints into actual working models of machines and then scale them up and produce them with low levels of engineering tolerance. Once built, these mechanics could install, operate, and maintain the machinery that embodied the new technology. Apprenticeship in Europe, with all its flaws, worked well enough. One part of this success was because apprentices and journeymen had far more choice in whom to study from, because they were not limited to masters to whom they were related. As long as that choice was substantial, best-practice techniques could diffuse faster, and productivity grew.<sup>100</sup> To show this in formal models, economists have to make some rather strong assumptions to reach precise conclusions. Relaxing these assumptions, however, only makes the results stronger if less tractable.<sup>101</sup>

To sum up, the Great Enrichment or the onset of modern economic growth is by all accounts an over-determined phenomenon. It has been explained by many scholars, through geography, politics, culture, religion, demography, and luck. To that list we must add something prosaic and down-to earth: technological competence, a practical *savoir faire* of making things through the right

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<sup>98</sup> Roy, “Apprenticeship and Industrialization,” pp. 71, 77.

<sup>99</sup>These are but three hypotheses advanced by recent scholars: Acemoglu and Robinson, *Why Nations Fail*; McCloskey, *Bourgeois Equality*; Mokyr, *Culture of Growth*.

<sup>100</sup>De la Croix, Doepke, and Mokyr, “Clans, Guilds and Markets.”

<sup>101</sup>For instance, the model assumes that the only way for a potential apprentice to learn of a master’s quality is to actually be apprenticed to this master — in reality some prior knowledge about the competence of masters was surely circulating, and while it was never perfect, it still meant that on average more skillful masters would, all other things equal, attract more apprentices and their superior knowledge would spread even faster.

combination of materials, workmanship, and a drive to do things right. Techniques are “prescriptive knowledge,” that is, a set of recipes that describe how to produce a good or service. Because the recipe is always incomplete, to carry out these instructions requires competence, a specific form of tacit knowledge. This competence is not hard-wired into people, it has to be acquired at an early age under the right circumstances. It had little to do with schooling and literacy and for most of the time it was independent of a theoretical understanding of why the techniques worked. Competence required a natural dexterity as well as learned tricks and procedures that were transmitted intergenerationally. The institution that took care of that was apprenticeship, and its crucial role merits the belated attention and research effort that it has received in the past decade. Like all institutions, its form and functionality differed greatly among different societies, and these differences mattered to the outcomes.

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