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European Economic History
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5. ECONOMIC THEORIES OF TECHNOLOGICAL STAGNATION

Introduction

Our examination of the sources of growth in the modern world establishes seemingly one simple point. There was no growth of real incomes in the long run from 10,000 BC to 1800 AD because of the failure of technology to improve at a sufficient pace to break the grip of the Malthusian Economy. Why was the early economy in the grip of such stasis? Why was the Classical world, despite its sophistication in other areas, so deficient in basic production technologies?

This crucial question has been the subject of endless debate by historians, and there are a multitude of theories, most of which can be easily shown to be untenable. Some historians have argued, for example, that Greece and Rome made few advances in production technology because they were slave societies where much of the basic production work was done by slaves so there was no "need" to advance the production technology. Since labor was "free" to slave owners they had no interest in new technologies which saved labor and gave higher output per worker. This ignores the fact that whether you are using slave or free labor has no effect on the financial incentives to innovate in production technologies. To see the fallacy here note that in most slave societies it was possible for owners to rent out slaves.[1] Thus an owner who used a less labor intensive method could generate extra income from any labor that was saved, just as the employer using free labor saves through the cost of less labor hired.

Theories of the stasis of the pre-industrial world can be divided into some basic types. The first of which are those favored by economists which assume that basically people in every age and culture have the same basic motivations and same basic rationality. If the outcomes differ it must be because of the incentives they faced. The second is that innovation depended on social changes - changes in the way people viewed themselves and the world. The third view is that the whole process was just an accident. The Industrial Revolution might have happened in ancient Greece, it might have happened in China in 1400, or it might never have happened.

[1] In ancient Greek cities, for example, there were many slaves who were skilled craft workers and who lived on their own practicing their craft in return for sending to their owners an annual fee.

1. A Lack of Investment in Knowledge

Many economists who have written about the lack of technological progress before 1800, such as Douglass North and Robert Thomas, have argued that the problem is one of a lack of investment in the search for new knowledge. Technical progress is under the control of societies. There are many accidents, much good and bad luck, but any society that invests enough in trying to discover new techniques will eventually discover them. So if progress was not occurring then it was because people were not investing time and energy in looking for new techniques. [2]

The second assumption these economists have wanted to make is that investment decisions are based on a calculus of costs and benefits. Private individuals will invest resources in trying to discover new techniques to the extent that the expected private material returns exceed the private costs.

North and Thomas give as an illustration of this argument that innovation is driven by the comparison of expected gains and expected losses the case of the determination of longitude at sea. To determine position at sea you need to measure both longitude and latitude. The problem of determining latitude was solved early, but the problem of measuring longitude was not solved until well into the eighteenth century. Until then in voyages across the oceans longitude could only be estimated by trying to keep track of how far the ship had progressed each day. Mathematicians convened by Henry the Navigator of Portugal had determined around 1500 that position could be determined if there was an accurate enough measure of time. This clearly defined the technical problem. Thereafter prizes for the invention of a sufficiently accurate clock were in turn offered by Spain, the Netherlands, and then Britain (in 1714), as each became a major sea power. The offer of the prize in Britain stimulated a search by clockmakers for a clock mechanism that would be sufficiently accurate. There was a clear gain to whoever produced the device – the British government was offering £20,000, which was about 500 times the annual wage of a carpenter. One watchmaker, John Harrison, spent most of his life in pursuit of this reward, producing on the third attempt a winning entry, but only after nearly 40 years of effort.[3] Here is a case where the existence of the reward clearly drove the search for the innovation. Had the reward been only £20 then Harrison would not have devoted any effort to the quest. Had it been £20,000,000 then many other watchmakers would have been interested in the search.

Most times, however, innovators were not rewarded by a one time prize, but by some stream of benefits each year into the indefinite future that came

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[2] See, for example, the introduction to Douglass C. North and Robert P. Thomas, The Rise of the Western World. Cambridge: Cambridge University Press, 1973.

[3] Even though he succeeded in meeting the standards set by the British Parliament the inventor still had to press his case for nearly a decade before he got his money.

from exploiting their discovery. In general if C is the expected investment an innovator needs to make to develop an innovation, and B is the expected annual benefit, then the innovation will only be expected to be profitable if

$$C < \frac{B}{(1+i)} + \frac{B}{(1+i)^2} + ... + \frac{B}{(1+i)^n} + ...$$

$$\Rightarrow C < \frac{B}{i}$$

where *i* is the interest cost of the capital invested.

That means that there will be three crucial factors determining the incentive to innovate:

A. The annual benefits of innovation, B.
B. The costs of innovation, C.
C. The interest cost of capital, *i.*

The Material Benefits from Innovation, B

Even though the social benefits of an innovation are great, what will drive individuals is the private benefit - benefits to individuals alone. But the private rewards from technical progress are heavily dependent on social institutions. For the product of invention, knowledge, is a good that cannot generally be kept to the discoverer if it is employed in production. The spinning wheel, for example, was an innovation of the medieval period in Europe. But the 1300 economy had no effective mechanism to protect property in knowledge. I could have worked the machine myself and profited by being able to produce much more yarn per hour than other spinners. In that case the return from innovation would be very modest, and there would be little incentive for anyone to innovate. But suppose I try to increase my rewards by hiring others to work the machine. If it is relatively simple then when others see how it works they will be able to describe that the machine sufficiently well to other craftsmen so that they will be able to produce a replica. Once that happens the machine will spread to all my competitors and my profits will be exhausted. As Richard Roberts, the inventor of the power loom in the Industrial Revolution period noted, "no trade can be kept secret long; a quart of ale will do wonders in that way." Similarly Arkwright the inventor of the first water-powered spinning wheel noted "We may swear [the hands] as we pleased, but if any body would give them a penny more, they would divulge it."[4] Thus there will be little financial inducement for people to pursue easily copied innovations if there is no effective system to protect property rights in knowledge in place in a society.

Similarly we saw that the crucial element in increasing grain yields seemed to be simply introducing nitrogen fixing crops into the rotation. But once the discoverer of this told anyone else how could they profit from the

[4] Houghton, p. 111.

knowledge? They would have nothing to sell to farmers using the new technique. Thus for the discovers of early technologies to make profits there has to be some institution which rewards the innovator. This could be a monopoly right to produce a product, a right to collect royalties from the users or a lump sum reward from the government.[5]

Thus only if society has a mechanism to give property rights in knowledge to the discoverer will there be much private reward. North and Thomas conclude that if technical progress does not occur in early societies it must be because the social institutions had not been established to reward investors in knowledge. Institutions are the key to innovation, and hence to economic growth.

Thus in the case of the marine chronometer, the prize of £20,000 offered by the British government was very small in relation to the social benefit of the innovation. The future social gains from better navigation far exceeded the £20,000 prize. Even one ship saved by the device would have paid the prize cost.[6] Had the government offered more money, or had the money been offered before 1714, then more people would have pursued the device earlier and hence with high probability the breakthrough would have been made earlier.

But early societies seem to have lacked the legal notion that you could own property in ideas or innovations. Thus in both the Roman and Greek worlds when an author published a book there was no legal or practical way to stop the pirating of the text. Copies could be freely made by anyone who acquired a version of the manuscript (on papyrus rolls), and the copier could amend and alter the text at will. It was not uncommon for a text to be reissued under the name of a new "author."[7] It was common to condemn such pirating of works or ideas as immoral. Thus Pliny the Elder in his work *Naturalis Historia* laments "I have found the most professedly reliable and modern writers have copied the old authors word for word, without acknowledgement." But writings and inventions were just not viewed as commodities with a market value, as we now view all such works.[8]

By the thirteenth century in Venice, however, documents show up indicating the state was probably giving inventors exclusive rights to exploit

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[5] In the case of our more sophisticated technologies the discoverer of a new technique may be the only person with the required technological competence to produce the device. In this case they can profit even without any property rights in knowledge.

[6] The monarchies of pre-industrial Europe were typically strapped for cash. And it was likely that the details of any innovation would have leaked out to competing naval powers who would have acquired the benefits at little cost.

[7] This problem continued into at least the seventeenth century in England, where publishers quite freely pirated the works of authors.

[8] See Pamela Long, "Invention, Authorship and Intellectual Property…, pp. 853-7. The struggle over what you can have a property right in continues in modern society. Now the question is whether people have property rights over their genetic code, over information about their consumption patterns, over the use of pictures of them taken in public places and so on.

innovations. By the 15th century true patents in the modern sense were regularly being awarded. Thus in 1416 the Council of Venice gave a 50 year patent to Franciscus Petri from Rhodes, who was thus a foreigner, for a new type of fulling mill. By 1474 the Venetian patent law had been codified. There is evidence for Florence also in the fifteenth century of the awarding of patents. The Venetian innovation granting property rights in knowledge, which was very important to the famous Venetian glass industry, spread to Belgium, the Netherlands, England, Germany, France and Austria in the sixteenth century as a consequence of the movement of Italian glass workers to these other countries. Thus by the sixteenth century all the major European countries, at least on an ad hoc basis, granted property rights in knowledge to innovators. They did this in order to attract skilled craftsmen with superior techniques to their lands.

There were complaints, however, about the effectiveness of these early systems. In England, for example, under the patent system introduced in the reign of Elizabeth I (1568-1603) a patent cost £100, which was a considerable sum for a small innovator, for a 14 year monopoly on the device. The system was originally designed to promote the immigration of Continental craftsmen to England, and was actively supervised by government ministers seeking to introduce better techniques. In the seventeenth century this system was subject to abuse by the impecunious Stuart Kings who sought the revenue the patent fee generated. They would grant spurious monopolies as a way of inducing people to pay for patents. After the Glorious Revolution of 1688-9 the new regime sought to escape the taint of scandal associated with the system by devolving the supervision of patents to the courts. Generally the courts would allow any patent to be registered as long a no other party objected. No major European country had a formal patent system as in England before 1791.

Why did the patent system only develop in the 13th century? And why was it still relatively ad hoc in most countries even in the 18th century? If great social benefits are known to be available then why were all governments from the earliest times not trying to foster innovation at home, and attract innovators from abroad?

One possibility, however, is that a patent system was not brought into place in early Europe because there was no demand for it. Laws are created to deal with a perceived problem or need. Suppose for other reasons no innovation was occurring in these societies. Then there would be no group lobbying the king to grant them a means by which to earn returns from innovation. Trade did exist, and merchant groups formed a powerful lobby to kings pushing for laws and institutions that would foster trade. Cities, for example, were thus often able to buy themselves out of various medieval laws and regulations that hindered their commercial activities. But perhaps there was simply no lobby of potential innovators, and thus no pressure to introduce protection for innovation.

There is also a long lag in Britain between the introduction of an effective patent system and the upsurge of patenting activity in the 1760s just at the time of the Industrial Revolution, which make it unclear if patents were either a necessary or a sufficient condition for rapid innovation. Even after the reforms of 1688-9 the system in Britain was cumbersome and difficult to use, and there

is plenty of dispute about how much this system actually did to promote innovation in the Industrial Revolution. Most of the innovators in the early Industrial Revolution period either did not try to protect their innovations with patents, or were unsuccessful when they tried to do so. Kay patented the first major innovation in textiles in the Industrial Revolution, the flying shuttle, but was financially ruined by litigation costs in trying to defend the patent. Later the textile innovators Hargreaves, Crompton, and Cartwright all derived no benefit from patent protection (Crompton and Cartwright were awarded modest pensions by the government later in compensation). The only early cotton textile innovator able to derive profits from patent protection was Arkwright. But Arkwright made most of his money from setting up factories of his own or in partnership after his patents were invalidated in 1785. Thus it is hard to know exactly how much of the fortune Arkwright made in the textile industry came from the patent rights he took out.

The uncertainties of legal protection for patents are illustrated in the case of John Heathcoat, who patented a lace making machine in 1808. In 1813 when he tried to prosecute an infringer of his patent, he had to abandon the case when it was discovered that a copyist had omitted a single line from the patent specification. In 1816 his patent was secured in a different court case. But at this point there were said to be 156 unlicensed makers and owners of his machines. After the successful legal case Heathcoat agreed to issue licenses for 700 outstanding machines, licenses which produced an income of £10,000 per year. But many unlicensed machines continued in operation, reducing the price of lace, and hence the profit derived from the patent.

Thus the record of the British patent system was a very mixed one. Some innovators were able to secure their rights, but equally some fared very poorly in the courts. From 1750 to 1799 of 18 patent infringement cases brought to court where the verdict is known, only 7 were concluded in favor of the patent owner.[9] Only in the 1830s did the courts become much more favorable to the plaintiffs. And the risk and cost of litigation induced many innovators to compromise with infringers for modest sums, or to tolerate infringement of their patents.

There is also good evidence that a lot of the innovation in the textile industry was quickly leaking from the innovators to other producers with no rewards to the innovators. Knick Harley has reconstructed the profit rates being made by some of the more successful cotton spinning and weaving firms in the early Industrial Revolution period. The cotton spinners *Samuel Greg and partners* earned an average profit from 1796 to 1819 of 11.7% per year, where the safe return on capital would be 5%. This is just a very normal commercial return for a risky venture such as manufacturing. Given the rapid improvements in cotton spinning productivity going on in the industry in these years it suggests that whatever innovations were being introduced were spreading from one firm to another very quickly. Otherwise leading firms such as *Samuel Greg* would have made large profits compared to their competitors. Similarly the firm of *William Grey and partners* made less than 2% per year from 1801 to 1810, which is a negative economic profit rate. The innovations

[9] Dutton, p. 78.

in the cotton spinning industry seem to have mainly caused prices to fall, leaving little excess profits for the firms that were innovating.

The firm of *Richard Hornby and partners* in the years 1777 to 1809 was in a sector of the industry, hand loom weaving, which had not yet been transformed by any technological advance. Yet its average profit rate was 11.4%, as high as *Samuel Greg* in the innovating part of the industry. The conclusion is that the host of innovations in cotton textiles do not seem to have particularly rewarded the innovators. Only a few such as Arkwright and the Peels became noticeably wealthy.

The deficiencies in the patent system led some innovators to prefer secrecy as a way of trying to earn profits from their innovations. A famous example of this is Henry Bessemer's machine for producing gilt powder. Until 1843 gilt powder for decorating was made from little sheets of bronze which were hammered by hand between skins to form bronze leaf which was then pulverized. This hand industry was so time consuming that the resulting powder cost as much as gold. The world gilt industry was concentrated in Nuremberg in Germany.

When Bessemer discovered a set of simple machines which would make gilt powder at far lower cost he decided against patenting his discovery since a patent required describing the machine well enough so that someone else could copy it, and patents only protected the invention in England, not in other countries. To keep his discovery secret he had the machine parts made by different metal forming firms. He and his two brothers-in-law then assembled the parts in an inner room of a factory which had a double set of doors. The inner door was only opened once the outer door had been locked. The factory operated for many years without others discovering the secret producing gilt for about 5% of the cost in Germany and earning Bessemer huge profits. The German industry allegedly sent agents to England to try to bribe workmen to reveal the nature of the machinery, but without success.

If the financial benefits to innovation were often limited, even in the Industrial Revolution, perhaps innovation occurred then at an enhanced rate because the social structure in Britain then made the rewards unusually high. In eighteenth century Britain wealth led quickly to social prestige and political power. Thus Arkwright, the textile magnate, who had completely humble origins was knighted, and became the sheriff of Derby County, a high local position. Robert Peel senior, another early cotton magnate, became a member of Parliament, and saw his son go on to become Britain's youngest prime minister. But it was the case in most continental countries that wealth also led to easy access to the nobility. Thus in seventeenth and eighteenth century France the Kings ennobled large numbers of people in return for cash as a way of raising revenue. Louis XIV is said to have ennobled 500 people in one year alone.[10]

[10] In France before the revolution nobles were exempt from taxes, so that a title was also a valuable thing to possess economically.

Guilds

Guilds are blamed in traditional accounts as a major barrier to technological advance in pre-industrial Europe. But in the light of these problems of getting returns from knowledge they are as likely to have fostered technological change as have retarded it.

What was a guild? In the pre-industrial Europe manufacturing production in most cities was carried out by associations of craftsmen. Those who wished to carry on the trade in a town would have to obtain membership of the guild. There would be separate guilds for each of the trades. Thus in London there were the Goldsmiths, the Grocers, the Merchant Tailors, the Haberdashers, the Ironmongers, the Clothmakers, and so on. The master craftsmen in the guild would employ "journeymen" and "apprentices." Typically to become a journeyman a person would serve a 7 year apprenticeship under a guild master. To become a master required further proof of ability in the trade, and sometimes an entrance fee. The guild imposed restrictions on its members about the methods they could use, and the number of apprentices they could have. The guild would also impose on its members the obligation to protect the secrecy of the craft's methods.

In most countries guilds got their power over their members by virtue of charters granted by the king or by city corporations. These charter granters were willing to confer these privileges since the guilds would often have to pay for the right.

Adam Smith in a famous passage in the *Wealth of Nations* attacks the guilds as being mainly just monopolies in restraint of trade.

> People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices. (p. 128)

Combined with this has been a widespread belief that guilds "systematically opposed technical innovation." However, the evidence that guilds actually did oppose innovation is rather weak. The leading manufacturing economy in Europe from 1580 to 1680 was the Dutch Republic. Much of this production was carried out by members of craft guilds which employed the most advanced technology in Europe in this period.

The reason guilds might foster innovation is that they would be able at least locally to reward innovation. Since they grouped together a large number of producers an innovator could offer to reveal his/her new technology to them for a substantial price (much more than any single producer would pay). Or they can set up incentives for their members to share innovations with their guild brothers. Thus the guild could supplement the early patent system in promoting technological progress.

Prizes

An alternative to a patent system is for the government to reward innovators with prizes in return for their making their innovations public. Such a system operated alongside patents in many European countries. In France in the eighteenth century the King would sometimes reward worthy innovators through either lump sum grants or life pensions, ennoblement and hence exemption from taxes, or setting them up in royal manufacturies. Thus when John Kay failed to enforce his English patent for the flying shuttle in the courts in England he went to France in 1749 and received large cash grants for instructing weavers on how to use the flying shuttle. The Swiss inventor Aimé Argand took out a patent for a new type of oil lamp in England in 1784, licensing the production to Matthew Boulton, James Watt's partner. The ease with which the lamp could be made encouraged a host of infringements, and legal action had to be taken against them. But the legal case failed in 1785, and the patent was declared invalid. In contrast in France Argand was granted a royal subsidy of £1,000 to set up a factory to produce his lamps, and his business flourished until the Revolution.

Prizes as rewards for innovation have two advantages. First it encourages more rapid use of innovations than the patent system. Under a patent system an innovator gets rewarded by charging people a premium to use an idea whose cost to society is now zero. Efficient production of any good in a society has to meet the simple condition

$$p = \text{marginal cost (mc)}$$

where p is the price it sells for, and marginal cost is the cost of producing the last unit. Since knowledge has a zero marginal cost, efficient use of it demands that the innovator charge nothing! By giving a lump sum prize to innovators the king can both get efficient use from the new knowledge and also encourage innovation.[11] Secondly the drawback in the pre-industrial period of a patent system as we saw above was the difficulty of pursuing many small violators of a patent. For an innovation like the railway or the steam engine, where there is a large investment made, and the machine is very visible and easy to locate patent rights are more easily enforced. The patent violator can be located and forced to pay recompense. But for a device that is easily manufactured or copied, and which is used by many, many people, such as a spinning wheel, enforcing patent rights can be impossible. The costs of suing each violator in such a case could easily exceed the benefits, especially if the violators have no assets which can be seized. In that case patent rights would be unenforceable. Such a situation arises now with such products as computer software, which is widely used by individuals. Consequently large amounts of software are illegally copied.[12]

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[11] The patent system for modern drugs often leads to very inefficient use of new drugs. Thus the drug companies charge thousands of dollars for a year's supply of the antiviral drug cocktail used to fight AIDS. This means that in poorer countries most people with AIDS go untreated. But the cost of producing these drugs is only a small fraction of the price charged - most of the price is to cover sunk costs of the research and development of the drug regime. If the governments were simply to buy out from the manufacturers the 17 year patent term for a large lump sum many more people would be treated.

[12] Software firms are able to successfully pursue large corporations for using

Were medieval governments likely to have been awarding prizes to innovators which were equivalent to the benefits to society of their innovations? Here the questions comes as to what the objectives of government are. In modern America the government clearly is inclined towards policies which maximize the growth of GNP. The electorate looks favorably on the politicians who preside over periods of economic growth. But in earlier societies power was never in the hands of a broad electorate. Instead it lay within a small elite - the king and his principle followers. It has been argued that the objective of these kings was not to maximize the output per person in the society, but to maximize the total revenue that accrued to them while ensuring their own position. This revenue the king would use for consumption and for warfare. In modern democratic societies governments collect a large fraction of total income in taxes - typically 30-50%. But medieval kings actually taxed a very small fraction of the total income of their subjects - typically only 1-2%. In this case if an innovation is perceived to lead to an increase in income for the kingdom as a whole of ΔY per year, then the king will get an extra revenue of only $\theta(\Delta Y)$ where $\theta = 0.01$ or 0.02. So the amount the king on average would be willing to pay to encourage innovation would in general be only a small fraction of the value of innovations to society.

Serfdom

In the middle ages in Europe there was supposedly a division of society into three classes or 'orders': noblemen, clerics, and peasants. The benign view of this division was that the lords provided protection, the clergy interceded with God, and the peasants supported the other two groups. A harsher view is that the lords intrigued and fought against each other, the clergy accumulated possessions by selling salvation to the superstitious, and the peasants, the vast bulk of the population, were oppressed and subjugated by both. Allegedly it was a society in which only the clergy were literate. Indeed in English the work 'clerk' or 'clark,' later used for a scholar or a secretary, is from 'cleric,' and earlier was the standard word for a priest of the Catholic Church.

The way the lords were supported initially was by their ownership of both land and of people. In what for us is the most bizarre feature of medieval society, in 1100 in large parts of Northern Europe many of the peasantry consisted of "serfs" (also called "bondsmen," or "villeins," from which we get the modern term villain). Thus the Domesday Book of 1086 in England shows that only about 15% of the population were legally freemen, the rest being villeins or slaves. By the thirteenth century still about 40% of the population are estimated to be villeins. A serf in legal theory was completely owned by the lord. Again in theory all his possessions were the possessions of the lord, he had no legal standing against the lord in the king's court, and in England short of maiming or death, the lord could do with him and his family what he

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unlicensed copies of software, by getting disgruntled employees to report the violations to a national hotline.

wished.[13]

Serfdom was distinct from outright slavery in that the duties and obligations of the serf were defined by the customs of the manor (the estate) on which the serf lived, and he could appeal to the manorial court where he was judged by a jury of peasants (though with the lord or the lord's agent presiding). Indeed there coexisted with serfs a class of outright slaves, though for some reason by 1300 slaves had largely disappeared from countries like England, even though slavery was still perfectly legal.[14] It is not known how exactly the population of peasants was reduced to the position of serfdom by the beginning of the high middle ages. People could become serfs in a variety of ways - as the result of legal punishments, through giving themselves to the church (the "donati"), through selling themselves to lay lords in times of poverty, or through giving themselves to lords in times of disorder and violence in exchange for protection. In England many peasants whom the Domesday book of 1086 showed to be free had been reduced to villain status within the next 100 years. Serfs could be bought and sold. Generally whole manors with the accompanying serfs would be the object of these transactions, but there are records of sales of individual serfs apart from the land. Further when two serfs from different manors were allowed to marry, their lords often agreed to divide any resulting children between them.

If most of the population in early years existed in this state of serfdom, in theory completely owned by their lords, then perhaps they had little incentive to try and better their lot and improve the primitive technology of the society. Did economic growth of the modern form crucially depend on the development of a society of free people? The answer it seems is that while serfdom in legal theory might have destroyed all the incentives for most of the population, in practice the system imposed much less constraint on people.

The details of serf sales, for example, suggest that from fairly early on what was being transacted was not total possession of the individual, but the rights to a defined amount of labor and other dues from the individual. Thus in France in 807 AD two serfs were sold for the equivalent of 45 bushels of wheat each, which would represent no more than two years wages for a free worker.[15] Sometimes lords agreed to each take a defined share of a serf, one taking one quarter, the other three quarters for example, which again implies they were agreeing to share the work and other obligations of the serf.

The serf provided income to the lord in a variety of ways. Typically serfs

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[13] Even in the case of maiming the serf could not appeal in person to the king's court, but a third party could appeal for him, much as a third party can appeal a case of an owner's cruelty to a dog in modern society. The serf had no legal persona in medieval England in the king's courts.

[14] There were still many slaves in Italy in the sixteenth century, and when slavery was outlawed in England in the eighteenth century thousands of people, mainly of African descent, were freed.

[15] Coulton, The Medieval Village, p. 15.

occupied land holdings owned by the lord, and owed both a money rent and labor dues. But the serf also had to grind his corn in the lord's mill or pay a fine, and pay a fine to the manorial court for brewing beer, and pay a fine to marry his children outside the manor, or to send his son to school, and also pay a fine at his death to allow his children to take over the land (called the "heriot").[16] In theory serfs also had to pay fines at the arbitrary will of the lord called "tallage" (or "taille" in France), which was only limited by public opinion and the informal resistance of the peasants collectively. In practice in France the *taille* became an annual tax of a fixed amount of money. The size and extent of these obligations varied from manor to manor, as they were determined initially by the unwritten customs of the manor, and only began to be codified in writing in the late twelfth century. Thereafter most manors had "customals" which recorded the duties owed by each tenant of the manor. In the period where rights and customs were guarded only by memory it is alleged that peculiar methods were used to ensure that a particular right was enshrined in the community memory. Thus in one case in 1294 a lord fixed in memory the grant of half the fines of a local fair to himself by giving 2d. (which would be almost two days wages) to two children to buy themselves cherries. In other cases boys were solemnly flogged or cuffed to impress in their memories the important event that had taken place on that day.[17]

The manorial court where these customs was regulated was another source of profit for the lord, and manorial accounts always had a section titled "profits of the court." For the typical penalty for all infractions in the manorial court was a fine that went to the lord. Thus lords were eager to see that these courts met regularly and pursued wrong doers. Indeed peasants who did not attend each court were themselves fined, the fine being typically about 1.5 days wages. The court levied fines for a variety of offenses including trespass, wounding, eavesdropping, playing football, and calling others names such as "rusticus" (meaning serf), "leprous" or "adulterer." A significant source of court income was fines for "leyrwite," which was a fine for sex outside marriage. Sometimes the fine for "leyrwite" was levied against the parish priest.

Another infamous source of profit was the "jus primae noctis" or "droit de seigneur" found only on the European mainland, not in England. This was the alleged customary right of some lords to spend the first night of the marriage with the bride of their serfs to do with as they wished. Without a doubt this right formally existed - it is found in a customal of Beàrn in 1538, for example - but typically the actual right of the lord was to spend the night with the bride or receive a fine from the serf. Presumably in all cases the fine was paid, so the actual force of this right was just the same as the right to receive a fine on

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[16] The lord's monopoly of the mill was called "ban-mill," and the monopoly of the oven or bakehouse was called "ban-bakehouse." The French peasant thus had to eat "pain banal" all his days, and thus we get the modern terms "to ban" meaning to forbid, and "banal" meaning things that are commonplace or trite. The miller took payment by taking a share of the corn ground called the "mulctura," from which comes the modern expression "to mulct" meaning to defraud.

[17] Coulton, The Medieval Village, p. 73.

marriage.[18]

Lords also claimed the right to require single male serfs to marry widows (presumably to ensure that the dues from the land holding the widow was occupying were paid). Thus in the court roll of Hales Abbey in England in 1274 is recorded "John of Romsley and Nicolas Sewal are given until the next court meeting to decide as to the widows offered to them." Since neither accepted the offer, they were ordered at the next court meeting to pay a fine.

Since early on the obligations of serfs became fixed by the custom of the manner, they effectively owed a lump sum tax to the lord. But this is the kind of taxation system that modern economists have promoted on efficiency grounds. In the modern USA there is a graduated tax on incomes, which is argued to discourage extra efforts and investment in improving personal productivity. There is also a tax on investments and on bequests, which is argued to discourage saving. The medieval serf who had a set of fixed obligations to the lord faced no such disincentives. Once he had supplied his fixed labor obligation and his rent mostly he was free of any tax on his marginal income.

Though the vast majority of the population of western Europe was serf in 1000 over the next 400 years most of the serfs disappeared. They did so not because of any legal reform - in France, for example, there were still 300,000 serfs at the time of the French Revolution in 1789 - but largely because the serfs were gradually able to buy their freedom from the feudal obligations. Once the obligations became fixed by custom they had a market value that depended on the interest rate. Thus the serf could offer to buy out his obligations.

In France this often took the form of entire communities contracting with their lord to buy their freedom in exchange for a large capital sum. Since the obligations of the serfs were limited by manorial custom and could be quite difficult to extract, and since serfdom carried with it social disabilities, lords found that frequently serfs were willing to pay more than the equivalent of the dues the lord received to attain freedom. In England a similar process occurred but in a piecemeal fashion. The feudal dues were always less onerous, and by 1349 most have been commuted into fixed money payments associated with a land holding. Yet personal serfdom still survived as a legal form till much later. In 1537, for example, the English House of Lords rejected a bill that would manumit (free) all villeins. On Forncett manor there were still 8 bond families in 1500, though by 1575 all had bought their freedom, in one case for £120 which is a very large sum in that period compared to average annual wages of rural laborers. In some cases lay lords freed serfs as an act of charity for the good of their souls, but the church which had many serfs on its estates never granted free manumission.

Another way in which serfs would become free would be to run away to

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[18] Coulton, p. 465-6. Coulton gives other examples where the right to receive a fine from the peasant in given circumstances was expressed as either some outrageous penalty was paid or a fine was paid. The writers of medieval customals seemingly had a robust sense of humor.

towns which were free. In England, for example, if a serf managed to live in such a town for a year and a day, then they were deemed to have become free of their lord.

After 1349, the shortage of labor as a result of the Black Death drove up wages and led to lords offering freedom to serfs on much more generous terms, for fear that otherwise serfs would simply run away to other lords who were willing to harbor them as free tenants in order to get their land cultivated. Thus a formal legal structure of serfdom, and of outright ownership of people, gradually eroded in most of western Europe to a system of free labor. Between 1000 and 1400 there was a great institutional change in the economy, though largely by free market means.

The disappearance of serfdom is an interesting case where gradually personal and unlimited ties of dependence between peasants and lords were transformed into impersonal and fixed obligations. The rights to these obligations could then be sold to third parties, or part of the obligation could be sold. And the buyer of the right to the obligation could be the serf himself. Thus while the basic distinction in peasant society early on was between the free and the unfree, market forces gradually began to blur the meaning of this distinction. Serfs could often be much better off materially than their free brethren. There were serfs who were substantial land holders, and who employed many workers. Similarly while the lords in the idealized vision of medieval society were the warrior class, from quite early on manorial estates were increasingly purchased by *parvenus* who had accumulated money from activity as merchants or financiers in cities. As early as the thirteenth century these new 'lords' were buying estates which came with serfs, and with the right to seigneurial monopolies, and the right to levy justice. Some of the purchasers were even wealthier peasants who made their money in farming. Thus the literature of thirteenth century France has many sarcastic references to "villeins" who had set themselves up as lords.[19] Similarly in France one of the most important servile dues, the *taille*, even though it was levied on the serf personally, was often sold by the lord to other purchasers and came to be levied not on the peasant but on the land holding of the peasant. Thus what had been a personal tax transferred and became a tax on land. To confuse the issue further owners of great estates began to give up direct cultivation and management of these estates in the thirteenth and fourteenth centuries, and instead they leased out the rights to the income of the manor, including the right to levy justice, to sub-contractors for a fixed sum in money. These sub-contractors were known in England as *firmarius* or "farmer," which is the origin of the modern word farmer. These manorial rights were still existent in the sixteenth and seventeenth centuries, and were traded as income earning property. Indeed it is still possible to buy the lordship of a manor in England to this very day, though the surviving manorial rights are generally rather limited. There has thus been some debate among historians whether the status of serf was in the middle ages, by for example 1300, regarded as a purely formal one, with a certain fixed set of monetary obligations attached, or whether it was regarded as a shameful position socially.

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[19] Georges Duby, Rural Economy and Country Life in the Medieval West (1962), pp. 235-6.

While serfdom had largely disappeared in western Europe by 1400 to the east of the Elbe river in Germany, serfdom after declining before the Black Death as in the west, began to strengthen again in the sixteenth century and the bounds of serfdom became stronger. By 1700 in large areas of eastern Europe the peasantry was bound in a serfdom that was as severe as that of the early middle ages. In Prussia, for example, ordinances of 1526, 1540, 1577, 1612, and 1633 progressively limited the freedom of peasants to leave the lords land, or to inherit property. Labor burdens were also increased. In Brandenburg in the early seventeenth century the High Court ruled that all peasants were liable to give unlimited labor services to their lords unless they could prove to the contrary. In Bohemia (the western part of modern Czechoslovakia) by 1654 only about 500 out of 64,000 peasants were personally free. It is widely held that the persistence of feudalism in the East of Europe until nineteenth century was responsible for the very low productivity of the agriculture there. The argument is that labor extracted from coerced peasants was of little value being done grudgingly (e.g. the word *robot* comes for the Slavic word for such labor obligations). And peasants had little incentive to improve their own plots since they had no security of tenure.

Overall though we see that fairly early on the institution of serfdom was translated into one in Western Europe at least which provided little in the way of disincentives to innovate or invest, since the obligations of the serf were fixed ones by and large.

Can we say then that small material benefits to innovation delayed technological progress until the Industrial Revolution period. The answer is "probably not." A patent system did exist in the advanced areas of Europe - Northern Italy, then the Netherlands, then England - from perhaps as early as the thirteenth century. It was supplemented by the activities of guilds and by prizes from sovereigns. There was at least some material incentive to innovate before innovation began on a large scale. And the incentives do not seem to have improved appreciably before the nineteenth century.

The Costs of Innovation, C

In economics the cost of any activity such as innovation is the opportunity cost of the innovator's time. What else might smart energetic people do with their energies in 1300 compared to investing energy in expanding the useful knowledge of the society? If there were other easier avenues for advancement then perhaps the problem with pre-industrial society was not so much the low benefits of innovation as the high rewards available to smart people in other activities. The major methods of advancement for an ambitious young man in 1300 in most of Europe would be war, the Church, trade or law. We consider each in turn.

War

War was the normal state of affairs within pre-industrial Europe rather than the exception. The states of pre-industrial Europe engaged in frequent low level hostilities against each other. Thus Scotland engaged in a struggle to stay free of English domination that lasted for over 300 years from the 1296 to 1603, a struggle that was only ended by the Scottish king also becoming the English king. As a result of frequent Scottish raids in these years the area of England within 50 miles of the Scottish border remained very lightly populated in these years because of the frequent destruction of property. Similarly the English kings engaged in a two hundred year struggle to assert their claims to the throne of France and hold on to their French lands that lasted from 1346 until the reign of Henry VIII in the sixteenth century. The table below shows the percentage of years in which there was warfare somewhere in Europe at various times:

700-1000	83%
1501-1600	90%
1601-1700	96%
1701-1800	84%

In the sixteenth century France and Spain were at war almost continually. In the seventeenth century Russia and Poland were at war for 4 out of 5 years, Spain for 3 out of 4 years, and Austria and Sweden for 2 out of 3 years.

Warfare from fairly early on offered an avenue for upward mobility within pre-industrial society. Was the return from waging war, and so redistributing the economic pie within society so high that it diverted the attentions of the resourceful away from the task of increasing the economic pie? War in England from the twelfth century onwards was pretty much a business for the ordinary soldier who expected to be paid well in wages, with the hope of further rewards through booty, plunder and ransom. Wages for soldiers rose in line with general wages in the economy. In the 1260s Welsh archers were being paid 3 d. per day, compared to a typical wage of 1.5 d. a day for farm workers. These wages, however, largely served to cover just the costs of campaigning. The real rewards came in the form of grants of land when an area was conquered, and from ransoms for captured opponents.

Important prisoners would be ransomed by their families for handsome

amounts, so in wars between countries the aim after defeating an opponent was to capture as many as possible. King John of France was ransomed by the English for the staggering sum at the time of £500,000 (this was the equivalent of 1,250,000 acres worth of farmland). Richard the Lionheart, captured on the way back from a crusade, was ransomed for £100,000. The Scottish king fetched only £67,000 when captured by the English. The typical procedure would be that if a high ranked opponent was captured he would be sold first by his captor to his own the King, who would house the captive until arrangements were made to ransom him (for a mark-up) back to his family. Of course, while there was profit in ransoms if a prisoner was captured, there was loss if you yourself were taken prisoner. So while there are many tales of low ranked knights becoming rich as a result of the fortunes of war, there as many of already poor families further impoverished by ransom demands.

Yet though warfare was endemic, the numbers of people directly engaging in warfare in the middle ages was very small. ar in the end probably did not divert too many people from other activities because it was largely what is called a "zero sum game." The gains of one side came from the losses of the other, so that the expected return was 0. Indeed knights at the time seem to have realized the costs of doing battle, and pitched battles were relatively rare. A soldier in the English or French armies in the Hundred Years war would be lucky to have engaged in even one major battle in the course of a military career. Thus Edward I of England, who reigned from 12.. to 13.., and took part in military campaigns in Wales, Scotland, Flanders and Palestine, participated in only one true Battle, in 1298 at Falkirk against the Scots. Instead armies spent most of their time maneuvering, besieging castles and towns, and despoiling the countryside.

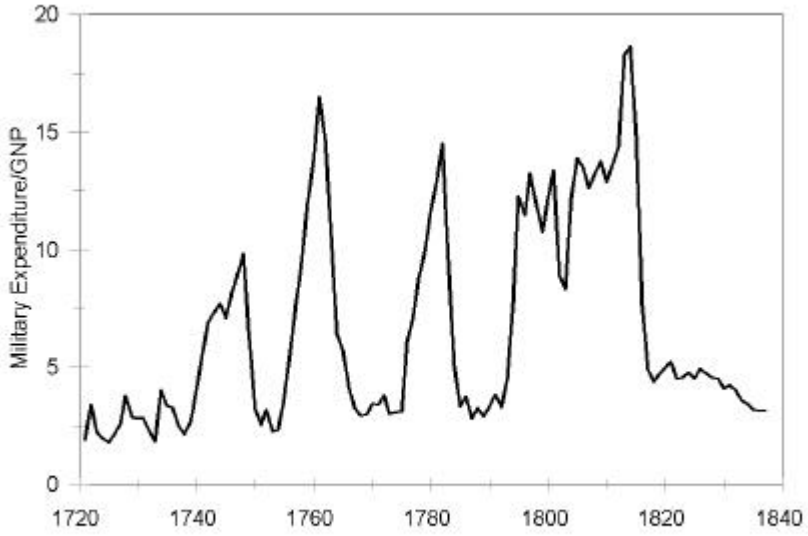
States in these early years were able to raise very modest amounts of money by taxation, and consequently they could support only very small armies. In the campaigns of Edward III against the French in the Hundred Years War from 1345 to 1360 the English typically fielded armies of less than 6,000 men, and their largest forces were only about 10,000. The French fielded larger armies of about 20,000. In Spain Isabella and Ferdinand conquered Granada in 1492 with about 20,000 men.

Indeed the years 1300 to 1800 saw a constant upward movement in the amounts states were spending on warfare, and in the consequent sizes of armies. The grandson of Isabella and Ferdinand, Charles V, deployed as many as 100,000 soldiers against the Turks in Hungary in 1532, and almost 150,000 at Metz in 1552. Charles VIII of France invaded Italy in 1494 with only 18,000 men, but Francis I attacked again in 1525 with 32,000, and Henry II deployed 40,000 at Metz in 1552.

By the mid-sixteenth century both France and Spain seem to have been able to support armies of about 150,000. Only in the 1670s as the French army got bigger did any army exceed this size. By 1691 Louis XIV's army was at 273,000, and by 1696 it had reached 395,000. There was another big increase in the size of armies after the French Revolution of 1789. On the eve of the French Revolution in 1788-9 the royal army had about 150,000 men. By 1794 France had about 730,000 men under arms. Napoleon invaded Russia in 1812 with his Grande Armee of 600,000 men over a front 125 miles wide.

The growing size and sophistication of armies was reflected in a growing tax burden. Figure 1 shows military expenditure in Britain as a percentage of GNP from 1720 to 1840. As can be seen just at the time of the Industrial Revolution, which begins about 1760, expenditures on war had risen to very high levels, averaging about 6-10% of GNP. Thus war was drawing much moree on the energies of society at just the time when economic growth through technological advance was beginning.

Figure 1: British Military Expenditure as a Percentage of GNP



The Church

The church probably provided a more significant diversion of talent. Pre-industrial Europe was by all appearances an intensely religious society, where the church was in all periods at the center of peoples' lives. But this piety meant that by 1100 the church had become enormously wealthy in most of northern Europe. For pious lords and ladies gave or bequeathed land and property to the church in the hope of redeeming their sins after death. Church possessions tended to grow since the abbots and bishops were forbidden to part with endowments, while private estates would be split by inheritance, or sold to pay debts. Indeed it is estimated in England that the church owned about one third of the land by the late middle ages. By 1279 the English king was so concerned about the ever growing wealth of the church that he passed a law requiring that any further donations to the church receive a royal license (the Statute of Mortmain).

The church as a property owner acted just like a very large lay landlord, owning serfs and extracting as much income from these as possible. Bishops and abbots were thus also very substantial lords, with many possessions to manage. This made careers in the church very attractive. Indeed the best positions in the church were generally reserved for the younger sons of the most influential lay landlords. The church further extracted a special tax, called the tithe, from all its members to support the local clergy. The tithe was a tenth of the gross product of all land, so that on arable land where the farmer had to pay for seed, animals, and labor it was a much larger share of the net output. Theoretically the tithe also provided the income for the church to take care of the poor, for there was no government provision for this. By church rules one quarter of the tithe was to be devoted to this purpose, but in practice the amount so used was probably considerably less.

In large parishes the tithe was a substantial source of income. Thus the person appointed priest in such a parish got a rich living. Those appointed to direct such parishes (the *rectors*) found that they could cheaply hire other priests to carry out the duties keeping most of the income for themselves (the term *vicar* comes from the Latin *vicarius* for a substitute, thus the modern term "vicarious"). Thus the income from many parishes began to flow to distant monasteries who owned the right to the position, or to politically influential laymen appointed to the position. Further in both England, France, and Italy some people, in a practice called *pluralism*, began to occupy many of these benefices at the same time, deriving large incomes. Though Pope Alexander III legislated against this practice in the Lateran Council of 1179, the practice continued to be widespread. In the late thirteenth century, for example, Bogo de Clare, a younger son of an Earl of Gloucester, held simultaneously 29 church positions in England: he was probably not even a priest.[20] Bogo could hold his many benefices because he had obtained, presumably by suitable payment, a dispensation from the Pope to hold pluralities.

[20] G. G. Coulton, Medieval Panorama: the English Scene from Conquest to Reformation, pp. 137-141, 154-157.

Within the church money also had its influence. The rich parishioners would have their own special seats in the church, and burial within the church itself was a privilege which could also be purchased. Further the clergy evidently frequently demanded money to perform weddings and burials. Finally the rich often left money to monasteries to pay for masses to be prayed for their souls (the monasteries at times had so many of these bequests that to say the contracted masses they had to hire in poor priests to supplement their numbers).

Though the church in the classical conception of medieval Europe was the repository of learning and education, in practice many clerics had only the most rudimentary knowledge of Latin, the language of the church. An examination of 17 parish priests in the Diocese of Salisbury in England in 1222 found that five had no knowledge of what even the first line of the mass service meant. Further at the local level priests engaged in theological practices which were quite bizarre - one not uncommon practice in the middle ages was the excommunication of animals, typically caterpillars and other rural insect or bird pests, by local priests.[21]

Another odd feature to modern eyes was that churches were often used as places of commerce. Thus parts of Chartres Cathedral in France in the early thirteenth century was rented out on market days to traders and stallholders of various kinds, including money changers. There was a dispute between the canons and the deans as two what share of the income each should receive.[22] Similarly in medieval London lawyers and their clerks would meet each day after lunch in St Bartholomew's Church to transact business.

Church discipline decreed a strict rule of celibacy for priests, but there was widespread keeping of concubines by local parish priests, and clerical bastards were common. Often this practice seems to have been connived at by the parishioners.

In those countries which converted to Protestantism in the reformation - England, the Netherlands, Northern Germany and Scandinavia - the great church estates were largely broken up before 1700. But in countries like France the Catholic Church continued to be a major land owner, though as noted the church as a landowner behaved just like lay landlords.

Did the wealth of the church divert enough talented people away from wealth creating activities in favor of attempting to get a share of the benefits that came from high position in the church? Again the answer is probably "no" when we compare medieval Europe with modern societies. For since the Industrial Revolution there have arisen many other distractions that divert productive energies away from expanding the output of society to redistributing it. The taxing power of governments has risen enormously in the modern world. Figure 2 below shows the percentage of GDP that was spent by

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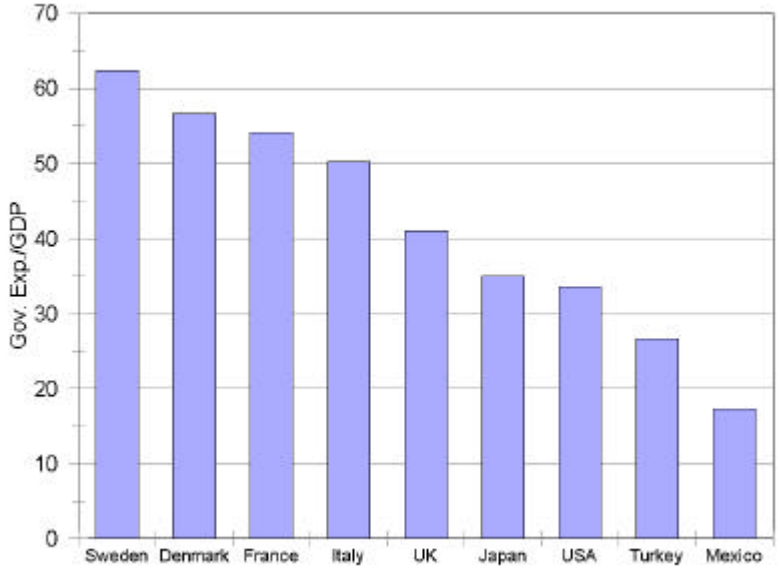
[21] Coulton, The Medieval Village, p. 268.

[22] David Hackett Fischer, The Great Wave: Price Revolutions and the Rhythm of History, p. 12.

Figure 2: Share of Government Expenditure in GDP, 1997 (%)



Source: OECD.

government in various countries in 1997. As can be seen some modern governments spend a very large share of GDP. Thus in Sweden more than 60 cents of every $ is spent by the government. It has been argued by many conservative economists that this huge government sector attracts people of talent and energy away from the productive sector of the economy.

The Interest Cost of Capital, i

The third element in our formula for the decision to invest in innovation above is the interest cost of capital. The higher the interest rate the less investment there will be. We shall see in the next chapter that while modern real interest costs are in the range of 3%, in 1300 real interest costs in Europe were about 10%. This is one key area where the incentives facing pre-industrial producers were very different, and in the next chapter I will consider whether this was the key problem which explains the slow technological development of the pre-industrial world.

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