ECONOMIC PROGRESS AND THE TECHNOLOGY OF WAR IN PRE-INDUSTRIAL EUROPE*

Meir Kohn

Department of Economics
Dartmouth College
Hanover, NH 03755
email: mkohn@dartmouth.edu

November 2005

ABSTRACT: In pre-industrial Europe the technology of war advanced at an unusually rapid pace. The period's almost incessant warfare ensured a strong demand for improvements in the technology of war. At the same time, rapid economic development created an environment that was conducive to the supply of such improvements.

JEL Categories: N430, H560, O310

*This paper is a draft chapter of *The Origins of Western Economic Success: Commerce, Finance, and Government in Pre-Industrial Europe.* Other draft chapters may be downloaded from http://www.dartmouth.edu/~mkohn/

In pre-industrial Europe the technology of war advanced at an unusually rapid pace. The period's almost incessant warfare ensured a strong demand for improvements in the technology of war. At the same time, rapid economic development created an environment that was conducive to the supply of such improvements.

There were two distinct types of government involved in the periods wars.[1] One, territorial government, was predominantly predatory in nature. It was imposed from above by a warrior nobility of kings, princes, and lords. The second type of government—typical of cities and villages—was associational: it was created from below as a framework of joint action. The most important cause for joint action was, of course, military.

War was usually about the control of territory. Territorial rulers went to war to extend their territories or to subdue subjects who resisted their will. Cities, and sometimes villages, fought to protect their liberties from oppressive rulers. Cities, and later territorial rulers, also fought wars for economic reasons—to obtain access to markets or to secure sources of raw materials.

Wars were fought predominantly on land. Armies fought to take or to defend territory and to impose internal control or to resist it. However, wars were also fought at sea. The ability to wage war depended on economic resources, so adversaries engaged in economic warfare—each side harassing the shipping of the other. They might try too to interfere too with the transportation and supply of the other's armies. Governments also used their navies to secure access to markets or to deny it to others.

It is convenient to break our period into two sub-periods, corresponding to two iterations of the political-economic cycle.[2] Each sub-period opens with a time of relative peace and rapid economic development followed by a time of widespread and intense warfare. The first iteration begins in the eleventh century. Trade, previously depressed by raids and invasions, recovers, ushering in an interlude of economic growth and expansion—the Commercial Revolution. At the end of the thirteenth century, a wave of wars breaks out that continues until the middle of the fifteenth century. With the return of peace, a new iteration of the cycle begins with a second, shorter, interlude of peace and

[1]See (Kohn forthcoming) Ch 18 on the structure of government and its evolution.
[2]See (Kohn forthcoming) Ch 18 on the political-economic cycle.

renewed economic progress. A new rash of wars breaks out in the early sixteenth century and continues into the middle of the seventeenth.

THE FIRST CYCLE: ELEVENTH THROUGH FIFTEENTH CENTURIES

The story of Europe's military technology, like much else, begins with Rome. The early Roman empire had a professional standing army numbering in the hundreds of thousands and consisting primarily of formations of massed infantry (the legions).[3] This army was financed from general tax revenue. From the third century, severe fiscal problems led to a progressive decentralization of the empire. Armies were now based locally at the province level and paid for locally. Increasingly, these armies were made up of barbarian tribes recruited as mercenaries and led by their own chiefs.[4] Further disintegration of this structure produced the feudal military of the Middle Ages.

The feudal military

With the disintegration of the western empire, the barbarian mercenaries, and in some areas barbarian invaders, became the territorial rulers. A large standing military was no longer affordable, and it was replaced by much smaller armies that could be mobilized by local rulers as needed. These armies were made up of two parts that corresponded to the two types of government.

The territorial government of the warrior class was organized in a feudal hierarchy. At the top was the king. Below him were the barons or great vassals. They in turn had vassals of their own, and so on, down to the lowliest knight.[5] Vassals were required to provide military assistance to their lords. When called they were obliged to appear for service together with their own vassals and men.

Members of the warrior class fought as armored cavalry. This type of cavalry, and the powerful horses needed to carry it, had originated in Iran. There, it had been used successfully in defending territory against lightly-armed raiders from the steppes.[6] Europeans adopted the idea and found it equally useful against the raiders then harassing

---

[3](Adkins and Adkins 1994) The army grew from about 150,000 in the early empire (plus a similar number of auxiliaries) to between 400,000 and 600,000 in the late empire.

[4](Finer 1997) Ch. 8

[5]For more on the organization of feudal government see (Kohn forthcoming) Ch 18 and (Kohn forthcoming) Ch 21.

[6](McNeill 1982)

their own territories.[7] The invention of the stirrup in the sixth century increased the power of the charge and made heavy cavalry even more formidable. There followed a process of steady technological improvement—better horses, longer and stronger lances, more effective armor.

Armored cavalry was strictly for the nobility: only they had the time for the necessary training and only they could afford the considerable cost.[8] Facility with the use of horse and arms required specialization and full-time training from early youth. The cost of equipping a knight, including his horses (at least one remount was essential), was roughly equal to the cost of 40 cattle—a huge expense. But that was not all. Each knight required in addition the support of a squire to help him arm, a groom to care for his horses, lightly mounted horsemen as scouts and skirmishers, and one or two foot soldiers as guards (the knight and entourage together were known as a 'lance'). The knight himself was expected to cover the entire cost of all this.[9]

Associational government created a very different type of military. To protect themselves against raiders and bandits, villages and cities organized militias.[10] For those that were organized as communes, the communal oath required members to participate in the militia. City militias were often organized on guild or parish lines. Militias consisted mostly of infantry, usually armed with pole weapons or bows. This armament was much less expensive than that of the nobility and better suited to part-time soldiers with little time to train. Members of the militia were expected to provide the necessary arms themselves. Some regions and cities produced better infantry than others. These were typically areas of constant conflict, like the Welsh and Scottish borders and the Iberian peninsula; or mountainous areas, like Switzerland, where cavalry was of little use.[11] Although the essential purpose of the village or city militia was local protection, it could be mobilized by its feudal lord for territorial defense.

---

[7](Bean 1973). The Europeans probably learned the technology from Sarmatian (Iranian) tribesmen who had been employed by the Romans as *cataphracti* or heavy cavalry since the time of Hadrian ((Adkins and Adkins 1994)).

[8](Downing 1992) Ch. 3

[9](Howard 1976) Ch. 1

[10]On villages see (Downing 1992) Ch. 2. On cities see (Nicholas 1997) Ch 7; (Nicholas 1997) Ch. 5; (Hall 1997)).

[11](Downing 1992) Ch. 2; (Hall 1997)

Feudal armies, therefore, combined these two elements—the armored cavalry of the nobility and the infantry of the villages and cities. The infantry was generally of only secondary importance on the battlefield—Hastings being a notable exception. The principal role of the infantry was to defend the cavalry as it formed up for the charge.[12] During sieges, however, infantry was essential.[13]

The feudal military was not particularly effective.[14] The cavalry did not train as a group and it therefore lacked coordination and discipline. Individual knights might break off in the middle of a battle to take hostages or to engage in plunder. Moreover, the level of skill of knights declined over time as nobles devoted more attention to managing their estates and less to military training. Loyalty was frequently an issue as well: nobles could have dynastic ambitions of their own, which might best be served by going over to the enemy. The infantry had its problems too. It was often untrained and poorly armed. Rulers did not necessarily encourage improvement, since there was a danger that city and village militias could be turned against them in rebellion—as they were in northern Italy and Switzerland.

Furthermore, the mobilization of feudal armies was a problem. The obligation of vassals to serve was limited. Generally it extended to no more than two months, after which knights expected to be paid or they went home. Frequently vassals were not required to serve abroad—their feudal obligation being limited to the defense of the realm. Vassals were generally unreliable: they showed up with forces smaller than promised or they failed to show up at all.[15] Since armies were expensive and territorial rulers generally poor, feudal armies were small: no army before the sixteenth century seems to have exceeded a size of 12,000.[16] Armies were therefore much smaller relative to population than the armies of Rome. In all, then, the feudal military had some value in defense, but it was of limited use as an instrument of territorial expansion.

---

[12](Rogers 1995)
[13](Bean 1973)
[14](Downing 1992) Ch. 3
[15](Finer 1997) Vol 2 Ch. 5
[16](Nef 1950) Ch. 5

Early naval warfare

If war on land was the domain of the nobility, war at sea was the domain of merchants and cities. Merchants, because they traveled, were particularly vulnerable to predation. Since governments were unable to provide them with satisfactory protection, they had to protect themselves: armed defense was a normal part of doing business.[17] Merchant ships, therefore, went well armed either alone or in convoy. Of course, a capability for defense also meant a capability for offense. When the opportunity arose, merchant ships were not immune to the temptations of raiding and piracy.[18]

During the Middle Ages, the maritime cities of the Mediterranean maintained permanent war fleets. They used them both to open up new areas of trade and to establish exclusive zones of trade from which they could exclude rival cities.[19] Venice and Genoa fought a series of wars, with Venice eventually victorious, over access to the markets of the Levant. Warships in the Mediterranean were specialized—galleys manned by free oarsmen and carrying archers and swordsmen. Naval battles were much like battles on land: one ship would ram another, then the men would board and fight it out hand to hand. Galleys could also land their men to attack coastal positions.

In the northern seas, there were neither specialized warships nor naval battles. When rulers needed ships they hired or requisitioned them from their merchants; if necessary they supplemented their armament by adding more fighting men.[20] Rulers used these ships to carry troops and supplies. They also used them as instruments of economic warfare, harassing the coasts and shipping of their enemies and defending their own.

The impact of the Commercial Revolution

The Commercial Revolution increased the resources available to rulers, lords, and cities. This had a huge impact on the technology of war.

Both nobles and cities strengthened their fortifications.[21] Before the eleventh century castles had been made of wood. Wooden castles were of limited value because they rotted quickly and were vulnerable to fire in a siege. Their advantage was that they could

---

[17]See (Kohn forthcoming) Ch 5.
[18](Nicholas 1997) Ch 11
[19](Tracy 1993), (Mallett 1994)
[20](Mallett 1994)
[21](Brice 1990)

be constructed easily and cheaply from local materials. Stone castles, while more durable and nearly invulnerable, were far more expensive. The construction of a stone castle took years and required the skills of specialized masons and scoffolders and the planning and supervision of professional architect-builders. The necessary stone usually had to be brought from a distance. Both services and materials had to be paid for in cash. Consequently, it was not any advances in technology that lay behind the widespread construction of stone castles. Rather it was the commercialization of agriculture and the rising income of the nobility from their land. Advances in technology were a result of the building boom that went on into the fourteenth century. Similarly, it was the rising incomes of the cities that enabled them to improve their fortifications: the number of cities with stone walls doubled by the end of the thirteenth century.[22] The rapidly growing cities of northern Italy had to build new sets of walls each time they expanded beyond the old ones.

The proliferation of stone castles and of walled cities changed the nature of warfare.[23] Set-piece battles became a rarity, and war became a series of sieges. In this type of war, the advantage was with the defender. Stone fortifications could not be carried by force and their defenders could be subdued only by starvation. Unfortunately the besieging force—which needed to be much larger than the one defending—was only slightly less vulnerable to starvation and considerably more vulnerable to disease. Wars were therefore long, and they rarely managed to change the political map. The nature of war made it possible for smaller entities—such as local lords and cities—to hold out against larger and much more powerful adversaries.[24]

The increasing prosperity of the cities also provided them with the means to improve the effectiveness of their militias.[25] Such improvement was partly the result of larger numbers: as cities grew in size they could field larger forces. The Flemish army at

---

[22](Tracy 2000). In France, the building of city walls began only in the fourteenth century with the onset of the Hundred Years War ((Wolfe 2000)).

[23](Bean 1973)

[24]The right of fortification, therefore, became an important issue ((Tracy 2000)). Territorial rulers insisted that no fortifications be built without their permission. Cities demanded or purchased the right to do so. Of, course, to build walls was to invite a siege from an invading army, so not all cities were eager to do this. In some cases, as in France, it was the ruler who insisted on the building of walls. ((Wolfe 2000))

[25](Downing 1992) Ch. 3

Courtrai, for example, was larger than the French army that it faced.[26] Better training helped too, as the tactics of employing massed infantry were rediscovered. Better weapons also made a contribution. The cities were the centers of manufacturing, and they produced for themselves the arms that best suited their own needs. The prime example was the crossbow.[27] A merchant's weapon *par excellence,* the crossbow was the 'equalizer' of the Middle Ages: knights tried to have it banned as unfair. It was expensive but easy to use and a much safer bet for the unskilled than hand-to-hand combat with lance, sword or mace. The crossbow was particularly useful in defending city walls and in naval warfare.

As a result of these improvements, urban infantry was increasingly able to stand up to and defeat the knight-based armies of territorial rulers—most importantly at Legnano in 1176 when the Italian cities defeated the cavalry of the German emperor and at Courtrai in 1302 when the cities of Flanders defeated the knights of France. Village infantry improved too. Swiss villagers were able to defeat repeatedly the knights of the Hapsburgs and later of the Burgundians. England came to depend more on its village infantry—especially its longbowmen—than on its noble cavalry.[28] Of course, the greater effectiveness of infantry militias had political implications.[29] Towns and even rural communities (in Switzerland) succeeded in asserting their independence from territorial rulers and in gaining a voice in representative assemblies.[30] Popular rebellions became a serious threat to territorial rulers and to city elites.

The commercialization of warfare

The most important way in which the Commercial Revolution affected the technology of war was, however, indirect. By putting greater resources at the disposal of territorial rulers and local lords, it made it possible for them to go to war. They never

---

[26](Rogers 1995)

[27](Hall 1997) The crossbow was far from new. It had been used in China since the fourth century BC and had been known to the Romans. It was only during the Commercial Revolution, however, that its use in Europe became widespread. Improved technology lowered the cost of manufacture and rising urban incomes made the crossbow affordable.

[28](Howard 1976) Ch 1. Heavy cavalry was ineffective in guerilla war on the borders: English knights were decisively defeated by the Scots at Bannockburn in 1314. In place of heavy cavalry, the English developed companies of longbowmen as a sort of field artillery.

[29](Rogers 1995)

[30]See (Kohn forthcoming) Ch 21.

lacked the motivation—that was always there—but they often lacked the means.[31] So more resources meant more war. Independent cities too became more aggressive as they became wealthier. As a result, from the end of the thirteenth century until the middle of the fifteenth Europe was engulfed in a series of wars. The pressure of constant warfare brought important changes. The biggest change was that war became increasingly commercialized. Both rulers and cities, each for their own reasons, came increasingly to rely on mercenaries.

For territorial rulers, it was primarily the deficiencies of the feudal military that led them to increase their reliance on mercenaries. Trained professionals were both more reliable and more effective: "In war, as in most trades, the specialist has the advantage."[32] It was, for example, confidence in his mercenaries that allowed Edward III of England to attack France, a larger and more powerful adversary.[33] The king of France was forced to follow suit and he soon hired mercenaries of his own. By the middle of the fourteenth century mercenaries made up the core of both armies.[34] Other territorial rulers, such as those of Castile and Aragon, learned the lesson. Increasingly, rulers commuted the feudal obligation of their vassals to serve in exchange for the payment of money 'scutage' and used the proceeds to hire mercenaries in their stead.

In the cities, economic growth raised the value of a citizen's time and made service in the militia increasingly onerous. At the same time, the growing population of the cities weakened social bonds, so the obligation to serve was felt less keenly. Internal conflicts within the cities—between rival factions and clans or between merchants and artisans—made an armed citizenry seem less desirable. The hiring of mercenaries from outside the city offered a solution to all of these problems.[35] And, of course, full-time professionals were more effective. The independent cities of northern Italy began to hire mercenaries in the late thirteenth century and by the mid-fourteenth their citizen militias had largely disappeared.[36] By the end of the fourteenth century, the major cities had used their

---

[31]See (Kohn forthcoming) Ch 18.
[32](Bean 1973) p 217
[33](Ertman 1997) Ch. 2
[34](Howard 1976) Ch. 1
[35](McNeill 1982) Ch. 3
[36](Nicholas 1997) Ch. 5; (Hall 1997)

improved armies to bring the smaller cities around them under their control, creating city-centered territorial states. These larger states required more or less permanent armies to man their garrisons and to protect their borders, and they hired companies of mercenaries under long-term contract to perform these tasks.[37]

Of course, mercenaries were not an invention of the fourteenth century. England was already hiring mercenaries in the eleventh century. The first territorial state to collect significant taxes in money, it used the proceeds at first to pay the Vikings protection money (the danegeld). However, in 1012 the king came to the conclusion that the money would be better spent on mercenaries to defend the country against the Vikings.[38] When William of Normandy conquered England in 1066, many of his knights were foreign mercenaries. More generally, many of the medieval campaigns of conquest—in Sicily, Spain, and the Levant—were undertaken not by feudal armies but by *ad hoc* bands of adventurers who expected to be rewarded in land or loot.[39]

What was new in the fourteenth and fifteenth centuries was that the profession of mercenary became more organized and business-like. Rather than individuals hiring on under short-term contracts, military entrepreneurs put together complete companies of mercenaries and contracted them out on a long-term basis. In England this arrangement grew out of the practice of paying vassals for service beyond that required by feudal obligations. This payment created an incentive for vassals to show up with more than their required force so as to collect more pay. By the end of the thirteenth century, some great nobles were putting together forces of thousands of men and offering them for hire.[40] At about the same time, the Italian cities began to pay contractors (*condottieri*) to put together formations of troops, train them, and lead them in battle.[41] Military entrepreneurship extended to the sea as well with contractors offering complete war fleets for hire. Philip VI of France, for example, brought a Genoese mercenary fleet from the

---

[37](Mallett 1994)
[38](Kaeuper 1988)
[39](Redlich 1964) Ch. 1; (Bean 1973). For example, El Cid was a mercenary ((Downing 1992) Ch. 3).
[40](Redlich 1964) Ch. 1
[41](Ertman 1997) Ch. 2

Mediterranean to harass the English in the Channel: in 1338, this fleet sacked Southampton.[42]

Military entrepreneurs faced no shortage of potential recruits. Initially, most mercenaries were mounted knights. The military class produced a surplus of warriors—landless second sons or illegitimate sons with no profession other than arms.[43] Men like these, together with their supporting 'lances', were happy to sign on with any captain in need of men. The supply of potential recruits expanded whenever a major campaign ended, throwing many knights out of work. Among the first mercenary companies in Italy was a group of English knights under Sir John Hawkwood that had been left unemployed by a lull in the Hundred Years War.[44] Mercenary cavalry was soon joined by mercenary infantry. The battlefield success of infantry in defeating mounted knights created a demand for their services, and military entrepreneurs were quick to capitalize by organizing town and village militias into mercenary companies—crossbowmen from Genoa and Provence and pikemen from Brabant and the Swiss valleys.[45]

Employing mercenaries, for all its advantages, was not without its problems. As demand grew, good mercenaries became increasingly expensive. If the money ran the mercenaries would quit: as the saying went, *pas d'argent, pas de Suisse*. Worse, if they received a better offer, they might switch sides.[46] Mercenaries could also become a menace to their employers. Great nobles who organized armies for hire, could and did turn them against their rulers in support of their own dynastic claims.[47] Cities too were at risk from *condottieri* who might decide to take over the cities that employed them (this happened in Milan with the Viscontis and again later with the Sforzas).[48] Once their contracts were up, paid-off mercenaries alone or in groups often supported themselves by becoming brigands. In the period of the Hundred Years War, bands of unemployed mercenaries (*écorcheurs*) roamed France plundering more or less at will. One group, the

---

[42](Scammell 1981) Ch. 4. Genoese naval *condottieri* provided war fleets to rulers from France to Persia.

[43](Howard 1976) Ch. 1

[44](Howard 1976) Ch. 2

[45](Hall 1997), (Bean 1973)

[46](Veseth 1990)

[47](Ertman 1997) Ch. 2

[48](Howard 1976) Ch. 2

'Great Company', some ten thousand strong, descended into Italy and for years lived on protection money extorted from the smaller cities there.[49] Of course, an obvious solution to the problem of unemployed mercenaries was to keep them employed, and this was an important motive for the establishment of the first standing armies.[50]

Commercialization changed not only the organization of war and the weapons of war, but also the very nature of war.[51] The military profession shifted from a warrior culture (chivalry) to a market culture—from prowess and honor to whatever works.[52] One of the results was that war became more deadly. Battles between feudal armies had been more like sporting events with relatively few casualties. Knights, united by a 'fellowship of arms', fought each other one-on-one with the loser usually taken captive and ransomed: substantial ransoms provided a strong incentive to capture rather than to kill. In one striking example, John II of France, captured at Poitiers in 1356, was ransomed for £500,000—about twenty times the annual income of the king of England.[53] All this changed as armies were drawn more and more from the non-noble population, as they fought in formation rather than individually, and as they came to rely on weapons that killed at a distance. Moreover, as soldiers fought for pay, the right to ransom and booty increasingly passed to their employers.[54] Mercenary armies were not, however, reckless: good companies were hard to assemble and expensive to arm, and their captains did their best to minimize casualties.[55]

Technological progress

The commercialization of war accelerated technological progress, as suppliers of military services competed with one another for contracts and as suppliers of weaponry

---

[49](Howard 1976) Ch. 2. Siena was so weakened by the cost that it volunteered to be taken over by Milan which was able to defend it against the 'companies of adventure' ((Caferro 1992))

[50](Bean 1973) France established the *gens d'armes* and *compagnies d'ordonnance* in the mid-fifteenth century largely for this reason. Their officers were directly employed by the crown rather than by contractors.

This 'nationalization' of the commercial military is consistent with a more general movement towards state-owned enterprise in France at this time: see (Kohn forthcoming) Ch 22.

[51](Rogers 1995)

[52](McNeill 1982)

[53](Rogers 1995)Even ordinary noblemen could be ransomed for amounts in the tens of thousands of pounds.

[54](Contamine 2000)

[55](Howard 1976) Ch. 2

competed with one another for sales. Professional armies that trained as units were able to develop and to execute more complex and more effective battlefield tactics. And the captains of mercenary companies were in the market for the best and latest weapons. This created a lucrative and highly competitive market for the manufacture of arms.[56]

Before the Commercial Revolution, the manufacture of arms had largely been in the hands of hundreds of government-operated armories across Europe. Not facing much competition, these had not been especially innovative, and they had turned out weapons of mediocre quality. However, competition among commercial manufacturers changed the picture radically. A number of cities came to specialize in the large-scale manufacture of arms, with a consequent acceleration of technological progress. The most important producers were located in the two urbanized central regions of Europe: Milan, Brescia, and Venice in northern Italy; Augsburg, Innsbruck and Nuremberg in neighboring Southern Germany; Bruges, Lille, and Liege in the Low Countries.[57]

The most significant new weapon of the period was the cannon. Gunpowder was invented in the early thirteenth century, apparently independently of its more or less simultaneous invention in China and elsewhere. The technology of casting from bronze, first applied to the manufacture of church bells, was developed in the twelfth and thirteenth centuries. These two technologies were combined to produce the first cannon in northern Italy in the early fourteenth century.[58] The earliest recorded evidence is of an order for bronze cannon for the defense of Florence in 1326.[59] The French were quick to adopt the new weapon to provide counterfire against English archer 'artillery', using it to break up formations of English bowmen.[60] Improvements in arrow technology that enabled arrows to penetrate chain mail had made the English archers a much greater threat to French armored cavalry, as was demonstrated dramatically at Agincourt in 1415.[61]

---

[56]"Commercialization of military service depended upon, and simultaneously helped to sustain, the commercialization of weapons' manufacture and supply.… Easy and open access to arms was therefore a *sine qua non* of mercenary war." (McNeill 1982) p 79

[57](Hall 1997)

[58](Nef 1950) Ch, 2

[59](Batchelor and Hogg 1972)

[60](Howard 1976) Ch. 1

[61](Nef 1950) Ch, 2

The first cannon were small and their effect mostly psychological. They did not initially have much impact on the battlefield: mechanical siege engines continued in use for at least another century. However, there was steady technological progress, much of it the result of contemporary advances in chemistry, mining, and metallurgy.[62] The discovery in the late fourteenth century that saltpeter could be extracted from organic material dramatically lowered the cost of gunpowder.[63] New techniques of extracting silver in the fifteenth century produced large quantities of copper as a side-product and greatly reduced the cost of bronze. By the early fifteenth century, mobile trains of bronze cannon were starting to be used successfully to reduce stone fortifications.[64] The development of lighter guns and the invention of the two-wheel gun carriage towards the end of the fifteenth century further improved mobility.[65] In the sixteenth century, new methods of producing iron lowered its cost enough for iron to replace stone in the manufacture of cannon balls. In addition, improvements in design, especially the lengthening of barrels, and better gunpowder (granulated rather than fine dust), resulted in improved accuracy.

The taste of urban militias for missile weapons created an obvious market for a smaller, more portable firearm that could be used by a single individual.[66] In 1418, arms manufacturers in the South German cities came up with a mini-cannon, called the 'hook gun', that proved invaluable in defending city walls against besiegers. The hook gun evolved into the matchlock and arquebus and in the early sixteenth century into the musket. These firearms were cheaper and easier to operate than crossbows.[67] Around 1500, manufacturers also invented for their urban customers the wheel-lock pistol (the precursor of the flintlock)—a weapon that could be carried in a holster, fully primed and ready to shoot.

---

[62](Contamine 1984)
[63](Hall 1997)
[64](Rogers 1995)
[65](Nef 1950) Ch, 2
[66](Hall 1997)
[67]Crossbows themselves were undergoing significant technological progress—composite bows, better strings, and more reliable trigger mechanisms. The introduction of steel bows in the early fifteenth century increased power and reduced weight, but it also raised cost significantly.

Not only did commercialization and competition lead to technological progress in the products of the arms industry, it also led to technological progress in production. The cost of weapons fell steadily for centuries.[68] Moreover, the competitive pressure in this industry must have been particularly strong, because the price of weapons fell even relative to comparable non-military manufactures.

THE SECOND CYCLE: FIFTEENTH THROUGH SEVENTEENTH CENTURIES

The wars that began at the end of the fifteenth century saw an acceleration in the development of the technology of war. It was so rapid that it has come to be known as the 'military revolution'.

The military revolution on land

The development of mobile siege guns by the late fifteenth century temporarily shifted the advantage to the offensive. Existing stone fortifications proved unable to withstand the pounding of cannon. For example, Constantinople and Granada, which had held out for centuries, fell to siege artillery in 1453 and 1492 respectively.[69] The result was a shift in tactics: the enemy now had to be defeated on the battlefield. The early sixteenth century consequently saw more open battles and fewer sieges. In these new circumstances, campaigns of conquest became a realistic and tempting possibility. Most notably, France launched a series of aggressive campaigns in Italy from 1495 in the first extensive use of horse-drawn siege artillery.[70]

Initially taken by surprise, the Italians, the acknowledged masters of military technology, soon developed new techniques of fortification. They created what came to be called the *trace Italienne*—low earthworks, able to absorb cannon fire, arranged in a pattern to maximize the effectiveness of defensive artillery. By the 1530s, the balance had shifted back in favor of the defensive and war became once again a series of sieges.[71] The principle difference was that fortifications now needed to be on a much larger scale.

---

[68](Hoffman 2005)

[69](Bean 1973); (Parker 1995)

[70](Nef 1950) Ch, 2

[71](Howard 1976) Ch. 2. The Dutch, for example, held out behind their fortifications for eighty years against the might of the Hapsburg empire.

This meant fewer fortified places and larger garrisons to defend them.[72] This meant of course that the besieging armies had to be larger too.

The core of the new larger armies was professional infantry. This consisted of battalions of pikemen increasingly supplemented with units equipped with firearms. The new infantryman was much less costly to equip and to train than the feudal knight. Pikes and muskets were relatively inexpensive. An infantryman's equipment cost no more than a week's wages (a cost that was often deducted from his pay). And the use of pike and musket required no more than modest skill:

> The mercenary in the middle of a pike-square needed little training and less skill: if he inclined his pike in correct alignment and leaned heavily on the man in front of him, he had done almost all that could be required of him. So too with the musketeer: a certain dexterity in loading… a certain steadiness in the ranks, sufficed to execute the counter-march, since no one could reasonably demand of a musket that it should be aimed with accuracy. The training of a bowman, schooled to be a dead shot at a distance, would be wasted on so imperfect an instrument as an arquebus or a wheel-lock pistol; and the pike, unlike the lance, was not an individual weapon at all. One reason why firearms drove out the bow and the lance was precisely this, that they economized on training.[73]

This made it possible to recruit and to field much larger armies: while the supply of knights was limited, the supply of men who could be turned into tolerable infantry was almost inexhaustible.[74]

In this environment, armored cavalry had become an anachronism. Defeats by organized infantry in the fourteenth century were followed by more defeats in the fifteenth: in particular, the Swiss repeatedly vanquished armies of knights sent against them by the Dukes of Burgundy.[75] Despite its repeated failure on the battlefield, armored heavy cavalry persisted into the sixteenth century. One reason it did so was the mystique. Succumbing to nostalgia for the chivalric ideal, the nobility invested in ornate armor, staged costly tournaments, and vied for membership of bogus new 'orders' such as the

---

[72](Bean 1973)
[73](Roberts 1995) p 14
[74](Parker 1995)
[75](Mallett 1994)

Garter and the Golden Fleece.[76] A second and perhaps more important reason was that rulers were hard pressed for cash and feudal levies, where they still existed, were relatively inexpensive.[77] Nonetheless, by the middle of the sixteenth century, armored heavy cavalry had largely disappeared from the battlefield. It was gradually replaced by more effective light cavalry, which the Europeans copied from the Ottomans.[78] Like professional infantry, light cavalry fought not as individuals but in formations and, increasingly, using firearms (pistols).[79] By the 1550s, armies were composed of varying proportions of infantry, light cavalry, and artillery.

For much of the sixteenth century the Spaniards were the masters of infantry warfare. Their continuing war with France over the control of Italy required them to maintain a permanent army there—the first substantial standing army in Europe since the time of the Romans. This army was made up of a number of relatively large infantry units, the *tercios.* The typical *tercio* consisted of ten companies each of 250-300 men. Half were armed with long pikes and body armor (corselet); the other half were armed with arquebuses and subsequently (from 1521) with muskets.[80] Their heavy reliance on firearms gave the Spanish infantry a significant advantage over the French.

Towards the end of the sixteenth century, the Spanish infantry was surpassed by the Dutch. The Dutch too were faced with a continuing war—with Spain—and they too had to maintain a permanent army. However, unlike the Spanish army in Italy—or the Spanish army in the Low Countries—the Dutch army was stationed on Dutch territory. This created a serious problem, because soldiers were notorious for the crime and destruction that they visited on their civilian hosts—whether hostile or friendly. The Dutch addressed this problem by imposing unusually strict discipline on their troops and by keeping them constantly occupied with training and drill.[81] Beyond the benefits to the civilian population, their discipline and training enabled the Dutch infantry to execute complex new infantry tactics, such as the volley and the 'countermarch', that would not

---

[76](Howard 1976) Ch 1: "And as their usefulness diminished, so their pretension grew."
[77](Downing 1992) Ch. 3
[78](Howard 1976) Ch. 1; (Parker 1995) The Spanish light cavalry even wore turbans.
[79](Hall 1997)
[80](Glete 2002) Ch. 3
[81](Israel 1995) Ch. 12

otherwise have been possible.[82] Maurice of Nassau, the great Dutch military innovator, also introduced new siege tactics. Instead of trying to starve out an enemy, he relied on massive bombardment and the use of his infantry to dig trenches (an unprecedented indignity for the professional soldier). This enabled them to approach and finally to breach enemy fortifications.[83]

The military revolution at sea

The cannon revolutionized war at sea even more than it did war on land.[84] From the fourteenth century, ships began to carry small cannon as anti-personnel weapons. However, it was not until the late fifteenth century that cannon became sufficiently accurate and reliable to have a significant impact on naval warfare. The first sea battles to be decided by gunfire rather than by boarding took place in the Indian Ocean in the early sixteenth century.[85]

Initially, far from making the galley obsolete, the cannon gave it a new lease on life. The cannon was an 'equalizer' enabling the smaller low-lying galley to hold its own against large high-sided sailing ships that had previously been impervious to its attacks. It also enabled galleys to act as floating siege artillery, reducing coastal fortifications.

As a result, naval warfare in the Mediterranean during the sixteenth century was dominated by the galley. Sea power was of vital importance in the Franco-Spanish war in Italy. Both sides relied on their naval forces to secure their communications, to supply their armies and transport them up and down the peninsula, and to provide artillery support.[86] Sea power played an even more vital role in the war between Spain, aided by other Christian powers, and the Ottomans. This war, which ranged across the whole of the Mediterranean, came to a climax with the great sea battle of Lepanto in 1571, where a

---

[82]The countermarch consisted of the first rank fining a volley and then retiring to the rear to reload (which could take ten to fifteen minutes), while the next rank and then the next did likewise. The Dutch used smaller companies (of 120-150), with more officers, arranged in ten ranks rather than the massive square of the Spaniards. The smaller units, with more officers, were more maneuverable in battle. ((Glete 2002) Ch. 4)

[83](Israel 1995) Ch. 12

[84](Unger 1980)

[85](Mallett 1994)

[86](Glete 1999) Ch. 6

joint Spanish-Venetian—papal fleet of over two hundred galleys defeated an Ottoman fleet of nearly 300.[87]

The galley was less suited to stormier conditions of the northern seas. There, from the late fifteenth century, territorial rulers began to build large specialized sailings ships designed to carry cannon. By the late sixteenth century such ships had gun ports that enabled them to mount heavy muzzle-loaders and to fire them in a broadside. However, these large specialized warships (some of them of over 1000 tons) proved inferior in battle to 'swarms' of smaller and more lightly armed ships.

While the great ships of war were commissioned and, frequently, built by territorial governments, the smaller ships that proved to be their nemesis were entirely the product of private enterprise. They were initially developed by Dutch and English merchants for their trade in the dangerous waters of the Mediterranean. Later, when this trade was cut off by war with Spain, they turned their efforts to privateering.

The highly profitable Spanish and Portuguese monopolies on transoceanic trade provided an attractive target for pirates and interlopers. In England, joint stock companies were formed to finance privateering ventures. Most famous of these was the 1577-80 expedition of Sir Francis Drake that returned with over £500,000 in captured treasure. Half of this went to the crown and the other half to the shareholders—not a bad return on an initial investment of £5,000.[88] Not surprisingly, Drake's dramatic success set off a veritable privateering boom. Privateering by the nobility was not new: English nobles had been privateering since the fifteenth century. Privateering provided an outlet for noble violence at a time that private armies on land were being suppressed by the crown. Now, however, the spectacular profitability of the business attracted merchant investors: "…the privateering war against Spain was a different matter once London mercantile wealth, energies and talent were involved."[89]

Both in the armed trade of the Mediterranean and in privateering, the key to success was having a faster, more maneuverable, and better-armed ship than your adversaries and

---

[87](Glete 1999) Ch. 2 and Ch. 6

[88](Scott 1912); (Unwin 1927)

[89]((Scammell 1972) p396) The interruption of trade with Spain as a result of the outbreak of war in 1585, deprived the many Bristol and London merchants involved in that trade without a living. Privateering provided a useful stopgap. ((Armstrong 1958) Ch. 1)

competitors. So merchants and privateers were willing to pay top dollar for the best ships and armament, and shipbuilders and gunmakers vied for their business. The result was some major advances in technology. English, Breton, and Dutch shipbuilders produced smaller, faster and more maneuverable ships. English gunmakers solved the technological problems of casting iron cannon to produce a much less expensive weapon.[90] Iron cannon still had some problems: if fired repeatedly they tended to overheat and blow up. This made them useless for warships, which continued to use bronze cannon until the middle of the seventeenth century when the problems of iron cannon had been solved.[91] However, an armed merchantman needed only to get off a round or two to enable it to escape, and the lower cost per cannon meant that many more could be carried.[92] It was these ships and these guns, developed for armed trade and for privateering, that defeated the great ships of the Spanish Armada in 1588.[93]

While naval warfare had traditionally been much less important in the northern seas than in the Mediterranean, from the late sixteenth century it became strategically decisive. Naval superiority enabled England and the Netherlands to hold out against their much more powerful adversaries—Spain and France.[94] Naval power was critical in defending them against invasion by sea—both England and the Netherlands had good natural protection against invasion by land. Naval power also made the war in the Low Countries much more expensive for Spain by forcing it to supply its armies by land (via the inland 'Spanish Road' from Lombardy).[95] And English and Dutch privateers forced Spain to divert significant resources to defending its possessions in the Americas and to protecting its communications with them.

The organization of war

The organization of war progressed too. Rulers were still contracting with captains for single companies. For example, the Spanish army in Italy consisted largely of

---

[90](Unger 1980) Ch. 6

[91](Glete 1999) Ch. 2

[92]"…battery guns had ceased to be the status symbol of the powerful, and became a workaday commodity within the pocket of any pirate or privateer." (Rodger 1998) Ch. 16

[93]"The privateering expeditions against the Spaniards in America constituted the training school for the battle against the Armada." ((Scott 1912) p73). "It was English cast-iron ordnance which defeated the Spanish Armada and assisted the Dutch to achieve their independence." ((Rees 1968) p26)

[94](Tilly 1985)

[95]Most transportation, especially of bulk goods, was by sea (see (Kohn forthcoming) Ch 5).

companies raised in this way. A captain would receive a commission from the crown and be assigned an area, usually in Castile, from which he could recruit volunteers.[96] The captain was responsible for providing his men with loans to enable them to purchase their equipment (for which each individual soldier was responsible). He was also responsible for paying them until he in turn received payment from the crown.[97] However, beginning in the sixteenth century, rulers also began to contract with 'military enterprisers' who could provide them not with companies but with whole regiments and even complete armies.[98] These enterprisers depended on similarly large-scale dealers to provide them with the necessary arms and supplies.[99]

Military enterprisers recruited, armed, trained and commanded the armies they raised. Governments no longer paid their mercenary troops directly, as had once been the custom, but rather paid a lump sum to the enterpriser: the enterpriser provided interim financing until pay or pillage were forthcoming.[100] Indeed, the capacity to provide financing was no less important a qualification for the military enterpriser than military skill. Enterprisers, many of them German princes, were themselves wealthy, but they usually had to borrow to finance their 'working capital'.[101] They borrowed from fellow nobles and from churches and monasteries. Often they relied too on credit from their own officers. For example, in the late 1570s, Prince Alexander Farnese, the Hapsburg governor-general of the Low Countries, owed Colonel Florens de Barlaymont, who commanded a regiment of eleven companies, a total of 717,329 florins. Florens in turn owed one of his captains, Ruprecht von Eggenberg, 23,725 florins.[102] Military enterprisers were no less important on the other side of the conflict: in the early years of the Dutch revolt, they were the rebel's single most important source of financing, advancing some 500,000 florins in pay to the troops.[103] Merchant bankers played an increasing role in supporting this system of financing. Ruprecht von Eggenberg, for

---

[96](Glete 2002) Ch. 3

[97](Thompson 1976) Ch. 4

[98](Redlich 1964). In the 1630s where mere 400 military enterprisers active ((Parker 1996))

[99](Hale 1985)

[100](Parker 1996)

[101]The loan was usually in the form of a mortgage, secured by the enterpriser's lands. ((Redlich 1964) Ch. 2)

[102](Redlich 1964) Ch. 2

[103](Fritschy 2003)

example, was able to discount his IOU from Barlaymont with the Fuggers for 15,000 florins.

At sea there was an additional reason why rulers should rely heavily on mercenaries: naval warfare was not the natural domain of nobles and rulers, but rather that of merchants and cities.[104] Naval mercenaries—like the great Genoese admiral Andrea Doria who served first France and then Spain—often came from the cities that had historically dominated naval warfare in the Mediterranean. Sometimes rulers would hire individual captains together with their ships. But often they would contract with captains-general like Doria who could provide them with a complete fleet and command it in battle. Like military enterprisers on land, these naval enterprisers would be responsible for everything—ships, officers and men, supplies and—especially—financing.[105]

The reliance on private contractors on land and at sea was not without its problems. Because their role in financing was crucial, they were often chosen with little regard for their military ability.[106] Another problem was that individual units, each under the command of a different contractor, often worked poorly together.[107] Each commander looked out for his own interests, and was reluctant to provide assistance others, even in battle. Morale naturally suffered. Since contractors were interested primarily in the bottom line, they frequently cut corners to the detriment of performance. Contract galley fleets, for example, were often in bad repair and their crews poorly fed.[108] Contractors both on land and at sea frequently pocketed a good part of the pay intended for their men. They standard way to do this was by inflating the rolls with phantom men, with the result that units were often undermanned.

The biggest problem with mercenaries was, of course, their irritating insistence on being paid. If the money ran out, the army evaporated. For example, in the early days of the Dutch revolt, William of Orange raised about a million florins of his own money to assemble what was then a huge army of 30,000. His intention was to expel the Spanish

---

[104](Glete 1999) Ch. 6

[105](Thompson 1976) Ch 6

[106]"The intrusion of non-military considerations into the appointment of captains was largely responsible for the poor quality of Spanish military leadership." (Thompson 1976) p111

[107](Thompson 1976) Ch. 6

[108](Thompson 1976) Ch. 6. The owners of contract galleys often carried commercial cargo as an illicit side-line. Sometimes they carried so much cargo that it left little room for fighting men.

from the Low Countries. However, to defeat him, the Duke of Alva, the Spanish commander, had merely to avoid battle for a few months until William ran out of cash. This duly happened and William was forced to disband his army and skip town to escape his creditors.[109]

Even when governments had the resources in principle, they were always short of cash, and they were consequently often late in making payment. When this happened, contractors did their best to provide interim financing themselves. However, if they too ran out of cash the result could be mutiny, with the men plundering the civilian population in lieu of pay. The most famous such incident occurred in 1576, when Philip II failed to deliver to the Low Countries the funds needed to pay his troops there. The men finally lost patience and took what was due to them by sacking the city of Antwerp, giving the rebel cause a major propaganda boost.[110]

Partly because of these sorts of problems, Philip II, from his succession to the throne of Spain in 1556, tried to reduce his dependence on military contractors.[111] He tried to 'decommercialize' his military apparatus, replacing reliance on the market with direct administration by the government wherever possible. He immediately replaced the contract galley fleets with government-owned fleets under direct administrative control. In the 1570s, in response to the privateering threat in the north Atlantic, he began building a fleet of royal ships to protect the coasts and to guard the Indies treasure fleets. Rather than relying on contractors and dealers to recruit men and to arm them and supply them, he set up bureaucracies for recruiting and procurement and expanded government production of arms and munitions.[112]

---

[109](Fritschy 2003)

[110]This was not, however, the soldiers' typical response to not being paid: "In contrast with what happened in the Netherlands, mutiny was rare and impracticable. The troops either took alternative employment where they were garrisoned or they deserted; if they could do neither they died. In despair starving soldiers fled to the Moors and surrendered themselves into slavery; virtual prisoners in their garrisons they threw themselves from the battlements or hanged themselves in their barrack-rooms. Even their enemies pitied them." (Thompson 1976) p75

[111]The following discussion of the Spanish experience is based largely on (Thompson 1976),

[112]Soldiers were generally expected to purchase their provisions themselves out of their own pay. However, those in garrisons and on board ship could not do this and they had to be provisioned by the state. Before the reign of Philip II, most of this provisioning had been carried out under contract by commercial suppliers.

Philip's attempts at decommercialization were a total failure, with seriously deleterious effects on military preparedness and effectiveness. The government-owned and operated galley fleets in the Mediterranean were typical: "[they] were costing twice as much and they were half as effective."[113] Corrupt and lazy officials had no incentive to care about cost, and they had to obtain their supplies through a cumbersome and corrupt central bureaucracy. As a result, the expense of the galley fleets soon ballooned to fully half of Spain's total military expenditure.

Because the government was in a perpetual financial crisis, there was never enough money for men, arms, or supplies. Spain's centrally controlled system of recruiting set wages with little regard for market realities. Wages were not adjusted to compensate for rising prices, and they soon sank well below market levels. The consequences for the quality of recruits and for their morale were predictably negative.[114] In the Atlantic, there were never enough royal ships. Consequently, the government had to rely primarily on mobilizing the ships of Spanish merchants and on commandeering foreign ships. Government provisioning was a disaster: for example, the Armada of 1588 had to go on short rations a month out of port and was forced to turn back at least in part because of a lack of provisions (two of its best pilots had actually starved to death before the fleet even left Lisbon).[115]

Faced by rising costs and deteriorating performance, Philip was forced to reverse his policy. By the 1590s, he was giving up on direct control and returning to reliance on contractors. In 1591, the government transferred responsibility for protecting the transatlantic fleets from the *Casa de Contratacíon*, the government agency in charge of trade with the Americas, to the merchant *consulado* of Seville. It did so because it had come to realize that the private sector would do a better job than "the penurious, unreliable and distracted central government and would do it more cheaply to boot."[116] The return to mercenary galley fleets had started even earlier. The Council of War

---

[113](Thompson 1976) p 167

[114]While the general wage index rose threefold in the century after 1534, the level of soldiers' pay remained unchanged. Sailors' pay was just as bad: by the 1580s, pay on merchant ships was three to six times that offered by the navy: not surprisingly, naval ships had to rely increasingly on force to find their crews (usually not of the best elements). ((Thompson 1976) Chs 4 and 7)

[115](Thompson 1995) p 74

[116](Thompson 1976) p 203

decided that the system of government procurement was ureformable and they turned increasingly to private contractors for supplies. Of course, a decisive advantage of private contractors was that they could provide supplies on credit.[117] It took longer for the government to get itself out of the manufacture of armaments, but it met its needs increasingly in the open market. In 1633, it finally gave up and put out all remaining royal arms factories to contract.

The Dutch approach to military organization was almost the reverse of that of Philip of Spain. Rather than trying to control every detail, the central government played only a minimal, coordinating role, relying heavily on local governments and on the market. The military success of the Dutch Republic was due as much to its superior military organization as it was to its military innovation and generalship.

Although every Dutch city had its volunteer citizen militia—the *schutterijen*[118]—the Republic's armies were made up entirely of mercenaries. Like the citizens of the Italian city-states in the fourteenth century, the Dutch burghers found their time too valuable to serve in the standing army in person.[119] They preferred to pay taxes to fund a professional military, so that they themselves could devote their energies to business.

The Dutch armies were not, however, organized by military enterprisers. Rather it was the provinces themselves that organized and financed individual units.[120] The central government—the Stadholder and the States General—decided on the level of forces and then allotted companies to the different provinces. The provinces were responsible for both for raising the companies and for paying them.[121] They could nominate their commanding officers (many of them were foreign nobles), but the final decision was up to the Stadholder. Commanders received a fixed sum to pay their companies, with private

---

[117](Thompson 1976) Ch 8.

[118]Cities maintained militias of about 100-150 per 5,000 of population (Amsterdam had a militia of about 600). Their organization resembled that of guilds, with a significant social and religious element to their activities (the painting of group portraits became popular from the 1520s). Militias were used mainly to enforce internal order, but they could be mobilized to help defend the city in case of siege. ((Israel 1995) Ch. 6)

[119](Price and Clemens 1987)

[120]The following is based mainly on ((Hart 1993) Ch. 2) and ((Glete 2002) Ch. 4)

[121]Apart from this general system of mobilization, the States General did sometimes contract with military enterprises for additional troops; individual cities also did this occasionally (Hart 1993) Ch. 2

financiers (*solliciteurs-militair*) provided them with interim financing when necessary.[122] The lower-ranking officers were salaried employees rather than subcontractors. The provinces had a say in the granting of commissions, which were open to commoners as well as to the nobility; commissions were not for sale. There was no centralized system of provisioning: disciplined soldiers, regularly paid an adequate wage, could be relied upon to purchase for themselves locally whatever they needed.

The navy was organized in much the same way. Its origins lay in the Sea Beggars—the bands of privateers that had harassed Spanish commerce in the early days of the revolt.[123] They were later organized into several 'admiralties', each based in one of the principal maritime cities. The admiralty fleets were combined into war fleets under the overall command of an admiral-general appointed by the States General. Each individual admiralty was responsible for building, maintaining, manning and provisioning its own ships. The governing board of each admiralty was drawn from among the local shipping magnates: with a strong personal interest in the effectiveness of the navy, they paid close attention to its management.[124] The governing board hired the ships' captains who were in turn responsible for finding crews and for provisioning their ships. For provisioning they relied on the same open market that served commercial shipping rather than on a system of government procurement.

A major advantage of this decentralized and competitive Dutch system was in the quality of the personnel that it attracted. Most of the soldiers were foreign volunteers.[125] The sailors too were volunteers, drawn from the men of the merchant fleet (many of these were also foreigners). To attract such volunteers, the Dutch were obliged to pay them a market wage.

---

[122]Dutch captains too therefore had an incentive to pad their rolls. They were known to hire passers-by to boost the number of troops for the pay-day head-count.

[123]In the first years of the revolt, William of Orange and his brother Louis of Nassau issued letters of marque to Dutch seamen authorizing them to capture enemy ships, on condition they divide the spoils with the rebel government. (Fritschy 2003)

[124]"The Dutch admiralty organization… provided a link between the policy of the state and local networks, interests, sentiments, resources and know-how that, during the seventeenth century, created a very large and efficient navy." ((Glete 2002) p167)

[125]They included French, Walloons, Germans, Swiss, Danish, Irish, English, and Scottish, many of them Catholics. ((Hart 1993) Ch. 2)

The Dutch had the additional advantage of hosting the premier international arms market of Europe. Previously located in Antwerp, it had moved to Amsterdam with the former's rapid decline.[126] Amsterdam was also a center of arms manufacture, largely assembling weapons from parts imported from Germany and from the Low Countries.[127] The Netherlands was, of course, also host to the largest and most dynamic shipbuilding industry in Europe.[128] The Amsterdam arms market supplied munitions, supplies, and ships not only to the Dutch but also to their allies and even to their enemies. Spain regularly purchased supplies there for its armies in the Low Countries as well as Dutch ships for its navy.[129] For the Dutch, business was business!

The Dutch system of organization was not, of course, free of problems. There was no lack of patronage, corruption and peculation—all endemic in early modern Europe. Personal and local interests sometimes triumphed over the public good. However, the Netherlands, with a population of no more than a million, managed nonetheless to support a large army, considered the best in Europe, and a highly effective navy. These enabled the Dutch Republic to hold its own against adversaries many times its size.

The rising cost of war

War became much more expensive during the sixteenth century. For example, Spanish government expenditure, almost all of it war-related, rose four-fold between 1500 and 1650, adjusting for inflation.[130]

Some historians have attributed this increase in military expenditure to the rising cost of the new military technology—artillery, firearms, fortifications. This was not the case, however, as we can clearly see by examining the Spanish military budget.[131] Artillery accounted for no more than 5% of the domestic military budget.[132] The new type of fortifications were expensive, but they were a once-over expense and again accounted for

---

[126](Barbour 1950); (Hart 1993) Ch. 2

[127](Vogel 1998)

[128]See (Kohn forthcoming) Ch 4.

[129]"As early as the 1560s, when the Dutch revolt against Spain began, individual merchants in the rebellious provinces were not loathe to export weapons and ammunitions, even to the Spanish enemy." (Vogel 1998)p199

[130](Thompson 1995)

[131](Thompson 1995)

[132]Contrary to the standard story, artillery was not too expensive for the private armies of nobles: even in the seventeenth century some Spanish magnates had considerable private arsenals.

only a small part of total expenditure: Philip II spent more on the Escorial palace than he did on all his fortifications. As we have seen already, the cost of pikes and firearms was modest—considerably less than the cost of crossbows and armor. It cost more to clothe a musketeer than it did to arm him. In fact, the greatest part of expenditure by far went not for capital but for labor. Even for the relatively capital-intensive galley fleet, pay and provisions accounted for 80% of costs, while ships accounted for no more than 12.5% and munitions, 7.5%.

The huge increase in expenditure was therefore the consequence of an equally huge increase in the number of men under arms. For example, the total number of men under arms in Spain grew during the sixteenth century from 5% of the adult male population to 15%; in the Netherlands it grew to 23%.[133] Not only did total military manpower grow, but so did the size of individual armies. While before 1500 an army of 5,000 was considered a large force to send into battle, by the early seventeenth century it was not unusual to see armies of 25,000.[134]

The new technology did play a role in increasing the size of armies by lowering the unit cost of a soldier. Also, by reducing the necessary level of skill, it made the supply of soldiers much more elastic.

However, the main reason for the growth of armies and for the rise in military expenditure was that governments were able to afford larger armies and higher military expenditure. That is, it was demand factors rather than supply factors. As we shall see in Chapter 20, governments were able to afford larger armies and higher levels of expenditure because of improvements in government finance—especially in their ability to borrow.[135]

CONCLUSION

Overall, technological progress in war was much like technological progress in production. As in production, technological progress in war was endogenous: the expansion of the market promoted specialization and this led to improvements in

[133](De Long 2000)
[134](Nef 1950) Ch. 5
[135]See (Kohn forthcoming) Ch 20.

technique and in the nature of the product.[136] As in agriculture, the key step was commercialization. Once war became commercialized, technological progress began to be driven by the same powerful forces of profit-seeking and competition that were responsible for technological progress in the productive sectors of the economy.

As with technological progress in production, it was the cities that played the leading role in technological progress in war. It was the cities that produced the key elements of the 'military revolution'—massed infantry and firearms. Moreover, as we have seen, naval warfare was entirely in the domain of the cities and it was they who were responsible for advances in the design of warships and of their armament. When a territorial government tried to take direct control, as in Spain, the result was technological stagnation.[137]It was in particular the cities first of northern Italy and then of the Netherlands that were the great innovators in all aspects of the technology of war.[138]

Towards the end of our second political-economic cycle, two very different forms of government were emerging in Europe. One, the imperial state, was exemplified by Spain. The other, the associational state, was exemplified by the Dutch Republic. We have seen that these two types of state differed significantly in their effectiveness in waging war. We shall see in the next chapter that they differed even more in their ability to finance war. The differences both in effectiveness and in financing were to prove decisive in the evolutionary struggle between different forms of government over the subsequent centuries.

---

[136]See (Kohn forthcoming) Chs 3, 4, and 5

[137] See (Kohn forthcoming) Ch 22 on the effect of government intervention in the manufacture of armaments and ships.

[138](Glete 2002) (Ch. 4) attributes the military success of the Dutch to the same factors that underlay the 'Dutch miracle' in general—essentially the advantages of an urban civilization and the benefits of associational government.

REFERENCES

Adkins, L. and R. A. Adkins (1994). *Handbook to Life in Ancient Rome*. New York, Oxford University Press.

Armstrong, W. A. (1958). *The Elizabethan private theatres; facts and problems.* London, Printed for the Society.

Barbour, V. (1950). *Capitalism in Amsterdam in the Seventeenth Century*. Baltimore, The Johns Hopkins Press.

Batchelor, J. and I. Hogg (1972). *Artillery.* New York, Scribner.

Bean, R. (1973). "War and the Birth of the Nation State." *The Journal of Economic History* Vol. 33, No. 1((Mar.): 203-221.

Brice, M. (1990). *Forts and Fortresses*. New York, Facts On File.

Caferro, W. (1992). The companies of adventure and the decline of Siena: A study of the impact of mercenary bands on a fourteenth century Italian commune, Yale.

Contamine, P. (1984). *War in the Middle Ages*. New York, NY, USA, B. Blackwell.

Contamine, P. (2000). The growth of state control. Practices of war, 1300-1800: Ransom and booty. *War and competition between states*. P. Contamine. New York, Clarendon Press.

De Long, J. B. (2000). Overstrong against thyself: War, the state, and growth in Europe on the eve of the Industrial Revolution. *A not-so-dismal science: a broader view of economies and societies.* M. Olson and S. Kahkonen. Oxford, Oxford University Press.

Downing, B. M. (1992). *The military revolution and political change: origins of democracy and autocracy in early modern Europe.* Princeton, N.J., Princeton University Press.

Ertman, T. (1997). *Birth of the leviathan: building states and regimes in medieval and early modern Europe.* Cambridge, [Eng.], Cambridge University Press.

Finer, S. E. (1997). *The history of government from the earliest times*. Oxford, Oxford University Press.

Fritschy, W. (2003). "A 'Financial Revolution' revisited: public finance in Holland during the Dutch Revolt, 15681648." *Economic History Review* Volume 56 Issue 1(February): 57-89.

Glete, J. (1999). *Warfare at Sea, 1500-1650: Maritime Conflicts and the Transformation of Europe.* London, Routledge.

Glete, J. (2002). *War and the state in early modern Europe: Spain, the Dutch Republic and Sweden as fiscal-military states, 1500-1660*. London, Routledge.

Hale, J. R. (1985). *War and society in Renaissance Europe, 1450-1620*. New York, St. Martin's Press.

Hall, B. (1997). Weapons of war and late medieval cities: technological innovation and tactical changes. *Technology and Resource Use in Medieval Europe: Cathedrals, Mills, and Mines*. E. B. Smith and M. Wolfe. Brookfield, Vt, Ashgate.

Hart, M. C. t. (1993). *The making of a bourgeois state: war, politics, and finance during the Dutch revolt.* Manchester, UK; New York, Manchester University Press: Distributed in the USA and Canada by St. Martin's Press.

Hoffman, P. T. (2005). Why is it that Europeans ended up conquering the rest of the globe? Prices, the Military Revolution, and Western Europe's comparative advantage in violence. C. I. o. Technology. January.

Howard, M. E. (1976). *War in European history*. London New York, Oxford University Press.

Israel, J. I. (1995). *The Dutch republic: its rise, greatness, and fall, 1477-1806*. Oxford, Oxford University Press.

Kaeuper, R. W. (1988). *War, justice, and public order: England and France in the later Middle Ages.* Oxford [Oxfordshire]

New York, Clarendon Press; Oxford University Press.

Kohn, M. (forthcoming). *The Origins of Western Economic Success: Commerce, Finance, and Government in Pre-Industrial Europe.* *http://www.dartmouth.edu/~mkohn/*

Mallett, M. E. (1994). The art of war. *Handbook of European History 1400-1600*. J. Thomas A. Brady, H. A. Oberman and J. D. Tracy. Leiden, E.J. Brill.

McNeill, W. H. (1982). *The Pursuit of Power: Technology, Armed Force, and Society*. Chicago, University of Chicago Press.

Nef, J. U. (1950). *War and human progress; an essay on the rise of industrial civilization.* Cambridge, Harvard University Press.

Nicholas, D. (1997). *The growth of the medieval city: from late antiquity to the early fourteenth century*. London; New York, Longman.

Nicholas, D. (1997). *The later medieval city, 1300-1500*. London; New York, Longman.

Parker, G. (1995). The 'Military Revolution, 1560-1660'--A myth? *The military revolution debate: readings on the military transformation of early modern Europe*. C. J. Rogers. Boulder, Westview Press: xi, 387.

Parker, G. (1996). *The military revolution: military innovation and the rise of the west, 1500-1800*. New York, Cambridge University Press.

Price, J. M. and P. G. E. Clemens (1987). "A revolution of scale in overseas trade: British firms in the Chesapeake trade, 1675-1775." *Journal of Economic History* 47 (1)(March): 1-43.

Redlich, F. (1964). *The German military enterpriser and his work force; a study in European economic and social history*. Wiesbaden, F. Steiner.

Rees, W. (1968). *Industry before the Industrial Revolution, incorporating a study of the Chartered Companies of the Society of Mines Royal and of Mineral and Battery Works v.1-2*. Cardiff, University of Wales P.

Roberts, M. (1995). The Military Revolution, 1560-1660. *The military revolution debate: readings on the military transformation of early modern Europe.* C. J. Rogers. Boulder, Westview Press: xi, 387.

Rodger, N. A. M. (1998). *The safeguard of the sea: a naval history of Britain, 660-1649*. New York, W.W. Norton.

Rogers, C. J. (1995). The Military Revolutions of the Hundred Year War. *The military revolution debate: readings on the military transformation of early modern Europe*. C. J. Rogers. Boulder, Westview Press: xi, 387.

Scammell, G. V. (1972). "Shipowning in the economy and politics of early modern England." *The Historical Journal* 15: 385-407.

Scammell, G. V. (1981). *The world encompassed: the first European maritime empires, c. 800-1650*. Berkeley, University of California Press.

Scott, W. R. (1912). *The Constitution and Finance of English, Scottish and Irish Joint-Stock Companies to 1720: Volume 1*. Cambridge, Cambridge University Press.

Thompson, I. A. A. (1976). *War and government in Habsburg Spain, 1560-1620*. London

[Atlantic Highlands] N. J., Athlone Press;

distributed by Humanities Press.

Thompson, I. A. A. (1995). 'Money, money, and yet more money!' Finance, the Fiscal-State, and the Military Revolution. *The military revolution debate: readings on the military transformation of early modern Europe*. C. J. Rogers. Boulder, Westview Press: xi, 387.

Tilly, C. (1985). War making and state making as organized crime. *Bringing the state back in*. P. B. Evans, D. Rueschemeyer and T. Skocpol. Cambridge, Cambridge University Press.

Tracy, J. D. (1993). "Herring Wars: The Habsburg Netherlands and the Struggle for Control of the North Sea, ca. 1520-1560." *Sixteenth Century Journal* Vol. 24, No. 2(Summer): 249-272.

Tracy, J. D. (2000). To wall or not to wall: evidence from medieval Germany. *City walls: the urban enceinte in global perspective*. J. D. Tracy. New York, Cambridge University Press.

Unger, R. W. (1980). *The ship in the medieval economy, 600-1600*. London, Croom Helm.

Unwin, G. (1927). The Merchant Adventurers' Company in the reign of Elizabeth. *Studies in Economic History: the Collected Papers of George Unwin*. R. H. Tawney. London, Macmillan: 133-220.

Veseth, M. (1990). *Mountains of debt: crisis and change in renaissance Florence, Victorian Britain, and postwar America*. New York, Oxford University Press.

Vogel, H. (1998). Arms production and exports in the Dutch Republic, 1600-1650. *Exercise of arms: warfare in the Netherlands, 1568-1648*. M. v. d. Hoeven. New York, Brill: xi, 235.

Wolfe, M. (2000). Walled towns during the French wars of religion (1560-1630). *City walls: the urban enceinte in global perspective*. J. D. Tracy. New York, Cambridge University Press.