Timber and hemp: Swedish naval stores procurement in the reign of Gustav II Adolf and its international context

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The projection of naval power requires a steady flow of capital and consumable raw materials in order to build, outfit and maintain a fleet of ships. Before steam propulsion and iron construction replaced sail and wood, the key materials were timber for hull construction, iron for fittings and fastenings, hemp for rope and sails, and tar for waterproofing. These were collectively known as naval stores, and the sourcing and delivery of these materials in the necessary quantity and quality to keep a fleet in being challenged the skills of naval administrators in every country. Some nations were fortunate to have local sources for some materials, although few if any had adequate sources completely under domestic control to meet the growing demands of naval warfare after 1600. As the scope of naval warfare increased, as the role of fleets expanded, as the sailing season lengthened, and as the size and killing power of ships grew, the demand for naval stores rapidly outstripped both local sources of supply and the capacity of medieval procurement systems. In the course of the 17th century, all of the major naval powers of northern Europe developed professional administrative machinery to gather and direct the flow of raw materials into the insatiable maw of production and maintenance. At the same time, the geographical distribution of key sources and the increasing sophistication of commercial trade in raw materials turned the naval stores market into a strategic arena, where different nations intervened in foreign wars in order to enhance or maintain their access to the materials they needed.

In this arena, Sweden held a number of advantages at the start of the 17th century. It was rich in natural resources, specifically naval stores, and it had, by the reign of Gustav II Adolf (1611-1632), relatively stable control over its own territory. Under Gustav Adolf, Swedish territorial power expanded to include control over significant sources of all of the core naval stores: timber, tar, hemp and iron. It was one of the few naval powers which could supply itself from sources within its own control, and it was a major international supplier; the English navy in particular relied on Swedish iron, tar and mast timber for most of the 17th and 18th centuries.

Swedish procurement from the establishment of the navy in the 1520s until the end of the Great Northern War two centuries later is a central theme in Jan Glete's magisterial administrative study of the early navy. [1] Through the collation of a vast amount of primary data, he established the main trends in procurement and administration. In terms of naval stores, as well as the supply of ships, Sweden tended to progress from an initial reliance on foreign suppliers, exemplified by the acquisition of Gustav Eriksson's fleet in Lübeck, towards greater self-reliance as the Vasa state built up an administrative framework for the management of resources and gained control of key sources of supply. This included the establishment of crown navy yards for construction and maintenance of ships and financial tools for collecting raw materials, initially on a demand or in-kind basis but becoming increasingly sophisticated and formalized as part of the state's taxation system. The trend toward self-reliance was not monolithic, but conditioned by the specific economic and technical factors relevant for each of the key naval stores. The general trend is paralleled by a shift towards natives in the officer corps instead of foreigners,[2] in stark contrast to the heavy reliance on mercenaries in the army. At the same time, Sweden relied heavily on foreign-born master shipwrights for most of the

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17th century, initially recruiting in the Low Countries but shifting after the middle of the century to Britain.

However, during the 1620s, developments within Sweden and abroad created the conditions for a brief period in which foreign sources again played a significant role in the procurement process for some materials, while accelerating the shift towards domestic production for others. A widespread economic crisis in Europe, the resumption of the Dutch War of Independence, the rapid expansion of the Swedish navy for the war with Poland-Lithuania, and the imposition of an experiment in taxation and procurement by the Swedish state contributed to the emergence of a small group of foreign, mostly Dutch, entrepreneurs. These businessmen, forced to rely on the open market rather than in-kind taxation for raw materials, were able to take advantage of their international contact networks to reduce transaction costs and provide the naval stores Sweden required from sources from as far apart as Livonia, England and France. They even made it economically viable to ship timber, a mainstay of Baltic exports to the West, back into the Baltic to help build the navy, something unseen either before or since.

Sweden was weakened by its small population, which made it uneconomical to exploit some of its resources, and in the course of Gustaf Adolf's naval expansion in the 1620s, the navy came to rely on foreign sources of supply for certain items. Experimentation with different forms of procurement machinery, especially the shift from direct crown control to entrepreneurial contracts under the *arrende* system, led to greater monetization of the system and greater internationalization of the process, at least in the short term. Naval retrenchment in the 1630s and 1640s combined with efforts to develop domestic sources led to the abandonment of some of the international network developed in the 1620s, but the shift to market-based supply and monetization could not be reversed. When the Admiralty Board (*Amiralitetskollegium*) was formally established in the 1630s, institutionalizing many of the practices of the 1610s and 1620s, the fundamental changes wrought by the *arrende* experiment were formalized with it. The renewed construction of ships on a large scale in the 1650s and 1660s required the re-establishment of a large-scale procurement system, but it looked very little like the system before 1620.

This article focuses on the brief period of international reliance in the 1620s and how it came about, the factors at work both at home and abroad, and several of the key figures who drove the move towards foreign suppliers. It concentrates on the supply of timber and hemp, as unlike tar and metals, they could not always be sourced within the traditional Swedish homeland and required more complicated mechanisms to assure an adequate supply. Timber and hemp followed different trajectories in the shift between domestic and foreign sourcing due to specific technical and economic factors.

At issue is how and why the 1620s were different from the periods before and after. Do the events of this period represent a temporary diversion from the overall trend, or did they have longer term effects? Who were the central figures in this development, and how were they able to source materials abroad effectively? How was Sweden affected by the international situation? What effect did the *arrende* system have on the supply of timber and hemp?

In addition to more comprehensive sources covering the longer period, this study benefits from a unique historical source for the 1620s which can be linked directly to an unparalleled archaeological source. The detailed system of naval inventories developed in the 16th century was abandoned with the *arrende* experiment, but perhaps thanks to a case of peculation, the account books for the private entrepreneurs who ran the Stockholm navy yard in the later 1620s survive for the years 1625-1626.[3] These provide a wealth of fine-grained detail on all of the navy yard's purchases, from massive shipments of timber to individual paintbrushes, usually with the supplier, location of the source, and unit cost. It also includes transaction costs, such as shipping, tolls, and fees for exchanging domestic for international currency. This two-year period is when most of the material for the new ship *Vasa* was purchased, and so comparison with the ship itself is instructive. In particular, dendrochronological study of the timber has revealed the existence of a previously unremarked pathway for timber. Together, these historical and archaeological sources provide a useful illustration of the pressures on the navy yard and the solutions adopted in the 1620s, at the peak of new ship production under Gustav Adolf.

Economic forces abroad and at home

The 1620s were a period of general economic stress throughout Europe, with global implications. The first phases of the Thirty Years War disrupted the agricultural infrastructure at a regional level, which expanded as the war drew in more participants on its way to becoming a general war that would visit devastation on large sections of Germany. The Spanish empire was losing the battle to balance its budget and integrate the influx of gold and silver it was extracting from the New World into the broader economy of its European possessions. Periodic state bankruptcy, as in 1627, and the devaluation of Spanish coinage further contributed to the growing economic chaos, which had implications for the many other countries bordering or allied with Spain.

The resumption of the war between the United Provinces and Spain in 1621 after twelve years of peace expanded the war zone in northern Europe and disrupted Dutch trade. This had significant consequences in the Baltic, where Dutch ships carried most of the long-distance cargo and where Dutch merchants had established a dominant position at the expense of the old Hanseatic towns. This can be seen clearly in the records of the Sound Toll. The number of ships transiting Öresund dropped precipitously after the middle of 1621, with almost all of the decline seen in Dutch shipping.

From the earliest surviving records in 1497, the Dutch had usually carried the majority of goods transiting Öresund,[4] and by the 1560s, the Dutch share of Sound traffic ranged between 65-85 per cent annually. This dropped catastrophically, to less than 35 per cent at the start of the Dutch War of Independence in 1567, steadily recovering as the Dutch adapted to the war and made the most of their Baltic connections. Their share had risen to 55-60 per cent in the first decade of the 17th century. After the Twelve Years Truce between Spain and the Dutch Republic was agreed in 1609, Dutch traffic increased to over 65 per cent, peaking in 1618-1620 at over 70 percent. After the war resumed, the Dutch share declined steadily through the 1620s to only 50 percent by the mid-1630s. It recovered briefly to Truce levels in the 1640s, but then declined, never again reaching the heights of the mid-16th century.

Sweden was directly and indirectly affected by all of these developments, and economic measures the crown took contributed to the stress at home. The debasement of the Spanish *vellón* coinage had depended heavily on Swedish copper, which had propped up the international market for one of Sweden's most lucrative exports. When the Cortes pressured the new Spanish king, Phillip IV, to abandon his father's chaotic monetary policy after 1621, the bottom fell out of the copper market.

Gustav Adolf responded in part by instituting a new copper-only coinage for domestic use in 1624. The new coins were unpopular and inconvenient. They were only minted in small denominations (from ¼ öre to 2 öre) and were originally established at par with the silver öre which had been the basis of the earlier coinage. The value of copper continued to fall, so that the real value of the new coins quickly declined to less than half of their silver equivalents, and they were so unpopular that their working value in real transactions was in fact less than the bullion value of the metal in them. For the navy yard, making domestic payments in copper added an unusual transaction cost: hiring wagons, teamsters and labourers to load, transport and unload sacks of coins. A payment of 1000 dalers (silver equivalent, the money of account), such as the navy yard made to more than one timber supplier, involved moving over 60 000 öre of copper coins at a total weight of more than 1500 kg. Foreign creditors were loath to take the copper coins, and seasonal labour imported from the Low Countries had to be paid at a higher rate than local craftsmen partly to compensate for the worthlessness of the currency.

On the other hand, Sweden's international currency, the riksdaler, was a stable, fine silver coin well respected in Europe. It held its purchasing power in the turbulent economy, preserving and even enhancing access to foreign markets and sources of supply.

The instigation of the war with Poland-Lithuania in 1621 created a specific set of demands on the Swedish navy, and with it opportunities for its suppliers. The war required a large and capable navy, as it involved convoying and supplying troops to establish bridgeheads in hostile territory as well as the interdiction of foreign trade. One of the aims of the war was to capture some of the revenue generated by the trade in raw materials from Polish ports to the West, one of the most lucrative trades in

the world. At the same time, part of the Swedish strategy was to strangle Zygmunt III's income by closing off foreign trade to his domains. Naval action during the 1620s thus consisted of a combination of convoy duty, blockade of ports, and the interception of commercial traffic and its escort to Swedish-controlled ports, such as Pillau (now Baltijsk, Russia), where it could be taxed. These tasks were in addition to the navy's traditional role of protecting Swedish ports and traffic from Danish interdiction. In addition, Habsburg intentions to establish an Imperial navy in the Baltic as part of the expansion of the German war after Denmark intervened required a response.

These demands for a larger, more capable navy in a hurry put a premium on delivery over cost, and the state turned in the 1620s to a number of foreign-born entrepreneurs, many of them from the Low Countries, to co-opt their financial resources and technical expertise. This created opportunities for well-connected and ambitious merchants and specialists to serve an enthusiastic customer in an environment with reduced state control.

Naval construction and maintenance under Gustav II Adolf

Although Gustav Eriksson acquired his first navy abroad, it was not long before he established the Stockholm navy yard and the navy began building most of its ships domestically. However, when demand exceeded supply in the short term, the crown still bought or hired ships from abroad. In 1624, for example, the Crown purchased a number of small warships/armed merchantmen in Holland. These ships served in a variety of roles, from messengers to blockade, and two of them (*Solen* and *Tigern*) were lost in the one naval battle of Gustav Adolf's reign, at Oliwa in 1627.[5]Domestic construction until the 1610s was dispersed around the country, establishing shipyards, some only temporary, near the sources of timber. As just one example, dendrochronology of the remains of *Scepter*, built at Arnö in 1612-1615, allowed it to be identified by determining both the date of felling and the source of the timber, which corresponded

with the time and place of building recorded in historical sources.[6] Even large ships were built in seemingly remote places, and the crown's navy yard in Stockholm was primarily a repair and outfitting station. Glete argues convincingly that the economic motivation for this approach was not the timber itself, but the transaction costs of food and unskilled labour, which could be supplied locally and cheaply from in-kind taxation, but were expensive to convert into a portable form if construction occurred elsewhere.[7] Timber should not be ignored completely, as it had a high transport cost relative to its value (see below).

This system was adequate as long as a sustained program of shipbuilding was not anticipated, since it dispersed the limited resource of technical knowledge regarding naval shipbuilding, and as long as food and unskilled labour were part of the tax base. This meant that timber was sourced entirely locally, often out of crown-controlled forests or as in-kind taxation, but that scarce specialist labour had to be imported and maintained. It eventually became clear that the supply of expertise was insufficient to allow this type of distributed production on the scale needed for the renewal and expansion of the navy undertaken by Gustav Adolf.[8] He had inherited a large fleet from his father, but it was not well suited to the young king's foreign policy and by the later 1610s these ships were becoming old. Karl IX had built a navy of relatively small ships which could serve in both military and commercial roles, but his son's ambitions required a specialized war fleet of more powerful ships. The age of dual-purpose state shipping was past, and the heavily armed gun platforms that characterized 17th-century navies were not useful as merchantmen. Gustav Adolf embarked on a program of expansion and replacement, generally trying to add about two new ships per year from 1620 onwards, and began ordering new types of ships, larger and more heavily armed.

From about 1618, new ship construction was consolidated into two principal yards, the royal navy yard in Stockholm (on what was then called Skeppsholmen, present day Blasieholmen), owned by the state, and a private yard in Västervik. Smaller vessels might still be built in the countryside, and some construction took place in Göteborg, which became a maintenance centre for a squadron stationed there to protect Swedish interests on the west coast, but this was a small operation and usually

accounted separately from the bulk of the navy. The consolidation of major work to Stockholm and Västervik meant that in principle, all material had to be transported to the site, whether it came from Mälaren or Poland. It concentrated the limited amount of available expertise, which could thus produce ships at the rate required by the king's strategic vision, but it opened naval shipbuilding to international economic forces from which it had been somewhat insulated previously.

Consolidation occurred simultaneously with a shift from the Crown providing raw materials and other supplies directly from its estates or in-kind taxation to direct cash payments to private entrepreneurs managing the navy yard. This represented not only a significant administrative development, but an economic sea-change to a much more monetized system, as entrepreneurs were expected to source materials on the open market rather than the crown supplying them. This shift coincided with a new approach to the state's resource management in general.

The *arrende* experiment

From the later 1610s, instead of direct crown administration of its revenue generation and expenditure, both tax collection and military procurement were outsourced to private entrepreneurs. Individual revenue streams, from tolls on foreign goods to the taxes on grinding grain to the general tax obligations of specific parishes or entire regions, were leased as tax farms, mostly to private individuals but occasionally to collective bodies. In return for a cash payment, the contractor was granted an *arrende* which allowed him or her to collect the relevant tax or toll. Whatever income the contractor could extract over the payment was profit. Some *arrenden* were granted for production facilities owned by the crown, with the contractor required to deliver a stated amount of production to the state, but could use the facility to produce for private sale and profit as well.[9]

From 1620, the navy yard in Stockholm was leased to a private entrepreneur, who was responsible for maintaining all of the existing hulls of the fleet (rigging maintenance was a separate contract) and building new

ships as needed. The initial contractor was Anton Monier.[10] As with many of the new entrepreneurs, he did not bring specific technical expertise to the arrangement, but his business acumen. Monier had been a specialist in metals and armaments, and returned to that field when his navy yard contract ran out. Because he was not himself a shipwright, in 1622 he took in a Dutch master shipwright, Henrik Hybertsson, as his partner.[11] Henrik had immigrated to Sweden at the start of the century and had designed and built a number of warships at different yards. When the contract came up for renewal in the winter of 1624-1625, Monier opted not to continue and Henrik recruited Arendt de Groote, a young Amsterdam merchant, as partner. They agreed to maintain the hulls of the navy's ships for the following four years and to build four new ships: two smaller vessels based on the design of an earlier ship Henrik had built and two ships of a larger, entirely new design. *Vasa* was the first of this new class.[12]

At the same time, the maintenance of rigging and sails was contracted to a different entrepreneur, initially Richard Clerk, a Scottish immigrant usually referred to as Admiral Clerk. He held the rigging contract from 1615 until his death in 1625,[13] when his younger brother[14] John Clerk (Captain Clerk) took over.[15] In 1626, John Clerk signed a contract in his own right to maintain the fleet's rigging at a fixed rate related to the tonnage of the ships named in the contract; this is the first source to mention *Vasa* by name, as *Nya Wassan*.[16] Unlike the navy yard contracts, rigging for new ships was not included in the general contract for maintenance, but was arranged through separate contracts.[17] This allowed the Crown some flexibility, and rigging was occasionally supplied by other contractors. *Vasa*'s rigging and sails were not provided by Clerk, but by the Dutch entrepreneurs who held the contract for the Västervik yard, Paridon von Horn and Christian Welshuisen.[18] The rigging for *Vasa*'s sister ship, Äpplet, was provided by Louis de Geer.[19]

These naval procurement contracts are sometimes held up as examples of the *arrende* system which dominated the Crown's resource management approach from the end of the 1610s to the middle of the 1630s, and while they are part of the larger network of interlinked agreements, they are not like the normal arrangements that made up the bulk of the system. Both the wording of the contracts and the registers for the 1620s consis-

tently distinguish between *arrende* and *contract*, although the former are occasionally referred to by one of the chancery clerks as *arrende contract*, and in later correspondence, all of the private arrangements tend to be called *arrende*. In its initial configuration, an *arrende* specifically refers to the leasing of a crown income source or production facility to a private person in return for either a cash advance or delivery of the production from the source. Most of these agreements involve tax farms of various sorts, but a few grant control of a production facility to an entrepreneur. By far the most common version of the latter grants control of a mill for grinding grain, and even here the main source of income is the tax charged on grinding grain rather than the surplus production, but there are some *arrenden* which are relevant for military procurement, such as control of iron works.[20]

In general, contracts for military procurement are more traditional and straightforward: the crown commits to paying an agreed price for an agreed quantity of goods, such as muskets, breastplates, barrels of gunpowder, pieces of artillery, or ships and their rigging.[21] There is no provision for income other than the cash being paid by the crown, with the occasional exception that the entrepreneur's maintenance may be assured by the living from a particular estate held in a personal grant as a form of salary or compensation (*förläning*, a form of compensation which had been in use long before the *arrende* system). In the case of large iron works, the entrepreneur could be granted the tax rights on the surrounding countryside in order to provide the income necessary to maintain production.

The naval procurement contracts are something in between, as the entrepreneur leased a state-owned production facility, such as the navy yard or the Stockholm ropewalk, but operated it as a private business with the Crown as sole customer. All of the potential income was agreed up front, in the form of the sum paid by the Crown, with no real possibility of selling surplus production, as the Crown's requirements were often at or beyond the capacity of the facility. Privatisation of the operation offered several potential benefits to the Crown, from the possibility of introducing some predictability of expenses for budgeting purposes to transferring the administrative cost of procurement to the entrepreneur, while the

entrepreneur could make a profit if he or she could negotiate a favourable price for the goods and control costs. This changed the nature of both the economic and administrative relationship between the shipbuilder and the crown, creating pressures on the shipbuilder which had not previously existed but also reducing the Crown's leverage over the management of the shipyard, especially when it became clear that the Crown was unable to maintain its end of the bargain and supply the agreed sums of cash. This diminishing of the Crown's authority was a problem which plagued the entire system of outsourcing, and was no doubt part of the reason for its abandonment in the 1630s.[22]

Even though these contracts are not *arrenden* in the purest sense, they are still effectively tied to the *arrende* system, since they grant control of a Crown facility to a private person and the income being used to pay the entrepreneurs is being raised through *arrenden* (often tolls). The people involved in the transactions are often the same, especially as the 1620s wore on. In the first rush after the widespread institution of the *arrende* system for raising the state's revenue, a large number of people at several levels of society, as well as municipalities and other collective institutions, signed on, but many of these actors found that the business model did not work for individual small holdings. As the historian Mats Hallenberg has pointed out, one flaw in the system was that, after many years of collecting taxes, the state had a very good idea of the actual value of the properties it leased, and the prices it negotiated left very little margin for the entrepreneur.[23] The bulk of the system, especially its most profitable parts, was consolidated into a few, mostly foreign-born, hands by the later 1620s, where *arrenden* effectively became collateral for venture capitalists willing to loan large sums to the state.[24] These entrepreneurs formed a closely-knit business community whose specific obligations, ownership and financial relationships can be difficult to disentangle.

The main characters

The Swedish crown had been recruiting foreign experts long before Gustav Adolf came to the throne in 1611. Foreigners served in the military, and a number of master shipwrights had come from Holland at the beginning of the century. The merchants of the Low Countries were seen as being especially useful, as they had both the means to finance industrial development and the financial knowledge and networks to make efficient use of the resources available. These men brought their wealth and skills to bear on the problem of outfitting a military that could compete with the best in Europe in a country with no significant central markets, a small, widely dispersed population, and a revenue infrastructure that looked decidedly medieval. It is hardly surprising that they turned to the markets and economic structures they knew best.

These men knew each other and formed an ever-shifting constellation of individual ventures. The main players were never very many in number, but they carried along a larger number of minor figures in their orbit, attracted by the gravity they projected. In addition to doing business with each other, they maintained their contacts in the Low Countries. In November 1626, Hendrik Hybertsson recorded in his account book debts of 9896 daler 12 öre he owed to creditors in Holland for that year, while his debts in Sweden were 13397 daler, of which half was owed to his wife and a third to his partner. He owed significant sums to one of his creditors, Rombout Johanszoon, in both Sweden and Holland.

His accounts also show business dealings with the Clerks and other military entrepreneurs, especially Paridon von Horn. There are no entries for Louis de Geer, who often stands in general histories as the exemplar of the Dutch businessman in Great Power Sweden, but he had not yet really arrived on the scene in Stockholm when the accounts were written. He did start to play a direct role in the navy in 1627, as a rigging contractor (cf. discussion of Äpplet's rigging, below), but one might say that Paridon von Horn was the dominant foreign financier in military procurement before then.

Together with his business partner Christian Welshuisen, von Horn held every imaginable type of *arrende*, from rural tax farms on individual

härader and toll mills to one of the top prizes, the lucrative foreign tolls for Stockholm.[25] At the same time he held conventional procurement contracts for the military – he built ships in Västervik,[26] supplied salted fish to the Crown,[27] and in one particularly complicated deal, delivered the rigging for *Vasa*.[28] Von Horn supplied some of the toll income directly to the navy yard contractor,[29] without it passing through the treasury (contrary to the terms of the navy yard contract), while at the same time he loaned money as a private businessman to his fellow businessman, Henrik Hybertsson.[30] In the series of Liquidations that wound up the *arrenden* after 1630,[31] most of the contractors show up in summary accounts of a few pages, but Paridon has an entire bound volume of over a hundred pages. His relationships and dealings were so complex that it was never possible to disentangle all of them, and in some cases the crown eventually gave up arguing with him and agreed to pay him what he claimed he was owed.[32]

Timber

Shipbuilding is often blamed for deforestation, especially in small states with large navies, such as Early Modern England and Renaissance Venice, with contemporary complaints about the woeful supply of ship timber seen as some of the evidence, but this is an oversimplification and misleading. Shipbuilding timber can be in short supply even in a heavily forested country because the demand is extremely specific. In northern Europe, the timber normally used for building warships after the Middle Ages was oak. It was durable, strong, and widely available in the large scantlings (cross-sectional dimensions) needed for shipbuilding. The range of the species most commonly used for all types of heavy construction, *Quercus robur* and *Q. petraea*, covers more or less all of temperate Europe, including Sweden as far north as the Mälaren basin. Oak can be found both as long, straight trees growing in dense stands, which are suitable for keels, beams and planking, and as broad, solitary spreading trees with curved branches suitable for stems, framing and the many curved parts needed for ships.

However, not every tree is suitable for shipbuilding, and clearcutting forest is not an effective way to manage the timber resource. Curved timbers have to be chosen to match the shapes desired for specific elements, and so trees are selected and processed individually. Finding enough trees with the right curves for a single warship requires knowledgeable people to search a large area of forest and field. Straight trees also have to be selected carefully, to avoid those which have started to develop heart rot (as oaks tend to do past a certain age and size) and those which have twisted or irregular grain. Shipbuilders thus do not denude the countryside of trees, but they do need access to a lot of countryside in order to find the few trees which are suitable. In a survey of domestic sources of shipbuilding oak in England in 1671, useful trees were widely scattered.[33] Shipbuilders might be forced to resort to foreign timber markets due to depletion of the specific kinds of trees they needed.

Poland-Lithuania had been a major international supplier of oak timber for a wide range of applications since the 14th century, with large tracts of dense oak forest. Most of what it exported was straight timber, in the form of balks (beams), wainscot (planks), boards (thinner than planks) and roughly shaped barrel staves in the hundreds of thousands. Curved timber was expensive to ship, as it could not be stowed efficiently in a ship's hold and it was not possible to predict what shapes most of the market needed, although Dutch shipyards, which were dependent on imported timber and made large numbers of ships to standardized designs, provided a market for some export of *kromhout* (literally "crooked timber"). Dutch timber merchants controlled most of the commercial timber trade out of the Baltic by the 17th century, buying at source and shipping directly to large international markets, such as Amsterdam. They also had agents in smaller but lucrative trades, such as the export of timber from the Danish counties of Halland and Skåne and mast timber from western Sweden.

Timber has a high volume relative to its value, so shipping costs represent a substantial fraction of the retail price – in the late Middle Ages, shipping could be up to 80 per cent of the cost at source for timber shipped from the Baltic to western markets.[34] This is true even for short-haul routes, as loading and unloading are a large part of the overall cost. Once all timber has to be shipped to the yard, the cost penalty for buying on

the international market becomes less prohibitive, especially as the operators of the Stockholm navy yard were exempt from paying import duty on timber and fuel.[35] At the same time, the shortage of labour in the countryside, due to the combination of a small population and the depletion of the workforce through conscription into military service, increased the cost of sourcing timber locally. In the 1620s, this imbalance was further shifted in favour of international sources by the sharp drop in Dutch traffic into and out of the Baltic, which should have made some of the timber sources formerly in their control available for purchase within the Baltic, especially by well-connected Dutch entrepreneurs working for the king of Sweden.

The result was an opportunity for the navy yard contractors, who were foreign businessmen, to purchase timber abroad at advantageous prices. This was limited to straight timber, in the form of rough-sawn plank (plank is thicker than 1½ inches or 37 mm; boards are thinner than 1½ inches), which was needed in large quantities for the planking, ceiling and decks of ships. It was still not advantageous to purchase *kromhout* abroad, as trees had to be selected individually. In practice, this meant sending teams of shipwrights into the forest with full-sized patterns of the timbers needed. They selected the trees and did much of the rough shaping in the woods, which minimized transport costs. This was not practical for overseas sources, and in practice limited the harvested resource to forests with water transport links to the capital.

Apart from a small amount of timber which they were allowed to cut on royal estates (one hundred trees over four years, when a single ship the size of *Vasa* would require thousands of trees), Henrik and Arendt were responsible for sourcing all of the raw material and labour themselves from the open market. They were given control of a number of Crown forges and a wind-powered sawmill[36] for processing the materials, but only for handling the navy's material, not for production in their own right. They were to be paid 66 000 daler annually, disbursed monthly (presumably in cash) as the treasury would bear it. Several drafts of this contract survive, as well as notes and scratch paper attempts to calculate the total amount of money needed for the contracted cost,[37] showing that Henrik and Arendt were considering the costs and potential sources of labour

and materials carefully. An accounting of the cost of *Vasa* compiled after the ship was finished lists all of the materials and labour, but specifically states that it omits transport and other transaction costs.[38] Against the contract price of 40 000 daler (or 42 000 daler[39]) the hull actually cost 53 300 daler. Of this, 14 100 daler (26.5 per cent) was spent on timber, 16 500 daler (31.0 per cent) on iron (anchors, hardware, nails and bolts) and 22 700 daler (42.5 per cent) on labour.

Although the contract did not take effect until January 1626, Henrik and Arendt were expected to deliver the first ship that year, so they began buying materials already in 1625. Their account books for 1625 and 1626 survive and show where they purchased most of the timber that eventually went into *Vasa*, as well as timber held for use in one of the smaller ships and timber used for the maintenance of the fleet. These accounts show quantities and unit prices, as well as the names and locations of suppliers. They also provide information on transaction costs, including not only transport, but fees for exchanging foreign currency, expenses for carpenters sent out into the forests to cut and rough shape timber, and even the cost of hiring teamsters to transport sacks and chests of cash to pay for significant purchases.[40]

The organization of the navy yard workforce was adapted to the requirements of a centralized production site with a disbursed resource base. Henrik employed two master shipwrights, Henrik "Hein" Jakobsson and Johan Isbrandtsson. Hein was the *gårdsmästare*, the yard master, who worked in the navy yard itself, overseeing the construction and repair of ships. Johan was the *skogsmästare*, the forest master, who travelled the countryside with gangs of carpenters, selecting and rough shaping trees on various estates. In addition to their salaries, the forest carpenters were also entitled to travelling expenses and maintenance. Johan was responsible for hiring local labour to move timber to the water so that it could be loaded on boats for shipment to Stockholm. This kind of labour could be expensive, due to the sparse population and demands from other users. Most *arrenden* included the contractor's right to claim the labour and transport duties owed to the king by local peasants, and this use of their time was seen as a heavy burden.[41] Henrik and Arendt's contract did not include this right, and so there are many entries for paying local peasants

and their teams of horses to haul timber out of the woods to the nearest point reachable by boat.

Because of the wide dispersion of suitable shipbuilding timber, the navy yard bought timber, sometimes in lots as small as a few trees, from a number of different owners of wooded estates. Most of these suppliers were members of noble families, who formed a close network of their own. The navy purchased timber from, among others, Johan Skytte (the acting treasurer of the realm), Prince Johan Casimir, Mathias Soop, and several prominent widows, among them "Countess" Ingeborg Claesdotter,[42] wife of the former *riksamiral* Göran Nilsson Gyllenstierna. One of the largest and most consistent suppliers was Fru Brita Gustafsdotter Bååt, who had held the estate of Ängsö (Engzöö) since she received it as *morgongåva* in her marriage to Arvid Posse in 1598.[43] She was active in the timber and iron markets, and the navy yard maintained a nearly permanent presence on her property, which seems to have been a good source for oak. She was well connected in Swedish society (her cousin was married to Chancellor Axel Oxenstierna), and her house at Ängsö is still standing.

As the account books show, the geographic range from which the navy yard sourced domestic timber stretched from the northern shores of Mälaren as far south as Kalmar, with substantial amounts of timber coming from areas near Västerås, Nyköping and Gamleby/Västervik. Smaller amounts came from Erstavik and isolated estates south of Stockholm. Henrik owned and operated a small merchant ship, the *Sankt Jakob*, which he used for transport, but also hired freight tonnage as necessary, as well as paying crews and local tolls and fees. His transaction costs were thus spread over a wide range of people and mounted up rapidly.

At the same time that Henrik was deploying his carpenters and sawyers out into the forests, Arendt de Groote was travelling between Amsterdam and Sweden as well as all over the Baltic to source materials that were either not available in Sweden or were available at a competitive price elsewhere. The account books show him sending purchases back to Stockholm from various places and money being forwarded to him to allow him to make purchases. Along with compasses, paint, coal and whetstones, a major foreign purchase was timber. The account books list substantial

purchases in three prominent timber markets: Riga, Königsberg (now Kaliningrad in Russia) and Holland (probably the Amsterdam area). In all of these cases, the timber was oak purchased as rough-sawn plank. Riga and Königsberg were both termini for the export of oak grown in the dense stands of the Polish-Lithuanian forests, and so Arendt's connections with merchants in those towns allowed Sweden to take advantage of the strategic resources of its enemy. Amsterdam was his home town, but its market was full of timber imported from other places, primarily Germany and Poland. The Dutch had organized this trade so well, driving transport and other transaction costs down through the use of specialized ships, direct purchase at the source, and favourable commercial arrangements that relieved them of many of the more onerous tolls, that it was possible for them to market imported timber competitively. It is thus possible that some of the timber Arendt purchased in Holland and shipped back to Stockholm had come from the Baltic to begin with. That this timber was competitive provides some indication of how difficult it was to source timber economically within Sweden, even if it was, in theory, widely available.

As an illustration, in 1625 the navy yard paid a total of 21 338 daler 19 öre for timber, including transaction costs.[44] Because much of the transaction cost of foreign timber (felling, sawing, hauling to market) is subsumed in the purchase price at market it is not possible to identify it in the accounts. It is more instructive to look at the domestic picture in detail. In 1625, the navy yard purchased timber in Sweden, the vast majority of it oak, for a total of 4664 daler paid to the sellers. In addition to this, the transaction costs, including labour to cut the timber, transport over land to water (usually by local peasant labour), and freight by water to the navy yard, amounted to 2898 d 16 ö, or more than 62 per cent of the price of the timber. This is a substantial addition to the cost for timber being sourced at relatively short distances from the navy yard, and suggests that there was room to get better prices by buying in a well-organized market, even if it meant longer transport. Long-distance transport by sea was in any case relatively cheap, compared to the cost of dragging the trees out of the forest to the nearest navigable water.

It has been possible to corroborate the historical data on the specific

sources of some of the timber in the *Vasa* directly, by dendrochronological analysis. This type of study looks at the variation in annual ring width, which is a result of local variations in weather, to identify not only when a tree was growing but where. Oaks in the Mälaren valley have a different signature from oaks near Kalmar, and both differ from timber growing in the Vistula basin. In the course of a project led by Aoife Daly, it has been possible to take more than 300 samples from timbers in the hull of *Vasa* and compare their annual rings to master curves developed for different areas in northern Europe.[45] These show a regional distribution which reflects the sources reported in the purchase records. All of the curved timbers sampled appear to have domestic Swedish sources, with two distinctly different signatures which probably reflect the division between sources in Mälaren and those along the south-eastern coast.

The planking reflects these two sources as well, but includes two signatures only found in the planking. One of these matches a diffuse master chronology known as "Baltic oak", which refers to a Polish-Lithuanian source, while the other was a surprise. Some of the ceiling (interior planking) in the gundecks can be localized with confidence to the area around Göteborg and southward, on the west coast of what is now Sweden but was then mostly Denmark. This was initially puzzling, as all histories of Baltic timber trade are based on the assumption that the flow of timber is strictly westward, and there are no entries in the Sound Toll records for timber entering the Baltic in the 17th century. However, Swedish ships or ships carrying goods for the Swedish king were exempt from the Sound Toll in this period. The Danish town of Varberg, south of Göteborg, maintained a trade in oak timber with Amsterdam merchants until well into the 17th century. It seems most likely that some of the timber purchased in Holland and shipped back to Stockholm originally came from western Sweden, further evidence of how complicated the supply of an essential commodity could become.

Hemp

Hemp (*Cannabis sativa*) was the raw material for ships' rigging, both for spinning and laying into rope and for weaving into sailcloth. It was needed in large quantities – a typical medium to large Swedish warship needed 15-17 tonnes of hemp fibre in the form of rope and sailcloth for its initial outfitting[46] - and it was not very durable. Maintenance contracts indicate that the navy budgeted about an eighth of the capital cost of a ship's rigging for its maintenance and replacement every year[47] in working ships. It was also expensive. *Vasa*'s rig was valued at 6 500 daler, or 10.8 per cent of the combined cost of hull and rigging, but represents less than 2 per cent of the combined weight of hull and rigging. Hemp was also one of the few naval stores which Sweden could not source domestically.

Although hemp grows as a weed throughout the temperate zones of northern Europe, like shipbuilding timber it cannot be harvested indiscriminately. Hemp of sufficient quality to make into rope or sailcloth has to be cultivated in the proper soil and processed very carefully. The conversion of the plant into useful fibre is labour-intensive. The fibre, which is the bast lining between the woody outer cortex and the central pulp of the stem, has to be separated from the rest of the plant without damaging it. This begins with retting, soaking the stems in water to start a controlled process of rotting, followed by successive applications of increasingly refined violence to break up the woody cortex, separate it from the fibre, and clean and align the fibre. The process and result is very similar to flax, and finished hemp and flax fibre can be difficult to distinguish. Mixing the weaker and less durable flax in with hemp was considered a form of fraud, and was a pernicious practice in the hemp trade, especially as it was almost impossible to detect once the fibre had been made into rope or cloth.[48]

Russia held an early dominant position in the international hemp market, exporting via Archangel on its northern coast, but attempts by a major international trader, the Muscovy Company of London, to manipulate the price in the early 17th century led consumers outside of the Baltic to consider alternative sources.[49] Riga and Königsberg hemp rapidly assumed a prominent place in the market, as the fibre was considered to be as good or better than the earlier Russian product, and it could be purchased as fibre and made into rope by the user, which made it easier

to assure quality. The rigging maintenance contract for the Swedish fleet in 1626 specified that all rope was to be made of "the finest Königsberg or Riga hemp".[50]

The Swedish navy purchased much of its rope and all of its sailcloth from foreign sources for most of the first quarter of the 17th century, even though there were ropewalks in most of the major maritime centres in Sweden.[51] Certain types of cordage, such as boltrope (the rope sewn into the edges of sails) and anchor cable, required specialized skill and tight quality control to produce, so these were often purchased abroad until well into the 1620s. However, in the 1620s, Sweden began to develop its domestic ropemaking industry. A clear indication of this is the improvement of the Stockholm ropewalk, which was a major supplier to the navy A ropewalk need not be more than an open piece of ground several hundred meters long. The longest ropes made were anchor cables, which were standardized at 100-120 fathoms (178-214 m for fathoms of Swedish feet), and one had to start with yarns (and an open space) which were almost twice this long, due to shortening which occurred in the manufacturing process. Very little machinery or infrastructure was required in order to produce serviceable rope for many applications, but naval rope required more consistent quality and fixed infrastructure was advantageous.[52]

In the rigging maintenance contract for the fleet signed by John Clerk in August 1626, he was given command over the Stockholm ropewalk, with a separate budget from his main maintenance budget, but not specifically required to use it.[53] The rope of this time found on *Vasa* exhibits highly variable quality. Some of it is excellent, such as the sail boltropes, very evenly spun and laid from carefully and consistently processed fibre, while other ropes are lumpy and uneven, with snarled yarns inside the strands.[54] This suggests that Paridon von Horn, who supplied the rigging, was using a wide range of sources rather than a single, professional ropewalk. His instruction specified that he would supply the rigging from foreign sources, so he could not exercise direct control over production as the Clerks could. In this matter, he used Arendt de Groote as his agent for purchasing sailcloth and cordage in Holland,[55] and Arendt may not have had the technical expertise to judge the quality of products he was purchasing.

In April 1627, Louis de Geer, the powerful Dutch arms merchant, together with his partner Wellam Giliusson de Besche, signed a long series of *arrenden* and contracts for various aspects of military supply. Among these they agreed to import the rigging for *Vasa*'s sister ship Äpplet from Holland, and take over the Stockholm ropewalk.[56] The terms of the contract suggest that part of their mandate there was to convert the ropewalk into a more permanent, roofed installation. The Stockholm ropewalk does not appear on the earliest map of the city, from the mid-1620s, but by the 1640s, it was two long buildings occupying the space along what is now Birger Jarlsgatan in the area of Stureplan. With preferential access to Riga hemp, the development of Swedish ropewalks and the downturn in new construction for the navy after Gustav Adolf's death in 1632, the navy began to be able to rely increasingly on domestic rope production.

Sailcloth was another matter. The navy had functioned on domestic production of sailcloth, usually identified as *vadmal* (a heavily fulled woollen cloth with a dense nap) and *lärft* (a coarse linen cloth) for much of the 16th century, with some imports, but from the 1590s the reliance on imported cloth increased. Hemp was a superior material for sailcloth; it was lighter and more manageable than wool and more durable than flax, but hemp sailcloth of the quality demanded by the navy was not produced in Sweden until much later in the 17th century. Attempts to start domestic production in the 1630s were unsuccessful,[57] and the navy relied on imported cloth for another generation. Naval quality sailcloth was available from a number of international sources, which can be identified from purchase records. At various times the navy bought sailcloth made in the Low Countries, Lübeck and Gdańsk, with German cloth predominating in the 1610s, but by the reign of Gustav Adolf, it frequently if not usually specified French sailcloth for some or all of its sails. Richard Clerk's contracts in 1618, 1621, and 1622 specified French cloth for the courses (lowest, heaviest sails), Gdańsk or Lübeck cloth for the topsails and mizzen, and Norman[58] cloth for the topgallants (the lightest sails)[59] on larger vessels, with Holland cloth specified for some smaller vessels. The maintenance contract of 1626 with Richard's brother John called for two weights of cloth for new sails: broad French cloth for the courses and good French canvas for the topsails.[60] Although Glete questioned whether this meant that the cloth was actually made in France or was just a grade

of Dutch cloth, as both were exported from Holland,[61] sailcloth was known in the international market by its place of manufacture rather than its point of purchase. Cloth made in France was widely respected for its quality and specified by other navies as well as the Swedish. French cloth was made in a number of major production centres in northern France. The English navy specified French cloth for its sails for much of the 16th century, and even after the development of a domestic sailcloth industry by the early 17th century, French cloth continued to be imported.[62] French cloth was expensive, and not always available. In its absence, Dutch cloth, largely produced in the weaving centre of Krommenie in Holland, was an acceptable substitute.[63] Both French and Dutch cloth could be purchased in Amsterdam. A shortage of French cloth in the Swedish navy's stores in the summer of 1623 led to a suggestion by Richard Clerk to use Gdańsk cloth, of which he had plenty, but the king refused, insisting on French cloth.[64]

Six of *Vasa*'s sails survive, and they are made from two weights of cloth, with the lighter weight occurring in two different widths. It is not possible to be certain where this cloth was made, but the widths are consistent with known widths produced in France, less so with known widths from Krommenie.[65]

The roping sewn to the edges of the sails was made differently than normal rope for rigging, with the individual strands laid harder but the overall lay looser. Normal rope could be altered by stretching it to approximate the performance of purpose-made boltrope, but the specialist product was preferred. It had to be matched carefully to the cloth, and had to be as consistent as possible in its quality in order to give the sail a proper shape. We can see in the *Vasa* material that the sail roping is of much higher and more consistent quality than any of the other rope in the ship, from the initial selection of high-quality fibre through the processes of spinning, laying and closing.[66] It was likely purchased from a specialist supplier, possibly in conjunction with the purchase of the cloth. In 1637, the need to match sails and roping better was one of the reasons given when the English admiralty decided to abandon its sailmakers of 60 years, the Pruson family.[67] The Swedish navy may have continued to import sail roping after the bulk of rope production shifted to Sweden for the same reason.

Conclusion

The Swedish capture of Riga in 1621 gave Sweden access not only to a major entrépôt and its wealth, but also a source of supply for two key naval stores, timber and hemp. Riga was an export point for both, with a well-developed economic infrastructure stretching deep into the hinterland as a legacy of its Hanseatic past. Hemp was a strategic material with limited sources of supply, and Riga was considered to offer the best quality for naval use. The acquisition of the outlets for such a commodity was critical for the expansion of the navy, as it allowed the development of a larger domestic rope industry and relieved the navy of the need to rely as much on imports. It did not by itself eliminate the import of rope or rigging, as particular circumstances could make importation a viable option. That Paridon von Horn and Louis de Geer were both expected to supply the rigging of *Vasa* and Äpplet from sources in Holland shows that such circumstances continued to exist. There is evidence that the navy's normal rigging contractor, John Clerk, was having difficulty meeting his obligations within a year of signing the maintenance contract,[68] and the quantities of rope and sailcloth needed for two ships substantially larger than the ships normally ordered before 1625 may have exceeded the capacity of domestic production.

The expansion of the shipbuilding program after 1620, building not just more ships but larger ships, at the same time that new construction was centralized to the capital and Västervik (with a few ships built in Göteborg), no doubt applied significant stress to the timber procurement process. Oak may have been abundant, but it had to be found, selected, cut and transported on a scale not previously seen, while labour was becoming more expensive and harder to source, as conscription (initiated in 1618) began to take men out of the pool of available labour and the private entrepreneurs who had signed *arrende* began to over-exploit the peasantry. These effects no doubt raised the transaction costs of sourcing timber domestically, but there was no escaping the use of local forests for the curved timbers needed to build ships. Foreign sources could supply rough planking stock at competitive prices.

While unskilled labour for moving timber to the water and performing other menial tasks in the shipbuilding process was starting to become scarce, there was already a shortage of the skilled labour needed to build ships at the pace the king demanded. From 1620, the workforce at the Stockholm navy yard was expanded, in fact doubled, by the recruitment of skilled seasonal labour from abroad, primarily the Low Countries.[69] These men were paid at a higher rate than domestic shipwrights. If the number of Swedish and Dutch carpenters at the navy yard were about equal, as Cederlund suggests, and the Dutch carpenters worked only during the warmer months, then they were being paid at a daily rate more than twice that of the Swedish carpenters.[70] That the state could support this expense is another indication of the pressure on the procurement and production process.

The recruitment of foreign merchants with their international connections to the procurement process enhanced the navy's access to labour and materials in foreign markets, and certainly led to a more international procurement approach in the short term. The use of their financial expertise, combined with the exemption from key tolls, probably reduced the transaction costs of foreign purchases to where they were not just competitive with domestic supply but preferable. Familiarity with the international market probably also played a psychological role for the entrepreneurs, while the strong Swedish international currency gave them effective purchasing power abroad.

The Swedish naval expansion of the 1620s coincided with a temporary, marked decline in Dutch engagement in Baltic trade after 1621, which should have increased the supply of foreign timber and hemp available for Swedish purchase, even while Dutch merchants could take advantage of remaining contacts in foreign markets. This should have not only increased availability, but pushed the price at source downward, as timber merchants in Riga and Königsberg sought to find new buyers in the absence of Dutch demand.

After Gustav Adolf's death in 1632, the regency government cancelled many of the outstanding contracts for new ships, especially a series of large ships which the king had ordered late in his reign. New construction came to a standstill for a decade, and the navy focused on maintenance, which provided a breathing space in which to develop domestic production of

naval stores. The naval battles of Torstensson's War in the 1640s were fought for the most part with ships built in the 1620s and early 1630s; at the outbreak of the war, only eight of the navy's forty-two combatant ships had been added to the fleet after 1634. Four were recent purchases in the run-up to the war, and none were especially large.[71] Even Karl X's fleet at Öresund in 1658 included a handful of Gustav Adolf's ships. By the time that new construction resumed in volume in the 1650s, Sweden had lost its close relationship with the Low Countries, as the United Provinces had switched sides in the Baltic wars, allying with Denmark-Norway in both the wars of the 1650s and the Scanian War of the 1670s. The navy turned increasingly to English expertise instead of Dutch[72], and developed a very different network of suppliers.

One of the lasting consequences of the events of the 1620s was a distinct shift throughout the government's finances from in-kind sourcing of materials to cash accounting and transactions. Even after the cancellation of most of the *arrenden* in the 1630s, the advantages of dealing in money rather than barrels of flour and cattle on the hoof were readily apparent. And even if no one liked the new copper coinage, the shift towards monetization could not be reversed. Sweden still lagged behind many other countries in its bookkeeping practices and financial sophistication, but had taken a giant step forward. The increased reliance on foreign sources during the 1620s played a part in this, as it exposed the government to international, monetized markets. The war in Germany would draw Sweden more fully into the continental European economy during the 1630s and 1640s, even as it sought to improve its domestic supply networks.

Samanfattning

Byggandet, utrustandet och upprätthållandet av en flotta kräver en stadig ström av kapital och råvaror. Innan ånga och järn tog över från segel och trä så var de viktigaste råvarorna för att bygga och utrusta fartyg: timmer för att bygga skrovet, järn för beslag och fästen, hampa för trossar och segel och tjära för göra skrovet vattentätt. Under 1600-talet utvecklade alla de stora sjömakterna i norra Europa professionella administrativa apparater för att samla in och styra flödet av de stora mängder råvaror som krävdes för att bygga och underhålla örlogsfartyg. Det uppstod en alltmer sofistikerad marknad kring dessa strategiska råvaror och flera stater ingrep i krig för att öka eller säkra sin tillgång till de råvaror de behövde.

Under Gustav II Adolf utökade Sverige sitt territorium och fick kontroll över betydande mängder av alla de viktiga råvaror som behövdes för att bygga och underhålla örlogsfartyg (naval stores): timmer, tjära, hampa och järn. Sverige var en av få större sjömakter vid denna tid som kunde tillfredsställa sina behov av dessa råvaror från områden under egen kontroll. Men under kortare period på 1620-talet ledde olika samverkande processer i Sverige och utomlands till att utländska källor åter kom att spela en viktig roll i införskaffandet av timmer och tjära. Samtidigt pågick en allt snabbare process mot en ökad inhemsk produktion av andra av de nödvändiga råvarorna. En ekonomisk kris i Europa, det återupptagna Nederländska frihetskriget, den svenska flottans snabba expansion inför kriget med Polen-Litauen, svenska statens nya metoder för beskattning och anskaffande av råvaror bidrog tillsammans till att en liten grupp utländska, huvudsakligen nederländska, affärsmän fick en central roll i införskaffandet av timmer och tjära till den svenska flottan. De kunde under en period framgångsrikt dra nytta av sina internationella nätverk för att hålla nere transaktionskostnaderna och tillhandahålla de råvaror som Sverige behövde från områden så spridda som Livland, England och Frankrike. De kunde till och med tjäna pengar på att skeppa timmer, en av de viktigaste exportvarorna från Östersjöområdet, tillbaka till sitt ursprungsområde för att fylla flottans behov. Det hade aldrig hänt tidigare och har inte heller hänt sedan dess.

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RR – Riksregistraturet (Calendar of State Papers)

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Noter

[1] Glete 2010 covers the development of the Swedish naval administration in its first two centuries in detail, effectively superseding previous studies such as Zettersten 1890.
[2] See Ingvar Sjöblom's recent (2019) detailed study of the development of the navy's personnel in the 16th century.
[3] RA Skeppsgårdshandlingar 70.8 and 70.9. These may have been submitted in evidence after one of the navy yard contractors was accused of exporting timber purchased with crown funds (RA KK protocol 26 February 1628).
[4] Readily seen in the records of the Sound Toll, summarized in Bang 1906.
[5] The wreck of *Solen* has been excavated by the Polish National Maritime Museum and is currently in the process of publication in scientific monograph form.
[6] The remains were identified in 2017, when they were discovered to have been used as cribbing to stabilise the expansion of the shoreline on Skeppsholmen, probably in the late 1630s or early 1640s; Daly 2017 and 2018, Hansson 2019.
[7] Glete 2010, p. 284
[8] Glete 2010, pp. 286-287.
[9] The *arrende* system, especially the tax farming aspects and their social and political implications, are covered comprehensively in Hallenberg 2008, with discussion of the earlier literature.
[10] Variously Anton, Anthony or Antonio; RA KK Kontraktsböcker 1 1617-1622, ff94-96.
[11] RA KK Kontraktsböcker 1 1617-1622, ff152, 166.
[12] Two slightly different versions of this contract were signed, one in December 1624 and one in 1625. The former was signed by the admiralty, the latter by the king, and while there seems to have been some initial confusion over which was the definitive version, the latter contract (RA KK Kontraktsböcker 2 1623-1625: ff110-112) is the one usually cited by modern sources.
[13] Usually named as Rickard Klerck/Klärck. RA KK Kontraktsböcker 1 1617-1622 f153; RA KK Kontraktsböcker 1 1617-1622, ff50-51; RA KK Kontraksböcker 1 1617-1622, ff125, 174, 176.
[14] Most Swedish authors state that the relationship between Richard and John is unclear, but the Swedish history of the Clerk family is well known in Scotland. The Clerks were from Montrose on the east coast of Scotland, and had come to Sweden in 1610 with a ship they had outfitted at their own expense to serve Karl IX (Adams 1984, p. 18).
[15] John Clerk usually appears as Johan or Hans Klerck/Klärck; 6 December 1625 (RA KK Kontraktsböcker 2 1623-1625, ff160-161).
[16] RA KK Kontraktsböcker 3 1626 ff106-109.
[17] For example, a contract of 8 March 1622, in which Richard Clerk agrees to provide the rigging and sails for the new ship *Stockholm* (launched in Stockholm the previous year), twelve galleys and sixty *lodjor* at a cost of 10 500 daler (RA KK Kontraktsböcker 1 1617-1622, f125).
[18] Open letter of 16 February 1627 from Gustav II Adolf to Paridon von Horn and Christian Welshuisen, RA KK Reg. 1627, f22.

[19] Glete (2010, p. 488, n. 97) believed that John Clerk had provided Äpplet's rigging, but the Council's letter to the king on 10 June 1628 (RA royal correspondence 1628, f115) specifically notes that the rigging for the ship then being completed in Stockholm (which was Äpplet) would be supplied by de Geer. Treasury records (RA KK Reg. 17 July 1628) show that de Geer had already supplied some of the rigging by the middle of the summer.
[20] Such as the *arrende* for the Brän Ekeby iron works signed by Louis de Geer and Wellam Giliusson in April 1627 (RA KK Kontraktsböcker 4 1627-1628, ff33-34).
[21] See the contracts of March and December 1625 with Johan von Kassell for the supply of *ammunition* (small arms and armour; RA KK Kontraktsböcker 2 1623-1625 ff127-127, 162) or the several contracts with Jacob Dankwardt for cast-iron guns and ammunition (such as RA KK Kontraktsböcker 4 1627-1628, f65). These follow a standard form which is little different from pre- or post-*arrende* procurement contracts except that payments are in cash.
[22] The wider problems in the Crown's relationship with its subjects caused by the *arrende* system are discussed at length in Hallenberg 2008, pp.167-208.
[23] Hallenberg 2008, p.77.
[24] Hallenberg 2008, pp. 81-126.
[25] RA KK Kontraktsböcker 1 1617-1622, ff43-44; RA KK Kontraktsböcker 2 1623-1625 f9.
[26] RA KK Kontraktsböcker 1 1617-1622, ff42-43; RA KK Kontraktsböcker 2 1623-1625, f24.
[27] RA KK Kontraktsböcker 3 1626, f11; RA KK Kontraktsböcker 4 1627-1628 ff
[28] This was in lieu of repaying the cost of rigging a ship he had built, Äpplet (not *Vasa*'s sister ship but an earlier ship of the same name; see Glete 2002) which he had been required to buy back when it was not accepted for service (stated in an open letter from the king to von Horn and Welshuisen on 16 February 1627; RA KK Reg. 1627, f22). The value of *Vasa*'s rigging and whether it equalled the value of the rigging of the slightly larger Äpplet became the subject of a dispute between von Horn and the Crown which ran for several years after *Vasa* had sunk; RA KK Likvidationer 92-93.9).
[29] As recorded in Henrik's account books; RA Skeppsgårdhandlingar 70.8, 70.9.
[30] As also recorded in Henriks account books; RA Skeppsgårdshandlingar 70.8, 70.9.
[31] RA KK Likividationer.
[32] The specific case of the rigging for *Vasa* appears numerous times in von Horn's *Likvidation*, in various forms and in various combinations with other expenses. The earlier documents show a discrepancy between the government's accounting, valuing the rigging at 6000 daler, and von Horn's claims, at 6500 daler. In the later documents, the discrepancy disappears and the rigging is valued at 6500 daler.
[33] Pepys Library PL 2265 (Naval papers collected for Parliament 1677), pp. 56i-iv.
[34] Dollinger 1970, p. 157.
[35] Henrik Hybertsson and Arendt de Groote's contract specified this exemption: RA KK Kontraktsböcker 3 1626 ff113-114, §10.
[36] Marks left by a wind-powered mechanical "up-down" saw are readily distinguished from the marks left by hand sawing; powered mill marks, mostly on planks and boards of spruce and pine, have been documented on timbers from *Vasa*.
[37] For example, RA Skeppsgårdshandlingar 1625, ff27-32.

[38] RA M1779.
[39] The first version gave 42 000 daler, the definitive version 40 000.
[40] RA Skeppsgårdshandlingar 70.8 and 70.9. The 1625 accounts are a "clean" final version, with different expenses grouped by subject; transport and other transaction costs start on f16. The 1626 accounts are a rough running account, organized by date, and transaction costs are scattered throughout.
[41] Hallenberg 2008, pp. 170-171.
[42] Her family achieved baronial status in 1652 under the name Bielkenstierna (rank nr. 28). She is given the title of *grevinna* in one of the entries in the accounts, but this was probably simply a courtesy, as her husband had been a *friherre*, roughly equivalent to a baron in England, but not a count (*greve*).
[43] Nisbeth 2011, pp. 24-29; there is some confusion in the records about her status, as most Swedish biographical sources list Arvid as dying in 1630 (the same year as Brita), but in 1614 she wrote twice to Axel Oxenstierna to invite him to her husband's funeral and to ask for his assistance (RA Brevskrivarregister Oxenstierna collection, E 691), and all of the dealings that the navy yard had with her in the mid-1620s were either directly with her or with her agents, indicating that she held full control over the estate.
[44] RA Skeppsgårdshandlingar 70.8 ff10-14.
[45] Daly 2021.
[46] The rope and cable for rigging *Tre Kronor* (a ship about three-quarters the size of *Vasa* in tonnage) when new in 1626 came to 103 skeppund 13 lispund 7 skålpund (17208 kg, for a skålpund of 415g), costing 3317 daler 12½ öre (RA Skeppsgårdshandlingar 1622-1628). This ship was among the larger in the normal class of ship used by the navy, although *Vasa*'s cables and rigging probably required closer to 20 tonnes of hemp, as its cables were much larger (cf. Magnus and Seeberg, in press).
[47] Based on the maintenance cost per last against the capital cost as presented in the rigging contracts of Richard and John Clerk referenced above; see Glete 2010, pp. 456-460 for a discussion of the navy's overall needs.
[48] This was a common complaint by the ropemakers working for the English navy; cf. Pepys Library PL 2878 (Naval Miscellany 10), pp. 559-562.
[49] The story was summarized by Messrs. William Greenwell and Thomas Styles as part of their correspondence to secure the contract for supplying hemp to the English admiralty in 1610; Pepys Library PL 2878 (Naval Miscellany 10), pp. 531-553, 559-562.
[50] RA KK Kontraktsböcker 3 1626, f106.
[51] Glete 2010, pp.452-459.
[52] Magnus and Seeberg, in press.
[53] RA KK Kontraktsböcker 3 1626, ff106-109.
[54] The cordage of *Vasa* is presented in detail in Magnus and Seeberg, in press.
[55] As revealed by bills of lading for the ships de Groote hired in Amsterdam to transport goods back to Sweden; Reinders 2014.
[56] The Council, in its letter to the king on 10 June 1628, informed him that Louis de Geer had already purchased the rigging for Äpplet in Holland; RA royal correspondence 1628, f115; RA KK Kontraktsböcker 4 1627-1628, ff31-32.
[57] This included using child labour from the Stockholm orphanage; Glete 2010, p. 493.

[58] This term is difficult to be certain of; Glete (2010, pp. 485-486) transcribed it as *wurms* cloth, and Zettersten (1890: 354) believed it was a synonym for *vadmal* (heavily fulled, coarse woollen cloth), which is hardly likely as it was used for the lightest sails. In Richard Clerk's general contract of November 1618, it is clearly *Wurms duk*. In his contract of February 1621, the lightest weight of canvas is clearly identified as *Normans duuk*, which would mean cloth from Normandy, which was a production centre for sailcloth. In his contract for the rigging of *Stockholm* and other ships, the lightest sails should be of *Wurms* or possibly *Nurms duuk*. W and N can be difficult to distinguish among some secretarial hands in this period, and because both letters start with the same stroke, it may be a common scribal error to write one for the other. In any case, it is certainly an imported product.
[59] RA KK Kontraktsböcker 1 1617-1622, f153; RA KK Kontraktsböcker 1 1617-1622, ff50-51; RA KK Kontrakstböcker 1 1617-1622, ff125, 174, 176.
[60] RA KK Kontraktsböcker 3 1626, f106v.
[61] Glete 2010, p.454.
[62] In the 16th century, cloth from Ollerons and Poldaveis was preferred (Knighton and Loades 2000, p. 156); Morris 1998; By the later 17th century, the most common cloth specified was from Vitry or Noyelles (see for example, the building account for the 3rd rate *Lenox* in 1677; Pepys Library PL 1339: 41-42).
[63] Van Yk 1697, pp. 252-253, Lootsma 1929.
[64] Letter from the king to Vice Admiral Klas Fleming, 26 August 1623; RA RR 1623, f270.
[65] There are two preliminary publications of the sails (Svensson 1964 and Bengtsson 1975), with a comprehensive publication due to appear shortly (Bengtsson, Bartoš and Hocker, in press).
[66] Magnus and Seeberg, in press.
[67] Pepys Library PL 2875 (Naval Miscellany 7), p. 287.
[68] In September 1627 the king wrote to Riksamiral Karl Karlsson Gyllenhjielm to tell him that Clerk must make up his mind about whether to continue with the rigging of the navy's ships or not (RA RR 1627, f368).
[69] Cederlund 1966.
[70] As shown in the summary account of construction costs for *Vasa* and *Tre Kronor* (RA M1779). This is substantiated by individual payments reported in the navy yard account books for 1625-1626 (RA Skeppsgårdshandlingar 70.8 and 70.9).
[71] According to the dates of service presented in Glete 2010, pp. 683-703.
[72] See Eriksson 2017, pp. 89-112 on the shift from Dutch to English practices in the later 17th century.