The lifecycle of casks: the production, use, and repurposing of casks in the Netherlands (1300–1800)

Oosterbaan, J.

2. The lifecycle and lifespan of casks

2. The lifecycle and lifespan of casks

This chapter is based on: Oosterbaan, J. (2025). Lifespan of Casks. *International Journal of Wood Culture* (published online ahead of print 2025). https://doi.org/10.1163/27723194-bja10037

2.1 Introduction

Casks are frequently encountered in urban and maritime archaeological excavations of sites dating from the Late Middle Ages and the Early Modern period. When subjected to thorough investigation, these casks offer significant potential for various fields of study. The initial exploration of the research potential of casks commenced several decades ago within maritime archaeology, particularly through the analysis of shipwrecks that yielded numerous casks.[51] A similar approach has been applied to casks recovered from urban archaeological sites, where they have been examined as a distinct artifact category when a substantial number is found.[52] However, studies exclusively dedicated to casks remain scarce. Consequently, there is a paucity of comprehensive knowledge regarding this type of transport container, including fundamental questions such as the duration of a casks' lifespan.

The cask's lifespan is considered to begin with the formation of the oldest timber actually incorporated into the cask and to extend through all phases of human activity associated with it, including its production, use as packaging material, and subsequent repurposing. Consequently, the lifespan of a cask is anchored to the oldest tree ring present in the cask itself, rather than to the oldest growth ring of the tree from which the timber was sourced for its production. The lifespan of a cask is considered to end when it ceases to be actively employed, whether during its initial function as packaging material, for instance if a ship transporting casks sinks, or during a subsequent repurposed phase, such as when a cask used as a cesspit lining is no longer functional. Defining the cask's lifespan in this manner situates this sub-study firmly from the perspective of the cask itself, in line with the approach taken in the other sub-studies of this dissertation.

Prior to examining the lifespan of a cask, it is essential to clarify its relationship with the cask's lifecycle. In this study, the lifespan is understood as the total temporal span necessary for a cask to progress through all stages of its lifecycle. This lifecycle can be broadly divided into three phases: production, use as a transport container,

51 Manders, 1996; Loewen, 1999, 2017; Ratcliffe, 2012; Hansson et al., 2022.

52 Houbrechts & Pieters, 1996; Oosterbaan & Griffioen, 2015; Verduin, 2019.

and repurposing (Figure 2.1). In section 2.3 the lifecycle of cask is addressed in relation to the possible duration of its individual phases and the extent to which each phase can be independently dated using archaeological data.

The timeline of the three phases in a casks' lifespan can be accurately determined using archaeological dating techniques. Information about the production of casks can be obtained through dendrochronological dating of the timber used and marks made at the time of their commissioning. Marks can also be employed to ascertain the duration of the use of casks as transport containers, the second phase in their lifespan. The third and final phase, their repurposing as a shaft of a barrel well, can be determined through the datable artifacts found in the well. In this chapter, these dating methods are utilized to develop a comprehensive understanding of the lifespan of casks during the Late Middle Ages and the Early Modern period.

In addition to elucidating the lifespan of casks, this research significantly contributes to dating the context in which casks are found. Furthermore, this chapter involves a systematic comparison between dendrochronological dating and artifact dating of the contents. While these chronological indicators or dating evidences are often presented together in reports, a systematic comparison of *terminus ante quem* and *terminus post quem* dating has been lacking. This chapter conducts this comparison and evaluates how to interpret and utilize the dating of casks.

2.2 Materials and methods

Source material

The first step of this sub-study involved identifying casks recovered from Dutch archaeological contexts, dated between the 12th and 18th centuries. These spatiotemporal parameters were selected due to the relatively high number of casks from archaeological contexts found within this region and timeframe, facilitating the creation of a substantial dataset. Inclusion criteria for the casks required that at least one component, such as a stave or headboard, had undergone dendrochronological analysis. The dataset is divided into two segments: one comprising casks from urban archaeological contexts and the other from maritime archaeological assemblages.

For the urban archaeological segment, casks from Dutch archaeological contexts were used, resulting in a dataset of 345 casks, dated using 1048 dendrochronological samples from either staves or headboards. The analyses of these samples were conducted by four dendrochronologists: Ing. Petra Doeve MA (BAAC), Ir. Sjoerd van Daalen (Van Daalen Dendrochronologie), the late Em. prof. dr. Esther Jansma (formerly Cultural Heritage Agency), and Dr. Marjolein van der Linden (Biax Consult). These data were supplemented with information from archaeological project reports, primarily based on the dating of artifacts found in repurposed casks.

The maritime archaeological dataset predominantly comprises casks recovered from shipwrecks in Dutch waters, including ships such as *De Kamper Kogge*[53], *Burgerzand Noord* 2 and 9[54], and the *Scheurrak S01*.[55] This dataset was augmented with material from four shipwrecks located outside Dutch waters: *the Copper shipwreck*[56], *the Gribshunden shipwreck*[57], *La Belle shipwreck*[58], and *the Skaftö shipwreck*.[59] Dendrochronologically dated casks from these maritime sites were incorporated into the broader database to enhance its representativeness and analytical robustness. These casks underwent extensive examination, and the ships were associated with trade networks that included the Netherlands. The maritime component of the dataset includes 119 casks, dated using 283 dendrochronological samples. When combined with the urban archaeological datasets, the complete dataset comprises 464 casks, with 1331 timber samples analyzed using dendrochronology. Notably, there is considerable variability in the number of staves or headboards per cask that were subjected to analysis (Table 2.1).

Table 2.1: Number of staves per cask analyzed dendrochronologically.

Number of staves or headboards per cask analyzed dendrochronologically	**Number of casks**
1	221
2	88
3	46
4	29
5	19
6	14
7	11
8	4
9	9
10	7
11	7
12	2
13	1
14	1

53 Schoute, 2017.

54 Vos, 2012, 2019.

55 Manders, 1996.

56 Poland; Ossowski et al., 2014.

57 Sweden; Hansson et al., 2022.

58 United States; Loewen, 2017.

59 Norway; Von Arbin, 2014.

Number of staves or headboards per cask analyzed dendrochronologically	**Number of casks**
16	1
17	1
20	1
25	1
35	1
Total	464

Notably, the dataset represents a specific archaeological sample of casks that circulated during the study period. The casks recovered from urban archaeological contexts, which comprise approximately 74% of the dataset, were predominantly repurposed as shafts or barrel wells. Not all casks were suitable for such repurpose; for example, smaller casks were generally excluded for this purpose.

The dataset includes the dating of the repurposing phase of the casks based on the context dating of the cesspit or water well containing the casks, primarily determined by the dating of the ceramic assemblage. However, this does not always correspond with the repurposing date, as ceramic predating the casks could have been discarded in the pit. Consequently, when necessary, the dating of the finds within the casks was reassessed. The date of the ceramic assemblage and other material finds was integrated with dendrochronological dating to establish a more precise dating of the casks' repurposing. These refined dates were subsequently incorporated into the dataset.

Furthermore, the dataset exclusively includes casks that have been subjected to dendrochronological analysis. This criterion also introduces a sampling bias selective effect, as only casks containing parts with a relatively high number of tree rings were selected by the researchers.

Dating accuracy

The study presented in this chapter employs multiple dating methods. The primary approaches used to date the cask are dendrochronological analysis and context dating of casks in their repurposed phase, based on the associated artefacts recovered from cesspits or water wells. These two methods rely on different techniques and therefore possess distinct levels of dating accuracy.

Dendrochronological dating is based on establishing a match between a tree-ring series and a reference chronology. Depending on the degree of parallel variation, assessed using the Student's t-value and *Gleichläufigkeit* (GLK), an absolute calendar year can be established. This allows for the determination of either the estimated felling interval, when sapwood is present, or the earliest possible felling date, when sapwood is absent.

Of the 464 individual casks examined, 157 (34%) contained at least one tree-ring series with sapwood. The proportion of sapwood-bearing components varied markedly between urban and maritime contexts. In urban contexts, sapwood was present in only 26% of casks (91 of 345 urban casks), whereas in maritime contexts it was found in 55% of casks (66 of 119 maritime casks).

In some cases, casks without sapwood were treated as having zero sapwood rings for estimating the felling interval. In such cases, several staves from the same cask displayed nearly identical outermost rings, indicating comparable felling dates. Based on the research of Van Daalen[60], it is assumed that these staves most likely extended up to the sapwood, which justifies recording them in the dataset as having zero sapwood rings.

In addition, a significant portion of the casks in this sub-study were dated based on their repurposed phase, using artefacts recovered from cesspits or water wells. This context dating is derived from an interpretative process in which the individual datings of the associated finds are combined to establish a period of use of the feature. The oldest and youngest artefacts together define the most probable period of use. Such context-based dates therefore represent a general chronological range rather than a precise year or *terminus ante quem*, as can be achieved through dendrochronology.

However, since dendrochronological and context-based dates provided the most comprehensive chronological evidence, both methods were nonetheless employed in this sub-study. The interpretation of the results, however, takes into account the inherent discrepancies between the two approaches. In interpreting the results of this sub-study, the inherent discrepancies between the two dating methods need to be taken into account.

Chronological distribution of the dataset over the research period

As stated, the dataset includes 464 casks dating from the 12th to the 18th centuries, each assigned absolute dates for various phases of its lifespan wherever feasible (Table 2.2). Dendrochronological dating is available for all 464 casks, as this was a prerequisite for inclusion in the dataset. For 157 casks, samples containing sapwood are also available, enabling the estimation of the felling interval.
Additionally, the dating of the casks in the dataset is informed by the dating of associated artifacts discovered during their repurposed phase as barrel wells. This determination was possible for 183 of the 464 casks.

60 Van Daalen, 2021.

Table 2.2: Chronological distribution of casks over the research period.

Grouped time periods		Number of casks				
Date (start)	**Date (end)**	**Oldest tree ring**	**Youngest tree ring tree ring**	**Youngest tree ring (sapwood)**	**Context date (start)**	**Context date (end)**
	<1000	7	0	0	0	0
1001	**1100**	25	6	0	1	0
1101	**1200**	76	13	3	5	1
1201	**1300**	125	34	8	9	4
1301	**1400**	80	126	43	38	16
1401	**1500**	109	89	49	29	36
1501	**1600**	37	123	28	60	46
1601	**1700**	3	63	22	35	52
1701	**1800**	2	10	4	6	24
>1801		0	0	0	0	4
Total		464	464	157	183	183

Provenance

To ascertain the origin of individual casks within the dataset, the documentation pertaining to the provenance of staves and headboards was utilized. In instances where a cask comprised timber from multiple origins, it was designated as having a "combination" of provenances. In total, the provenance of the timber used could be determined for 374 of the 464 casks.

Associated products (cask contents)

The database also includes information on the intended contents for which the casks were constructed. Of the 464 casks, the primary contents were identified for 126. In certain instances, the primary contents were ascertained from archaeological reports discussing the casks. Nevertheless, in most cases, the products could be inferred from the characteristics of the casks, as they were custom-built for specific products such as wine, beer, and herring during particular periods and in specific regions. Notable characteristics include cask capacity, the number of staves and headboards, stave thickness, hoop types, the timber used, and the presence of holes.[61]

61 Oosterbaan, 2023.

2.3 The lifecycle and lifespan of casks

The lifecycle of casks from the Late Medieval and Early Modern periods encompasses a sequence of events, divided into three distinct phases: the production phase (Figure 2.1_1a–1f), their utilization as transport containers (Figure 2.1_2a–c), and their subsequent repurposing (Figure 2.1_3a–3b). Each of these phases is characterized by specific features on the casks, which facilitate their dating.

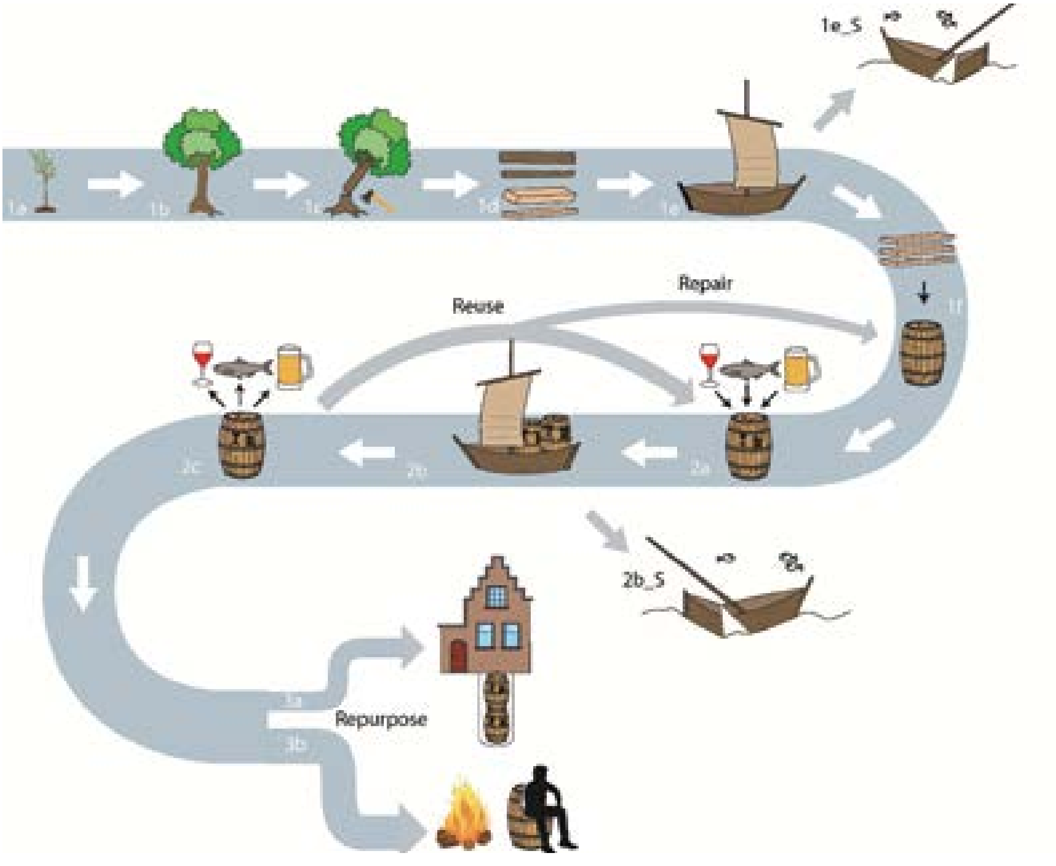

Figure 2.1: Schematic overview of the lifecycle of casks, also indicating the phases at which a ship carrying casks could havesunk.

Production phase

The lifecycle of a cask commences with timber production, which can be traced back to the oldest tree ring in the timber utilized for its construction (Figure 2.1_1a). This production phase concludes when the completed cask has been gauged and is initially employed as a transport container (Figure 2.1_1f).

In Dutch archaeological contexts, the first stage of cask production, timber production, predominantly took place in timber-abundant regions across Northern Europe, including the Rhineland, Meuse Valley, North German Plain, Baltics, Poland, Burgundy/Loire Valley, and northern France.[62]

Dendrochronological analysis of tree rings allows for the dating of timber production. The oldest tree ring among all samples from an individual cask is used to establish the commencement of the casks' lifespan (Figure 2.1_1a). Similarly, the youngest tree ring from all samples of a cask is employed to determine the age of the timber used (Figure 2.1_1b). If sapwood is present, the estimated felling date of the tree used for a cask can also be ascertained (Figure 2.1_1c).

Following felling and processing, the timber required drying and transportation from the timber-producing area to cooperages (Figure 2.1_1e). Timber sourced from the Rhineland or the Meuse Valley likely underwent minimal processing and was primarily transported as logs.[63] Initially, the felled logs were transported to a gathering place with sufficiently wide and deep water. The logs were then bundled into wooden rafts, facilitating their downstream transportation to cooperages. The duration of transportation was contingent upon the distance to be covered.

Timber from the North German Plain, Baltic areas, Poland, the Burgundy/Loire Valley, and northern France was transported by sea. It was first processed into wainscot, planks, or *clapboard* to facilitate shipping (Figure 2.1_1d).[64] During the excavation of the *Copper shipwreck*, examples of wainscot and *clapboard* were discovered. This ship was possibly in transit in the port of Gdańsk when it sank in 1408.[65]

The wainscot found on the *Copper shipwreck* ranged in size from 185 to 252 cm in length and 19 to 31 cm in width. Conversely, the ship's clapboard was significantly smaller, with lengths spanning 54 to 86 cm and widths of 7 to 17 cm (Figure 2.2). This material would have been used to make staves. The term *clapboard*, in Dutch *klaphout*, may have originated from *klepka*, the Polish term for stave. Since a substantial portion of the timber used for casks in Dutch archaeological contexts originated near Gdansk or along the Vistula River within present-day Poland, it is plausible that this term was adopted in the Netherlands.

62 Oosterbaan et al., 2022. 18.

63 Domínguez-Delmás & Berselaar, 2009, 15.

64 Domínguez-Delmás & Berselaar, 2009, 16.

65 Ossowski et al., 2014, 261.

Figure 2.2: Clapboard and wainscot found on the Copper shipwreck (Ossowski et al., 2014).

In the Late Middle Ages and Early Modern period, coopers sought to acquire adequately dried timber, facilitating the ease of splitting while retaining sufficient flexibility for shaping into the desired form. Furthermore, the timber needed to possess stability to ensure the casks' watertight integrity. Although the precise drying duration for coopers' timber during this era remains undetermined, 20th-century coopers' timber with a thickness of 2.5 cm, typically necessitates an average drying period of one year.[66] To eliminate all substances that might impart aroma to the packaged product, a drying period of 36 months is required.[67]

The drying duration for timber used in other applications than cask production provides insights into the drying period for coopers' timber. For ship timber, a minimum period of three years is generally required from the time of felling to ship construction.[68] Timber used in construction typically requires a drying period of

---

66 Porter, 2005, 38.

67 Waelput, 2004, 75.

68 Vos, 2019, 121.

two years, as evidenced by architectural historical research conducted on buildings in Amsterdam and Utrecht, among other locations, utilizing dendrochronological data.[69]

Upon acquiring timber, coopers either soaked it in water to remove undesirable substances or laid it out to dry further in their warehouses (Figure 2.3). This additional drying period likely lasted at least six weeks. Archival sources document a mandatory additional drying period of eight weeks in Haarlem[70] and six weeks in Gouda.[71] It is reasonable to assume that cooperies in other cities would have implemented similar mandatory drying periods for their newly acquired timber. Once the timber was partially dried yet retained sufficient flexibility, it could be processed into casks (Figure 2.1_1f). The cask-making process involved numerous steps and required approximately 40 hours to complete.[72] However, this refers to the total production time involved in making a cask, including periods when the staves needed to be soaked, heated, and bent into shape. The actual hands-on labor required for a single cask was likely considerably lower than the 40 hours indicated here.

Figure 2.3: Coopers' timber being dried at the present day Vicard cooperage in Cognac, France (Pineau JL. (2020). Groupe Vicard. Élever la tradition innovation & performance. Retrieved June 17, 2024, from https://www.groupe-vicard.com/files/fr/1591368313.1353/FR_Ctlg_TonnellerieVicard2020-planche.pdf).

69 De Vries, 1994, 379; Van Tussenbroek, 2012, 28.

70 Kuiperskeur, 25 October 1567, published in: Huizinga, 1911, 426.

71 Ordinance of the Coopers, 1490, published in: Rollin Couquerque & Meerkamp van Embden, 1917, 105.

72 Written communication from Cor de Groot, cooper at the Zaans Museum in Zaandam, Netherlands.

Use as transport containers

Upon completion, each cask underwent gauging to ensure adherence to pertinent legislative standards. The specifications of the casks were required to align with the criteria established by provincial or urban authorities, as well as guild regulations.[73] Once approved, officials marked the casks, occasionally including the year of approval, providing a means to date this particular phase in the casks' lifecycle (Figure 2.4). Subsequently, the casks were filled, predominantly with fish, wine, or beer, for transportation to their respective destinations (Figure 2.1_2a–b). Additionally, casks served as containers for other goods such as meat, gunpowder, and spices. The majority of casks were transported via rivers or the sea. However, this transportation was not always successful, particularly in instances where the ships carrying the casks sank (Figure 2.1_2b_S).

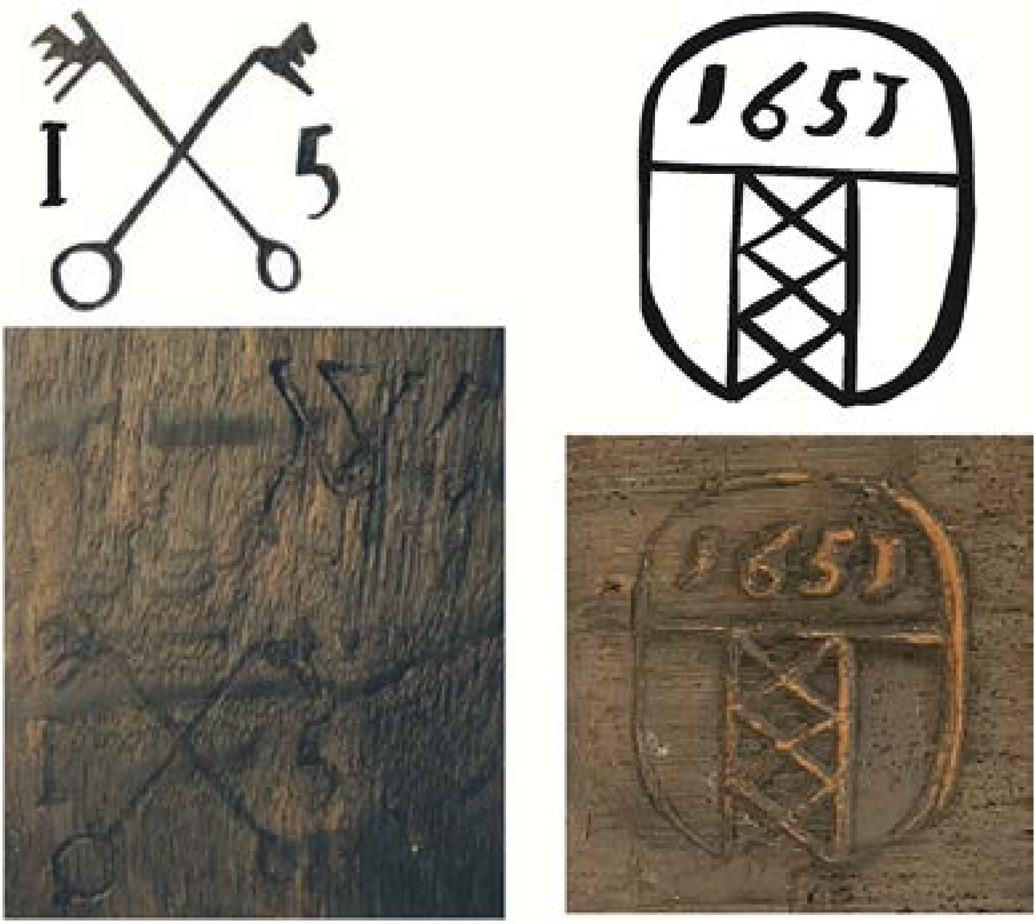

Figure 2.4: Gauge marks with the year of application incorporated in the coat of arms of the city of Leiden (left: Verduin 2019) and Amsterdam (right: author's photo).

73 Yntema, 1992, 218; Oosterbaan, 2023, 105-108.

Casks recovered from shipwrecks facilitate the determination of the interval between the felling of the timber used in their construction and their subsequent utilization as transport containers, contingent upon the known date of the shipwreck. Casks from shipwrecks offer the additional benefit of containing identifiable contents if they held dry merchandise. Conversely, the liquid contents of casks are more challenging to ascertain, as the liquid would have dissipated long before any archaeological research.

Upon reaching their intended destination, casks were typically sold to consumers (Figure 2.1_2c). Once emptied, a cask could be repurposed, returned to the original producer of the product it contained, or, if necessary, taken to a cooperage for repair. In certain cases, casks were dismantled to save space on ships. Casks could also be reused in cities other than their place of origin. In such instances, casks required re-gauging before reuse, with these marks including the year of application, providing a means to date this phase in the lifecycle of a cask.

Repurposing

When casks were no longer required for trade purposes, some were repurposed as shafts for cesspits and water wells (Figure 2.1_3a). However, certain casks, such as those designed for gunpowder and measuring no more than 30 cm in width, were unsuitable for such repurposing due to their small size. Additionally, casks were converted into tables or chairs, as illustrated in iconographic sources (Figure 2.5), or utilized as firewood (Figure 2.1_3b). However, such repurposing is seldom reflected in the archaeological record.

Casks employed as shafts for cesspits and water wells represent the most archaeologically accessible form of repurposed casks. Given that these features are often filled with datable artifacts, the dating results have been incorporated into the dataset to enable a comparison of dates between their production, use as transport containers, and subsequent repurposing.

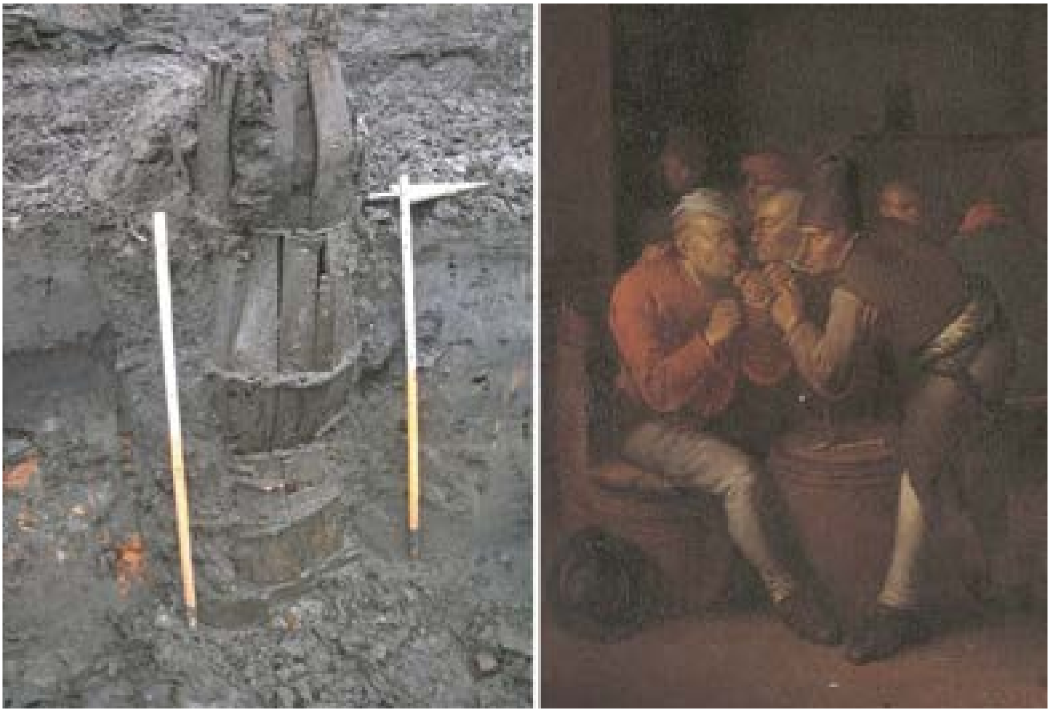

Figure 2.5: Repurposed casks: Left: shaft of a cesspit or water well (Oosterbaan & Griffioen, 2015); Right: cask used as a table and chair (Smoking and Drinking Peasants in an Interior Setting [Oil on canvas, personal collection], by Egbert van Heemskerck, 1646–1704. Database RKD Netherlands Institute of Art History, n.d., https://rkd.nl/images/203359).

2.4 Results

2.4.1 Production

The first stage involves the cultivation of timber used for coopering, followed by its drying and transformation into wainscot, planks, or clapboards. These materials are subsequently transported to cooperies, where they undergo further drying and are utilized in the construction of casks. A critical component of this phase is the selection of appropriate timber for coopering.

Age of the timber used (Figure 2.1_1a–1c)

Coopers' timber was required to fulfill several criteria, including ease of splitting and flexibility. Oak satisfied these requirements and additionally did not impart an undesirable taste to the contents.[74] Consequently, casks were predominantly constructed from oak, with 97.8% of the casks in the dataset being made from this timber species. The diameter and, thus, the age of the timber were also significant,

74 Waelput, 2004, 52-53, 75.

as trees needed to possess sufficient thickness to allow staves to be cut from quarter-sawn timber (Figure 2.6_A). The dataset indicates that the maximum width of staves in the casks ranged from 6.5 cm to 23 cm, with an average width of 14.2 cm. To cut staves of this average width from a quarter-sawn log, the diameter would have needed to be at least 30 cm. Naturally, trees exceeding a diameter of 30 cm were also utilized for coopers' timber (Figure 2.6_B).

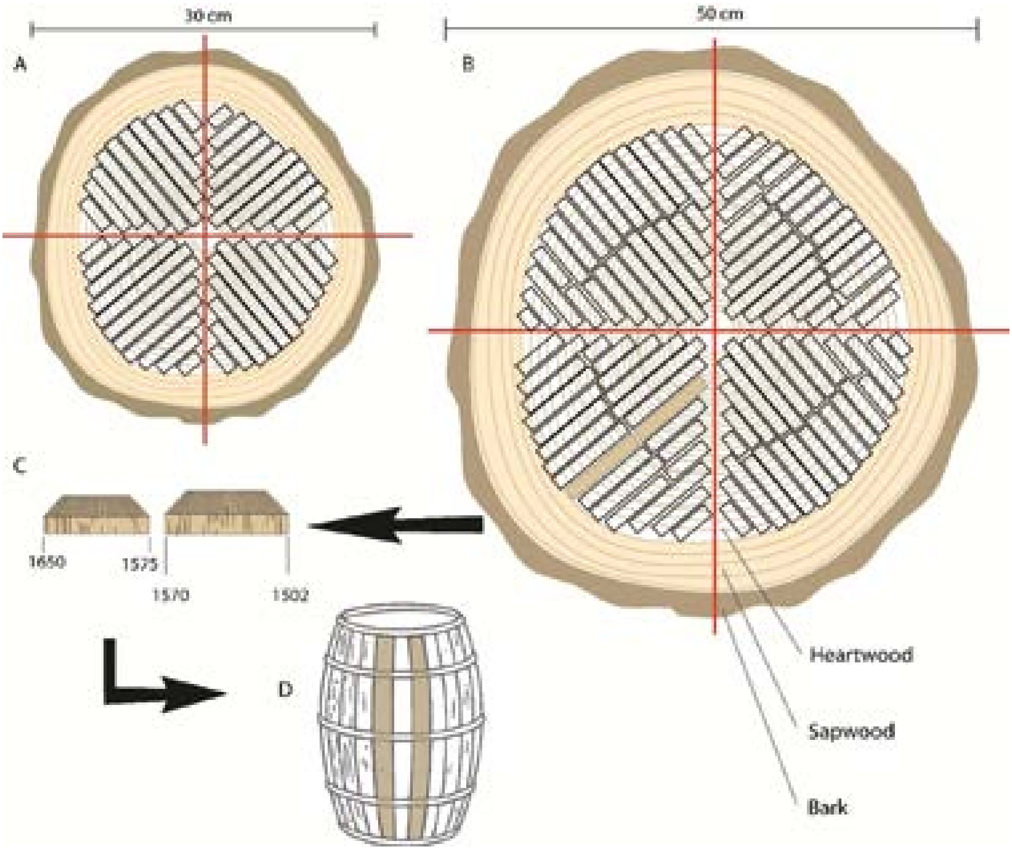

Figure 2.6: The method used to extract staves from quartered oak logs with diameters of 30 cm (A) and 50 cm (B); the placement of staves in casks (C and D).

To examine the age selection of timber used by coopers, several analyzes were employed and subsequently compared to assess consistency and coherence, with the ultimate aim of determining the most probable duration of this phase within the lifespan of casks. First, the oldest and youngest tree rings in individual staves from casks recovered in urban archaeological contexts were examined. This analysis was then repeated at the cask level across the entire dataset. Finally, the cask level analysis was refined by focusing exclusively on those casks for which at least two staves had been subjected to dendrochronological analysis.

First, the oldest and youngest tree rings in individual staves of casks from urban archaeological contexts were analyzed. This analysis, centered on the youngest tree ring, does not ascertain the estimated felling date but rather identifies a year after which the tree was felled (*terminus post quem*), as in many cases estimated missing sapwood rings were not taken into account. This methodology was selected because only 91 of the 1048 samples from urban archaeology contained dendrochronological samples with sapwood. An analysis based on samples with sapwood, which permits an estimated felling date, would have resulted in a limited dataset. The analyses of the oldest and youngest tree rings revealed that staves with between 30 and 274 tree rings were processed. The median of the oldest and youngest tree rings in individual staves was 115 tree rings, with an average of 118 tree rings per stave (Figure 2.7).

Second, an analysis of timber selection was conducted at the cask level, where it is crucial to consider the number of tree rings present in all the staves of a cask. A total of 464 separate casks were analyzed, comprising 1331 dendrochronological samples.[75] The dendrochronological datings of the staves from individual casks were compared, utilizing the oldest and youngest tree rings to determine the period of timber production for the cask. The median of the oldest and youngest tree rings in individual casks was 141 tree rings, with an average of 144 tree rings and a variation of 40 to 330 tree rings in individual casks (Figure 2.7).

The third analysis, focused on the duration of the production phase within the lifespan of casks, was conducted exclusively on casks for which at least two staves had been dendrochronologically analyzed. As shown in Table 2.1, for 221 of the 464 casks in the dataset, only a single stave was analyzed; this analysis therefore concentrated on the remaining 243 casks for which a minimum of two staves had been examined. This revealed a median of 150 tree rings per cask, with a an average of 156 tree rings per cask. Thus, conducting dendrochronological dating on more than one stave increases the average number of tree rings from 144 to 156, representing only an 8% increase. This suggests that several staves within the same casks generally exhibited mostly overlapping tree ring patterns.

In essence, the three-step analysis demonstrates that the initial phase of a cask's lifespan lasted at least 150 years, based on the median number of tree rings in the dataset. This estimate is conservative, as missing sapwood rings in individual casks mean that 150 years represents a minimum duration.

75 In total, sapwood was present in 157 of the 464 casks, representing 34 percent of the assemblage. For these casks, the number of missing sapwood rings was estimated and incorporated into the analysis, using the models proposed by Hollstein (1980) and Wazny (1990).

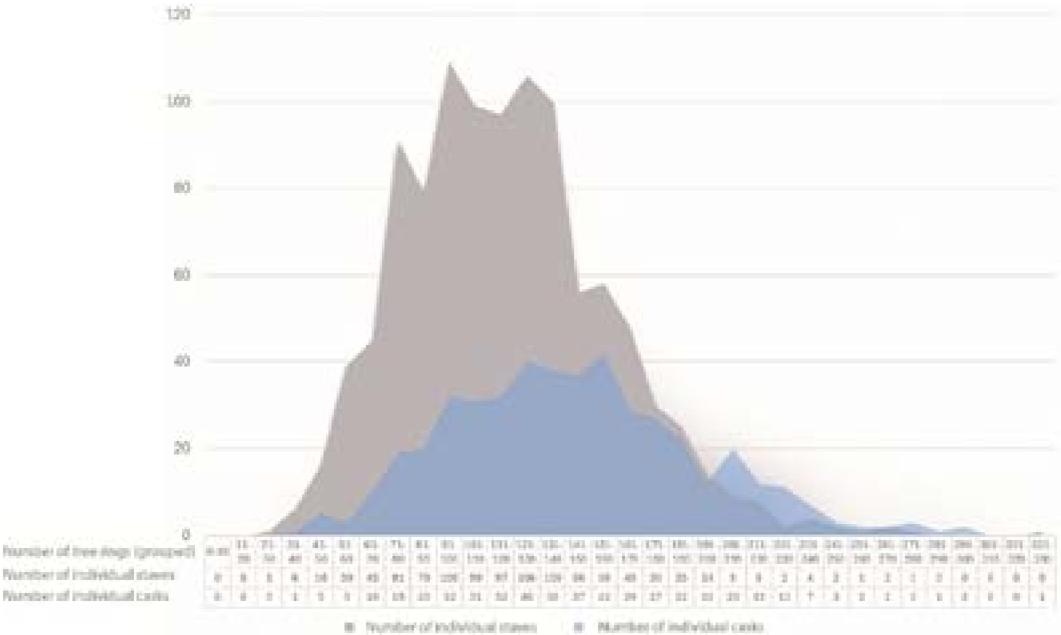

Figure 2.7: Grey: staves (Y-axis) that consisted of the specified number of grouped tree rings (X-axis). Blue: casks (Y-axis) that consisted of the specified number of grouped tree rings (X-axis). When determining the number of tree rings per cask, the difference between the oldest and youngest tree rings in various staves of the same cask is taken into account. For instance, the cask in Figure 2.6 would be placed in the 141–150 group because a difference of 148 tree rings was documented (1502–1650).

Provenance of coopers' timber (Figure 2.1_1a–1c)

The origin of coopers' timber may have influenced the number of tree rings and, consequently, the duration of a casks' production phase. Timber from different regions exhibits distinct characteristics that can affect its suitability for cask production. For instance, timber from the Baltic region was highly valued by artists and shipbuilders due to its slow growth rate, which resulted in a homogeneous, fine grain that ensured stability and durability.[76] This suggests that timber from the Baltic region generally had a higher density of tree rings per centimeter compared to timber from other regions.

To determine whether casks made from timber sourced from different regions exhibit varying numbers of tree rings, an analysis was conducted on timber from various provenances. The sub-study differentiated between casks made from timber transported via river trade routes, specifically the Rhine and Meuse rivers, and those transported via sea trade routes. The sea trade routes were further categorized into southern sea trade from France and northeastern sea trade from

76 Domínguez-Delmás & Berselaar, 2009, 16.

the Baltic region, Poland, and the North German Plain (Figure 2.8). No variation in the number of tree rings per cask was observed across provenances. However, the absence of variation in the number of tree rings per cask across provenances does not permit conclusions about growth-ring density. Determining ring density would require the widths of the individual staves; however, the dataset contains insufficient stave width data to perform this analysis reliably.

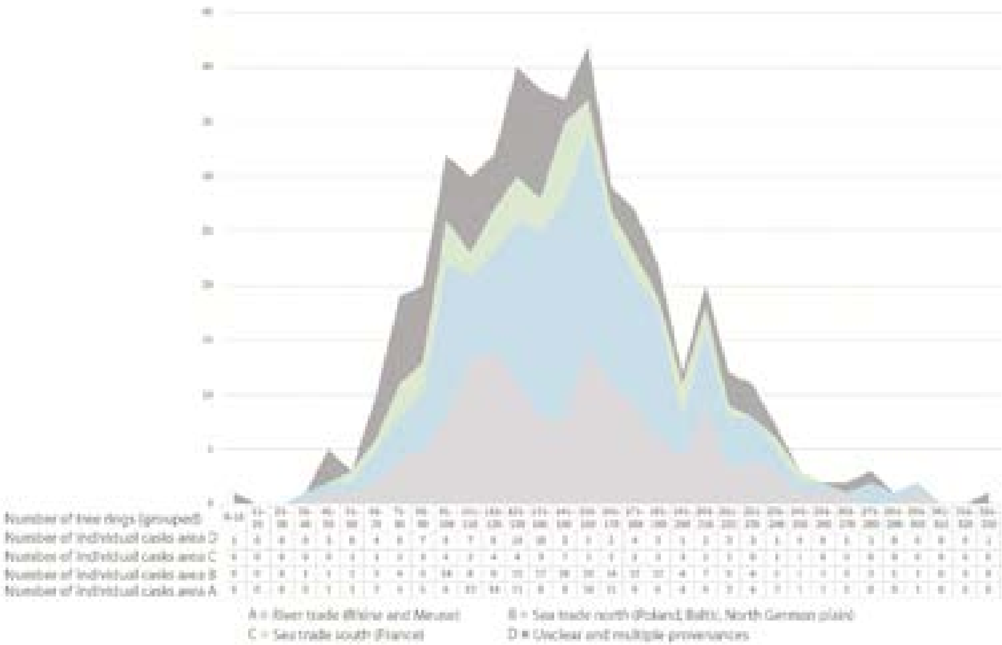

Figure 2.8: The number of casks (Y-axis) that consist of the specified number of grouped tree rings (X-axis), separated by collective provenance area.

Dendrochronological studies frequently demonstrate that staves within a single cask display considerable similarity. Such studies often reveal tree ring tree-ring series with significant similarity, indicating that these staves were sourced from the same provenance area and, potentially, the same tree or even a specific section of a trunk. In the Dutch city of Vlissingen, dendrochronological dating was performed on 14 casks. In 6 of these casks (nearly half), matching tree ring series were observed.[77] The case from Vlissingen represents only one instance of such findings, as similar observations where timber from the same tree was identified within individual casks have been reported in numerous dendrochronological studies.[78] The staves from

77 Doeve, 2021, 11.

78 see Van Daalen, 2012 [Gorinchem, Bluebandhuis]; Van Daalen, 2016 [Venhuizen, Westeinde 15]; Van Daalen, 2019 [Zoutelande – Duinweg]; Van Daalen, 2020 [Veldhoven – Dorpstraat 25]; Van Daalen, 2023 [Utrecht – Gruttersdijk].

these sites, originating from the same tree and utilized in an individual cask, exhibit only minor dating variations of less than 50 years. This suggests that a single radial series of staves was employed from each tree, as depicted in Figure 2.6_A.
Historical sources corroborate a similar preference for selecting timber with consistent properties for cask production. Kilby (1989) and Waelput (2004) assert that 20th-century coopers favored timber with uniform properties for cask construction, which is essential for ensuring a well-crafted cask. Variations in timber properties, such as hardness, could lead to compression and eventual cracking of the softer staves.

The consistent use of timber in casks during the Late Medieval and Early Modern periods was also stipulated in the *Rechtsbronnen* of several Dutch cities.[79] For instance, beer casks in the Dutch cities of Gouda in 1490 and Haarlem in 1567 were mandated to be constructed from high-quality eastern timber, implying the same provenance area. In other instances, such as in the Dutch cities of Dordrecht, Amsterdam, and Leiden, the only requirement was that the timber be of good quality, meaning it had been properly dried and was devoid of sapwood, knots, and wormholes.[80]

Timber processing, drying and shipping (Figure 2.1_1d–1e)

The duration required for the processing, drying, and transportation of coopers' timber remains challenging to ascertain. Nevertheless, the prefabricated staves discovered on the *Copper shipwreck*, located in the bay of Gdańsk, Poland, offer a distinctive opportunity for analysis. Approximately 40 planks originating from Poland were identified on this ship, which is believed to have been intended for cooperages.[81] The staves from this shipwreck are incorporated into the dataset of this sub-study.

Dendrochronological analysis has established that the majority of these planks were felled between 1406 and 1407, with a minority cut as early as 1404. The *Copper shipwreck* is determined to have sunk in 1408, as corroborated by dendrochronological dating and the ceramic assemblage recovered, likely during the spring of that year.[82] This suggests a processing and drying period of 1 to 4 years at the site of the timber producers, aligning with the 36-month drying period for 20th-century coopers' timber (Section 2.3).

79 Oosterbaan, 2023, 106.
80 Oosterbaan, 2023, 106.
81 Ossowski et al., 2014, 257.
82 Ossowski et al,. 2014.

Cask production (Figure 2.1_1f)

As the dataset used in this sub-study does not allow for determining the exact duration of cask production, additional information was obtained through consultation with contemporary coopers employing traditional methods. According to these craftsmen, producing a cask generally requires a total production time of approximately 40 hours, although the actual hands-on labour is likely considerably shorter. They further noted that production time varies substantially depending on the specific type of cask being produced.

In addition, production time was estimated by comparing historical sales prices with average wages. This approach assumes that the total labour hours, combined with material costs and profit margins, would roughly correspond to the selling price of a cask. Based on this calculation, the production of a salted-fish cask was estimated to require approximately 8.75 hours (Section 4.3).

Prior to the actual production process at cooperages, there is an additional drying phase for the coopers' timber. Archival sources indicate that this mandatory drying period lasts for a minimum of six weeks (Section 2.3).

2.4.2 Casks used as transport containers

The examination of the duration of casks as transport containers constitutes a central inquiry in this sub-study. Certain casks were designed for single-use, remaining in service for only a brief period (Figure 2.1_2a–2c). Conversely, other scenarios are conceivable, such as a wine cask filled with local wine in France, which could embark on an extensive maritime journey to the Netherlands. Upon arrival, it might be sold to a tavern, where it would be gradually emptied. Once emptied, the cask could be reused multiple times and potentially sent to a cooperage for repairs. Consequently, the lifespan of such wine casks would differ significantly from that of a herring cask. Though the duration of casks as transport containers can vary, this sub-study aims to estimate their average service life.

In the analysis of the duration of cask usage as transport containers, casks from urban archaeological contexts and those from maritime archaeological contexts are utilized in the dataset. These contexts differ in that the use phase of casks from maritime archaeological contexts as transport containers was abruptly terminated due to the sinking of the ship on which they were transported, whereas the transport-container phase of casks from urban archaeological contexts proceeded to completion.

Additionally, the markings on the casks can offer insights into their duration as transport containers and are therefore also examined.

Casks from urban contexts

This sub-study's analyses concentrated on casks from urban archaeological contexts that had been repurposed as shafts for cesspits and water wells, most of which contained dateable artifacts. The estimated felling date, or the youngest tree ring identified through dendrochronological analysis, was compared with the initial dating of the artifacts found in these cesspits and wells. The interval between these dates represents the duration of a casks' use as a transport container. Of the 345 casks in the dataset from urban archaeological contexts, only 183 possess dendrochronological and artifact-based datings.

Among the 183 casks, 141 were dated using dendrochronological samples that lacked sapwood, which only permitted the determination of the *terminus post quem* for the felling date of the timber used for these casks. For the remaining 42 casks, dendrochronological samples with sapwood were available, allowing for the estimation of the felling date of the timber used for these casks.

The dendrochronological analyses of cask samples without sapwood yielded a median of 9 years (Figure 2.9). The average difference between the *terminus post quem* for the felling date and the initial context dating was 23 years, as the average is significantly influenced by outliers at the extremes of the spectrum. For example, in 8 of the 183 casks, the difference was negative, due to artifacts in the cesspit or water well having an older date than the timber used for the cask. Notably, 23 of the 183 casks exhibited a *terminus post quem* for the felling date and an initial context more than 50 years apart. This discrepancy could potentially be attributed to the use of old casks as the shaft of a cesspit or water well. Alternatively, it could be explained by the fact that the cask was dated based on only a segment of the tree rings from the timber used for the cask. Interestingly, these casks were either wine casks or contained unknown contents. Additionally, there was one cask with a period of 367 years and another with 368 years between the *terminus post quem* for the felling date and the initial context dating. The cesspits containing these casks may have been emptied or filled at a much later period.

The period during which casks were utilized as transport containers can be more precisely determined for those casks with dendrochronological datings based on samples containing sapwood. This is because, for these casks, the discrepancy between the estimated felling date and the initial context dating can be ascertained. The analysis conducted on this subset of the dataset, comprising 42 casks, yielded a median of 9 years and an average of 11 years (Figure 2.10). This finding demonstrates a consistent pattern when compared to the analysis of casks lacking sapwood. The actual duration for which the casks served as transport containers was less than 9 years. Notably, dendrochronological dating does not indicate the commencement of their use as transport containers; the timber must first be processed into casks after being felled and dried, a process that could take 2–4 years. For a substantial number of casks, it is probable that their period of use was approximately 6 years.

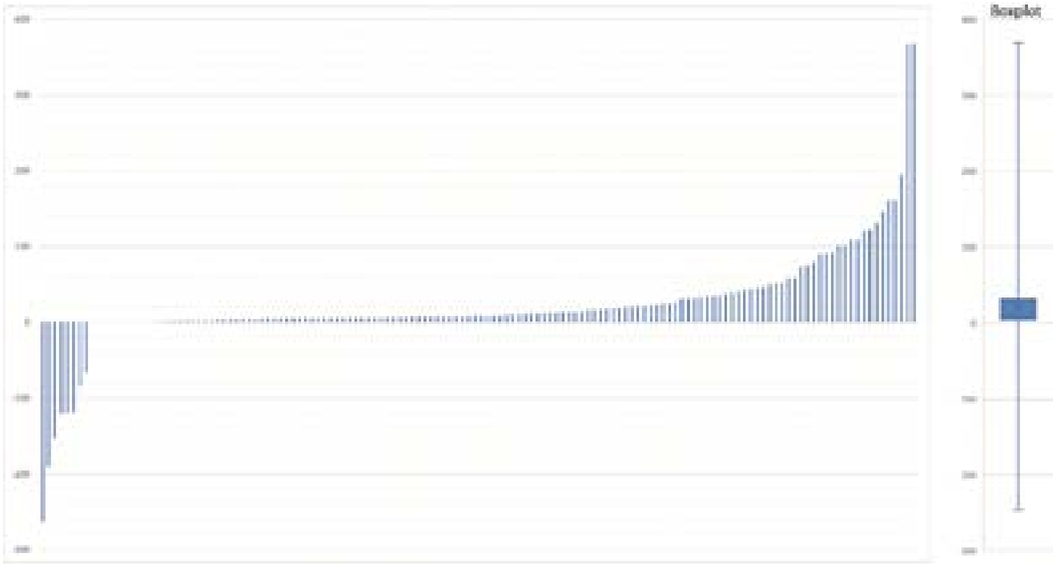

Figure 2.9: The difference of the terminus post quem for the felling date of individual casks and the beginning date of the repurpose phase, of casks from urban contexts (n=141). On the right, the boxplot illustrates, in sequence, the minimum, first quartile, median, mean (denoted by a cross), third quartile, and maximum values.

Figure 2.10: Estimated felling date based on samples with sapwood of individual casks compared to the beginning date of the repurpose phase of casks from urban contexts (n=42). On the right, the boxplot illustrates, in sequence, the minimum, first quartile, median, mean (denoted by a cross), third quartile, and maximum values.

Repurposed casks discovered in urban archaeological contexts were often stacked to function as shafts for cesspits and water wells. Since different casks were put into use simultaneously as shafts, the variation in dating of these individual casks within a single feature can also serve as an indicator of their duration of use as transport containers. A prolonged circulation of casks as transport containers would likely result in greater dating differences. The dataset, however, contains only a limited number of instances where multiple casks from the same cesspit or water well have been subjected to dendrochronological dating. This limitation arises primarily because archaeologists typically aim to date the barrel well itself when collecting dendrochronological samples from casks. Consequently, samples are generally taken from the cask most likely to yield results, while other casks are often not sampled.

Nonetheless, during exca*vat*ions at Vlissingen Groote Markt and Leiden Aalmarkt, instances of barrel wells were identified where dendrochronological samples from different casks were available. In Vlissingen, the absence of sapwood in the dendrochronological samples from both casks allowed only for a *terminus post quem* dating, resulting in dates of 1582 ± 7 and 1592 ± 7, which are within a decade of each other. It is improbable that these two casks were produced simultaneously, as one was constructed using French timber and the other with Meuse Valley timber.[83] The second example pertains to a barrel well discovered at the Aalmarkt in Leiden, where dendrochronological datings for both casks were identical, each dating to 1518 ± 6.[84]

However, these datings are based on dendrochronological analyses without sapwood, precluding the determination of the exact felling date and leaving it uncertain whether the casks were produced contemporaneously. Nevertheless, the minimal differences in dating do not necessarily contradict a brief circulation period of the casks as transport containers, as evidenced by the analysis of dendrochronological datings in comparison to the initial context datings.

Maritime context

The duration of casks employed as transport containers in maritime contexts can often be precisely determined by correlating the shipwreck date with dendrochronological dating results. This correlation offers insights into the interval between the casks' production (Figure 2.1_1b–1c) and its utilization as a transport container (Figure 2.1_2b-S).

The dataset comprises 62 casks from maritime contexts that have been successfully dated using dendrochronology, with known shipwreck dates. Among these, 21 casks contain sapwood, permitting an estimation of the felling date. The remaining 41 casks lack sapwood, only allowing for the determination of a *terminus post quem* for the felling date.

83 Doeve, 2021, 20.

84 Hoogendijk, 2020, 322.

The 41 casks without sapwood exhibited a median of 17.5 years and an average difference of 30 years between the *terminus post quem* for the felling date and the shipwreck date. However, significant variations exist within this range (Figure 2.11). Some casks demonstrated a difference of merely 1 or 2 years, while the maximum difference was 105 years. It is highly improbable that this cask was used as a transport container for 105 years; the exceptional difference may instead reflect the use of staves cut from the innermost part of the tree, where the rings are considerably older than the outermost growth, or the incorporation of older, repurposed staves used in the repair of the cask.

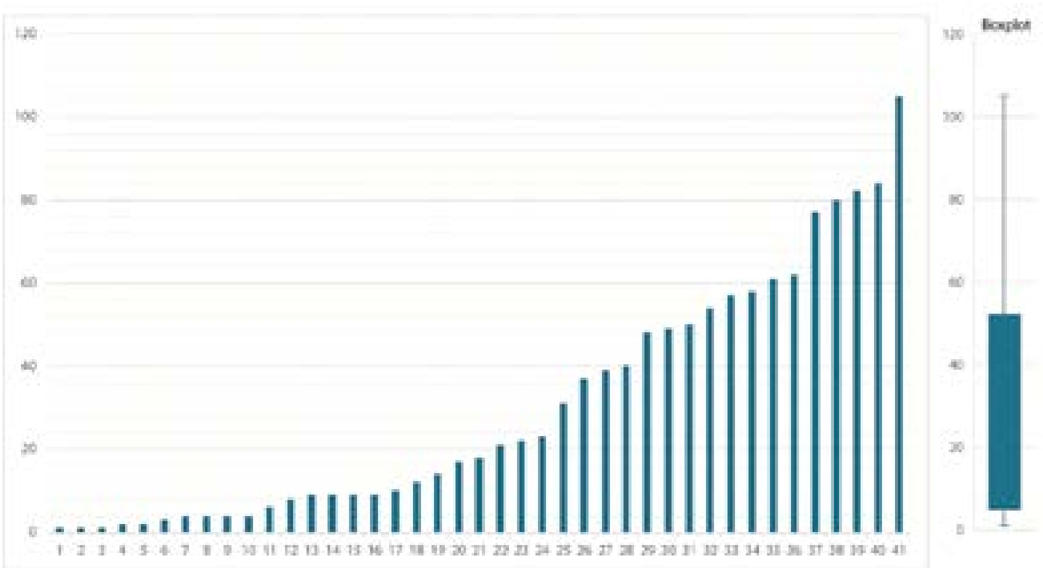

Figure 2.11: Terminus post quem for the felling date of casks from maritime contexts compared to the shipwreck date, in years (n=41). On the right, the boxplot illustrates, in sequence, the minimum, first quartile, median, mean (denoted by a cross), third quartile, and maximum values.

When examining the 21 casks containing sapwood, the median age is merely 8 years, and the average interval between the felling and shipwreck dates is only 15 years. The range also diminishes significantly, spanning from 1 to 51 years (Figure 2.12). However, even with the analysis of casks from maritime archaeological contexts, the median of 8 years cannot be directly equated with the duration of casks being utilized as transport containers. Following the felling of the timber, it required processing, drying, transportation, and fabrication into casks before they could be employed. As demonstrated in section 2.4.1, this process could take 2 to 4 years. Furthermore, these casks had not yet reached the end of their utility as transport containers, as evidenced by the ship carrying them sinking. Nonetheless, the average provides an indication of the period during which casks were employed for transport.

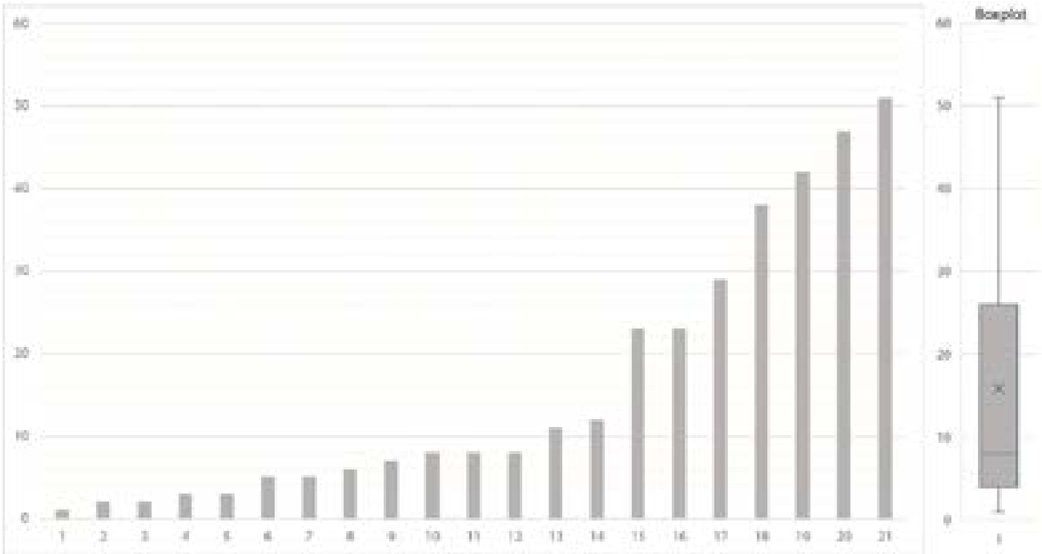

Figure 2.12: Estimated felling dates of casks from maritime contexts based on samples with sapwood compared to the shipwreck date, in years (n=21). On the right, the boxplot illustrates, in sequence, the minimum, first quartile, median, mean (denoted by a cross), third quartile, and maximum values.

The temporal use of casks as transport containers in maritime contexts can be investigated by treating each shipwreck as a find assemblage, which can be associated to a specific period of use. In other words, all casks found on a sunken ships are considered contemporaneous, as they were all present on the same ship. If casks had been utilized for an extended period as transport containers, one would expect a greater variance in the dating of the casks on the same ship. For three ships from Dutch waters, the differences in dating between casks, determined through dendrochronological analysis with sapwood, were investigated. The dating discrepancies range from 4 to 28 years (Table 2.3).

Table 2.3: The dates of casks from three shipwrecks from Dutch waters.

	Kamperkogge	***Burgzand Noord 2***	***Scheurrak SO1***
Oldest cask	1401	1669	1593
Youngest cask	1429	1673	1605
Date difference	28	4	12
Number of casks (with sapwood)	4	3	3

Marks

In certain instances, the duration for which a cask served as a transport container can be ascertained through its markings, particularly if these include dates.

However, dendrochronological or contextual dating is also essential to determine the period of use of the cask as a transport container. Within the dataset, only 2 out of the 464 casks possess such markings, both of which are depicted in Figure 2.4.

The marking “15” on one of the casks is believed to have been inscribed in 1615 (Figure 2.4 left). Dendrochronological analysis revealed that its youngest tree ring dates to 1599. The felling year is estimated to be post-1605, although the precise year remains indeterminate due to the absence of sapwood. Given the brief interval of merely 10 years between the *terminus post quem* and the year marked on the cask, it is plausible that this mark was added shortly after production, possibly at the time of its initial use. Subsequently, the cask was repurposed as a water well shaft, with ceramics discovered within it, dating between 1600 and 1650, indicating a short period of circulation before repurposing.

The other cask bears the year 1651 on its head, discovered in shipwreck OT23 in Flevoland (Figure 2.4 right).[85] Regrettably, no dendrochronological analysis was performed on this cask, but the shipwreck is estimated to have occurred between 1650 and 1675. This suggests that the cask, marked as 1651, also likely did not circulate for an extended period. The limited examples of casks with a year incorporated in the mark further suggest that these casks were likely in use for a brief duration, probably less than a decade. This observation aligns with other methodologies employed to estimate the usage period of casks as transport containers.

2.4.3 Repurposing casks

The repurposing of a cask signifies the commencement of the final phase of its lifecycle. As delineated in section 2.3, casks may be repurposed in various manners, such as being utilized for firewood or transformed into furniture (Figure 2.1_3b). These forms of repurposing present challenges for archaeological detection, as almost no remnants have been discovered. Nevertheless, the repurposing of casks as shafts for cesspits or water wells is documented in urban archaeological research. The dataset comprises 345 repurposed casks, of which 183 have been context dated (Figure 2.1_3a). The dataset indicates an increasing prevalence of these repurposed casks commencing from the 14th century (Table 2.2, Context start date). The duration of this phase is determined by the range of context dating. Repurposed casks employed as shafts for cesspits and water wells typically contain dateable artifacts; the interval between the initial context date and the end context date is considered the duration of the repurposing phase.

Of the 345 casks, the context dating for 183 casks was documented in the archaeological research reports. The analysis of the duration of their repurposing revealed a median of 75 years, with an average of 85 years (Figure 2.13). The

85 Database Maritieme opgravingsdocumentatie, n.d., T23-19, https://doi.org/10.17026/dans-xq9-mgh2.

difference between the initial context date and the end context date ranges from 10 to 325 years. However, context dating is based on the maximum dating range of the artifacts found in the cesspits and water wells. Unlike dendrochronological dating, which provides absolute years or terminus post quem constraints, ceramic dating is based on the production range of specific types of ceramics. This maximum dating range is determined by the production period of the ceramics, which can result in a broader timeframe compared to the repurposing phase of casks. Therefore, the duration of the repurposing phase of the casks must be situated within this range.

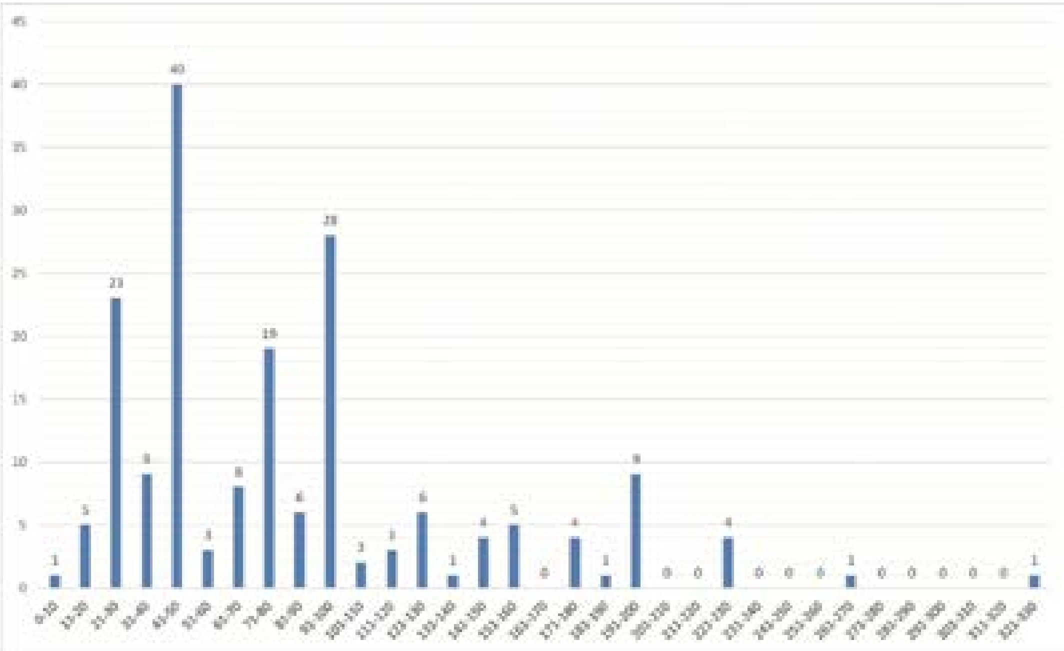

Figure 2.13: Individual casks (Y-axis) with the specified number of grouped duration of repurposing (X-axis) (n=183).

Provenance

The provenance of coopers' timber utilized in cask construction may have influenced the selection of casks for shafts, given that timber characteristics vary by origin. To examine whether this is reflected in the dataset, the dated repurposed casks were categorized according to their provenance and compared with the provenances of the entire dataset, which includes repurposed and non-repurposed casks identified during maritime archaeological research. The comparison is presented in absolute numbers and percentages (Figure 2.14).

The analysis of the repurposed casks and the provenance of the coopers' timber indicates a slight preference for casks made from timber originating from the Rhine and Meuse valleys, with 38% of the repurposed casks sourced from these regions, compared to 31% in the entire dataset. Conversely, the use of casks made from timber from Poland, the Baltic, and the North German Plain appears to be less prevalent, as the percentage from these areas decreases from 40% to 26%.

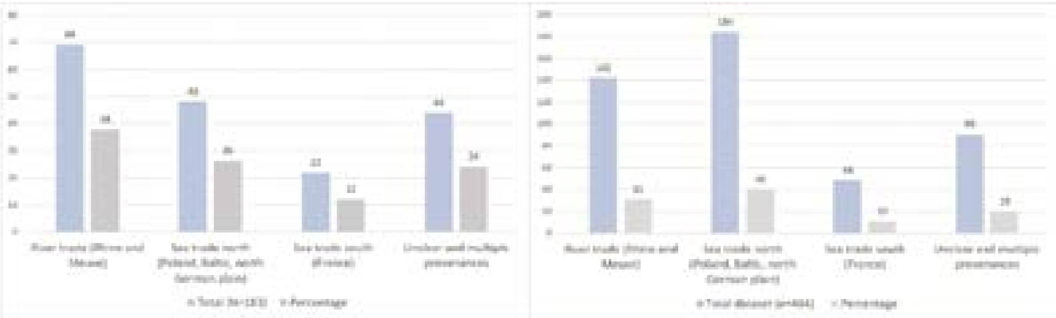

Figure 2.14: Left: Dated repurposed casks from the specified provenances shown in absolute numbers (blue) and percentages (grey) (n=183). Right: Casks in the complete dataset from the specified provenances shown in absolute numbers (blue) and percentages (grey) (n=464).

Associated products (contents)

Not all casks were deemed suitable for repurposing as shafts for cesspits or water wells. Casks with a diameter smaller than 45 cm were generally excluded from such repurposing due to their insufficient capacity for the barrel well.[86] As the size of casks varied according to the products they contained[87], it is plausible that a correlation exists between the products associated with the casks and the likelihood of their selection for repurposing as cesspits or water wells.

The analysis of the repurposed casks and their associated products shows a preference for using wine casks as shafts for cesspits and water wells (Figure 2.15). In total, 11% of the casks in the entire dataset were identified as wine casks, while 22% of the repurposed casks were identified as wine casks. This indicates a preference for repurposing wine casks.

Another notable distinction pertains to casks used for dry goods, such as gunpowder or other merchandise, which constitute 8% of the total 464 casks. These casks were not employed as shafts for cesspits or water wells (Figure 2.15), likely due to their diameter being less than 45 cm. Furthermore, casks for dry goods were often of inferior quality compared to those used for liquids, a factor attributable to the limited thickness of the staves. This lower quality likely represents another significant reason why casks for dry goods were not repurposed as shafts for cesspits and water wells.

86 Oosterbaan et al., 2022, 7.

87 Oosterbaan, 2023.

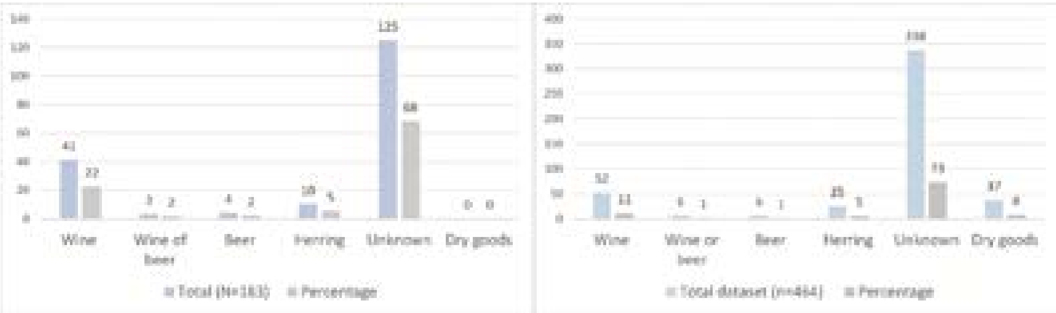

Figure 2.15: Left: Number of dated repurposed casks categorized by their associated product in absolute numbers (blue) and percentages (grey) (n=183). Right: Number of casks in the dataset categorized by their associated product in absolute numbers (blue) and percentages (grey) (n=464).

2.5 Conclusion

Casks are frequently encountered in urban and maritime archaeological excavations of sites dating from the Late Middle Ages and the Early Modern period. Although individual studies occasionally address these transport containers, comprehensive research on casks remains limited. Consequently, fundamental questions regarding casks remain unresolved, such as the nature and duration of a casks' lifespan.

This research seeks to ascertain the lifespan of casks in the Netherlands from the 12th to the 18th centuries. It enhances our understanding of cask utilization and aids in the dating of casks to contextualize their use. For instance, dendrochronological dating of casks can assist in determining the date of a shipwreck or in dating a cesspit or water well where the cask has been repurposed as a shaft.

For this sub-study, a dataset was compiled comprising casks that have been successfully dated through dendrochronological analysis. It includes casks from urban and maritime archaeological contexts. The dataset contains 1,048 dendrochronological samples from 345 casks discovered in urban archaeological contexts in the Netherlands. The maritime component of the dataset consists of 283 dendrochronological samples from 119 casks recovered in Dutch waters and four ships found outside Dutch waters. In total, the dataset comprises 1,331 dendrochronological samples from 464 casks. Specific dates determined through dendrochronological analysis are included in the dataset, such as the oldest and youngest documented tree rings. When sapwood is present, the estimated felling date is also recorded. The provenance of the timber is included if successfully identified through dendrochronological research.

For the casks from a maritime archaeological context, the dataset also includes the shipwreck dates, when available. For the urban archaeological context, dating is provided based on finds deposited in repurposed casks used as shafts for cesspits and water wells, resulting in the beginning and end dates of their repurposing. Additionally, associated products and markings that facilitate the dating of the casks, such as a date incorporated in the mark, are also recorded.

The lifespan of a cask was divided into three distinct phases, production, use as a transport container, and repurposing, to provide a comprehensive picture of the lifespans of casks. While the duration of the lifespan of individual casks may have varied, this research employs the median duration of the different phases, supplemented with information from archival sources, to create a general overview of casks in the Netherlands from the 12th to the 18th centuries.

Table 2.4: Overview of the lifespan of casks based on the median of the 464 casks in the dataset.

Phase	Phase number	Number of years	Number of weeks
Production phase, oldest tree ring till youngest tree ring	1a–1c	>150	>7800
Production phase, timber processing, drying, and shipment	1d–1e	3	156
Production phase, timber processing into casks	1f	0.1	7
Use as transport container	2a–2c	6	312
Repurposing	3a	75	3900
Total lifespan of casks		>234	>12175

Production phase

The analysis of the production phase yielded a comprehensive understanding of the duration of various phases involved, including timber production (Figure 2.1_1a–1c), its processing, drying, and shipment, (Figure 2.1_1d–1e), and the final processing into casks at cooperages (Figure 2.1_1f).

This analysis determined a median duration of at least 150 years for the production of timber used in individual casks, based on the comparison of the youngest and oldest tree rings from various dendrochronological samples of individual casks (Table 2.4). The sub-study also specifically investigated differences in the duration of the timber production process across different provenance areas (Figure 2.8), but no significant patterns were identified. The dataset analysis reveals no evidence suggesting that a cask made from, for instance, French oak contains a different number of tree rings compared to one made from Baltic oak.

The limited evidence for the phase of timber processing, drying, and shipment, between the felling of the tree and its arrival as usable lumber at the cooperages, indicated a duration of approximately three years. Once the coopers' timber arrived at the cooperages, it was dried for an additional six weeks before being processed into casks within a single week by a cooper.

Use as transport containers

The various methodologies employed to ascertain the duration of casks as transport containers consistently yield a coherent picture. For casks originating from urban archaeological contexts, where the youngest tree ring or the estimated felling date (when sapwood was present) was compared with the initial dating based on the casks' contents in the repurposed phase, the median discrepancy was found to be nine years. However, this period must be adjusted by subtracting three years to account for the requisite time for timber processing, drying, and shipment. Consequently, this results in a median usage duration of six years for casks utilized as transport containers (Table 2.4).

Casks from maritime contexts exhibited a median of 8 years between the dendrochronological dating of sapwood samples and the sinking of the ship, indicating a usage duration of five years (Figure 2.12). Notably, the usage period of these casks was prematurely curtailed, as the ship transporting them sank before the casks lost their utility as transport containers.

Alternative methods for evaluating the duration of cask use, such as the analysis of markings with dates and the discrepancies in dating of casks employed in the same cesspit or water well shaft, suggest that casks were typically in use as transport containers for less than a decade. Overall, it can be concluded that casks had a median usage duration of approximately six years during their phase as transport containers.

Repurposing

The repurposing phase exhibits a median duration of 75 years, as determined by the dating of associated artifacts found in cesspits and wells where the casks were utilized (Table 2.4). This phase also involved an examination of whether casks constructed from timber originating from specific regions were favored for repurposing (Figure 2.14). The findings indicate a slight preference for casks made from timber sourced from the Rhine and Meuse valleys, contrary to those made from timber from Poland, the Baltics, or the North German Plain, which were less frequently employed in casks repurposed as shafts in cesspits or wells. Wine casks were the preferred choice when considering the products transported in the casks prior to repurposing, whereas casks used for dry goods were not repurposed as shafts, likely due to their inferior quality and smaller size (Figure 2.15).

The lifespan of casks from the Netherlands during the 12th to 18th centuries is estimated to be at least 234 years, as determined by the median of the individual phases. This lifespan spans from the growth of the oldest tree ring utilized to the final dating based on the contents of cesspits and water wells during the repurposing phase. This research has also elucidated the various phases between these two points, offering a comprehensive account of the production, use as transport containers, and repurposing of casks in the Netherlands during the Late Medieval and Early Modern periods.

Moreover, the sub-study indicates that the examination of casks holds considerable untapped potential. The research presented herein could be further expanded by augmenting the dataset with additional casks, facilitating a more profound investigation into the diachronic developments within this research area. Additionally, this methodology could be applied to a dataset encompassing casks from other countries, such as Germany, Belgium, or other European nations. Furthermore, specific elements of casks, such as cask marks, may contain a wealth of supplementary information that warrants further exploration in future research.

Acknowledgements

The present research builds upon the dataset initially compiled for the article "Provenance and Production"[88], which has since been expanded. The study presented in this chapter benefited from the generous contributions of data from several dendrochronologists: Ing. Petra Doeve MA (BAAC), Ir. Sjoerd van Daalen (BAAC until 2012 and Van Daalen Dendrochronologie from 2013 onwards), the late Em. Prof. Dr. Esther Jansma (formerly Cultural Heritage Agency), and Dr. Marjolein van der Linden (Biax Consult). Throughout the research and the compilation of this article, valuable advice was provided by Dr. Roos van Oosten (Leiden University). Acknowledgment is also extended to Kerry Fast for editing the text. This sub-study constitutes a component of the PhD research conducted by Jeroen Oosterbaan, which is funded by the Dutch Research Council (NWO, Promotiebeurs voor Leraren 2019-I).

88 Oosterbaan et al., 2022.