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Tons, *Tonneaux*, *Toneladas*, *Lasts*
British and European Ship Tonnages in the Eighteenth and Early Nineteenth Centuries

Stephen D. Behrendt [α], Peter M. Solar [β], Luc Hens [γ], Aidan Kane [δ], Silvia Marzagalli [ε] & Maria Cristina Moreira [ζ]

Abstract. Eighteenth-century ship tonnages were imprecise and unstandardized. Comparisons across British sources show considerable variation, both systematic and unsystematic. Comparisons with continental units of measurement confirm, on average, the usual conversions for *tonneaux*, *toneladas* and *lasts*, but implicit conversions for individual vessels vary so much that they were clearly not used by contemporaries. Tonnages usually displayed pronounced heaping. Variation and heaping suggest that rather than being calculated using official formulae, tonnages were often approximated by ship-owners, surveyors and local officials. The British Shipping Act of 1786 brought greater precision to calculation and reporting, with British tonnages becoming increasingly standardized.

Keywords. eighteenth century, maritime history, comparative study, metrology, accuracy, shipping, standardization, tonnage, precision, Britain

Résumé. *Ton*, tonneau, *tonelada*, *last*. La jauge des navires britanniques et européens au XVIII^e^ et au début XIX^e^ siècle. La jauge des navires du XVIII^e^ siècle était imprécise et non normalisée. Les comparaisons entre les sources britanniques montrent de grandes variations, certaines d'ordre systématique, d'autres pas. Les comparaisons avec les unités de mesure continentales confirment, en moyenne, les taux de conversion habituels pour les tonneaux, les *toneladas* et les *lasts*, mais les conversions implicites dans les cas individuels varient tellement que ces taux n'ont manifestement pas été utilisés par les contemporains. Les tonnages étaient généralement arrondis de manière importante. Les variations et les arrondis suggèrent que la jauge, plutôt que calculée à l'aide de formules officielles, était souvent estimée par les armateurs, les experts techniques, et les autorités locales. Le British Shipping Act de 1786 a apporté une plus grande précision aux calculs et aux déclarations, le calcul britannique de la jauge devenant de plus en plus normalisé.

Mots-clés. XVIII^e^ siècle, histoire maritime, approche comparative, métrologie, justesse, précision, *shipping*, standardisation, tonnage, Îles britanniques

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The builders, buyers and users of sailing ships – along with the governments that taxed them and the underwriters who insured them – needed to be able to communicate effectively about their carrying capacity. In certain specialized trades, they could do so in terms of the quantity of merchandise that the ship could transport. In the sixteenth and seventeenth centuries the capacity of ships in the Dutch salt trade was denominated in *brouages*, that in the herring fishery in *haringlasten*, and that in the Baltic grain trade in *roggelasten* (rye *lasts*).[1] As late as the early 1790s ships for sale at Newcastle were generally advertised in terms of keels, these keels being the small lighters that brought coal downriver from the mines to sea-going colliers.[2] The shipping ton itself had its origins in the barrels (tuns) carried in the French wine trade. Such trade-specific measures of shipping capacity had the advantage of being easily verifiable by observing the amount of cargo loaded or unloaded.

But ships were fungible: they could operate in various trades and carry mixed cargoes. Moreover, the specific gravities of different products varied, as did the way in which they were shipped. In the mid-nineteenth century, for example, a ton (by weight) of coal was judged to occupy the same space as 3 tons of lead, 0.45 tons of compressed cotton, 0.25 tons of uncompressed cotton, 0.5 tons of glass bottles or 0.25 tons of crated table glass.[3] Because of such complications, from early modern times until today the shipping ton and other historic measures such as the *last*, though often confused with the weight of either ship or cargo, were primarily measured volume and sought to capture the amount of space in which cargo could be stowed.[4] As a result, when steamships were introduced in the early nineteenth century, the distinction arose between gross and net tons, the latter arrived at by subtracting the space occupied by the engine and other machinery.

The difficulty of calculating the volume of a ship's hull was its curvilinear form. From the sixteenth century various formulae were put forward for

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1. A. Van Driel, 1924, pp. 32-34. Timber *lasts* were rated at four-fifths of rye *lasts*; see J. Knoppers, 1975, pp. 69-78, who also reviews various formulae used in Amsterdam to calculate lastage.
2. *Newcastle Courant*, 1790–1792.
3. R. Stevens, 1858, pp. 164-165.
4. P. Stott, 2014, argues that the most appropriate benchmarks for conveying a sense of the size of modern ships are architectural volumes such as the Royal Albert Hall or the Gherkin. Most of the sailing vessels analyzed in this paper amounted to less than one per cent of the Albert Hall's volume. The more comparable architectural volume would be a small bungalow.

doing so.[5] These were based on taking the product of measures of a vessel's length, breadth and depth, then dividing it by a coefficient. The coefficient was chosen on two criteria: it had to be a reasonable approximation of the curved space and it had to yield results in line with measures already in common use, which is why calculated capacity was always expressed in tons, *lasts* or some traditional measure rather than in cubic units. Such simple formulae provided only rough approximations, the accuracy of which varied with hull design. The Dutch *fluyt*, used mainly in the Baltic grain trade, was a wide-bodied vessel, very different from the sharper hulls used in Dutch navy or in its trade to the Americas and the East Indies. As a result, in the seventeenth century the Dutch deployed coefficients ranging from 170 to 240 depending on the type of vessel or the trade.[6] During the seventeenth, eighteenth and early nineteenth centuries finding the "right" formula and the correct way to implement it occasionally exercised governments and savants. For example, after an 1717 inquiry that showed considerable variation across French ports in the way in which tonnage was measured, two French academicians advanced different proposals. Pierre Bouguer, brought in by the minister to arbitrate the dispute, applied their methods to two small vessels and subsequently made progress toward calculating displacement tonnage, the overall weight of the ship before launch.[7] Although this entirely different concept, a measure of weight rather than volume, made its way into the design of military vessels, the measurement of merchant ships in France was largely unaffected by this episode, with various volume measures being used in different ports as late as the 1780s.[8]

Volumetric formulae often proved difficult to operationalize. One problem was specifying where the length, breadth and depth were to be measured. Lengths could be defined along the keel or "between the perpendiculars". Breadth could be measured at half the length, wherever that was, or at its maximum; it could be measured at the level of the deck or that of the waterline, loaded or unloaded. Another problem was how to measure a ship that was afloat and loaded. The whole regime of ship measurement seems to have presumed that ships would be measured on the stocks, either by shipbuilders or official surveyors, but how could others know or verify the tonnage once the ship had been launched? Official certificates specifying tonnage and other identifying features were often issued to ship masters, sometimes because

5. L. Ferreiro, 2007, p. 192 notes that Venetian shipowners had been using such formulae even earlier, since the fourteenth century.

6. A. Van Driel, 1924, pp. 37-38.

7. From the sixteenth century, contemporaries were already exercised by the question of how to build a safe fully-loaded ship, particularly warships with gun ports. This seaworthiness problem related to the weight of the ship and of the cargo it contained, the latter of which could be estimated by using the difference in drafts between a loaded and an unloaded vessel to calculate the weight of the water displaced. On displacement tonnage and cargo deadweight tons, see L. Ferreiro, 2007, pp. 191-207 and D. Fauque, 2010.

8. D. Fauque, 2010.

international treaties required proof of a ship's nationality, as in the case of Mediterranean passes or Dutch *zeebrieven*. Sometimes such certificates involved official measurement; sometimes they were based only on tonnages reported by the owners or masters. But, as with other weights and measures, early modern European governments did not always systematically enforce prescribed volumetric tonnage measurement legislation, and shipowners might declare different tonnage figures to various port officials or in private contexts. Varying tonnage figures pose a particular problem for those who study British maritime history, as there are numerous government-produced sources, such as letters of marque or Mediterranean passes, and private sources, such as newspapers or *Lloyd's Registers*, that record tonnages, sometimes quite different for the same vessel. Solar and Duquette have shown, for example, how indiscriminate use of sources introduced biases in the tonnages contained in the Transatlantic Slave Trade Database and in research using those tonnages an indicators of slave-carrying capacity.[9]

Ship tonnage was thus only a more or less good approximation of a ship's carrying capacity. To have been of use to contemporaries as well as to scholars today, tonnages need some standardization and precision. By the late nineteenth century most countries had converged on the Moorsom ton. This measure – 100 cubic feet of cargo carrying space per shipping ton – was proposed by a committee chaired by Admiral George Moorsom from 1849 to 1854 and adopted by the United Kingdom in 1854, the United States in 1865 and most major shipping nations between 1867 and 1885.[10] Here, however, we concentrate on an earlier standardization, the one implemented by the British ship registration act of 1786, which applied to craft registered in Britain and Ireland. The newly independent United States adopted similar legislation.

Our focus is thus less on the theory of tonnage measurement than on its practice. We seek to reveal how measurements of tonnage were regarded by actors in the shipping industry in the eighteenth and early nineteenth centuries and in the process we provide guidance to historians making use of those measurements. We examine the extent to which the same ship could be assigned different tonnages in different sources. By matching ships whose tonnages are given in different sources before 1786 we find that there are systematic differences across sources and that, even allowing for these systematic differences, there is still considerable unsystematic variation in tonnages. By examining the degree of heaping in pre-1786 tonnages we also show that contemporaries may not have made much use of formulae or, if they did, they seem to have regarded the results as only very rough approximations.

9. P.M. Solar & N.J. Duquette, 2017.

10. Some countries, such as Germany, legislated slight deductions from the Moorsom ton regarding aerial space for propellers, hatchways and sailors' berths (R. Riegel, 1921, pp. 203-205, 227). For a discussion of how the Moorsom system produced significantly different tonnage figures depending on hull shape and between-deck spaces, see Y. Kaukiainen, 1995.

We then demonstrate how the measures Britain introduced in 1786 led both to standardization of tonnages across sources and to the reduction of heaping. Although the paper focuses on Britain, we also consider samples of vessels that were measured both in Britain and in several continental countries. These comparisons largely confirm the validity of the common equivalencies maritime historians have used to convert German and Dutch *lasts*, French *tonneaux* and Portuguese *toneladas* into British tons. But they again show considerable unsystematic variation in these relationships.

Our work builds on previous work in British maritime history. In his comprehensive studies on English tonnage measurement published a half century ago, Salisbury had already noted how "figures for tonnage vary considerably according to which source is used", though he presented only a few examples.[11] Building on Salisbury's pioneering research, McCusker examined small samples of British North American and English tonnages, c. 1709–1787.[12] French, in two articles, first used the Naval Office shipping lists to compare the tonnages of vessels in the West Indies trade just before and just after the 1786 Act, then later compared tonnages of vessels in trade between London and the Americas in the early 1750s as shown in the Seaman's Sixpence ledgers and the Naval Office shipping lists.[13] Ville analyzed the relationships among post-1786 register tonnage, tonnages in *Lloyd's Registers* and average tonnage of cargo for vessels owned by Michael Henley & Son of London.[14] For continental countries we are aware only of Knoppers' analysis of Dutch ships trading with Russia, in which he compares tonnages from various Dutch sources.[15]

We improve on earlier British studies by using larger samples from more sources and more ports. In particular, we rely heavily on *Lloyd's Registers*, produced by a private firm still extant today, which from the 1760s had its own surveyors in about 20 British and Irish ports. The firm served insurance underwriters and potential buyers and users of ships and as such had an interest in providing standard and accurate information. The tonnages in *Lloyd's Registers* have been shown by Solar and Duquette to be consistent over the 1786 breakpoint, that is, the average tonnages of ships surveyed both before and after the Act were essentially the same. Other sources, previously unused, include newspaper advertisements offering ships for sale, applications for letters of marque and the Liverpool Plantation Registers, as well as information on ships measured in French and Dutch ports and at Lisbon and Hamburg.

11. W. Salisbury, 1966c, p. 335.
12. J.J. McCusker, 1967; id., 1981.
13. C.J. French, 1973; id., 1995.
14. S. Ville, 1989.
15. J. Knoppers, 1975, pp. 69-78. The difference between ship *lasts*, probably volumes, and cargo *lasts*, probably weights, in the Galjootsgeld registers is well known in Dutch maritime history (P. De Buck & J.T. Lindblad, 1983).

For Britain we assess evidence on tonnage measurement at the major ports of Liverpool and Bristol as well as London, the locus of earlier work. Our comparisons across sources often involve hundreds of observations, far more than in previous studies.

This study of tonnage measurement helps lay the groundwork for other research in maritime history. It constitutes both a warning and a guide for scholars relying on a range of sources to study the nature and growth of particular trades. A prominent example, already mentioned, is the study of the slave trade, in which tonnage is sometimes taken as an indicator for the numbers of slaves that could be carried.[16] It also offers guidance for those wishing to compare shipping capacity and growth across countries.[17]

This study contributes to metrology by providing what was an early instance of effective national standardization. Zupko describes a profusion of legislation in Britain during seventeenth and early eighteenth centuries, but judges that it largely failed in bringing about much uniformity in weights and measures.[18] The successful standardization of tonnage preceded the adoption of the metric system in France and took place well before the Britain established the imperial system of weights and measures in 1824.[19]

1. British tonnages before the 1786 Registry Act

In England, as early as 1582, shipwrights estimated a vessel's carrying capacity by calculating cubical dimensions from a hull's keel length, its breadth and depth in the hold, a procedure refined by two parliamentary statutes in 1694.[20] These wartime Acts, in force for four years, attempted to measure a vessel's carrying capacity, approximating a carpenter's mensuration. In 1773 Parliament revisited the 1694 volumetric formula in a new Act that now approximated keel length before multiplying by breadth and estimated depth of the hold.[21] As noted above, these officially sanctioned tonnages were by no means standard.

The Liverpool Shipping and Trade Database (hereafter LST) contains the largest samples of pre-1786 British ship tonnages drawn from different sources.[22] Richardson, Beedham and Schofield, who created LST in the 1980s,

16. K. Rönnbäck, 2012; N. Duquette, 2014.
17. R. Romano, 1962.
18. R.E. Zupko, 1990, pp. 50, 58.
19. J. Hoppit, 1993.
20. W. Salisbury, 1966a.
21. Id., 1966c.
22. D. Richardson, K. Beedham & M.M. Schofield, 1992. The years 1744 and 1786 benchmark an Act of Parliament in 1742 (15 Geo. III c. 31), that tightened sections of earlier legislation concerning a vessel's re-registration, and the Registry Act of 1786, enforced for

began by extracting information from the Liverpool Plantation Registers, 1744–1786, and subsequently added detail about each registered vessel's voyages by gleaning data from Liverpool newspapers, letters of marque, impress protection documents, Mediterranean passes, Naval Office shipping lists and Seaman's Sixpences. These ancillary sources usually recorded the vessel's tonnage, and from the LST data it is straightforward to summarize tonnage figures per shipping source (Table 1), but difficult to create samples of vessels with tonnages in two or more different sources. The transcribed Liverpool certificates of registry record tonnages for 3,858 craft, and the LST contains tonnages for almost 2,000 vessels from the Mediterranean passes and hundreds of tonnages from the other sources.

Table 1. *Summary tonnage data contained in the Liverpool Shipping and Trade Database, 1744–1786*

Tonnage source	*Sample*	*Tonnage (ave.)*
Sailing notices[a]	464	242.3
Letters of Marque	315	207.7
Sale advertisements[b]	225	193.8
Protections from impress	551	162.9
Seaman's Sixpences	252	146.8
Mediterranean Passes	1,987	125.2
Naval Office shipping lists[c]	181	119.3
Plantation Registers[d]	3,858	102.1

Notes. [a] Sailing notices: advertisements for freight or passage in Liverpool newspapers;
[b] Sale advertisement: vessels advertised for sale in Liverpool newspapers;
[c] The Liverpool database included Naval Office tonnages that differed from Plantation Register tonnages;
[d] A vessel's transcribed certificate of registry.

Sample. 2,188 vessels recorded in Liverpool Plantation Registers. Since the same vessel might re-register, often with a new vessel name and new tonnage, there are 3,858 registrations in the database with a recorded tonnage.

Sources. D. Richardson, K. Beedham & M.M. Schofield, Liverpool Shipping and Trade, 1744–1786 [data collection], (1992), UK Data Service, SN 2923, URL: http://doi.org/10.5255/UKDA-SN-2923-1.

craft clearing customs after 31 July 1786. Though they exclude large numbers of smaller coastal craft, Plantation Registers document the majority of Liverpool vessels (R.C. Jarvis, 1954a; M.M. Schofield & D.J. Pope, 1978). For Liverpool, there are large runs of surviving ship registers from 1739 to 1792 (Wool Registers) and from 1744 (Plantation Registers). The Wool Registers document Liverpool-owned vessels legally allowed to transport wool from Ireland to England and exist because Act of Parliament in 1739 aimed to ban the export of wool from England (Merseyside Maritime Museum (hereafter MMM), C/EX/L/2/1, Wool registers, 1739–1792). The Act of 1739 (12 Geo. III c. 21) limited the shipment of wool from Ireland on British vessels (R.C. Jarvis, 1954a; id., 1954b).

The LST data suggest that tonnages could vary quite significantly across sources, but they are not conclusive for two reasons. First, the differences in average tonnages could be due to differences in the composition of the various samples. For example, ships advertised in newspapers tended to be larger vessels. So, too, did ships applying for letters of marque; smaller vessels were more likely to be prey than predators. Second, Richardson, Beedham and Schofield did not digitize tonnages from sources that replicated the registry tonnage figures. For example, Plantation Register tonnage – the Liverpool certificate of registry tonnage – matched Naval Office shipping list tonnage in most cases; as a result, there are only 181 tonnages from the latter. The exclusion of perfect matches would tend to exaggerate the differences in average tonnages across sources.

The LST database also does not include tonnage figures from *Lloyd's Registers*. The analysis in this paper will rely heavily on bilateral comparisons with the tonnages recorded in *Lloyd's Registers*, which began publication in 1764–1766 and appeared almost annually from 1776 onward. Lloyd's Register of Shipping located its own surveyors in more than 20 British and Irish ports, and though scant evidence survives about these surveyors, many of whom were probably ship carpenters by trade, *Lloyd's Register* tonnage data suggest that they produced regular and independent assessments. Surveys were conducted every two or three years, and annotations concerning the lengthening or rebuilding of vessels correspond to changes in their tonnages. Solar and Duquette have shown that Lloyd's Register of Shipping's surveyors produced tonnage measurements that were similar before and after the British Shipping Act of 1786.[23] The *Registers* targeted insurers and shipowners interested in a vessel's approximate cargo capacity and rating, a rating (A1 being the highest) determined by its surveyors according to the condition of the hull's timber and sheathing. That most subscribers to *Lloyd's Registers* were insurers incentivized the firm to provide accurate shipping information: Lloyd's Register of Shipping had no obvious incentive to over- or understate tonnages.

To refine analysis of tonnage variance per source and per Liverpool vessel c. 1780, we have matched craft with recorded tonnages in the Plantation Registers with those in *Lloyd's Register*, and also matched these same vessels when they appeared in letter of marque ledgers or in the columns of *The General Advertiser*, a weekly Liverpool newspaper (Table 2). The Plantation Registers for 1779–1783 list 625 distinct vessels, and we matched 306 with confidence to vessels in *Lloyd's Registers* via master's names, dates of construction and ownership. The vessels in this sample averaged 188 tons in *Lloyd's Registers*, but only 129 tons in Plantation Registers, 31 per cent lower. In much smaller matched samples, the average tonnages in the Plantation

23. P.M. Solar & N.J. Duquette, 2017.

Registers were 33 per cent lower than in the Letters of Marque and 46 per cent lower than in *The General Advertiser.*

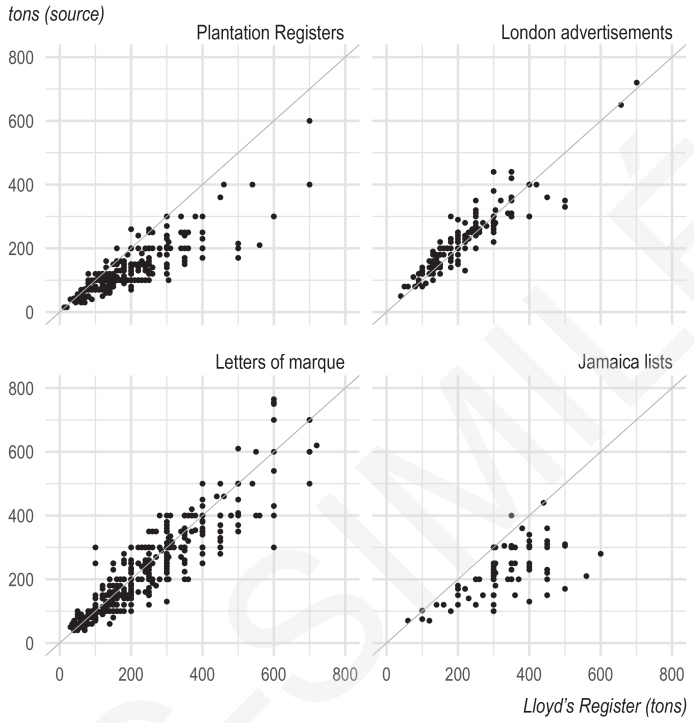
Table 2. *Mean reported tonnages of Liverpool vessels, c. 1780, in four sources*

Bilateral comparisons	*Sample*	Lloyd's Register of Shipping (LRS)	*Letters of Marque (LMQ)*	General Advertiser Liverpool (GAL)	*Liverpool Plantation Register (LPR)*
LRS, LMQ	(24)	215	208		
LRS, *GAL*	(177)	244		231	
LRS, LPR	(306)	188			129
LMQ, *GAL*	(18)		224	263	
LMQ, LPR	(22)		201		135
GAL, LPR	(57)			232	126
All four sources	(14)	216	219	250	143

Sources. *General Advertiser Liverpool*, 1780–1781; Letters of marque: TNA, HCA26/40–64; *Lloyd's Registers*, 1779–1781; Liverpool Plantation Registers, Merseyside Maritime Museum, Maritime Archives and Library, C/EX/L/3/1–4.

It is important to note that this exercise demonstrated great variation across the matched tonnages. Of the more than 300 matched vessels, only 28 had identical tonnages in the Plantation Registers and *Lloyd's Registers*. As shown in Figure 1, most tonnages in Plantation Registers were less than those recorded in *Lloyd's Registers*, as might be expected from the difference in means from Table 2. But there was little relationship between tonnages in the two sources. Take, for example, ships recorded as 200 tons in the Plantation Registers; their tonnages in *Lloyd's Registers* ranged from 160 to 560. Such large variation will feature in all our pre-1786 comparisons. We have tried to determine, using regression methods, if it can be explained by the size of vessels, their rigging, the place where they were constructed and the trade in which they were active, all based on information in *Lloyd's Registers*. In general, the results have been inconclusive.

Figure 1. *Bilateral comparisons of tonnages in* Lloyd's Registers *and other British sources*



Notes. The horizontal axis in each graph shows the vessel's tonnage in *Lloyd's Registers*; the vertical axis is the tonnage in the source shown in the title of the graph.

Sources. Plantation Registers: D. Richardson, K. Beedham & M. M. Schofield, Liverpool Shipping and Trade, 1744–1786 [data collection], (1992), UK Data Service, SN 2923, URL: http://doi.org/10.5255/UKDA-SN-2923-1; London advertisements: *Public Register*, 1775-9; Letters of marque: TNA, HCA26/40–64; Jamaica lists: TNA, CO 142/22; Lloyd's Register: *Lloyd's Register* database.

To illustrate pre-1786 tonnage variation for named Liverpool craft, we spotlight 12 large vessels, such as the *Rawlinson* voyaging to Jamaica between 1779 and 1784, all of which are documented by six different sources (Table 3).[24] When *Rawlinson's* captain John Daggers arrived in Kingston, he presented the Certificate of Registry to James Robertson, a naval officer

24. Seaman's Sixpences do not document any of these 12 vessels, as the surviving ledgers concern only vessels that arrived in London (The National Archives (hereafter TNA), ADM68/204, October 1778–August 1784). For vessels arriving in Liverpool, shipowners deducted sixpences per month and lodged "Hospital Pay" with the local customs officials, who then transferred monies to London.

and customs official. Robertson then transcribed Certificate of Registry information in his ledger. The Plantation Register and the Jamaica Naval Office shipping list thus recorded *Rawlinson's* registered tonnage as 170. *Rawlinson* carried a Mediterranean Pass that also reported its tonnage as 170. But a Liverpool newspaper notice, *Lloyd's Register*, and *Rawlinson's* Letter of Marque all reported its tonnage as 500. Similarly, from our sample of Liverpool vessels arriving in Jamaica, newspaper advertisements and *Lloyd's Registers* report tonnages sometimes 2–3 times greater than those in the certificates of registry.[25]

Table 3. *Multi-source tonnage comparisons, Liverpool vessels arriving in Jamaica, 1779-1784*

Vessel name	*Newspaper adverts*	Lloyd's Registers	*Letters of marque*	*Mediterranean Passes*	*Naval Office lists*	*Plantation registers*
Britannia	190	120	120	140	80	80
Dick	300	250	200	200	200	200
*Hinde**	180	140	120	100	100	100
Jamaica	500	400	300	200	170	170
James	500	450	400	*NA*	150	150
Juliana	350	305	400	100	100	100
Mentor	500	500	370	300	215	215
*Nancy**	250	260	170	100	120	120
Rawlinson	500	500	500	170	170	170
Sarah Goulborne	300	400	200	200	200	200
*Ulysses**	250	250	300	300	130	130
Viper	250	280	200	180	180	180
Average	339	319	273	181	151	151

Note. * - slaving vessels that arrive in Jamaica via Africa.

Sources. Newspaper adverts: *General Advertiser Liverpool*, 1780–1781; *Lloyd's Registers*, 1779–1784; Letters of marque: HCA26/40–64, TNA; Mediterranean passes: RICHARDSON, "Mediterranean Passes"; Naval Office lists: TNA, CO142/14–17 Plantation registers: Liverpool Plantation Registers, Merseyside Maritime Museum, Maritime Archives and Library C/EX/L/3/1–4.

25. *Hinde*, *Ulysses*, *Viper* made slaving voyages. *Voyages: The Transatlantic Slave Trade Database* adjusts the tonnage of *Ulysses* from 130 (taken from the Plantation Registers or the Naval Office shipping lists) to 236. This upward adjustment may be too small. Tonnage adjustments for select British slaving vessels would have little impact on the volume of the slave trade, as sources document slave numbers for the majority of Guineamen. *Ulysses*, for example (id 83884), arrived in Jamaica in December 1781 with 390 enslaved Africans. Increasing imputed tonnage figures, however, would impact calculations of slave crowding levels when measured per ton.

To confirm that the results for Liverpool are more general, we have conducted several bilateral source comparisons drawing on data involving other ports. For Bristol, David Richardson recorded slaving voyages by 28 distinct vessels between 1779 and 1783.[26] All of the vessels could be matched in *Lloyd's Registers* and were rated at an average of 201 tons. Richardson's preferred tonnages, which came from the Mediterranean passes and the Naval Office shipping lists, averaged 137 tons, 32 per cent less. Seven of these slaving vessels were advertised for sale with an average tonnage of 197, quite similar to their average tonnage in *Lloyd's Register* (201 tons), whilst the average of Richardson's preferred tonnages for these ships was only 139 tons, 29 per cent less.[27]

For London vessels we compare shipping advertisements to *Lloyd's Register*. The *Public Ledger*, a London daily, contains 273 advertisements that mention ship tonnage in the surviving issues from 1775 to 1779. We matched 170 of these to entries in *Lloyd's Registers*.[28] The matched London vessels were atypical of the British merchant fleet: they were large, averaging about 225 tons in the advertisements, and in accordance with their size, almost two-thirds were ship-rigged.[29] Tonnages reported in London advertisements were, on average, only three per cent greater than those in *Lloyd's Registers*. In about one fifth of the cases they were identical. But, generally, tonnages were not the same in the two sources, and there was significant variation: tonnages in the advertisements ranged from 40 per cent smaller to 67 per cent larger than in corresponding *Lloyd's Register* entries (Figure 1).[30] The differences between the tonnages related neither to a vessel's rig nor its place of construction. Tonnages of smaller craft did tend to be greater in the London advertisements than in the *Registers*, and those of larger ships tended to be lower in the advertisements.

26. D. Richardson, 1996.

27. Elsewhere D. Richardson, 1981 has examined tonnages in 1752-1756 for 96 Bristol slave ships with entries in Mediterranean pass registers, Bristol wharfage books and Naval Office shipping lists. He concludes that tonnages in these three sources were often identical and, in any case, very similar on average.

28. Tonnages were not used in matching, and where there was uncertainty, observations were set aside. Many of the ships that were not matched were either coasting vessels, which were rarely recorded in *Lloyd's Registers*, or prize vessels, whose names were often changed upon purchase.

29. Slightly more than half the London vessels were built in the Americas, about double the share for all ships in the *Registers* of the late 1770s.

30. Regarding tonnage variation, the difference between the means is not statistically significant from zero. We could not identify systematic discrepancies between the tonnages in the *Public Ledger* and those in *Lloyd's Registers*. The estimating equation was similar to that for the Liverpool ship registers, though the sets of dummy variables were somewhat different: rig (brig, ship, snow); place constructed (America, London, Northeast England, Other Britain); use (Africa & Privateers, Baltic, Greenland, Mediterranean, North America, Transports, West Indies).

For Liverpool we examined some small samples of tonnages drawn from letters of marque; now we can compare a much larger sample, from Liverpool and other ports, to the tonnages in *Lloyd's Registers*. Hillmann and Gathmann took a 10 per cent sample of the letters issued during several eighteenth-century wars,[31] but here we use their data from 1776 to 1782. We identified unambiguous and non-duplicated matches to entries in *Lloyd's Registers* for 460 observations.[32] These vessels averaged 245 tons in the applications, just five per cent less than in *Lloyd's Registers*, but as usual there was considerable variation (Figure 1). Statistical analysis of the privateers' dataset found the opposite relationship to tonnage as in the case of *Public Ledger* advertisements: the declared tonnages of smaller privateers tended to be lower than those in *Lloyd's Registers* and those of larger ones higher.[33] No systematic relationships were found to the rig of vessels, their place of construction or their use.

So, too, can we work with a somewhat larger sample from the Naval Office shipping lists, which, as noted above tend to reproduce tonnages from port shipping registers. Of the 96 ships in the Jamaica lists for 1784, we matched 87 to entries in *Lloyd's Registers*.[34] These ships were large, averaging 328 tons in *Lloyd's Register*, but only 221 tons in the Naval Office lists, 33 per cent less. Yet in four cases the tonnages in the two sources were identical, and in three the shipping list tonnage was larger than that in the *Registers*, indications of the variance in the data (Figure 1).

All pre-1786 sources, whether private (newspapers, *Lloyd's Registers*) or government records (Plantation Registers, Letters of Marque, Mediterranean Passes), contain rounded and hence not precisely measured tonnages. Of the 71 tonnage figures in Table 3, all end in zero except for three tonnages ending in five. If any of the six sources followed the volumetric formula in the 1773 Act of Parliament, with its divisor of 94, tonnages would likely not end in zero. That Act amended earlier legislation requiring carpenters to measure keels out of water, a requisite that became impracticable as the British merchant fleet expanded beyond the capacity of dry docks. Instead, the Act subtracted three-fifths of a vessel's breadth from its "extreme length", which "shall be

31. H. Hillmann & C. Gathmann, 2011. We are grateful to Henning Hillmann for making their data, originally drawn from TNA, HCA26/40–64, available to us.

32. It contains 855 observations, though many refer to the same vessel, as owners took out letters in several different years or against different enemy nations. When owners applied for more than one letter of marque, they generally reported the same tonnage on each application. We have omitted these duplicate observations. But in cases where owners reported different tonnages for the same ship, we have retained both observations.

33. The estimating equation was similar to those above, with the dummy variables being: rig (brig, ship, snow); place constructed (America, France, London, Northeast England, Northwest England, Other Britain); use (Africa, Baltic, Caribbean, Greenland, Mediterranean, North America, Privateer, Transport).

34. TNA, CO 142/22. These records are described in W.E. Minchinton, 1977.

esteemed the just Length of the Keel to find the Tonnage". The formula also approximated depth as one-half breadth, resulting in the following formula:

$$\frac{(\text{Length} - 3/5\ \text{breadth}) \times \text{breadth} \times \tfrac{1}{2}\ \text{breadth}}{94}$$

The 1773 Act (13 Geo. III c.74) applied to British vessels transporting alcohol, cargoes that required customs payments, or shipowners seeking government bounties. At least one of the conditions certainly applied to all 12 Liverpool ships sailing overseas and returning from Jamaica with taxable commodities. *Hinde*, *Ulysses* and *Viper* were Guineamen, and slaving vessels regularly transported alcohol to sell to African merchants.

Indeed, after the first comprehensive legislation, from the early eighteenth century onward, British vessel tonnage figures ending in zero feature regularly in sources documenting maritime ventures. The Barbados shipping ledger (a Naval Office list) first included the column "When and where Registered" in 1718, indicating that colonial officials gleaned the tonnage information from the vessel's paper certificate of registry. In the "tons" column, the first folio records tonnages of 23 British vessels, 22 figures ending in zero and one in five.[35] The first folio from the earliest surviving Seaman's Sixpence ledger (June 1725), records 28 of 30 British vessels' tonnages as multiples of 10.[36] Similarly, transcribed Mediterranean pass ledgers report tonnages in multiples of 10. All 19 vessels on the first folio of the 1730 ledger, for instance, are rounded tonnages, ranging from 40 to 400.[37] Transcribed Liverpool Plantation registers follow the same pattern. *Cleveland*, the first Liverpool vessel in the Plantation Registers (and LST database), "was Burthen of about Eighty tons".[38] Of the 3,858 Liverpool vessels in the Plantation Registers, 1744–1786, 3,414 tonnages end in zero and 290 in five.

Private sources, too, usually report British tonnages in rounded approximations, but occasionally they specify seemingly more precise tonnages. For

35. TNA, CO33/15, f. 65. Similarly, the earliest surviving colonial shipping list, from Barbados April–October 1679, records "burthen tunns" mostly in increments of 10 between 20 and 200. The first folio records 51 vessels, 41 of which report tonnages ending in zero, nine report tonnages ending in five; there was one 18-ton vessel (TNA, CO33/13, f. 1).

36. TNA, ADM68/194, f. 1. The exceptions: *Edmund* from Poole, 18 tons; *Farmer's Goodwill*, Brighton, 34 tons.

37. TNA, ADM7/77, f. 1. Rounded Mediterranean Pass tonnages post-1694 following earlier practice. The first Mediterranean Pass, a folio from June 1662, reports rounded tonnages as in "burthen 90 tons or thereabouts". By 1683, as trade increased to Mediterranean and Atlantic markets, more British vessels took out Passes. On a February–March 1683 folio, 16 out of 23 vessels report a rounded tonnage burthen ending in zero, the other seven tonnages ending in five.

38. MMM, C/EX/L/3/1, f. 1 (*Cleveland*). Liverpool vessels such as *Cunliffe*, registered at 294 tons on 5 April 1756 and again on 4 April 1758, exceptionally declared seemingly precise tonnage figures. In 1760, George Campbell purchased *Cunliffe* and renamed it *Quebeck*, but also declared its tonnage as 294 on its 31 March 1760 register.

example, in the Liverpool weeklies *General Advertiser* and *Williamson's Liverpool Advertiser*, 1756–1784, there were 448 unique vessels advertised with their tonnage or dimensions specified: 398 disclosed tonnages in multiples of 10, and shipowners reported another 18 vessels with tonnages ending in five. Only 32 of the 448 advertised tonnages, then, did not end in multiples of five. Of these 32 hulls advertised with seemingly precise tonnages, the shipowner usually specified carpenter's measurement. *General Wolfe*, 192 tons, carpenter's measure, would be auctioned in January 1761. *True Blue*, "a compleat Ship for the African or any other Trade", advertised at 161 tons "Burthen Carpenter's Measure" in 1775. In 1781 the notice for the ship *James and Rebecca* specified carpenter's measurement of 243 tons as well as giving potential buyers an approximate size of the hull's dimensions – about a 75-foot keel and beam measuring 25 feet.[39] The Liverpool newspaper sample noted three tonnages as "King's measurement": *Resolution* (303 tons); *Grange* (275 tons); and *Camelion* (267 tons).[40] Here sellers targeted potential buyers who might deploy their vessels in trades or service that paid per-ton bounties. *Resolution* might suit Greenland whaling, its private sale advertisement noted, and British Arctic whalers attracted a government bounty of 40 shillings per ton, "according to the Admeasurement of the Ship", as London customs official Henry Crouch stated.[41] *Camelion* was actually built in 1781 for "his majesty's service".

Pre-1786 *Lloyd's Register* tonnages are almost always rounded multiples of 10 (Figure 3). Whereas the Liverpool newspaper advertised *True Blue* at 161 tons "carpenter's measure", Lloyd's Register of Shipping surveyed the ship as 250 tons. *James and Rebecca* (243 measured tons) and *Bellona* (224 measured tons) both became 250 tons, respectively, in *Lloyd's Register.* A much larger discrepancy exists for a new Chester-built ship, 233 tons, "by admeasurement … Carpenter's ton[n]age": Lloyd Register's surveyed the ship, named *Lord Rodney*, at 350 tons.[42] Seemingly precise measured tonnages appear much less frequently than in Liverpool newspapers, and are usually disclosed only for large British ships sailing to India.[43] The few hulls with tonnages ending in five are usually smaller brigs, sloops and fishing smacks, less than 100 tons.[44] McCusker suggests that the organization followed their

39. *Williamson's Liverpool Advertiser*, 9 Jan. 1761 (*General Wolfe*), 8 Sept. 1775 (*True Blue*), 27 Sept. 1781 (*James and Rebecca*). Knowledgeable shipowners could use the published "carpenter's tonnage", the measure tonnage, to approximate a hull's dimensions, assuming keel length measured three times breadth: 75 × 25 × ½ (25) / 94 = 249.

40. *Williamson's Liverpool Advertiser*, 12 Dec. 1768 (Resolution), 20 Feb. 1783 (Grange); *Liverpool General Advertiser*, 15 May 1783 (Camelion).

41. H. Crouch, 1755, p. 369.

42. *Liverpool General Advertiser*, 2 Oct. 1783; *Lloyd's Register*, L229.

43. As in the London-built *True Blue*, 758 tons, surveyed by *Lloyd's Register* in 1774, and *Thames* and *Triton*, surveyed in 1775 at 676 and 637 tons, respectively.

44. Only a few vessels greater than 100 tons are listed with a tonnage such as 305 (such as ship *Hope* in 1779).

own "surveyors' visual estimates of vessels' measured tonnages", which were "merely an estimate of measured tonnage". From a small sample of seven London ships, he finds that *Lloyd's Register* tonnage compares to measured tonnage but is one third lower than cargo tonnage.[45]

To examine a larger sample, we compared the tonnages as advertised in Liverpool newspapers, with corresponding tonnages recorded in matched vessels in the Liverpool ship registers and *Lloyd's Register* (Table 4). For 30 Liverpool craft, measured tonnage, usually denoted as "carpenter's tonnage", exceeded registered tonnage by 40 per cent. *Lloyd's Registers*, on average, exceeded measured tonnage by about 10 per cent, but still recorded lower figures for 10 of 30 Liverpool vessels in the sample. Tonnages in *Lloyd's Registers* thus approximated shipowners' own estimates of carrying capacity.

The small samples in Tables 3 and 4 also suggest even greater imprecision in pre-1786 tonnage measurements. Of the 71 observations in the former, 43 are divisible by 50; in the latter, 33 of the 60 tonnages from the Plantation Registers and *Lloyd's Register* have the same property. Peter Solar has shown that the tonnages in the volumes of *Lloyd's Register* for 1779 and 1790 display pronounced heaping at values ending in 50 and 00.[46] In Figure 2 we show the heaping present in the major sources discussed above. In all of them peaks at 50s and 00s are prominent, particularly for larger vessels. It is highly unlikely that rigorous application of the statutory formulae to vessels' dimensions could have yielded so many values close to the nearest 100 or nearest 50.

This analysis of tonnages recorded in different sources suggests two lessons for the history of British shipping before the Registry Act of 1786. First, the sources fall roughly into two groups, with one group recording tonnages about a third lower than the other. Comparisons of mean tonnages in newspaper advertisements, applications for letters of marque and *Lloyd's Registers* show that, on average, they are quite similar in the tonnages that they report. Plantation Registers and Naval Office shipping lists clearly fall into the second group, with other candidates being Mediterranean passes and Seaman's Sixpences. Any historian aiming to quantify one or another aspect of eighteenth-century British shipping must rely on a variety of sources, created with different motivations. Historians studying British tonnage, then, must be alert to the context in which a tonnage figure appeared in various official and non-government sources.[47] Second, tonnage measurement was not standardized

45. J.J. McCusker, 1997, p. 68, n. 51.

46. P. Solar, 2016.

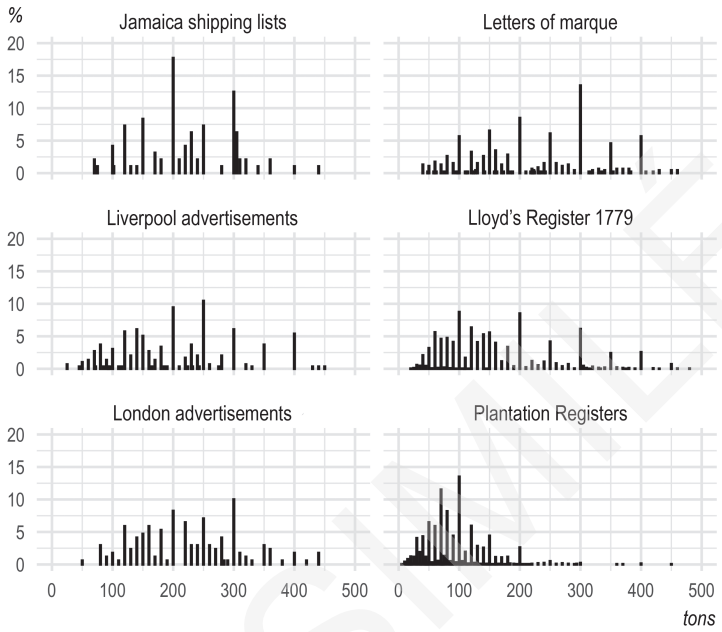
47. Owners might report lower tonnage figures to reduce their port fees and larger tonnage figures when hiring out vessels. This brief discussion of tonnage measurement draws heavily on A. Van Driel, 1924; P. Gille, 1957; F. Lane, 1964; M. Morineau, 1966, and the five important articles by W. Salisbury (1966a; 1966b; 1966c; 1967; 1968). For format of Certificates of Registry, see D. Pickering, 1773, p. 34. S. Ville, 1989, who examined the extensive papers from the London-based shipping firm Michael Henley and Son (1784–1830),

Table 4. *Liverpool newspapers advertising measured tonnage, as recorded also in Liverpool ship registers and* Lloyd's Register of Shipping, *1756–1784*

Liverpool vessel	*Year*	*Registered tonnage (LPR)*	*Measured tonnage*[a] *(GAL, WLA)*	Lloyd's Register *(LRS)*
Edward	1765	70	72	70
Molly	1765	80	130	100
Captain	1767	140	160	180
Mary and Ann	1767	100	110	100
Union	1768	106	151	140
Molly	1773	100	103	150
Rosanna	1773	100	100	200
Clayton	1773	200	260	300
Neddy and Nelly	1774	80	100 ("about")	200
True Blue	1775	100	161	160
Hartley	1775	130	180 ("about")	240
Sally	1775	70	70	90
Juba	1775	200	210	200
Triton	1777	200	278	280
Commerce	1778	100	160 ("about")	200
Three Friends	1780	100	160	200
Mary's	1780	75	72	70
Britannia	1780	80	140	120
Bellona	1780	150	224 ("more or less")	250
Charming Kitty	1780	100	140 ("more or less")	130
Stormont	1781	65	95	100
Hero	1781	180	280	250
Fancy	1781	70	93	100
James and Rebecca	1781	120	243	250
Jane	1781	80	150 ("about")	130
Sarah Goulbourn	1781	200	300 ("about")	400
Fanny	1782	150	232 ("about")	200
Grange	1783	200	275	400
Sally	1783	200	440	500
Thomas	1783	150	270	280
30 vessels		123.2	178.6	199.7

Sample. 30 Liverpool sailing vessels.
Note. [a] Carpenter, shipwright, king's measurement or "tons measurement." Words in parenthesis come from the advertisements.

Figure 2. *Tonnage heaping in eighteenth-century British sources*



Notes. Sample sizes: Jamaica shipping lists (96); Letters of marque (460); Liverpool advertisements (297); *Lloyd's Register*, 1779 (6608); London advertisements (170); Plantation Registers (2223).

Sources. Jamaica shipping lists: TNA, CO 142/22; Letters of marque: TNA, HCA26/40–64; Liverpool advertisements: *Williamson's Liverpool Advertiser*, 1756–1784; *General Advertiser Liverpool*, 1780–1783; Lloyd's Register 1779: *Lloyd's Register* database; London advertisements: *Public Register*, 1775-9; Plantation Registers: D. Richardson, K. Beedham & M. M. Schofield, Liverpool Shipping and Trade, 1744–1786 [data collection], (1992), UK Data Service, SN 2923, URL: http://doi.org/10.5255/UKDA-SN-2923-1.

before the 1786 Act and was subject to considerable imprecision.[48] Not only do different sources give different means, the tonnages from different sources are not well correlated. Some variation was inherent in the process. Both the length of the keel and the breadth of the vessel were subject to a range of interpretations, and for ships in the water various procedures estimated the

demonstrated that cargo capacity considerably exceeded the official tonnage, particularly for vessels built for Britain's east coast coal trade.

48. The extent of variation in the British sources contrasts with M. Morineau's (1966, pp. 23, 116-117) conclusion that tonnages of French ships declared by builders and captains tended to be similar to nearest 10 *tonneaux*, though he neither presents these data nor cites their source.

length of the keel.[49] But the degree of variation also suggests that tonnage was sometimes just in the eye of the beholder. Perhaps contemporaries recognized the difficulties of measuring a ship's cargo capacity and that is why they were content with citing values to the nearest 10 or 50 or 100 tons.

Of the sources analyzed here only *Lloyd's Registers* involved consistent measurement of tonnage by persons other than the builders or the owners. The tonnages in the Plantation Registers, the letters of marque and the Naval Offices lists were ultimately based on declarations under oath by the ships' owners. Newspaper advertisements depended as well on shipowners' assessments of tonnage. Only in 1786 was the machinery put in place for official measurement of the tonnages of British merchant ships.

2. British tonnage measurements after the 1786 Registry Act

A major landmark in the history of British tonnage measurement was the 1786 legislation entitled "An Act for the further Increase and Encouragement of Shipping and Navigation".[50] The motivation for this legislation was, after American independence, to clarify which vessels were "British" and thus entitled to privileges under the Navigation Acts. The 1786 Act went beyond earlier legislation by requiring shipowners to register or re-register all vessels of 15 tons or more whether they were involved in colonial trade or not, so it took in almost the entire British merchant fleet.

Owners needed to declare the particulars of their vessels on a standard form. A Customs officer or some other person "skilled in the building or admeasurement of ships" was required to "strictly and accurately examine and admeasure every such ship or vessel as to all and every particular contained in the form of certificate".[51] Hence, for the first time, merchant ships were being consistently measured. If the vessel qualified, it was issued with a certificate of registration which needed to be produced at any British port of call. Vessels without a valid certificate became subject to forfeiture. The 1773 Act had lacked penalties for non-compliance. Shipowners, facing the threat of forfeiting their craft, seem to have followed the 1786 Act to the letter.[52]

Tonnage was among the identifying features recorded on the certificate, as were length, breadth and depth from which tonnage could be calculated.

49. J.J. McCusker, 1981 has also suggested that the formulae for transforming dimensions into tonnage may have varied slightly from port to port.

50. 26 Geo III, c. 60; R.J. Jarvis, 1954a.

51. 26 Geo III, cap. 60.

52. Regarding a vessel's carrying capacity, the 1786 Act most concerned slaving shipowners, as from 1 August 1788 to 1 August 1799 parliamentary acts limited the number of enslaved Africans transported per ton. All parliamentary lists of slaving vessels tabled and published from 1789 to 1806 included tonnage.

The method for calculating a vessel's tonnage in the Act made general the tonnage formula specified in 1773, with one additional rule: for vessels measured afloat, it added a further deduction of three inches per "foot of the load draught of water" to the formula to calculate "the just length of the Keel to find the Tonnage". Calculating the keel thus required surveyors to take the vessel's extreme length, say, 80 feet, deduct three inches for every foot of "load draught" (say, a draft of 12 feet, or a three-foot deduction) and then deduct from that total three-fifths of the ship's breadth.[53]

We explore the effects of the 1786 Act on tonnage measurement in Britain by examining tonnage data from the first years of the Liverpool ship registers.[54] Of the 557 vessels registered there from September 1786 through March 1788, we matched 383 to entries in *Lloyd's Registers*.[55] The matched tonnages in *Lloyd's Registers* were on average five per cent larger than those in the Liverpool ship register. But there was so much variation across matches that the difference between the means was not statistically significant. The amount of variation is quite striking in the three-year period 1787–1789 after the Registration Act of 1786. On 4 October 1787, the owners of the Liverpool-built *Elizabeth*, for example, registered the newly-built ship at 328 tons, whereas *Lloyd's Register* listed *Elizabeth*, built in Liverpool in 1787, as 180 tons in 1787 and 1788, and did not update its tonnage to 328 tons until they surveyed *Elizabeth* fitting out for Jamaica in September 1789. By contrast, the Liverpool ship *Paragon*, built in Liverpool in 1788 and registered on 22 August 1788 at 185 tons, was surveyed in August 1788 by *Lloyd's Register* at 340 tons and subsequently by the Lloyd's Registration of Shipping surveyor in March 1789 at 185 tons.[56] There was a 2–3 year lag, then, after the 1 September 1786 Registration Act came into force – not surprising given that Lloyd's Register of Shipping's surveyors only examined vessels every few years.

We explore further the relationship between tonnages recorded in the official Liverpool ship registers and those listed in *Lloyd's Registers* by examining the tonnages of ships built in 1791 and registered at Liverpool in that year or in later years, that is, well after any transition in implementing or adapting to the 1786 Act. Of the 52 vessels registered at Liverpool, 20 were small vessels never recorded in *Lloyd's Registers*; small vessels were typically outside the purview of that publication. Of the 32 matched vessels the

53. The further reduction of keel length in the 1786 Act reduced tonnages from the 1773 Act by 4–6 per cent, a reduction not discussed by C.J. French, 1973.

54. R. Craig & R.J. Jarvis, 1967.

55. Some of the unmatched vessels were duplicate entries because several vessels were registered twice during this period. Many of the unmatched vessels were small coasters, which *Lloyd's Registers* rarely recorded (S.D. Behrendt & P.M. Solar, 2014).

56. MMM, C/EX/L/5/1,1787,248 (*Elizabeth*), C/EX/L/5/1,1788,72 (*Paragon*); *Lloyd's Register*, 1787, 1789, 1790.

tonnages of 15 were identical in the two sources and three became identical within a few years after registration. For another eight the tonnages were within three tons of each other, probably within margins of error in calculating and copying. But there were still five vessels for which the tonnages in the two sources differed by more than a few tons. *Gascoyne*, built at Liverpool, was registered there at 288 tons in 1791, but reported in *Lloyd's Registers* at 223 tons from 1792 to 1794. *Barrick*, built at Whitby, entered Liverpool registry in 1796 at 232 tons, though *Lloyd's Register* had it at 261 tons from 1792 to 1796 and at 252 tons until at least 1808. When the ship was reregistered in 1802 its tonnage was much closer, at 255 tons. *Winchester*'s history was similar: initially registered at 328 tons in 1802, then registered again in 1805 at 345 tons, just two tons less than *Lloyd's Register*'s figure of 347 tons from 1792 until 1808. *Lloyd's Register* consistently recorded *James*, built at Dysart, at 253 tons, yet it first appeared in the Liverpool register in 1796 at 245 tons. Finally, *Caroline*, an American-built brig, had a fleeting presence in both sources, being registered in Liverpool in 1796 at 104 tons and reported only in 1797 by *Lloyd's Register* at 130 tons. This comparison indicates that although the tonnages in *Lloyd's Registers* were generally identical or very similar to those in the official ship registers after 1786, its surveyors still made independent estimates for some vessels.[57]

Despite persisting differences in these two sources, their general convergence reflected the increasing standardization of tonnage measurement in Britain. The tonnages from the official registers became the norm for official documents, and by the mid-1790s ship register tonnages had already become common when advertising ships for sale or hire. In the *Public Ledger* the usual phrases were "register tons" or "tons per register". This convergence on register tonnage belies Ferreiro's verdict on British tonnages that "there would be no reasonable conformity until the Moorsom system was instated by the British Merchant Shipping Act of 1854".[58]

We have already shown that before the 1786 Act contemporaries did not pretend to great precision in capacity measurement, as indicated by the fact that tonnages were generally cited to the nearest number ending in zero.[59] By contrast, the 1786 Act led to tonnages being increasingly entered in the official ship registers as fractional values, indicating that they had been calculated according to the legal formula. *Lloyd's Register* followed suit after a few years and began reporting tonnages to the nearest unit. In newspaper advertisements tonnages to the nearest unit also became increasingly common.

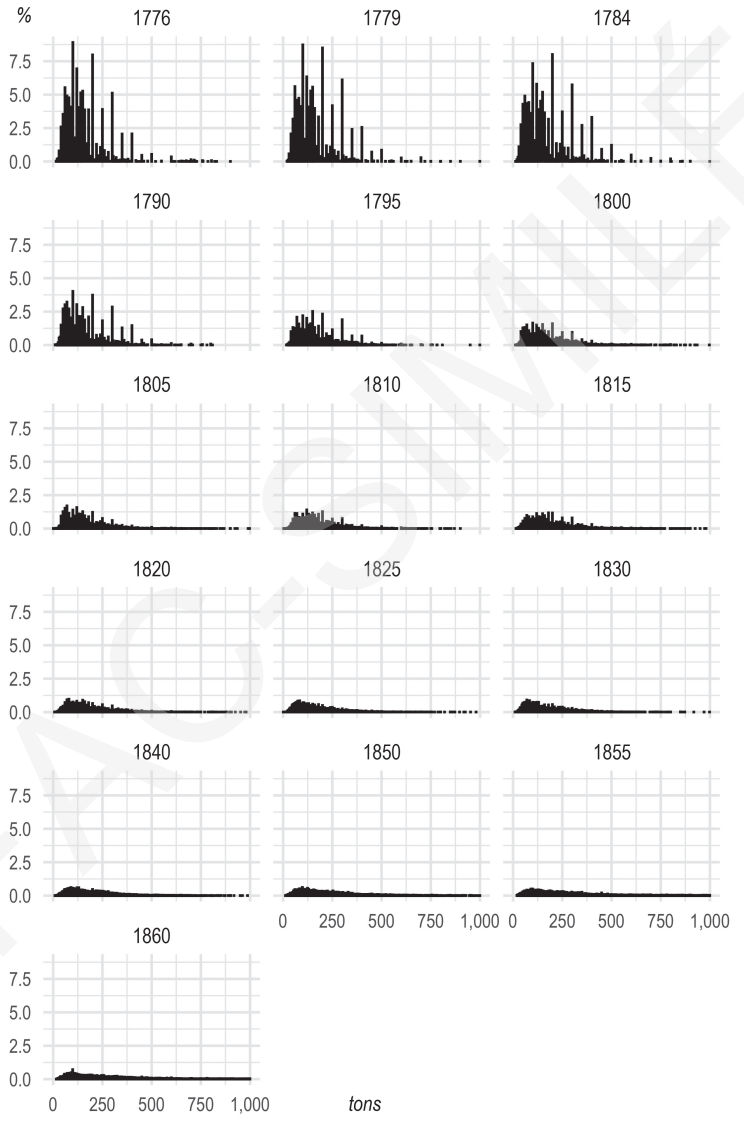
57. S. Ville, 1989, pp. 81-82 noted discrepancies between the official registers and *Lloyd's Registers* for some of Michael Henley's ships, concluding that *Lloyd's Registers* were "inaccurate", but this assumes that the register tons were indeed an accurate measure of tonnage.

58. L. Ferreiro, 2007, p. 193.

59. This preference for round numbers was also true of the Liverpool Plantation Registers (M.M. Schofield & D.J. Pope, 1978).

In Figure 3 we use data from *Lloyd's Registers* to show how general heaping had been in that source before the 1786 Act, how values to the nearest unit started to appear from 1790 and how long it took for heaping to disappear.

Figure 3. *Tonnage heaping in Lloyd's Registers, 1776-1860*



Sources. Lloyd's Register database.

3. International tonnage comparisons

Most countries adopted the Moorsom System in the late nineteenth century. Scholars interested in earlier international comparisons have proposed conversions to arrive at equivalent tonnages. Lane (1964), in his classic article on tonnage measurement, proposed equivalencies for the "whole medieval and early modern periods", which he ended in 1773 with the new British tonnage act from that year. He equated one metric ton with a British ton, which in turn equaled a French *tonneau de mer*, with each about half as large as Dutch or German *lasts* or Spanish *toneladas*. Morineau (1966) proposed similar equivalences, except that he equated the Spanish *tonelada* to the British ton and French *tonneau* and reckoned that the Portuguese *tonel* was a bit larger (Table 5).[60] Importantly, however, neither Lane nor Morineau were entirely clear about which British tonnage they were using; as we have seen above, there were essentially two tonnages current before the late eighteenth century, one used for registration and one for approximate cargo capacity, and registration tonnage was about one third less than the other.

Table 5. *Lane and Morineau's proposed European tonnage equivalences, c. 1650–1773*

Lane's proposed equivalencies		Morineau's proposed equivalencies	
1 metric ton	= 1 British ton	1 metric ton	= 1 British ton
	= 1 French *tonneau de mer*		= 1 French *tonneau de mer*
	= 0.5 Dutch or German *last*		= 0.5 Dutch or German *last*
	= 0.6* Spanish registered *tonelada*		= 1.0 Spanish registered *tonelada*
			= 0.9 Portuguese registered *tonel*

Note. * Lane's divided the French *tonneau de mer* of 1.44 cubic metres (1681) by the Spanish volumetric unit of 2.6 cubic metres per *tonelada* (1590s) to yield a conversion of 0.55, rounded to 0.6.
Sources. Lane, "Tonnages", p. 229; Morineau, *Jauges et méthodes*, p. 115.

To explore the relationships between British and continental European capacity measures in the late eighteenth and early nineteenth centuries we compare alternative measures of tonnage for the same vessels in a series of bilateral comparisons of British with French, Portuguese, German and Dutch sources. *Lloyd's Registers* recorded tonnages of British and foreign

60. F. Lane, 1964; M. Morineau, 1966. Conversions by Lane and Morineau vary slightly from equivalencies given by M. Rühlmann's (1857) treatise on hydrodynamics: 1 British ton = 1.05 French *tonneaux* = 0.52 Dutch or German *lasts* = 1.07 Spanish *toneladas*. We cannot account for Rühlmann's significantly different Spanish tonnage equivalent.

ships in Britain's foreign trade. When ships sailed to destinations on the continent, they were often involved in formalities that required a declaration of tonnage in local measure.[61] The French ordinance of 1681 required that all ships, including those of foreign ownership arriving in French ports, be registered and tonnages measured and recorded by officials in *tonneaux de mer*.[62] When vessels cleared customs, port officials collected anchorage fees and other duties on shipping, assessed per *tonneaux de mer* .[63] In Lisbon, officials collected the *marco*, a municipal tax levied per *tonelada* on all ships using port facilities. For the German and Dutch comparisons, by contrast, we have information on foreign ships measured in their home countries and glean their British tonnages when they appeared in *Lloyd's Registers*. For the German sample, we examined vessels belong to Hamburg shipowners, 1775–1794, as collected from German sources specifying capacity in *lasts*.[64] The sample of Dutch ships draws upon vessels' certificates of seaworthiness, also with measurements in *lasts*. The certificates issued from 1813 to 1818 have been digitized by the Marhisdata project.[65]

The basic results from these bilateral comparisons are the mean tonnages in the two sources – *Lloyd's Registers* and the particular foreign source – which yield implicit conversion rates. But given the great variation in the data (Figure 4), these conversion rates could be heavily influenced by outliers, so we have also estimated conversion rates using regression methods. Regression analysis enabled us to control for other variables, such as the size of the vessel, its rigging, where it was built and the trade in which it was employed.

61. The figures from foreign sources involved estimates or declarations of the vessels' capacities that were not, in the case of British ships, just conversions of the *Lloyd's Register* tonnages or, in the case of foreign ships, standard conversions of their foreign tonnages. If such simple conversions were used, they should show up in the data. Matching ships in British and foreign sources involves dealing with variant spellings of the names of ships and masters as well as translations of ship names. For example, *Loroanko* and the *Orange Tiré* were clearly the *Oronoco* and the *Orange Tree*. Vessels like *Trois Frères* and *Drie Gebroeders* were variously listed in the *Registers* either under these names or as the *Three Brothers*. In most cases matches were reasonably evident. Where there was uncertainty, the observations were dropped.

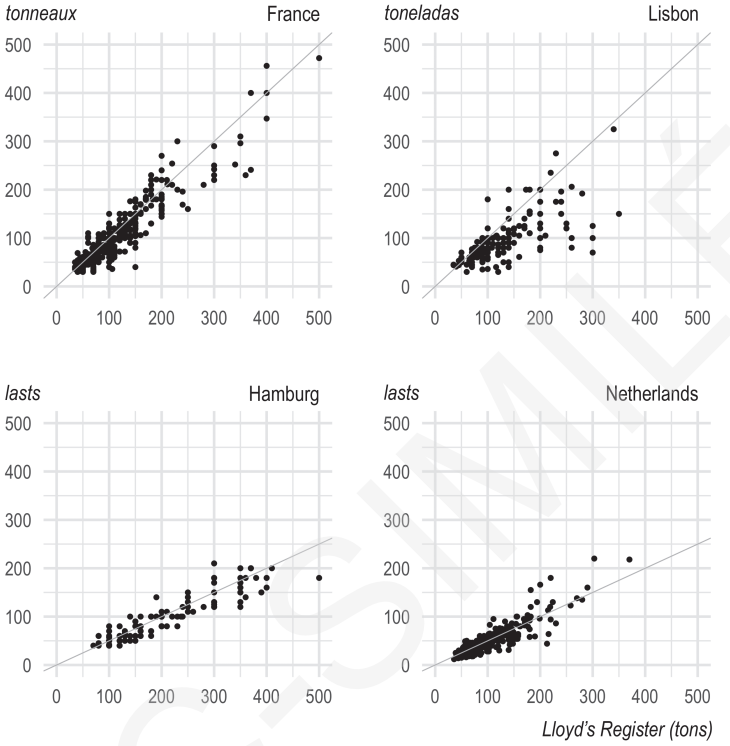
62. A. Van Driel, 1924; C. Schanakenbourg, 1975, pp. 119-126.

63. S. Llinares, 2008.

64. W. Kresse, 1966.

65. Stichting Maritiem-Historische Databank (URL: www.marhisdata.nl). We thank Ger Mulder for making data available to us and for patiently guiding us in their interpretation. The Marhisdata project documents the history of Dutch shipping from 1813 to the present. The central, but by no means not the only, source for this project is the official Certificate of Seaworthiness. The sample used here is based on the certificates issued from 1813 to 1818, several decades later than the other foreign data sets. The certificates do not generally include the capacity of the vessel, but for many ships this information has been added from bills of sale, certificates of ownership and other sources. In 1813–1818 officials issued 1,371 certificates. Many refer to the same vessel since shipowners needed to renew their certificates every two years.

Figure 4. *Bilateral comparisons of tonnages in* Lloyd's Registers *and foreign sources*



Notes. The 45° and 22.5° lines represent the conventional conversions for the *tonneau* and *tonelada* and the German and Dutch *lasts*, respectively.
Sources. France: Navigocorpus database (URL: navigocorpus.org); Lisbon: Arquivo Historico Municipal de Lisboa, *Livro das entradas e dos Despachos Feitos na Mesa do Marco dos Navios*; Hamburg: W. Kresse, *Materialien*, 1966; Netherlands: Stichting Maritiem-Historische Databank (URL: www.marhisdata.nl/); Lloyd's Register: *Lloyd's Register* database.

The Navicorpus project extracted information on 1,775 British vessels clearing customs in French ports in 1787.[66] Since many vessels were recorded repeatedly at one or more ports, the number of distinct vessels is much smaller, and there were further losses in matching, with a final yield of 301 observations, about an eighth of which involve variant French values for the same

66. This project is described at navigocorpus.org and in S. Marzagalli, 2016. The records used here come from the series of French *congés*, or clearance permits. For the purposes of this article, only vessels larger than 30 *tonneaux* were used because *Lloyd's Registers* rarely recorded smaller vessels.

ship.[67] The vessels in this sample were mostly smaller brigs, schooners and sloops making short voyages between England and France: they averaged 125 British tons, as reported by *Lloyd's Registers*, and 114 French *tonneaux*.[68] The implicit conversion of *Register* tonnages to French *tonneaux* is then 0.91, but there is little indication in the data that French authorities systematically deployed this conversion, or any other (Figure 4). There are relatively small clusters at some easy-to-calculate conversions: 20 observations where the British and French values were the same; 14 at a conversion of four-fifths; and 10 at a conversion of three-quarters. But altogether these amount to less than a sixth of all observations, which suggests that French officials determined tonnages of British ships independently from the way in which Lloyd's Register of Shipping's surveyors assessed them. Regression analysis of the implicit conversions between French and British capacity measures produced a somewhat lower value of 0.78 for the relationship of French *tonneaux* to *Lloyd's Register* tons.[69] The ton/*tonneaux* conversion did not vary significantly with the size of the vessel. The only statistically significant relationship was that ships shown in *Lloyd's Registers* as trading with North America tended to be somewhat larger as measured or declared in France.

For Portugal we drew upon data for British vessels taxed in Lisbon in 1787.[70] In the matched sample of 151 vessels,[71] the *Lloyd's Register* tonnages averaged 131 tons whereas Portuguese measures averaged 96 *toneladas*, implying a conversion of 0.78 *toneladas* per British ton. But the implicit conversions by observation ranged from 0.23 to 1.8 *toneladas* per British ton. There was modest clustering at some easy conversions: nine observations for which the values were the same; five for which the British tonnage would have been multiplied by three-quarters; five for which it would have been multiplied by four-fifths. But most values were not obvious conversions of the *Register* tonnages (Figure 4). Statistical analysis of the Portuguese data indicates that, relative to the tonnages in *Lloyd's Registers*, the implicit

67. Only twelve French vessels, out of several thousands, could be matched to the *Registers*. The implicit conversion for these vessels was 0.84 French *tonneaux* for each British ton. One might speculate that if vessels could have been easily insured in France, then Lloyd's Register of Shipping would have had little interest in surveying French ships calling in Britain.

68. Three-masted vessels, like ships and snows, were much less common than two-masted vessels. Brigs make up 58 per cent of the sample and sloops 28 per cent.

69. The estimating equation was similar to those above, with dummy variables: rig (brig, ship, sloop, snow); construction place (America, London, Northeast England, Other Britain); use (Baltic, Biscay, Channel, Mediterranean, North America, Portugal).

70. The Portuguese data come from the *Livro das entradas e dos Despachos Feitos na Mesa do Marco dos Navios*, held in the Arquivo Historico Municipal de Lisboa, Câmara Municipal de Lisboa. Maria Cristina Moreira extracted these data.

71. We identified 151 British vessels, including 131 distinct craft, with the additional observations being variant tonnages in the Portuguese source.

conversion tends to be larger for smaller vessels and smaller for larger ships.[72] Differences in rig, place of construction and destination had no discernable influence on the implicit conversion.

The sample of 109 Hamburg-owned vessels, generally larger than the vessels in the French and Portuguese samples, averaged 211 British tons and 104 *lasts*, with an implicit conversion of 0.48 German *lasts* per British ton.[73] For 19 observations the implicit conversion was equal to the conventional value of half a *last* per ton. But, as with the other samples, there was a great deal of variation, with implicit conversions ranging from 0.33 to 0.80 (Figure 4). Statistical analysis of the Hamburg data shows, as with the British sources, there was a tendency for *Lloyd's Register* tonnages to be relatively larger for smaller vessels and lower for larger vessels.[74]

Dutch-British tonnage conversions, based on a sample of 299 vessels, mirror those from the Hamburg sample, with an implicit conversion of 0.49 Dutch *lasts* per British ton. The Dutch craft, smaller two-masted vessels like those in the French and Portuguese samples, averaged 103 British tons and 50.3 Dutch *lasts*. In only four cases did the conversion equal the conventional half a *last* per ton. Even taking account of rounding, there are only about 20 observations that might have been based on some conventional conversion. These results would suggest that, as in the French, Portuguese and German cases, British and Dutch surveyors measured a vessel's carrying capacity independently. There was considerable variation (Figure 4), with implicit conversions ranging from 0.21 to 0.86. Statistical analysis arrives at an almost identical value for the conversion, with no biases by size of vessel.[75]

Tonnage measurement in other countries was also subject to heaping in the eighteenth century (Figure 5). The Hamburg tonnages, in *lasts*, were almost all recorded to the nearest 10, with multiples of 20, 50 and 100 getting additional preference. Reporting to the nearest unit was more common in the French and Portuguese sources, but even here there is considerable heaping,

72. The estimating equation was similar to those above, with dummy variables: rig (brig, ship, sloop); construction place (America, Northeast England, Foreign); use (America, Mediterranean, Portugal).

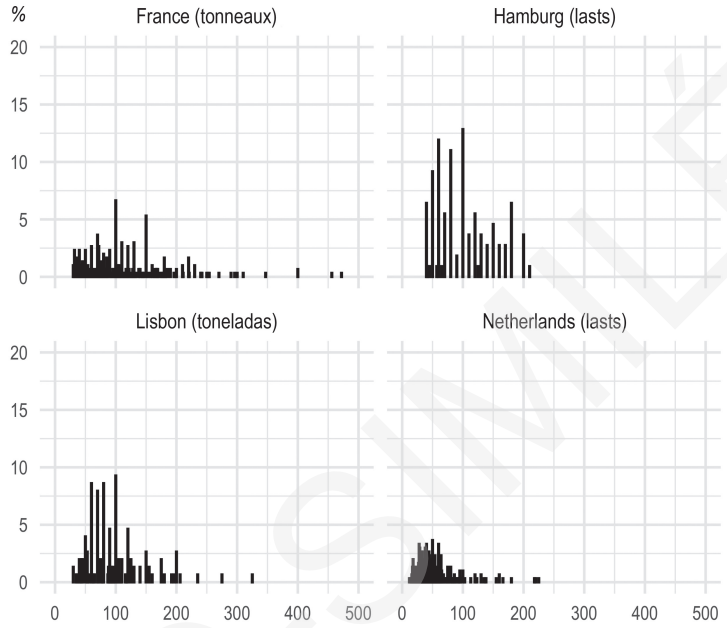
73. In some cases the capacity measures were drawn from other sources, including *Lloyd's Registers*, but these cases were clearly indicated and have been excluded from the matched sample. Matching was sometimes difficult because W. Kresse, 1966 gives only the names of the owners, not the names of the masters. Of the 414 ships voyaging between 1775 and 1794 it proved possible to match 109 to information in *Lloyd's Registers*. Many of the unmatched ships served ports other than those in Britain and would not have been subject to measurement by Lloyd Register of Shipping's surveyors.

74. The specification of the estimating equation is similar to that above, with dummy variables: rig (brig, hoy, ship); construction place (Germany); use (Hamburg).

75. The specification is as above, with dummy variables: rig (brig, galiot, ship, sloop, smack); construction place (Germany, Netherlands); use (Baltic, Netherlands).

though still somewhat less than in the British sources. The Dutch data, which come from the mid-1810s, show much less heaping.

Figure 5. *Tonnage heaping on the continent*



Notes. Sample sizes: France (301), Hamburg (151), Lisbon (109), Netherlands (301).
Sources. France: Navigocorpus database (URL: navigocorpus.org); Lisbon: Arquivo Historico Municipal de Lisboa, *Livro das entradas e dos Despachos Feitos na Mesa do Marco dos Navios*; Hamburg: W. Kresse, *Materialien*, 1966; Netherlands: Stichting Maritiem-Historische Databank (URL: www.marhisdata.nl).

These international comparisons, using *Lloyd's Registers* as the British standard, further confirm that ship capacity measurement was far from standardized in the late and eighteenth and early nineteenth centuries. As among the different British sources, there was considerable variation in the way in which the same ships were measured in different countries. Scholars comparing tonnages of British, French, Portuguese, German and Dutch sailing vessels must be aware of the significant range of possible conversions (Table 6). We have analyzed tonnages from the late eighteenth and early nineteenth centuries, but we suspect that similar variation would have characterized earlier periods. As for its causes, we have generally not been able to detect any ship characteristics that could explain much of the variation in implicit conversions. Tonnage measurement was a very imprecise activity and governments had yet to standardize it.

Table 6. *Mean tonnage comparisons, British and continental European measures*

		(A)	(B)	Conversion	
	Sample	*European measure*	Lloyd's Register	*Multiplier (A)/(B)*	*Range**
France, 1787	(301)	114 *tonneaux*	125 tons	0.91	0,27-1,80
Lisbon, 1787	(131)	96 *toneladas*	131 tons	0.78	0.23–1.80
Hamburg, 1775–1794	(109)	104 *lasts*	211 tons	0.48	0.33–0.80
Netherlands, 1813–1818	(299)	50 *lasts*	103 tons	0.49	0.21–0.86

Key. * – range indicates the extremes of the implicit conversions by observation.
Sources. France: Navigocorpus database (URL: navigocorpus.org); Lisbon: Arquivo Historico Municipal de Lisboa, *Livro das entradas e dos Despachos Feitos na Mesa do Marco dos Navios*; Hamburg: W. Kresse, *Materialien*, 1966; Netherlands: Stichting Maritiem-Historische Databank (URL: www.marhisdata.nl).

Nevertheless, the average conversions among the various measures generally confirm the Lane and Morineau's ton/*tonneau* and ton/*last* conversions, with the Portuguese results supporting Morineau's view on the Iberian *tonelada* over Lane's. In all comparisons, the British ton was on average slightly smaller than implied by Lane and Morineau's conventional values. But there was little evidence in the data that contemporaries dealing with individual vessels deployed any such standard conversions.

Conclusions

This study of tonnage measurement in western Europe, before Moorsom and, for the most part, before the British act of 1786, has revealed both systematic and unsystematic variation in assessments of a ship's carrying capacity. The systematic variation across British sources constitutes a warning to historians to pay careful attention to where they draw their tonnage data before using it to investigate crowding on slave ships, productivity growth in shipping or the development of particular trades. The unsystematic variation, among comparable British sources or across countries, should caution them against making strong inferences in the presence of what may be very considerable measurement error.

The measurement of ship carrying capacity, unlike that of the weights or volumes of agricultural produce, did not seem to vary systematically across regions, at least as far as we can tell. The variation seems to have arisen more

from the heterogeneity of ships, particularly in the shapes of their hulls. The unsystematic variation observed here, particularly before 1786, may reflect only the honest, but very imprecise efforts of individuals – shipowners, port officials, Lloyd Register of Shipping's surveyors – to arrive at an assessment of a ship's capacity for carrying cargo. Various formulae, whether statutory or drawn from the ship carpenter's art, existed to help them, but these were often very difficult to apply, particularly when the ship was afloat. Experience and a good eye may have been a better, or at least a more common, guide.

But, as for other goods, governments, national and local, recognized the need for convenient and standard measures. As the French author of a treatise on ship measurement put it in the mid-eighteenth century: the method needed "to be sufficiently exact for the collection of the duties levied by sovereigns on the merchandise carried by a ship; and this method must be very expeditious, usable by persons little versed in geometry, and standard for all ships and in all of the ports of the kingdom…".[76] Measures backed by government sanction were also useful to shipowners, shippers and insurers and constituted a public good. The British Shipping Act of 1786 took such a step toward standardization, and official register tonnage soon became the norm for shipowners seeking to sell or let their vessels. It represents a significant exception to what Hoppit shows to have been a period from 1713 to 1795 during which, despite repeated initiatives, the British government passed almost no legislation to standardize weights and measures.[77]

Tonnages standardized around the official values after 1786 did not necessarily mean they were any more accurate at capturing a vessel's cargo carrying capacity. The 1786 Registration Act's straightforward tonnage formula could not factor in all variants of a hull's construction and therefore provided only an approximate volumetric calculation. Writing in 1830, Scottish shipbuilder Peter Hedderwick stated that the 1786 Act's formula

> cannot be supposed to give the true tonnage of every vessel, as they differ so widely in their constructions; and therefore some vessels will carry nearly double their register tonnage, while others that are sharp will not carry near so much as their register tonnage.[78]

Moreover, the weight of cargo depended, in any case, on its specific gravity and on how it was packed and stowed. Unfortunately, the opportunities to compare official tonnages with the tonnage of cargo carried are rare. By the late eighteenth century cargo tonnage may have been well above measured

76. E. Pézenas, 1749, p. 31: "nécessairment voir deux méthodes pour le jaugeage des navires, l'une qui soit suffisamment exacte pour la perception des Droits que les Sourverains lèvent sur les marchandises qui font la charge du navire; et cette méthode doit être très expéditive, practicable par des personnes peu versées dans la géométrie et uniforme pour tous les bâtiments et dans tous les ports du Royaume…".

77. J. Hoppit, 1993.

78. P. Hedderwick, 1830, p. 150.

tonnage.[79] Evidence on colliers arriving in London in 1813 shows that the tons of coal they carried exceeded their ship tonnage by about 40 per cent, but coal was a cargo with a relatively high specific gravity.[80] In any case, given the large degree of variation that characterized tonnage measurements in practice, shippers and shipowners must have taken measured or official tonnage only as a starting point in negotiating freight and charter rates and ship sales.

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