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Research Note

The burden of complexity: Dealing with measurement and taxation in the Sound Toll registers – a response to Yrjö Kaukiainen

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Abstract
This paper replies to a research note outlining a method for the conversion of weights and measures in the Danish Sound Toll registers. Whereas Yrjö Kaukiainen argues that the use of values for Danish units of measurement is sufficient, Werner Scheltjens highlights the complexity of pre-modern weights and measures, and raises concerns about the simplification of the measurement and taxation procedures at the customs office in the Danish Sound.

Keywords
Historical metrology, methodology, Sound Toll registers, weights and measures

Introduction

'Tetradas' is an acronym for 'tonnage estimates of trade through the Danish Sound'. Tetradas is an online data set containing selected time series based on a conversion to tonnes of 1,000 metric units (litres, kilogrammes) of commodity registrations in Sound Toll Registers Online for the period 1670–1856.[1] The tonnage estimates in Tetradas

1. Werner Scheltjens, 'Tetradas: Tonnage Estimates of Trade through the Danish Sound, 1670–1856 (Replication Data and Selected Statistics)', Version 1, *VSWG – Journal of Social and Economic History*, http://dx.doi.org/10.15456/vswg.2020251.121019

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constituted the backbone of my study of North Eurasian trade in world history.[2] They facilitated the longitudinal analysis of the impact of changes in the economic and political relations between the stakeholders of trade through the Danish Sound on commodity flows entering and leaving the Baltic Sea. I converted the commodity registrations in Sound Toll Registers Online in an attempt to overcome the challenges posed by pre-modern weights and measures without avoiding the metrological issue per se.

I attempted to estimate tonnages for as many commodity registrations as possible, in a way that was as precise as possible (at least in the context of an individual research project). I used these tonnage estimates to produce time series that provide information about commodity flows to and from Baltic Sea ports, while having the additional benefit of being comparable across time and space. Alternative methods, such as computing the value of trade or the productivity of shipping (in ton-kilometers), were not pursued. The latter would entail a different set of research questions; the former would require much additional data and runs into the issue of distinguishing value from economic significance, which is particularly relevant for 'Baltic trade'.[3]

Summary of method

My conversion method starts from the well-known observation that pre-modern units of measurement differed from port to port and from commodity to commodity, resulting in a bewildering variety.[4] Researchers have long been aware of the challenges that this variety poses. Some have devoted case studies to dealing with specific historical weights and measures; others have compiled dictionaries to capture the variety at a (much) larger scale.[5] The determinants of pre-modern units of measurement are (1) quantity, often expressed as a relation to another unit of measurement; (2) location, which could be a place, region or territory; and (3) commodity. Any attempt to convert or interpret pre-modern units of measurement should account for these determinants; however, the results can never be more than an *estimate*. This has been my guiding principle while developing Tetradas.

The details of my method, the wide range of decisions and the issues encountered during the process have been published alongside the Tetradas time series.[6] Moreover, Tetradas itself includes a 50-page document about the rules of conversion employed

2. Werner Scheltjens, *North Eurasian Trade in World History, 1660–1860: The Economic and Political Importance of the Baltic Sea* (London, 2021).
3. Scheltjens, *North Eurasian Trade*, 2.
4. Peter Kramper, *The Battle of the Standards: Messen, Zählen und Wiegen in Westeuropa, 1660–1914* (Berlin, 2019).
5. See, for example, Ronald E. Zupko, *A Dictionary of Weights and Measures for the British Isles: The Middle Ages to the Twentieth Century* (Philadelphia, 1985); Harald Witthöft, *Handbuch der historischen Metrologie* (8 vols., St Katharinen, 1991–2007); Jan Gyllenbok, *Encyclopaedia of Historical Metrology, Weights, and Measures* (Cham, 2018).
6. Werner Scheltjens, 'Tetradas: Dataset of Tonnage Estimates of Trade through the Danish Sound, 1670–1856', *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, 108, No. 3 (2021), 373–94.

for the units of measurement.[7] This document specifies, for each unit of measurement, how I interpreted the evidence found in Horace Doursther's *Dictionnaire universel des poids et mesures anciens et modernes*.[8] My 2021 article, 'Tetradas: Dataset of Tonnage Estimates of Trade through the Danish Sound, 1670–1856', and the 'rules of conversion' document also explain how I dealt with, among other things, missing data, timber cargoes and ad valorem taxation. Moreover, the 2021 article discusses the losses that occurred during the conversion process and outlines why they occurred. Tetradas contains tonnage estimates based on 86.6% of all cargo registrations in Sound Toll Registers Online between 1670 and 1856; 13.4% of the registrations could not be converted.[9] Finally, the article contains a section on the reliability of my tonnage estimates, in which I compare my data with that from Herbert Kaplan's study of Anglo-Russian commerce in the eighteenth century.[10] Although the 2021 article is referenced in the first footnote of my book on North Eurasian trade,[11] and the 'rules of conversion' document is readily available as part of Tetradas – the target of the research note to which I reply here – Yrjö Kaukiainen did not care to consult either of these sources for his critique.

Summary of criticism

The research note, 'How Do We Measure the Commodity Flows of the Sound Toll Records?', argues that the method proposed by the Danish historian Hans Chr. Johansen is preferable to mine.[12] Kaukiainen dismisses my method on two major grounds: (1) my alleged misinterpretation of treaty stipulations regulating taxation in the Danish Sound and (2) the availability of a list of conversions of registered cargo measurements to Danish equivalents (the 'Odense list'), which provides 'inevitable' evidence that units of measurement were converted to Danish equivalents in the Sound Toll registers.

According to Kaukiainen, insights derived from Johansen's work make it clear that 'conversion to Danish (and Dutch) units was the normal procedure but foreign, unconverted units could also be recorded, [in particular for] measures with no Danish counterpart (such as the British coal measures of chaldron and keel)'. In other words, when dealing with the Sound Toll registers, it is not necessary to adhere to the triangle of measurement, origin and commodity to estimate the quantity of a unit – just the Danish units of measurement and some foreign units will suffice.

7. Scheltjens, 'Tetradas: Tonnage', 9_AUX_rules.pdf
8. Horace Doursther, *Dictionnaire universel des poids et mesures anciens et modernes, contenant des tables des monnaies de tous les pays* (Brussels, 1840).
9. Scheltjens, 'Tetradas: Dataset', 377.
10. Scheltjens, 'Tetradas: Dataset', 387–90; Herbert H. Kaplan, *Russian Overseas Commerce with Great Britain during the Reign of Catherine II* (Philadelphia, 1995).
11. Scheltjens, *North Eurasian Trade*, 22.
12. Hans Chr. Johansen, *Shipping and Trade between the Baltic and Western Europe 1784–95* (Odense, 1983).

In addition to his main arguments, Kaukiainen laments, among other things, that (1) I exaggerate the importance of local differences in weights and measures; (2) my conversions are weak for commodities that were counted by the piece, dozen or similar; and (3) I have not taken into account the relative weights of commodities, which makes it impossible to use my tonnage estimates to calculate shipping capacity. In short, he argues that my way of dealing with metrological issues is flawed.

In the following sections, I will deal with Kaukiainen's main arguments first, before briefly addressing the additional points of criticism. Some concluding remarks complete my response.

Registration versus taxation

In his opening statement, Kaukiainen asserts that 'Scheltjens *believes* that the commodities paying the Sound Toll were recorded according to the measuring systems of the respective ports of loading – that is, they were not converted into Danish weights and measures' (my emphasis). I do not 'believe' anything of the kind. I have based my understanding of the commodity registration practices at the customs office in Elsinore on historical evidence provided in an account of the history and current state of the Sound dues,[13] and found in the first articles of the Danish–Dutch treaties of 1645 and 1701.[14] Scherer describes a typical customs clearance procedure, which shows that cargoes were registered based on the bills of lading presented by shipmasters or their representatives.[15] I have inferred from this description that the cargoes carried on board were registered in the account books as found in the bills of lading. While often translated into Danish, the cargo items, quantities, and weights and measures were copied from the bills of lading.

I discussed this issue in 2009, in my first article on the conversion of weights and measures in the Danish Sound to their metric equivalents,[16] of which Kaukiainen does not take note. There, I provide the same quote as Kaukiainen from Article 2 of the 1701 Treaty of Copenhagen, which deals with the registration of cargo items and units of measurement in the Sound Toll registers. Relating it to Scherer's description of cargo clearance procedures, I have interpreted Article 2 as follows:

> Cargo items and their measures were translated into Danish, registered quantities were copied and the sum of customs due was calculated separately for each cargo item. While the calculation of customs was done according to a number of rules described in various customs treaties, there is no mention of any conversion of weights and measures used in the freight letters to local (Danish) equivalents.[17]

13. Hermann Scherer, *Der Sundzoll: Seine Geschichte, sein jetziger Bestand und seine staatsrechtlich-politische Lösung: Nebst einem Anhang über die Sundzollfreiheit der Pommerschen und Preusischen Städte* (Berlin, 1845), 63–73.
14. Werner Scheltjens, 'The Volume of Dutch Baltic Shipping at the End of the Eighteenth Century: A New Estimation Based on the Danish Sound Toll Registers', *Scripta Mercaturae*, 43, No. 1 (2009), 79.
15. Published 1845, not 1875, as the author indicates in footnote 4.
16. Scheltjens, 'Volume', 79n14.
17. Scheltjens, 'Volume', 79.

However, my quote from Article 2 is more extensive than Kaukiainen's and provides information that is essential for understanding its meaning. It states:

> to avoid differences in the calculation of wines, a barrel of Bordeaux wine will be estimated in the Sound at 52 rixdollars and a barrel of wine from Nantes at 45 rixdollars. Spanish wines, like a pipe of Malaga wine or other Spanish wines [will be estimated] at 45 rixdollars … . The tolls will be paid in accordance with this taxation.[18]

In other words, the first part of Article 2 of the Treaty of Copenhagen deals with the registration of cargoes and stipulates that they should be recorded as is. The second part deals with taxation practices and describes how they account for differences in the volume and size of units of measurement at the ports of departure of the registered cargoes.

Whereas I consistently deal with the registration of cargoes, Kaukiainen does not make the distinction between registration and taxation, and refers to the taxation practices as a 'principle of recording'. By arguing that the taxation practices were 'aimed at solving some ad hoc issues' and that 'the regulation on weights and measures was written in somewhat general terms', Kaukiainen seems to indicate that my interpretation of Article 2 is invalid. However, Kaukiainen's remarks miss their target, as I deal with the registrations of cargoes – not with the calculation of the taxes levied on them.

Service versus reference

Kaukiainen's second main argument is with regard to the availability of a list of conversions of registered cargo measurements to Danish equivalents (referred to as the 'Odense list').[19] The list in question was created by the Danish historian Hans Chr. Johansen, who 'mapped out all the weights and measures found in the relevant Sound Toll books [for the years 1784 to 1795] and also converted them into modern metric units'. The list contains '74 different eighteenth-century weights and measures, often with commodity-specific variations, [and] also contains some information on how different weights and measures were applied at Elsinore'. According to Kaukiainen, this list 'gives the impression that conversion to Danish (and Dutch) units was the normal procedure but foreign, unconverted units could also be recorded in the Sound Toll registers'. In the following paragraph, this 'impression' 'leads to an inevitable conclusion: the Sound Toll registers contain data converted into Danish weights and measures as well as unconverted "raw" data representing the scales of several other ports'. According to Kaukiainen, from Johansen's work, 'the reader … gets the impression that the "Danish mode" [that is, conversion of weights and measures to Danish units at the customs office in Elsinore] was the more common'. From his impressions with regard to the 'Odense list', which are not supported by any references, Kaukiainen then infers that 'converting the weights and measures into metric units according to the Danish standards seems as good as, or probably even better than, other alternatives'.

Referring to the 'Odense list', Kaukiainen calls for nothing less than the application of epistemologically unwarranted methods to estimate commodity flows through the Danish

18. Scheltjens, 'Volume', 79n14.
19. Johansen, *Shipping and Trade*, 125–9.

Sound. He argues that the determinants of location and commodity do not have to be taken into account (unless they are specified in the 'Odense list'?), and the Danish (and Dutch?) metric values are sufficient. This argument lacks both precision and supporting evidence. Kaukiainen reaches this conclusion based on the *impression* he gets from Johansen's work, but admits that Johansen did not give any estimations of the relative proportions of measurements converted into Danish units versus 'raw' measurements.

Let us try to make a bit more sense of the 'Odense list'. Johansen used the rate of duty at the customs office in Elsinore 'partly to find the conversion ratios between different units of measurement and partly to see if different qualities or sizes were involved for a commodity or unit of measurement'.[20] In this context, Johansen notes: 'For a number of corn types there are several different rates per last, due to the fact that the last varied in size in the Baltic ports'.[21] This indicates that Johansen was well aware of the relevance of location and commodity as determinants for the quantity of units of measurement. More importantly, however, the statement clearly shows that Johansen and I share the same understanding of measurement and taxation practices at the customs office in Elsinore. The units of measurement in the Sound Toll registers are those that were used at the port of departure. The customs officers in Elsinore established procedures for calculating the taxes on their basis, differentiating, for example, between grain lasts from different ports. Occasionally, some calculation steps seem to have ended up in the registers – for example, when the tax value of casks of wine was added to the commodity description ('stads viin à 52 rd.') or when two different measurements are given for the same cargo item, adding the Danish word *giør* or *er*, which may be interpreted as 'that is to say', between them ('42 læster rug etc. giør 50 2/5 læst'). Both examples have been discussed in previous publications, which Kaukiainen did not consult.[22]

My understanding is that the 'Odense list' put forward by Kaukiainen is meant merely as a service for users who may not be familiar with the variety of pre-modern units of measurement. The 'Odense list' most certainly does not describe 'Danish standards', nor were 'the principal metrological systems … fairly similar across the Baltic world and western Europe'. A recent survey, based on extensive research in historical reference works, provides much evidence for the bewildering variety of pre-modern weights and measures, also in Denmark.[23] This variety persisted well into the nineteenth century. The 'Odense list' does not capture any of this. It remains silent on the changes in measurement over time and the variety resulting from the application of measures to certain commodities in certain locations, both of which are essential components of pre-modern

20. Johansen, *Shipping and Trade*, 129.
21. Johansen, *Shipping and Trade*, 129.
22. Werner Scheltjens, Jan Willem Veluwenkamp and Siem Van der Woude, 'A Closer Look: STRO as Instrument for the Study of Early Modern Maritime History', in Jan Willem Veluwenkamp and Werner Scheltjens, eds., *Early Modern Shipping and Trade: Novel Approaches Using Sound Toll Registers Online* (Leiden, 2018), 1–18; Jan Willem Veluwenkamp, Werner Scheltjens and Siem Van der Woude, 'Sound Toll Registers Online', *TSEG – The Low Countries Journal of Social and Economic History*, 18, No. 1 (2021), 147–60.
23. Gyllenbok, *Encyclopaedia*, 991–1014.

metrology. Whereas I have devoted my efforts to dealing with commodities and locations, I admit that – so far – I have not had the chance to pay attention to changes over time. I have relied on assertions about metric equivalents for pre-modern weights and measures around 1840.

The 'Odense list' is not a reference list that qualifies for any kind of reuse or broader application, nor is it meant to be one. It describes in a few lines – and for the 'last', a few more – the 74 units of measurement that Johansen found in the Sound Toll registers for the period 1784–1795. The list only covers a fraction of the 240 different units of measurement in Tetradas. It does not contain any source references; Johansen does not say where he obtained his information about pre-modern weights and measures. The list describes the kind of unit (quantity, capacity, weight) and often provides an indication of equivalence inferred from a comparison with the rate of duty at the customs office in Elsinore. The latter takes a variety of forms, including the equivalent number of pieces, relation to other units or metric equivalence. Some descriptions indicate the use of certain units in a specific geographical context, others specify their application to certain commodities, and a few do both. Some examples from the 'Odense list' seem to confirm the necessity of applying my method rather than supporting the Kaukiainen's argument: '40-muid: A variable measure of capacity used for salt, equal to between ¼ and 1 last … 47-viertel: A variable measure of capacity used for bread'.[24] I wonder how Kaukiainen would use this information to produce better measurements of commodity flows through the Danish Sound.

Metrological issues

Following his main arguments, Kaukiainen criticizes my method for dealing with (not necessarily solving!) metrological issues in several ways. I have chosen to respond to three instances of such criticism. First, Kaukiainen compares the local variations in the units of 'anker' and 'pound' to substantiate that I exaggerate the importance of local differences in weights and measures. It is unclear on what basis the ports were selected. For the 'pound', the selection of ports results in a distorted view of the local variation. As can be seen in my 'rules of conversion', the estimated weight of one pound varied from 0.3013 kilogrammes in Menton and Venice to 0.891 kilogrammes in Naples.[25] Common generalizations – such as 'the pound' was 'approximately 450 grammes', the classic formula 'one last is two tonnes'[26] and indeed the entire 'Odense list' – disregard this variety and make misleading propositions.

Second, Kaukiainen argues that my conversions are weak for commodities that were counted by the piece, dozen or similar. This is true. I had a difficult time dealing with them, as I have documented elsewhere.[27] Kaukiainen argues that if we know the size of a piece of timber, it is possible to measure it fairly well, and indicates two sources that have recently done this, which – apparently – I have missed. However, I do refer

24. Johansen, *Shipping and Trade*, 126–7.
25. Scheltjens, 'Tetradas: Tonnage', 9_AUX_rules.pdf
26. For a critique, see Scheltjens, 'Volume'.
27. Scheltjens, 'Tetradas: Dataset', 384–6.

to Nathan Gallagher's work in my 2021 article, alongside a reference to Manish Kumar's 2018 article, which deals with the same subject. I duly noted that their estimates are more robust than mine but that time did not permit me to include them in Tetradas.[28] The same applies to Lauri Karvonen's work, which was finished after I had submitted my book on North Eurasian trade. Just like Gallagher, Kumar and Karvonen, I relied on external sources for my timber estimates,[29] so the criticism formulated with regard to my timber estimates is, in fact, also a critique of these sources.

Third, Kaukiainen criticizes that I have not taken into account the relative weights of commodities, which makes it impossible to use my tonnage estimates to calculate shipping capacity. This is also true and, in my documentation of Tetradas, I have explained why: I did not want to create a false impression of precision by systematically trying to add relative weights to the estimates.[30] Moreover, I did not pursue the calculation of shipping capacity, nor do I make any claims in that regard. I designed my tonnage estimates to serve a different purpose: to overcome the limitations that the variety of weights and measures poses to producing time series based on pre-modern source materials. My tonnage estimates are not intended to make claims about the requirements of shipping space. It is a fallacy to argue that they are not good for that, therefore I will not comment on that part of the research note. My tonnage estimates (only) facilitate the study of long-term trends and structural changes in commodity flows through the Danish Sound, while also offering a means to study flows at a high level of granularity (that is, estimates can be reproduced for each cargo item registered in Sound Toll Registers Online). I have clarified all this in my documentation.

Closing remarks

Kaukiainen proposes a 'one rule fits all' method for converting weights and measures in the Sound Toll registers based on Johansen's 'Odense list', and provides several arguments against my bottom-up approach. He is eager to show that Johansen's method is as good as, or even better than, mine, but in so doing overlooks several important points – not least almost the entire documentation of my method. Kaukiainen's research note could have been the beginning of a discussion about time-intensive, bottom-up methods and their opposites, which may seem simpler, faster and easier to implement but disregard the complexities of pre-modern metrological systems. However, due to his poor preparation, it is a missed opportunity.

Despite my obvious concerns about the quality of Kaukiainen's research note and his intentions, I would nevertheless like to close this response on a more encouraging note. Both the research note and my reply show that there is much work to be done on the metrological and fiscal practices at the customs office in Elsinore. The work of

28. Scheltjens, 'Tetradas: Dataset', 386.
29. Scheltjens, 'Tetradas: Dataset', 385; P. J. Middelhoven, 'De Amsterdamse veilingen van Noord-Europees naaldhout, 1717–1808: Een bijdrage tot de Nederlandse prijsgeschiedenis', *Economisch- en Sociaal-Historisch Jaarboek*, 41 (1978), 86–114; Tomasz Wazny, 'The Origin, Assortments and Transport of Baltic Timber', in Carl Van de Velde et al., eds., *Constructing Wooden Images* (Brussels, 2002), 115–26.
30. Scheltjens, 'Tetradas: Dataset', 384.

Ole Degn and others might provide a good starting point,[31] but there is still a definitive lack of scholarship that deals with the official regulations for measurement and taxation, as well as their practical implementation. Better insight into the fiscal history of the Sound Toll registers would significantly advance our knowledge of trade through the Danish Sound.

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31. Ole Degn, ed., *The Sound Toll at Elsinore: Politics, Shipping and the Collection of Duties* (Copenhagen, 2018).