Research Note

IJMH

Aggregate statistics on trafficker-destination relations in the Atlantic slave trade

SAGE

Philip Hans Franses
Wilco van den Heuvel
Erasmus School of Economics, Econometric Institute, The Netherlands

Abstract

The available aggregated data on the Atlantic slave trade in between 1519 and 1875 concern the numbers of slaves transported by a country and the numbers of slaves who arrived at various destinations (where one of the destinations is 'deceased'). It is however unknown how many slaves, at an aggregate level, were transported to where and by whom; that is, we know the row and column totals, but we do not known the numbers in the cells of the matrix. In this research note, we use a simple mathematical technique to fill in the void. It allows us to estimate trends in the deaths per transporting country, and also to estimate the fraction of slaves who went to the colonies of the transporting country, or to other colonies. For example, we estimate that of all the slaves who were transported by the Dutch only about 7 per cent went to Dutch colonies, whereas for the Portuguese this number is about 37 per cent.

Keywords

Atlantic, destinations, mortality, slave destinations, slave trade

It is by now a well-known and well-recognized fact that the transatlantic slave trade (1519–1875) involved around 12.5 million Africans.[1] The slave traders originated from

---

1. See, Philip D. Curtin, *The Atlantic Slave Trade: A Census* (Madison, 1969); Stanley Engerman, Seymour Drescher and Robert Paquette, eds., *Slavery* (Oxford, 2001); and Robin Haines and Ralph Shlomowitz, 'Explaining the decline of mortality in the eighteenth century British slave trade', Economic History Review, 53, No. 2 (2000), 262–83.

Corresponding author:
Philip Hans Franses, Erasmus School of Economics, Econometric Institute, Burgemeester Oudlaan 50. 3062 PA Rotterdam, The Netherlands.
Email: franses@ese.eur.nl

Table 1. Slaves trafficked by carrier (rounded 000s).

	1519–1600	1601–1650	1651–1675	1676–1700	1701–1725	
Portugal	264	440	54	161	378	
Great Britain	2	23	115	243	381	
France	0	0	6	34	106	
The Netherlands	0	41	65	56	66	
Spain	0	0	0	0	0	
USA	0	0	0	0	11	
Denmark	0	0	0	16	17	
	1726–1750	1751–1775	1776–1800	1801–1825	1826–1850	1851–1867
Portugal	406	473	626	872	1,248	154
Great Britain	491	859	741	257	0	0
France	254	322	420	218	94	3
The Netherlands	109	148	41	2	0	0
Spain	0	1	9	205	279	23
USA	45	89	54	81	0	0
Denmark	8	13	30	11	0	0

Source: Adapted from Table 1 (p.184), *Slavery*, edited by Stanley Engerman, Seymour Drescher and Robert Paquette (Oxford, 2001). Please note that the term 'USA' is used in the original for periods before 1783.

various countries, including Portugal, Spain, Great Britain, the Netherlands and France. Typically, the destinations of the slaves were the colonies of those countries, although a substantial number of slaves died *en route*, either aboard a vessel still at an African coastal location or during the ocean voyage.[2]

Our study aims to provide aggregate (estimated) statistics on the links between trading countries and destination. Although there are numerous studies with detailed and important analyses of various routes and voyages, it seems that such aggregate statistics are not available.[3] One way to generate them can be based on a detailed analysis of all the voyages, where an almost full account is available at http://www.slavevoyages.org/ (edited by David Eltis and Martin Halbert). Yet, an alternative method, which we propose below, is based on a computational exercise applied to the available aggregate numbers, as provided by Engerman et al in 2001.[4]

To be more precise, consider Tables 1 and 2. Table 1 contains, for 11 consecutive periods, the numbers of slaves that were trafficked by traders from Portugal, Great Britain, France, the Netherlands, Spain, the USA and Denmark. Table 2 contains, for the

---

2. Simon J. Hogerzeil and David Richardson, 'Slave Purchasing Strategies and Shipboard Mortality: Day-to-day Evidence from the Dutch African Trade, 1751–1797', *Journal of Economic History*, 67, No. 1 (2007), 160–90.

3. Robin Haines, John McDonald and Ralph Shlomowitz, 'Mortality and Voyage Length in the Middle Passage Revisited', *Explorations in Economic History*, 38, No. 4 (2001), 503–33; and Hogerzeil and Richardson, 'Slave Purchasing Strategies'.

4. Engerman et al, *Slavery*.

Table 2. Destinations of the enslaved (rounded 000s) – European colonies or deceased.

	1519–1600	1601–1650	1651–1675	1676–1700	1701–1725	
Portugal	50	176	47	136	346	
Great Britain	0	28	96	206	317	
France	0	2	7	21	75	
The Netherlands	0	2	43	40	43	
Spain	152	188	0	7	32	
Other	0	0	0	11	14	
Deceased	64	108	47	89	132	
	1726–1750	1751–1775	1776–1800	1801–1825	1826–1850	1851–1867
Portugal	370	432	571	806	963	6
Great Britain	481	808	624	235	6	1
France	212	311	387	60	20	0
The Netherlands	52	71	43	36	2	0
Spain	14	18	67	286	306	153
Other	8	14	44	37	102	18
Deceased	176	251	185	186	222	2

Source: Adapted from Table 3 (pp.186-7), *Slavery*, edited by Stanley Engerman, Seymour Drescher and Robert Paquette (Oxford, 2001).

same 11 periods, the final destinations of the traded slaves, here categorized as colonies of Portugal, Great Britain, France, the Netherlands, Spain, and other countries, and where there is an additional category called Deceased. The numbers in these two tables are the row sums and column sums of the data in Table 3. In simple notation, the available data in Tables and 1 and 2 are

$$N_j = \sum_{i=1}^{7} n_{ij}$$

and

$$M_i = \sum_{j=1}^{7} n_{ij}$$

In this paper, however, we have an interest in the numbers in Table 3, that is in the n_{ij}. At the same time, we are also interested in $\dfrac{n_{ij}}{N_j}$ and $\dfrac{n_{ij}}{M_i}$. In other words, we are interested in being able to make statements like 'of all the slaves who were transported by the Dutch, about x per cent went to Dutch colonies, whereas for the Portuguese this number is about y per cent'. Even more precise, a conclusion that we will draw from our exercise below is that of all slaves that were transported by the Dutch, 26 per cent went to Portuguese colonies, and only 7.4 per cent to Dutch colonies. Moreover, Dutch vessels

Table 3. Which data do we have and which numbers do we want to estimate?.

Trafficked by (i = 1,2,.., 7) / Destination (j = 1, 2, .., 7)	1	2	3	4	5	6	7	
1	n_{11}	n_{12}	n_{13}	n_{14}	n_{15}	n_{16}	n_{17}	M_1
2	n_{21}	n_{22}	n_{23}	n_{24}	n_{25}	n_{26}	n_{27}	M_2
3	n_{31}	n_{32}	n_{33}	n_{34}	n_{35}	n_{36}	n_{37}	M_3
4	n_{41}	n_{42}	n_{43}	n_{44}	n_{45}	n_{46}	n_{47}	M_4
5	n_{51}	n_{52}	n_{53}	n_{54}	n_{55}	n_{56}	n_{57}	M_5
6	n_{61}	n_{62}	n_{63}	n_{64}	n_{65}	n_{66}	n_{67}	M_6
7	n_{71}	n_{72}	n_{73}	n_{74}	n_{75}	n_{76}	n_{77}	M_7
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	

suffered the most casualties; that is, 18.3 per cent of the slaves carried by them did not survive the Atlantic crossing. Another conclusion is that of all slaves that arrived in Dutch colonies, 37.4 per cent were transported by the Portuguese, and 12.6 per cent by the Dutch. Of all the deceased slaves, 10.7 per cent died when shipped by the Dutch.

Our paper proceeds as follows. In the next section we explain our method. The computer code is available upon request. In the subsequent section we discuss the results and highlight some specific outcomes. The final section offers some conclusions.

Method

Given the data M_i and N_j, let us start with considering all possible trafficking tables given by the set

$$P = \left\{ n_{ij} \geq 0 : M_i = \sum_{j=1}^{7} n_{ij}, i = 1,\ldots,7; N_j = \sum_{i=1}^{7} n_{ij}, j = 1,\ldots,7 \right\}.$$

Note that a single point in P corresponds to a possible trafficking table, that is, it specifies the trafficking amount from each origin to each destination location. The set P is a so-called polyhedron, containing infinitely many points in general. As the origin/destination amounts are large, we do not have to assume the points to be integers. A nice property of a polyhedron is that it can be completely characterized by its vertices or extreme points, which can be considered as the 'corners' of this (bounded) set. In particular, any point in P can be written as a convex combination of the vertices.

A natural approach to estimate the numbers n_{ij} in Table 3 seems to take the average over all vertices, which we refer to as the midpoint. Formally, assume that P consists of p vertices of which the elements are denoted by $n_{ij}^{(1)}, \ldots, n_{ij}^{(p)}$. Then the (i,j)-th element of the midpoint, denoted by $\bar{n}_{ij}$ is defined as

$$\bar{n}_{ij} = \frac{1}{p} \sum_{k=1}^{p} n_{ij}^{(k)}.$$

Table 4. Some hypothetical cases.

n_{ij}	Destination 1	Destination 2	Destination 3	Total
Origin 1	3	4	3	10
Origin 2	0	0	5	5
Total	3	4	8	

Table 5. Some hypothetical cases.

n_{ij}	Destination 1	Destination 2	Destination 3	Total
Origin 1	3	0	7	10
Origin 2	0	4	1	5
Total	3	4	8	

Table 6. Some hypothetical cases.

n_{ij}	Destination 1	Destination 2	Destination 3	Total
Origin 1	1.83	2.33	5.83	10
Origin 2	1.17	1.67	2.17	5
Total	3	4	8	

In order to compute the midpoint, we need a procedure to compute all of the vertices. Informally, the procedure to compute the 'first' vertex is as follows. We begin with Origin 1 and assign as many slaves as possible to Destination 1, that is, $n_{11} = \min\{M_1, N_1\}$. If there are slaves left in Origin 1 (so $n_{11} = N_1$), then we assign as many remaining slaves from Destination 1 to Destination 2. If there are no slaves left (so $n_{11} = M_1$), then we assign as many slaves from Origin 2 to Destination 1. We continue this procedure until we reach Origin 7 and Destination 7. In order to compute another vertex, one can apply the same procedure, but taking a different order of the origins and destinations. So, by taking all possible orders of origins and destinations, we can compute all vertices and hence the midpoint. In our case with seven origins and seven destinations, we have 7! $\times$ 7! = 25,401,600 vertices to compute, which is accomplished in about 16 seconds.

Example

To illustrate the solution procedure, consider a small (artificial) example with only two origins and three destinations and $M_1 = 10$, $M_2 = 5$, $N_1 = 3$, $N_2 = 4$, and $N_3 = 8$. If we take the order 1 – 2 for the origins and the order 1 – 2 – 3 for the destinations, then the proposed method yields the vertex/table shown in Table 4.

When taking the order 2 – 1 for the origins and 2 – 3 – 1 for the destinations, this results in the vertex shown in Table 5.

Furthermore, when taking the average over all 2! $\times$ 3! = 12 vertices, we get the midpoint, which serves as the estimate for the trafficking amounts from each origin to each destination, as shown in Table 6.

Table 7. Some hypothetical cases.

s_{ij}	Destination 1	Destination 2	Destination 3	Total
Origin 1	1.40	1.87	2.21	10
Origin 2	1.40	1.87	2.21	5
Total	3	4	8	

Finally, given all the vertices, we can also compute the standard deviations s_{ij} over all vertices given by Table 7.

Back to the Atlantic slave trade

The data that we consider are presented in Tables 1 and 2. Table 1 is the same as Table 1 on page 184 of Engerman *et al*, after rounding to the nearest 1,000.[5] So, for example, 264.1 became 264 (the first number in the original Table 1). Table 2 is derived from Table 3 on pages 186–7 of the same work. We aggregated 'British mainland, North America', 'British Leewards', 'British Windwards + Trinidad', 'Jamaica', 'Barbados' and half of the total for 'Guianas' as the colonies of Great Britain. The other half of the Guianas is assumed to be Suriname, and together with 'Dutch Caribbean', are taken as colonies of the Netherlands. The French colonies are 'French Windwards' and 'St. Dominique'. The Spanish colonies are 'Spanish N. and S. America' and 'Spanish Caribbean'. The Portuguese colonies are 'N.E. Brazil', 'Bahia' and 'S.E. Brazil'. The category 'Other' includes 'Other Americas' and 'Africa'. Slave mortality *en route* has been computed from comparing the grand totals. Again, the resultant data are in Table 2.

Our computational method results in a 7 by 7 table with values for each of the 11 time periods, so that is 11 tables. Figure 1 reports on the estimated average death rates over these 11 periods for each of the trafficking countries. Over the 11 periods the averages are 13.4 per cent for Portugal, 17.4 for Great Britain, 16.1 for France, 18.3 for the Netherlands, 12.8 for Spain, 14.8 for the USA and 14.7 for Denmark. These results have face value when compared with the estimates by Hogerzeil and Richardson, and Klein.[6] Figure 1 at the same time shows a downward trend, on average from around 25 per cent in the earlier periods to around 10 per cent by the end of the legal slave trade.

Potentially there are many graphs to make and many numbers to present, but let us highlight just a few. Figure 2 shows the fraction of all slaves arriving at each of the seven destinations (where 'Deceased' is inappropriately called a destination too) who were shipped by the Dutch. This graph shows rather common patterns over time across the destinations, and this seems to suggest some sense of reliability of our method. Something similar holds for the patterns depicted in Figure 3, which reports slaves arriving in Dutch colonies by flag carrier. Tables 8 and 9 report on the fractions and $\frac{n_{ij}}{M_i}$ and $\frac{n_{ij}}{N_j}$, respectively. Thus, Table 8 gives the percentages of slave arrivals by destination, when transported by each of the seven carriers over the 11 periods. As an example of interpretation: of

5.   Engerman et al, *Slavery.*
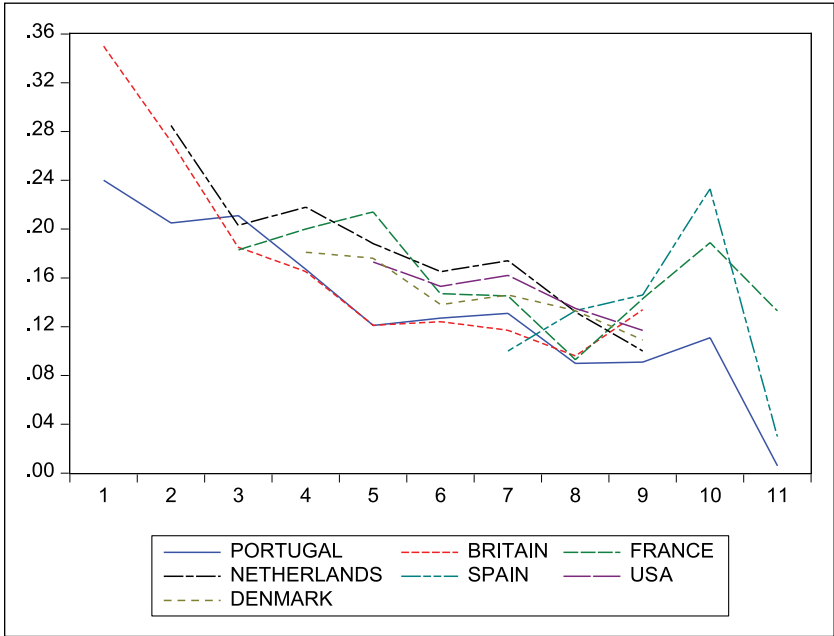6.   Herbert S. Klein, *The Atlantic Slave Trade* (Cambridge, 2002).

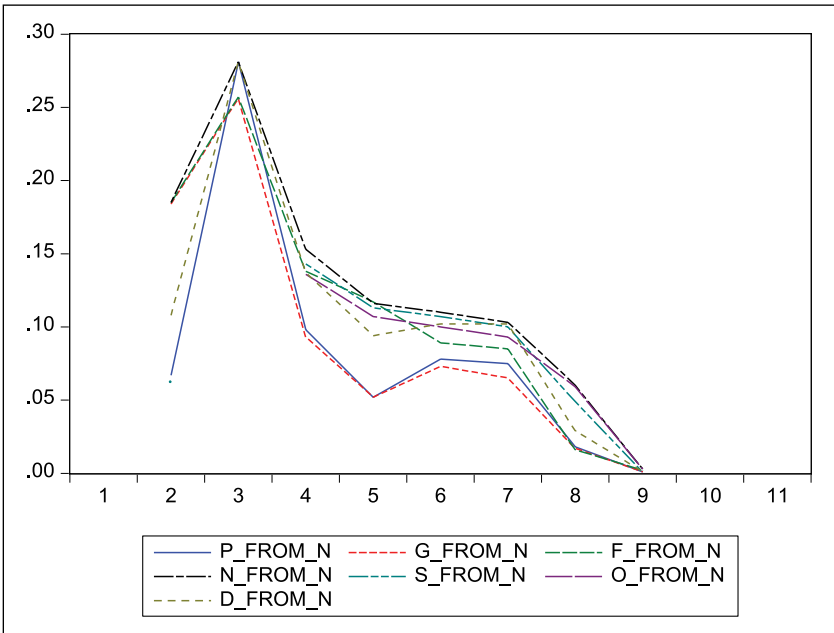**Figure 1.** Estimated average slave mortality rates by flag carrier (all periods).

Figure 2. Share of all slaves for each destination (where D is 'deceased') shipped by the Dutch (all periods).
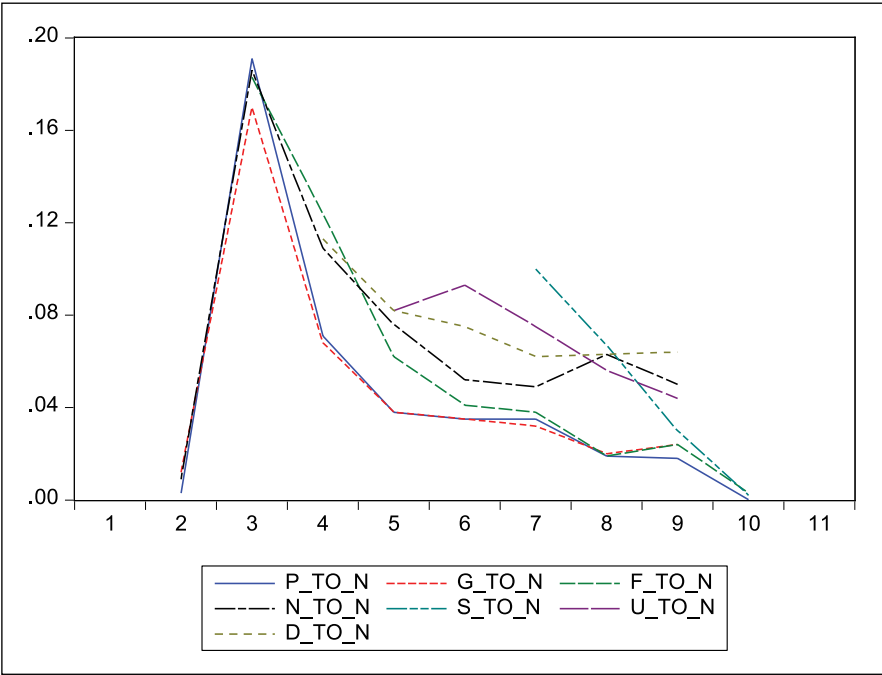
Figure 3. Share of all slaves arriving in Dutch colonies by flag carrier (all periods).

Table 8. Percentage slave arrivals by region and flagc.

Destination / Carrier	P	GB	F	NL	S	Other	Deceased
Portugal (P)	0.528	0.402	0.383	0.374	0.529	0.358	0.461
Britain (GB)	0.269	0.378	0.316	0.314	0.245	0.315	0.284
France (F)	0.109	0.139	0.169	0.142	0.131	0.142	0.145
Netherlands (NL)	0.084	0.093	0.111	0.126	0.082	0.083	0.107
Spain (S)	0.123	0.145	0.100	0.100	0.234	0.175	0.162
USA	0.028	0.030	0.045	0.073	0.061	0.075	0.040
Denmark (DK)	0.011	0.011	0.021	0.019	0.037	0.050	0.017
Total	I	I	I	I	I	I	I

Columns should sum to 1; $\frac{n_{ij}}{N_j}$ in Table 3.

all slaves who arrived in Dutch colonies, 37.4 per cent were transported by the Portuguese, and 12.6 per cent by the Dutch. Of all deceased slaves, 10.7 per cent died when shipped by the Dutch. Table 9 provides the percentages of arrivals of slaves in regions when transported by each of the carriers. For example, of all slaves who were transported by the Dutch, 26 per cent went to Portuguese colonies, and only 7.4 per cent to Dutch colonies. Dutch slavers suffered the most casualties at 18.3 per cent of the enslaved population.

Table 9. Percentage slave arrivals by region and flag carrier (2).

Destination / Carrier	P	GB	F	NL	S	Other	Deceased	Total
Portugal (P)	0.323	0.239	0.077	0.045	0.226	0.023	0.134	1
Britain (GB)	0.294	0.345	0.083	0.050	0.092	0.015	0.174	1
France (F)	0.267	0.245	0.123	0.062	0.122	0.062	0.161	1
Netherlands (NL)	0.260	0.274	0.097	0.074	0.094	0.030	0.183	1
Spain (S)	0.256	0.150	0.104	0.050	0.237	0.130	0.128	1
USA	0.266	0.263	0.137	0.070	0.079	0.037	0.148	1
Denmark (DK)	0.251	0.268	0.121	0.077	0.079	0.056	0.147	1

Rows should sum to 1; $\dfrac{n_{ij}}{M_i}$ in Table 3.

Conclusion

It must be reiterated that the data computed in this research note are all estimates. They are estimates of aggregate statistics in 7 by 7 tables linking the main seafaring countries involved in the Atlantic slave trade with regional destinations, with one destination to account for slave trade mortality once slaves were loaded. The tool is simple, but it yields some general conclusions. One is that slave mortality declined over time, supporting the available case-specific data in the literature. A second is that some countries transported most slaves to their own colonies (like Portugal), whereas other countries apparently focused most on the trade (like the Netherlands).

Our method also allowed for the computation of standard deviations. Naturally, as we study all possible combinations, including the boundary cases with 0 per cent and 100 per cent, the standard deviations are high relative to the estimates. On the other hand, when we compare our estimates with others, and when we evaluate patterns over time, we have substantial confidence in the findings reported here.

With:

$$N_j = \sum_{i=1}^{7} n_{ij}$$

(the actual numbers for N_j appear in Table 2), and:

$$M_i = \sum_{j=1}^{7} n_{ij}$$

(which appear in Table 1). We are interested in n_{ij} and in $\dfrac{n_{ij}}{N_j}$ and $\dfrac{n_{ij}}{M_i}$. That is, we are interested in $\dfrac{n_{ij}}{N_j}$, which is the fraction of arrivals at destination j trafficked by trading country i, and $\dfrac{n_{ij}}{M_i}$ is the fraction of those trafficked by trading country i that arrived at destination j.

Author biographies

Philip Hans Franses is Professor of Applied Econometrics at the Econometric Institute, Erasmus School of Economics.

Wilco van den Heuvel is Associate Professor of Operations Research at the Econometric Institute, Erasmus School of Economics.