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

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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 paper we use a simple mathematical technique to fill in the void. It allows us to estimate the trends in the deceases per transporting country, and also to estimate the fraction of slaves who went to own colonies or to others. For example, we estimate that of all the slaves who were transported by the Dutch only about 7 percent went to Dutch colonies, whereas for the Portuguese this number is about 37 percent.

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Introduction

It is by now a well-known and well-recognized fact that the transatlantic slave trade (1519-1875) involved around 12.5 million Africans, see Curtin (1969) and Engerman et al. (2001), among others. The slave traders originated from various countries, like for example Portugal, Spain, the Netherlands and France. The destinations of the slaves were for example colonies of those countries, although also a substantial number of slaves died. They died either on board of a vessel still at an African coastal location or during the voyage, see for example Hogerzeil and Richardson (2007).

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 descriptions of various voyages, see for example Haines et al. (2001) and Hogerzeil and Richardson (2007), it seems that such aggregate statistics are not available. One way to generate those aggregate estimates 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 they are given in Engerman et al. (2001).

To be more precise, consider Tables 1 and 2. Table 1 contains, for eleven subsequent periods, the amount of slaves that were trafficked by traders from Portugal, Great Britain, France, the Netherlands, Spain, the USA and Denmark. Table 2 contains, for the same eleven periods, the final destinations of the traded slaves, here categorized as colonies of Portugal, Great Britain, France, the Netherlands, Spain, and other countries, where there is a 7th category called Deceased. The numbers in these two tables are the row sums and column sums of the numbers 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 the 49 cells of Table 3, that is in the n_{ij}. At the same time, we are also interested in $\frac{n_{ij}}{N_j}$ and $\frac{n_{ij}}{M_i}$. In words, we are interested in the possibility to make statements like "of all the slaves who were transported by the Dutch about x percent went to Dutch colonies, whereas for the Portuguese this number is about y percent". Even more precise, a conclusion that we will draw from our computational exercise below is that of all slaves that were transported by the Dutch, 26.0% went to Portuguese colonies, and only 7.4% to Dutch colonies. And, the Dutch seafarers had the most casualties, that is, 18.3% of the slaves carried by the Dutch did not make it across the Atlantic. Another conclusion is that of all slaves that arrived in Dutch colonies, 37.4% were transported by the Portuguese, and 12.6% by the Dutch. Of all the deceased slaves, 10.7% died when transported by Dutch seafarers.

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

The 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 integer. A nice property of a polyhedron is that it can be completely characterized by its so-called 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

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

In order to compute the midpoint, we need a procedure to compute all vertices. Informally, the procedure to compute the 'first' vertex is as follows. We start 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! × 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:

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	

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

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	

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, like

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	

Finally, given all the vertices, we can also compute the standard deviations s_{ij} over all vertices given by the table below:

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	

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. (2001), after rounding at 1000. So, for example, 264.1 became 264 (the first number in the original Table 1). The numbers in Table 2 were obtained from Table 3 on pages 186-187 of Engerman, et al. (2001). We collected "British mainland, North America", "British Leewards", "British Windwards + Trinidad", "Jamaica", "Barbados" and half of the numbers under "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". The numbers of deceases are 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 numbers for each of the eleven time periods, so that is 11 tables. Figure 1 reports on the estimated average death rates over these eleven periods for each of the 7 trafficking countries. Over the eleven periods the averages are 13.4% 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 numbers have face value when compared with the estimates in Hogerzeil and Richardson (2001), and Klein (2002). Figure 1 at the same time shows a downward sloping trend, on average from around 25% in the earlier periods to around 10% in the last periods.

There are many graphs to make and many numbers to present, but let us highlight a few. Figure 2 shows the fraction of all slaves arriving at each of the 7 destinations (where "Deceased" is inappropriately called a destination too), who were trafficked 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 on the fractions of all slaves who arrived in Dutch colonies and who were transported by each of the 7 trafficking countries.

Tables 4 and 5 report on the fractions and $\frac{n_{ij}}{M_i}$ and $\frac{n_{ij}}{N_j}$, respectively. Table 4 thus gives the percentages of arrivals of slaves at their destinations, when transported by each of the 7 seafaring countries over the eleven time periods. As an example of interpretation: of all slaves who arrived in Dutch colonies, 37.4% were transported by the Portuguese, and 12.6% by the Dutch. And, of all the deceased slaves, 10.7% died when transported by Dutch seafarers. Table 5 gives the percentages of arrivals of slaves in regions when transported by each of the seafaring countries. Examples of the interpretation of these numbers are: of all slaves who were transported by the Dutch, 26.0% went to Portuguese colonies, and only 7.4% to Dutch colonies. The Dutch seafarers had the most casualties, that is, 18.3% of the slaves carried by the Dutch did not make it across the Atlantic.

Conclusion

The numbers that we computed in this paper are all estimates. They are estimates of aggregate statistics in 7 by 7 tables linking the 7 main seafaring countries involved in the Atlantic slave trade with 7 destinations, where one of these destinations heads "Deceased". Using a simple computational tool, we could come up with these estimates, and these numbers allowed us to provide some general conclusions. One is that the fraction of deceases trended downwards over time, supporting the available cases-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% and 100%, the standard deviations are high, relative to the estimates. On the other hand, when we compare our estimates with available estimates, and when we evaluate patterns over time, we have substantial confidence in the numbers to report them in this paper.

Table 1: Trafficked by a seafaring country (x1000) during eleven periods in time

Period

	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
Portugal	406	473	626	872	1248
Great Britain	491	859	741	257	0
France	254	322	420	218	94
The Netherlands	109	148	41	2	0
Spain	0	1	9	205	279
USA	45	89	54	81	0
Denmark	8	13	30	11	0

	1851-1867
Portugal	154
Great Britain	0
France	3
The Netherlands	0
Spain	23
USA	0
Denmark	0

Source: Adapted from Table 1 on page 184 of Slavery, edited by Stanley Engerman, Seymour Drescher and Robert Paquette, 2001, Oxford: Oxford University Press.

Table 2: Destination (colonies of trafficking countries) or deceased during eleven periods in time

| | Period | | | | |
	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
Portugal	370	432	571	806	963
Great Britain	481	808	624	235	6
France	212	311	387	60	20
The Netherlands	52	71	43	36	2
Spain	14	18	67	286	306
Other	8	14	44	37	102
Deceased	176	251	185	186	222

	1851-1867
Portugal	6
Great Britain	1
France	0
The Netherlands	0
Spain	153
Other	18
Deceased	2

Source: Adapted from Table 3 on pages 186-187 of Slavery, edited by Stanley Engerman, Seymour Drescher and Robert Paquette, 2001, Oxford: Oxford University Press.

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

Destination ($j = 1, 2, .., 7$)

Trafficked by ($i = 1,2,.., 7$)	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	

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 $\frac{n_{ij}}{N_j}$ and $\frac{n_{ij}}{M_i}$. In words, we are

interested in $\frac{n_{ij}}{N_j}$, which is the fraction of arrivals at destination j trafficked by trading country

i, and $\frac{n_{ij}}{M_i}$ is the fraction of those trafficked by trading country i that arrived at destination j.

Table 4: Percentage of arrivals of slaves in regions when transported by seafaring countries (the numbers in each of the columns should sum to 1), that is the $\frac{n_{ij}}{N_j}$ in Table 3

	Destination						
	P	GB	F	NL	S	USA other	Deceased
Trafficked by							
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	1	1	1	1	1	1	1

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Table 5: Percentage of arrivals of slaves in regions when transported by seafaring countries (Row numbers should sum to 1), that is, the $\frac{n_{ij}}{M_i}$ in Table 3.

|	P	GB	F	NL	S	USA	Destination Deceased other	Total
Trafficked by								
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
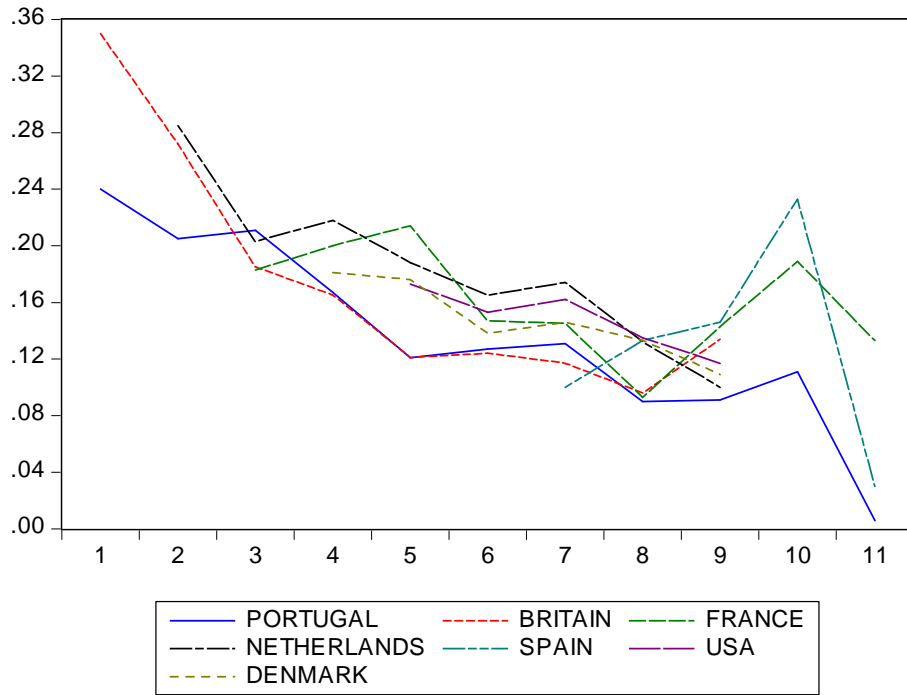
Figure 1: The estimated average deceased rates over the eleven periods for each of the 7 trafficking countries
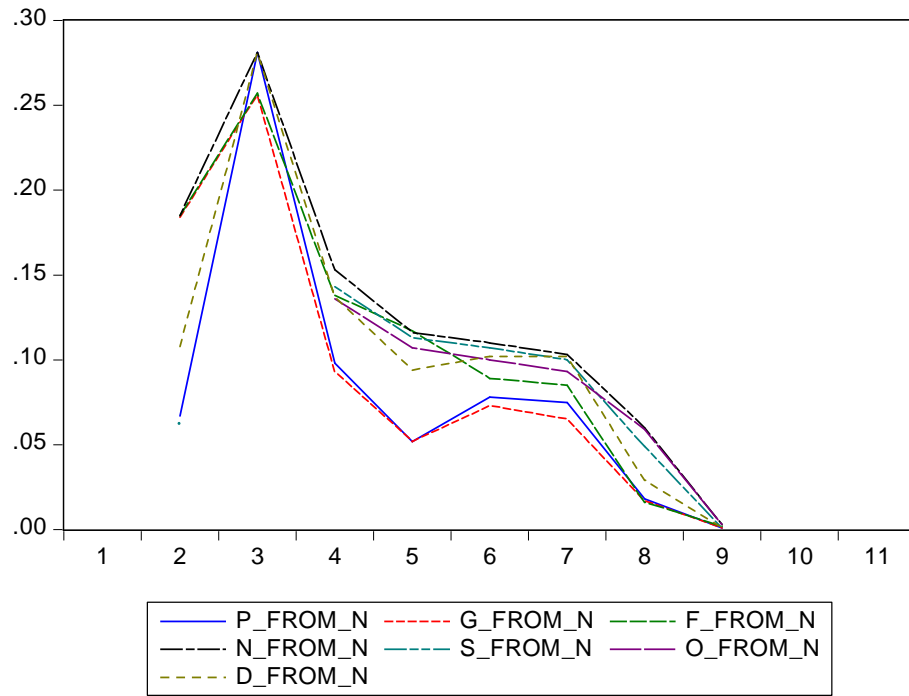
Figure 2: Fraction of all slaves at each of the 7 destinations (where D is "deceased"), when transported by Dutch seafarers.
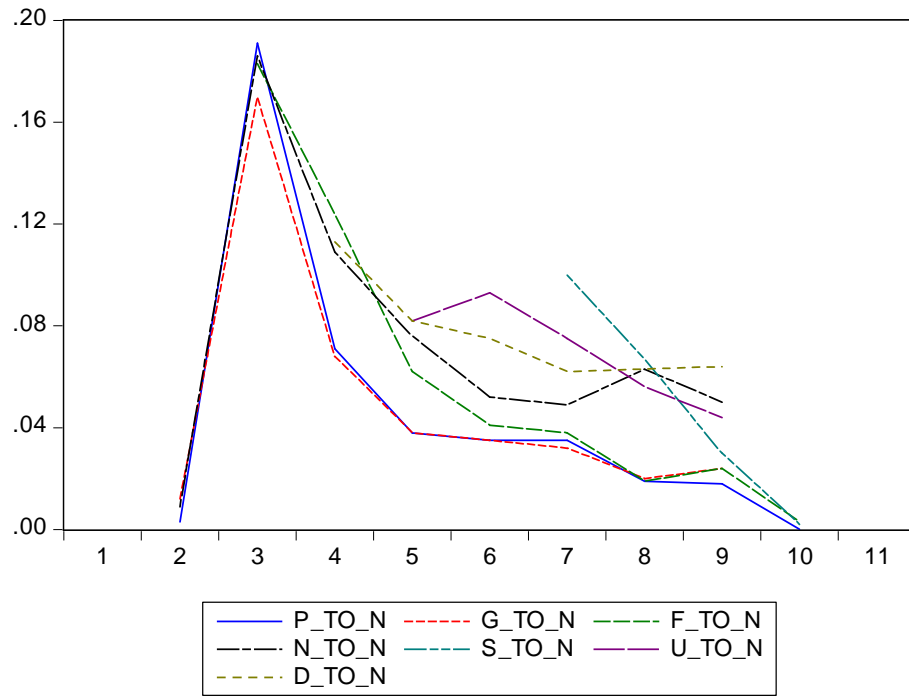
Figure 3: Fraction of all slaves that arrived in Dutch colonies and were transported by each of the seven trading countries.

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