Revealing the Relationship Between Ship Crowding and Slave Mortality

NICOLAS J. DUQUETTE

The Middle Passage of the transatlantic slave trade was crowded and often deadly. Many historical accounts have linked the overcrowded conditions on the voyages to slaves' ill health and high mortality rates. For example, Alexander Falconbridge (1788) describes a voyage where "the slaves were so crowded... that, without meeting with unusual bad weather, or having a longer voyage than common, nearly one-half of them died..." (p. 26).[1] Surprisingly three decades of studies by economic historians (see Table 1) have failed to find that more crowded voyages suffered higher slave mortality. Across a variety of data sets and empirical specifications, regressions of mortality on measures of crowding show no association, controlling for the duration of the passage, the size of the vessel,[2] and other covariates (Cohn and Jensen 1982; Steckel and Jensen 1986; Garland and Klein 1985; Haines, McDonald, and Shlomowitz 2001; Hogerzeil and Richardson 2007). To date, no published study has found a positive, statistically significant relationship between crowding and slave mortality.

This purported fact has so intrigued scholars that the more recent literature has proposed economic explanations for it. Herbert Klein (2010) argues that vessel overcrowding was exaggerated by European abolitionists, and that the conditions endured by slaves were comparable to those tolerated by European immigrants to the Americas (though worsened by tropical disease). Other scholars argue that there must be some omitted variable which mitigates mortality and is correlated with crowding, obscuring the effect—for instance, conditions in coastal slave forts (Haines, McDonald, and Shlomowitz 2001; Hogerzeil and Richardson 2007), or health improvements to shipping practices (Haines and Shlomowitz 2000; Klein *et al.* 2001).

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Nicolas J. Duquette is Assistant Professor, Sol Price School of Public Policy, University of Southern California, Lewis Hall 312, Los Angeles, California 90089-0626. E-mail: nduquett@umich.edu.

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[1] For descriptions of the Middle Passage linking overcrowding to high mortality rates, see for example: Falconbridge (1788, pp. 19–32); Riland (1828, pp. 50–66); Blake (1860, chap. 10); Tattersfield (1991, pp. 144–54).

[2] A control for vessel size is necessary to capture risk of disease. For the same degree of crowding, a larger vessel carried a larger number of slaves and crew, and took longer to procure and load the slave cargo, raising the absolute risk of a disease outbreak at sea.

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TABLE 1
QUANTITATIVE LITERATURE ON CROWDING AND SLAVE MORTALITY

Citation	Number of Voyages	Sample	Method	Voyage Duration Controls	Statistically Significant Correlation, Crowding, and Mortality
Klein and Engerman (1979)	763	Curtin (1969); Stein (1980)	OLS	Yes	No
Postma (1979)	≈ 100	Dutch West India Company	Scatterplot	Yes	No
Cohn and Jensen (1982)	478	Brazilian trade from Klein (1975); English from Curtin (1969)	Voyage time kink point	Yes	No
Eltis (1984)	765	Multiple sources	OLS	Yes	No
Garland and Klein (1985)	301	Lord's List A	Correlation	No	No
Galenson (1986)	33	Royal African Company	OLS	Yes	No
Steckel and Jensen (1986)	92	Surgeons' logs 1792–1796	Logit, daily mortality > 0 on regressors	Yes	No
Haines, McDonald, and Shlomowitz (2001)	1,410	Trans-Atlantic Slave Trade Database	Daily rate indirect inference	Yes	Yes, with negative sign
Hogerzeil and Richardson (2007)	39	Dutch Middelburgsche Commercie Compagnie	Hazard analysis	Yes	No
Eltis, Lewis, and MacIntyre (2010)	22	Royal African Company	OLS	No	No

Sources: Author's tabulations.

This article revisits this question and demonstrates that studies finding no positive relationship between vessel crowding and Middle Passage mortality relied on unrepresentative samples of slave voyages. The true relationship is obscured by missing

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observations on voyage duration—a covariate almost universally included in studies of slave mortality.[3] If the "missingness" of voyage duration is related to the correlations between variables of interest, dropping the incomplete observations will bias estimates of the relationship between crowding and mortality.

Studies seek to control for voyage duration in regressions so that they can understand the effect of vessel crowding, holding voyage duration constant. The longer a vessel was at sea, the greater risk of death from starvation, drowning, or infectious disease (Galenson 1986, chap. 2). Within the Trans-Atlantic Slave Trade Database, 89 percent of all slave voyages lack information on the duration of the Middle Passage; among voyages with information on slave mortality, slave crowding, and ship size, 65 percent of voyages lack information on duration of the Middle Passage.[4] This implies that quantitative studies which control for voyage duration must omit more than half of all voyages with otherwise complete information. Using simple methods to correct for missing data on voyage duration, my analysis of the Trans-Atlantic Slave Trade Database shows a strong and robust association between crowded slave voyages and slave mortality, consistent with historical accounts.

Table 2 shows that information on voyage duration is not missing at random. Specifically, the relationship between ship crowding and slave mortality depends on whether duration of the Middle Passage is observed. The top panel shows very similar means and standard deviations for key variables across three subsamples—voyages recording all variables of interest, voyages recording all variables except for Middle Passage duration, and finally all observations recording any of the variables—with slightly greater variance in crowding among the voyages with missing data.[5] The bottom panel shows that the correlation coefficient between crowding and mortality is negative (–0.10) for voyages with a recorded duration, but positive when duration is not observed (0.11), and positive in the combined sample (0.04).

This pattern also holds in the typical multivariate regressions used in this literature. Following David Galenson (1986, pp. 42–47),[6] I use ordinary least squares to estimate

$$Mortality_i = \beta_0 + \beta_1 Crowding_i + \beta_2 Tonnage_i + \beta_3 Duration_i + \psi_{route(i)} + \phi_{decade(i)} + \varepsilon_{i,} \quad (1)$$

[3] The sole exception is Garland and Klein (1985), who focus on alternative measures of crowding, and do not use a multivariate regression approach.

[4] Voyage duration is recorded for 3,798 observations of 34,957 in the complete database, or 763 voyages of 2,167 with largely complete information, as described in Appendix Table 7.

[5] The sample includes voyages with years of departure spanning 1622 to 1864, though almost all observations come from the hundred-year period from 1711 to 1810. Summary statistics are comparable to the sample of Haines, McDonald, and Shlomowitz (2001). Their sample has an average tonnage of 228.9 shipping tons (compared to 244 in the completely observed sample), an average mortality rate of 11 percent (11.9 percent), a slave/shipping ton ratio of 1.53 (1.48), and a Middle Passage duration of 64 days (73.6). Haines, McDonald, and Shlomowitz's sample differs by including voyages originating in East Africa, voyages seized mid-crossing, and voyages where ship tonnage is not observed.

[6] These regressions differ from Galenson's by using effects for route rather than region of origin. This more flexible specification is feasible because the Trans-Atlantic Slave Trade Database includes many more observations than Galenson's 33. Appendix Tables 3, 5, and 6 tabulate properties of key variables by decade and by regions of embarkment and disembarkment and show significant variation across each.

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TABLE 2
SUMMARY STATISTICS AND CORRELATIONS BY SUBSAMPLES

	Summary Statistics					
	With Voyage Duration		Without Voyage Duration		All Observations	
	Mean	SD	Mean	SD	Mean	SD
Death rate	11.9	13.5	11.1	12.9	11.5	13.2
Tonnage	244	106.1	213	98.8	210	98.5
Crowding	1.48	0.59	1.56	0.714	1.50	0.698
Departure date	1762	35.0	1765	37.4	1771	34.9
Duration	73.6	36.6			67.6	34.8
	Correlation Matrices					
Number of observations	763		1,404		2,167	
	Death Rate	Ship Size	Death Rate	Ship Size	Death Rate	Ship Size
Ship size	0.099		–0.0021		0.041	
Crowding	–0.095	–0.31	0.11	–0.35	0.042	–0.34

Notes: All panels have observed values for vessel name, shipping route, and shipping decade. Voyages which do not successfully complete a voyage on an Atlantic trading route are dropped. "All candidate observations" includes voyages that do not have observed values for vessel capacity, mortality rate, slave crowding, or middle passage duration; the other five panels only include the 2,167 observations that are not missing mortality rate, ship tonnage, or crowding. See Appendix Table 7 for construction of individual variables.

where *Mortality* is the mortality rate for voyage *i*, *Crowding* is the number of embarked slaves per shipping ton, *Tonnage* is the carrying capacity of the ship in English shipping tons, and *Duration* is the number of days on the Middle Passage.[7]

Unobserved differences in the slave trade over time and across regions are controlled for using decade and trade route fixed effects. The Atlantic economy and trading practices both changed over the centuries of the transatlantic slave trade's existence (Carlos 1991, 1994; Steckel and Jensen 1986; Klein and Engerman 1997; Haines and Shlomowitz 2000; Whatley and Gillezeau 2011). The mortality effects of these and other unobserved events are captured by decade fixed effects ($\phi_{decade(i)}$). The literature has also established substantial variation in mortality across regions of embarkment and disembarkment (Haines, McDonald, and Shlomowitz 2001). The regression includes dummy variables to control for unobserved effects of the trade route ($\psi_{route(i)}$).[8] Standard errors are clustered by ship name to correct for nonindependence of voyages on the same vessel.

[7] The mortality rate is defined as slave deaths between the last port of embarkation and the first port of disembarkation, divided by number of slaves on board at departure from Africa. See Appendix Table 7.

[8] Along with other unobservables, these decade and route effects control for expected voyage time. On longer trade routes, we would expect captains to manage the risks of the longer time at sea by crowding their vessels less. The effect of simply regressing slave mortality on crowding, then, would be ambiguous; it would be positive via the direct effects of more densely packing slave cargo, but negative through the negative correlation with time at sea.

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TABLE 3
MULTIVARIATE REGRESSION OF SLAVES' MIDDLE PASSAGE MORTALITY RATE ON VOYAGE CHARACTERISTICS

	(1) Duration Observed	(2) Duration Missing	(3) Duration Observed
Crowding (Slaves per shipping ton)	–0.617 (1.103)	2.038*** (0.705)	–1.017 (1.157)
Tonnage (Capacity in shipping tons)	0.0144** (0.00589)	0.00150 (0.00429)	0.0125** (0.00578)
Duration (Days on Middle Passage)	0.164*** (0.0255)		
Crowding x Duration			
Duration* (Duration if observed, 0 if missing)			
1{Missing Duration} (0 if Duration observed, 1 if missing)			
Crowding x Duration*			
Crowding x 1{Missing Duration}			
Constant	2.616 (6.767)	38.26*** (4.115)	16.70*** (6.133)
Observations	763	1,404	763
R-squared	0.290	0.243	0.198
Route and decade effects	√	√	√
Crowding *p*-value	0.576	0.004***	0.380

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
Notes: Standard errors in parentheses corrected for an arbitrary covariance structure by ship. In columns 6 and 7, estimates and errors are corrected for imputation bias using multiple random imputation (50 iterations). Crowding *p*-value is for *Crowding* variable alone in columns 1–4 and 6, and for a joint test of *Crowding* and interaction terms in columns 5 and 7. The *R*-squared presented in columns 6 and 7 is for an ordinary regression using the 50th imputation of *Duration*.

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Column 1 of Table 3 reports regression coefficients for the subsample of the data with recorded values for *Duration*.[9] Consistent with the literature, the relationship between crowding and mortality is statistically indistinguishable from zero. But this result is driven by the sample: columns 2 and 3 repeat the regression without the voyage duration variable. In column 2, which uses only voyages with unobserved duration, the relationship between crowding and mortality is positive and statistically significant. All else equal, within this sample we would expect a one-standard-deviation increase in crowding (0.714 slaves per shipping ton) to be associated with an increase in mortality of 1.46 percentage points, or 0.11 standard deviations. Column 3 repeats this regression for the sample with observed duration, and obtains an even larger negative point estimate on *Crowding*, so controlling for voyage duration is not the reason for not finding a positive coefficient on *Crowding* in column 1.

We can analyze the relationship between crowding and mortality in the whole sample while controlling for duration using two different missing data methods: the missing-indicator method and imputation analysis. Both approaches find a positive and statistically significant relationship between crowding and mortality, of similar and meaningful magnitudes.

First, I add two separate duration controls for observed and unobserved cases to the regression: a continuous variable equal to *Duration* when passage time is observed and zero when it is not, and a dummy variable equal to one if *Duration* is missing and zero if it is observed.[10] More precisely, I estimate

$$\begin{aligned} Mortality_i = {} & \beta_0 + \beta_1 Crowding_i + \beta_2 Tonnage_i \\ & + \beta_3 Duration_i^{\star} + \beta_4 1\{Duration_i\ missing\} \\ & + \beta_5 (Crowding_i * Duration_i^{\star}) \\ & + \beta_6 (Crowding_i * 1\{Duration_i\ missing\}) \\ & + \psi_{route(i)} + \phi_{decade(i)} + \varepsilon_i \end{aligned} \tag{2}$$

where $1\{Duration_i\ missing\}$ is equal to 0 if *Duration* is observed and 1 if *Duration* is missing, and $Duration_i^{\star}$ is defined

$$Duration_i^{\star} = \begin{cases} Duration_i, & \text{if } Duration_i \text{ is observed} \\ 0, & \text{if } Duration_i \text{ is missing} \end{cases}$$

The coefficient β_3 captures the correlation of duration and mortality when duration is observed, while β_4 captures the relationship with unobserved duration.

[9] All estimations in this article use 2,167 voyages from the Trans-Atlantic Slave Trade Database with observations on slave mortality, crowding, tonnage, trading route, and year of departure. Slave voyages that did not successfully complete a voyage on a trans-Atlantic trading route are omitted. Details on the sample and the construction of the variables are in Appendix Table 7.

[10] This method for handling missing data, the missing-indicator method, has well-known statistical weaknesses which imply that my estimate of the association between crowding and mortality is likely too small. Jones (1996) demonstrates that the missing-indicator method leads to overstated standard errors and biased coefficients on both missing and non-missing explanatory variables. If the covariance between *Duration* and *Crowding* is negative in the sample where *Duration* is not observed—consistent with captains crowding ships more when a voyage is expected to be brief—then $\hat{\beta}_1$ should be understated and $\hat{\beta}_3$ overstated in Table 3, columns 4 and 5.

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Much of the literature argues that slave mortality was affected by crowding and voyage duration in a nonlinear manner—more crowded voyages may have exhausted food supplies sooner, experiencing rising mortality late in the voyage (Cohn and Jensen 1982; Galenson 1986), or more crowded voyages may have spent longer embarking slaves at the African coast, increasing the risk of a disease outbreak in the early part of the voyage (Steckel and Jensen 1986; Haines, McDonald, and Shlomowitz 2001). I add interaction terms between crowding and the two duration variables to capture these relationships. β_5 estimates the association between mortality and the interaction of *Crowding* with $Duration_i^{\star}$; β_6 estimates the association between mortality and the interaction of *Crowding* with $1\{Duration_i\ missing\}$.

The regression is tabulated without interactions in Table 4, column 4, while column 5 includes the interaction terms. In column 4, the coefficient on *Crowding* is positive and statistically significant at the 5 percent level; an increase of one standard deviation (0.78 slaves per shipping ton) is associated with an increase of 1.1 percentage points in mortality rate in the pooled sample. When interaction terms are added, the *Crowding* coefficient remains large and positive, though the implied change in mortality of a marginal increase in crowding, for a voyage with a typical observed duration, becomes small.[11] A joint test in column 5 finds that the coefficients on *Crowding* and both interaction terms ($\hat{\beta}_1, \hat{\beta}_5,$ and $\hat{\beta}_6$) are jointly different from zero at the 5 percent significance level. The negative coefficients on the interaction terms ($\hat{\beta}_5$ and $\hat{\beta}_6$) are consistent with the literature finding nonlinear mortality rates driven by preboarding conditions.

I examine the robustness of these findings using imputation analysis. Where *Duration* is unobserved, I impute a value by regressing *Duration* all the other variables in equation 1 as regressors.[12] I use imputed values to estimate

$$Mortality_i = \beta_0 + \beta_1 Crowding_i + \beta_2 Tonnage_i + \beta_3 Duration_i + \beta_5(Crowding_i * Duration_i) + \psi_{route(i)} + \phi_{decade(i)} + \varepsilon_i \quad (3)$$

Columns 6 and 7 of Table 4 present results from this estimation. Consistent with the missing-indicator results from columns 4 and 5, the coefficient on *Crowding* is

[11] Within the sample with observed voyage duration, the mean voyage lasts 73.6 days. Within this sample, the marginal effect of crowding for the mean voyage would then be $\hat{\beta}_1 + \hat{\beta}_5 * 73.6$, which is approximately equal to 2.51 –0.0365*73.6 = –0.18 in column 5 and 2.59 –0.0312 * 73.6 = +0.29 in column 6. For a one-standard-deviation increase in crowding (0.59 slaves / ton), these translate into modest mortality changes of –0.11 and +0.18 percentage points, respectively.

For voyages with missing duration, $\hat{\beta}_1 + \hat{\beta}_6$ is 1.81 in column 5, implying that a one-standard-deviation increase in crowding (0.71 slaves/ton) on a voyage without observed voyage duration would have a mortality rate increase of about 1.3 percentage points,.

[12] Specifically, the imputation step regresses $Duration_i = \alpha_0 + \alpha_1 Crowding_i + \alpha_2 Tonnage_i + \psi_{route(i)} + \phi_{decade(i)} + \epsilon_i$. Imputed values of *Duration* are constructed from the predicted values estimated by this equation. Because imputing missing values will create an artificially high correlation between *Duration* and the other variables of interest, fifty imputations using randomized subsets of the data are used to estimate the robustness of the coefficients and fixed effects, as well as the distribution of the residual, ϵ_i. These estimates are used to correct estimates in table 3, columns 6 and 7, for imputation bias. Allison (2002) and Cameron and Trivedi (2005, chap. 27) provide good overviews of the multiple random imputation method for unbiased analysis with missing data.

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TABLE 4
MULTIVARIATE REGRESSION OF SLAVES' MIDDLE PASSAGE MORTALITY RATE ON VOYAGE CHARACTERISTICS

	Missing Indicator Method		Imputed Duration Method	
	(4)	(5)	(6)	(7)
	All Voyages	All Voyages	All Voyages	All Voyages
Crowding	1.378**	2.514	1.489**	3.206**
	(0.598)	(1.821)	(0.612)	(1.362)
Tonnage	0.00552*	0.00531	0.00546	0.00551
	(0.00331)	(0.00331)	(0.00337)	(0.00338)
Duration			0.0559***	0.0935***
			(0.0145)	(0.0293)
Crowding x Duration				–0.0254
				(0.0177)
Duration*	0.126***	0.174***		
	(0.0187)	(0.0427)		
1{Missing Duration}	8.738***	9.441***		
	(1.451)	(3.295)		
Crowding x Duration*		–0.0365		
		(0.0256)		
Crowding x **1**{Missing Duration}		–0.701		
		(1.812)		
Constant	26.70***	26.66***	30.34***	27.00***
	(4.457)	(5.387)	(5.190)	(6.701)
Observations	2,167	2,167	2,167	2,167
R-squared	0.222	0.224	0.203	0.206
Route and decade effects	√	√	√	√
Crowding *p*-value	0.021**	0.036**	0.015**	0.021**

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
Notes: Standard errors in parentheses corrected for an arbitrary covariance structure by ship. In columns 6 and 7, estimates and errors are corrected for imputation bias using multiple random imputation (50 iterations). Crowding *p*-value is for *Crowding* variable alone in columns 1–4 and 6, and for a joint test of *Crowding* and interaction terms in columns 5 and 7. The *R*-squared presented in columns 6 and 7 is for an ordinary regression using the 50th imputation of *Duration*.

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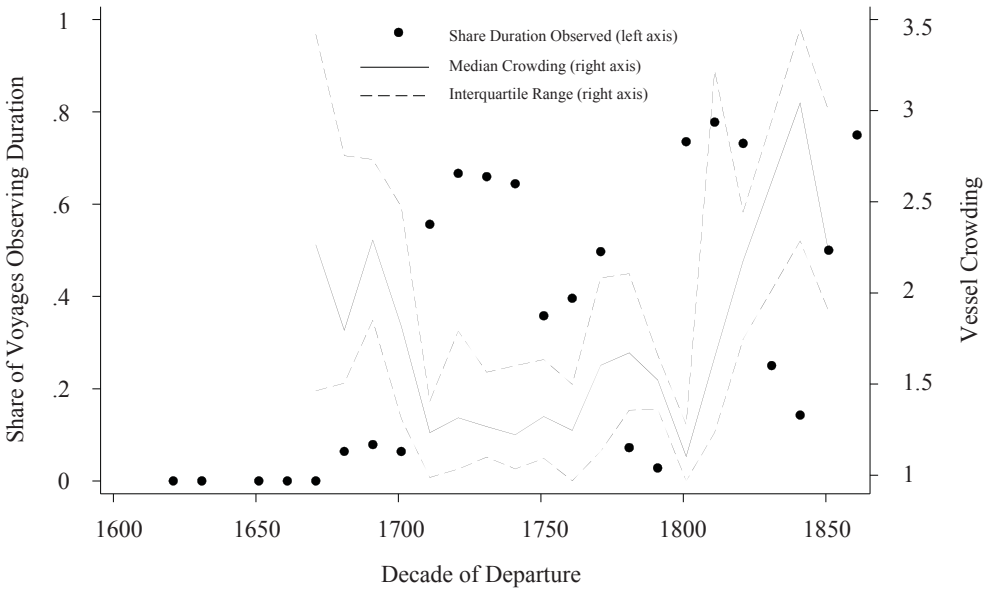


FIGURE 1
OBSERVED DURATION AND DISTRIBUTION OF CROWDING BY DECADE

Notes: Share Duration Observed is total observations with observed value of *Duration* divided by total observations in the sample, by decade. Lines chart medians and interquartile range of *Crowding*. Distribution statistics for *Crowding* are not presented for the decades before 1671 or after 1860, none of which have more than four voyages per decade. Appendix Table 2 presents voyage counts (total and observing *Duration*) and mean *Crowding* by decade.

statistically significant at the 5 percent level in both specifications, and point estimates are similar across specifications in columns 4 and 6 (1.489 using imputation compared to 1.378), and columns 5 and 7 (3.206 compared to 2.514). Like the missing-indicator results, imputation methods also estimate a negative coefficient on the interaction of *Crowding* and *Duration*. The coefficients on *Crowding* and on the interaction term ($\hat{\beta}_1$ and $\hat{\beta}_5$) are jointly significant at the 5 percent level in column 7.

Crowding, it seems, was associated with higher mortality—at least when voyage duration is not observed. Figure 1 charts the share of voyages with observed *Duration* and the distribution of *Crowding* by decade of departure from Europe. Of the 763 observations with observed *Duration*, 593 are from the period 1711–1780 when there were very few highly crowded voyages in the data set. In contrast, the periods before 1711 and after 1780 have more tightly packed voyages, yet a lower share of voyages with observed duration.[13] Almost all observations prior to 1710 are incomplete, as are a majority of voyages from 1751–1800 and after 1830.[14]

[13] Rates of missing *Duration* data and mean mortality rate and crowding are tabulated in Appendix Table 2.

[14] Appendix Table 7 reports estimates of regression $1\{Duration_i\ Missing\} = \delta_0 + \delta_1 Mortality_i + \delta_2 Crowding_i + \delta_3 Tonnage_i + \eta_{nation(i)} + \psi_{route(i)} + \phi_{decade(i)} + \varepsilon_i$, where $\eta_{nation(i)}$ are nation dummies and other variables are as previously described. Intriguingly,

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Changes in national composition over time explain part of this pattern: France and Great Britain are the two largest contributors of complete observations to the data set;[15] during the 1781–1800 period, both experienced radical change in their slave trade industries, as the 1788 Dolben's Act imposed the first regulations on the British trade, while in 1789 the detailed French voyage data ended with the Revolution.[16] Omitting voyages without recorded duration means ignoring most of the voyages affected by Dolben's Act—of 389 British voyages in the sample departing after 1788, only nine record voyage duration—as well as almost all voyages departing before 1710.

An examination of a broader subset of voyages than previous studies finds a positive correlation between slave crowding and mortality in the Middle Passage, consistent with historical accounts. This result holds both for simple correlations and for incomplete data regressions. Using partially incomplete observations allows the analysis to consider not only a larger sample, but a sample that includes many more voyages during the earliest decades of the slave trade and after 1788, when slave voyages were least likely to record Middle Passage voyage duration and more likely to be highly crowded. Determining the economic motivations and other factors that would have led some voyages, but not others, to create and preserve records of their voyage duration is a question for future research.

$\hat{\delta}_2$ is negative and statistically significant at the 5 percent level, even after controlling for other influences on data observation.

[15] Appendix Table 3 reports missing *Duration* data and mean mortality rate and crowding by nation of carrier. Of 763 complete observations in the data set, 549 are French and 67 British; only 6.6 percent of 1,018 British voyages report voyage duration. Though the French data constitutes a majority of the completely observed sample, the weak relationship between recorded duration and slave mortality is not a feature of the French data specifically. Omitting the French data or controlling for unobserved national influences on mortality with nation-fixed effects does not meaningfully change the regression results (estimates are suppressed for brevity).

[16] Appendix Figure 1 displays decadal *Duration* reporting rates for voyages of the five countries with the most voyages in the data set (Britain, France, the United States, Portugal, and the Netherlands). While the Royal African Company is a large contributor of observations (161 in in the data set, 35 of them with observed duration), the British rate of *Duration* observation is highest following Parliamentary actions unfavorable to the company, including repealing its monopoly (1698), granting the *asiento* trade to the South Sea Company (1713), and the passage of Dolben's Act (1788).

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Appendix

APPENDIX TABLE 1
SUMMARY STATISTICS FOR FULL SAMPLE

	N	Mean	Median	SD	Min	Max
Tonnage	2,167	223.9	218.3	102.5	16.75	906.9
Crowding	2,167	1.532	1.450	0.675	0.00571	8.950
Duration	763	73.57	66.0	36.65	18.0	310.0
Mortality rate	2,167	11.39	6.887	13.08	0.0	83.24
Year of departure	2,167	1,764	1,767	36.61	1,622	1,864

Notes: Included voyages have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure. See Appendix Table 7.

APPENDIX TABLE 2
OBSERVED VOYAGE DURATION BY DECADE

	Observations	Share with Duration Reported (%)	Average Crowding	Average Mortality (%)
1621–1630	1	0.0	0.86	38.2
1631–1640	1	0.0	0.04	0.0
1651–1660	2	0.0	0.66	31.9
1661–1670	4	0.0	1.39	13.0
1671–1680	11	0.0	2.26	16.4
1681–1690	78	6.4	2.09	18.9
1691–1700	38	7.9	2.30	17.4
1701–1710	47	6.4	2.02	14.7
1711–1720	142	55.6	1.24	16.5
1721–1730	129	66.7	1.46	11.9
1731–1740	94	66.0	1.35	15.4
1741–1750	90	64.4	1.31	14.3
1751–1760	176	35.8	1.35	12.6
1761–1770	399	39.6	1.29	12.7
1771–1780	175	49.7	1.66	8.7
1781–1790	221	7.2	1.73	9.8
1791–1800	356	2.8	1.47	5.4

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APPENDIX TABLE 2 — continued

	Observations	Share with Duration Reported (%)	Average Crowding	Average Mortality (%)
1801–1810	68	73.5	1.20	11.7
1811–1820	9	77.8	2.23	6.4
1821–1830	82	73.2	2.13	6.1
1831–1840	8	25.0	2.86	17.3
1841–1850	14	14.3	2.94	7.4
1851–1860	18	50.0	2.34	19.6
1861–1870	4	75.0	1.78	13.4
TOTAL	2,167			

Notes: Otherwise complete observations have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure. See Appendix Table 7.

APPENDIX TABLE 3
OBSERVED VOYAGE DURATION BY NATION OF REGISTRATION

	Observations	Share with Duration Reported (%)	Average Crowding	Average Mortality (%)
Great Britain	1,018	6.6	1.67	10.7
France	772	71.1	1.33	12.3
United States	166	37.3	1.42	14.5
Netherlands	62	17.7	0.99	8.7
Portugal	56	39.3	1.72	9.1
Brazil	47	57.4	2.38	6.2
Spain	4	0.0	1.84	24.9
Denmark	2	0.0	3.15	12.7
Not recorded	40	62.5	1.90	10.0
TOTAL	2,167			

Notes: Otherwise complete observations have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure. See Appendix Table 7.

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APPENDIX TABLE 4
OBSERVED VOYAGE DURATION BY EMBARKMENT REGION

	Observations	Share with Duration Reported (%)	Average Crowding	Average Mortality (%)
Senegambia and Offshore Atlantic	206	36.9	1.26	9.6
Sierra Leone	115	24.3	1.44	8.8
Windward Coast	73	21.9	1.52	8.3
Gold Coast	449	14.5	1.51	10.5
Bight of Benin	468	52.8	1.53	14.9
Bight of Biafra and Gulf of Guinea Islands	296	16.2	1.54	17.0
West Central Africa and St. Helena	560	50.5	1.67	7.8
TOTAL	2,167			

Notes: Otherwise complete observations have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure. See Appendix Table 7.

APPENDIX TABLE 5
OBSERVED VOYAGE DURATION BY DISEMBARKMENT REGION

	Observations	Share with Duration Reported (%)	Average Crowding	Average Mortality (%)
Europe	2	100	0.06	16.7
N Atlantic Coast NA	1	100	0.71	19.2
C Atlantic Coast NA	36	83.3	1.77	20.8
S Atlantic Coast NA	120	57.5	1.24	11.9
SE Caribbean	1,252	54.6	1.46	12.1
NW Caribbean	549	91.1	1.69	10.3
Guyana	73	76.7	1.07	10.3
Brazil	134	47.0	2.03	7.1
TOTAL	2,167			

Notes: Otherwise complete observations have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure. See Appendix Table 7 for a description of sample.

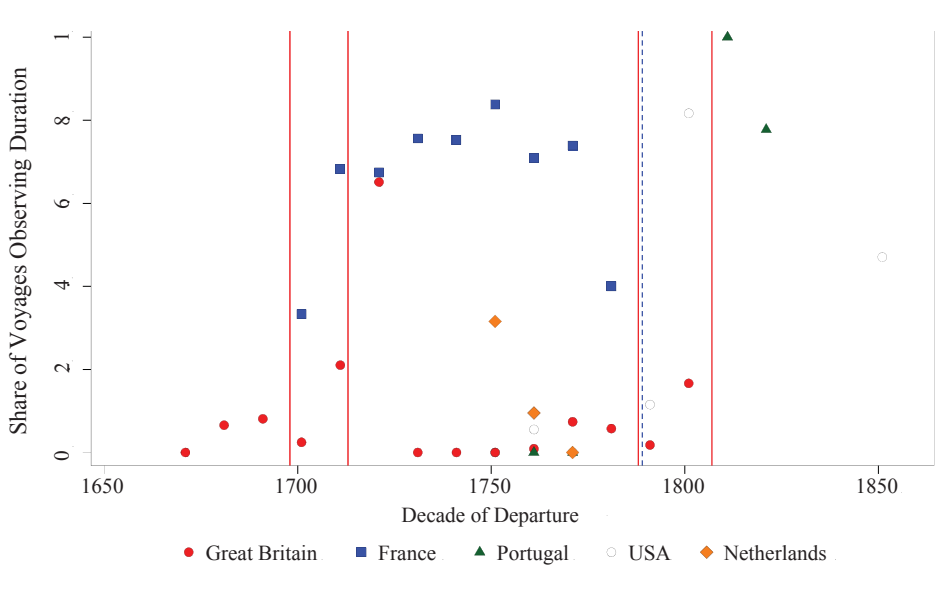
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APPENDIX TABLE 6
LINEAR PROBABILITY MODEL: 1{DURATION MISSING} ON OTHER VARIABLES

	Duration Missing
Tonnage	–0.0000491
	(0.000103)
Crowding	–0.0427**
	(0.0149)
Mortality	–0.000133
	(0.000707)
Nation Indicators	
Not recorded	–0.298**
	(0.115)
Spain	–0.0986
	(0.225)
Portugal	–0.187
	(0.160)
Brazil	–0.215
	(0.149)
Netherlands	–0.0504
	(0.0755)
United States	–0.0179
	(0.0355)
France	–0.576***
	(0.0319)
Denmark	0.705***
	(0.0800)
Constant	1.743***
	(0.124)
Observations	2,167
R-squared	0.48
Route and Decade Effects	√

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
Notes: Great Britain is the omitted category for nation indicators. Standard errors in parentheses corrected for heteroskedasticity. Otherwise complete observations have observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure.

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APPENDIX FIGURE 1
PROPORTION OF VOYAGES WITH OBSERVED DURATION BY NATION

Notes: The solid lines mark the repeal of the Royal African Company's monopoly of the British slave trade (1698), the *asiento* granting the South Sea Company the right to trade to Spanish territories (1713), Dolben's Act (1788), and British prohibition on international slave trade (1807). The dashed line marks the beginning of the French Revolution (1789). Observation shares are plotted only for nations with at least five voyages in each decade. Dependent variable is share of 2,167 observations by decade with observed values for vessel tonnage and crowding, mortality rate, travel route, and year of departure, that also have observed values for voyage duration.
Source: See Appendix Table 7.

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APPENDIX TABLE 7
DATA SOURCES AND VARIABLE CONSTRUCTION

Variable	*Sources and Construction*
Slaves embarked	Measured with variable *tslavesd*, "Total slaves on board at departure from last slaving port."
Mortality	Equal to slaves who died in the middle passage, *sladvoy*, divided by slaves shipped, measured using *tslavesd*, "Total slaves on board at departure from last slaving port." For 1,322 of 2,167 observations where *sladvoy* is unobserved, instead used the difference between slaves embarked and *slaarriv*, "total slaves on board at the first port of disembarkation," to measure number of deaths in the numerator.
Tonnage	*Tonmod*, "Tonnage standardized on British measured tons, 1773–1835."
Crowding	Slaves embarked / Tonnage.
Duration	Variable *voyage*, "Length of Middle Passage in days."
Decade indicators	Set of binary variables equal to 1 if the variable for decade of departure from place of origin, *year10*, takes a particular value.
Route indicators	Set of binary variables equal to 1 if voyage's last port of embarkation in Africa and first port of disembarkation in the New World both correspond to particular regions. Variables containing ports data are *regem1, regem2,* and *regem3* in Africa and *regdis1* in the New World. There are seven embarkment regions: Senegambia, Sierra Leone, Windward Coast, Gold Coast, Benin, and Biafra/Guinea. There are seven destination regions: Europe; North, Central and South Atlantic Coasts of North America; SE and NW Caribbean; Guyana; and Brazil. This means up to forty-nine route dummies, although in fact many combinations are rarely observed in the data; about forty have enough observations with other regressors observed to be included in the regression analysis. Voyages that embarked slaves at regions other than West Africa or disembarked anywhere other than the Americas are dropped.
Rigging indicators	Taken from variable *rig*, a categorical variable for "rig of vessel," *e.g.,* "brig," "schooner," "sloop," "barque" *et cetera*. A binary variable is created for each value, including one for missing observations.
Nation indicators	Taken from variable *national*, a categorical variable for "country in which ship registered (flag)." A binary variable is created for each value, including one for missing observations.
Vessel identification (for error clustering)	Voyages are assigned a ship name number using the name of the vessel, ship name, and the tonnage of the ship (to avoid pooling ships with common names). These variables are observed for all 2,167 observations used in this analysis. Within the sample, 1,654 distinct vessels are observed, sailing an average of 1.31 voyages each.

Note: The table explains the sources and construction of variables used in this article, denoting the database's variable names in *italics*.
Sources: Slave trade variables are from the Trans-Atlantic Slave Trade Database, a machine-readable data set gathered from archival records of individual voyages. The data and documentation are maintained by a consortium of scholars and academic institutions, and provided for public access and use at http://www.slavevoyages.org. My copy of the data was accessed in October, 2009.

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REFERENCES

Allison, Paul D. *Missing Data*. Sage University Paper 07-136. Thousand Oaks, CA: Sage Publications, 2002.

Blake, W. O. *The History of Slavery and the Slave Trade, Ancient and Modern.* Columbus, OH: H. Miller, 1860.

Cameron, A. Colin, and Pravin K. Trivedi. *Microeconometrics: Methods and Applications*. Cambridge: Cambridge University Press, 2005.

Carlos, Ann M. "Agent Opportunism and the Role of Company Culture: The Hudson's Bay and Royal African Companies Compared." *Business and Economic History* 20 (1991): 142–57.

_____. "Bonding and the Agency Problem: Evidence from the Royal African Company, 1672–1691." *Explorations in Economic History* 31, no. 3 (July 1994): 313–35.

Cohn, Raymond L., and Richard A. Jensen. "The Determinants of Slave Mortality Rates on the Middle Passage." *Explorations in Economic History* 19, no. 3 (July 1982): 269–82.

Curtin, Philip D. *The Atlantic Slave Trade: A Census*. Madison: University of Wisconsin Press, 1969.

Eltis, David. "Mortality and Voyage Length in the Middle Passage: New Evidence from the Nineteenth Century." *The Journal of Economic History* 44, no. 2 (1984): 301–08.

Eltis, David, Frank D. Lewis, and Kimberly McIntyre. "Accounting for the Traffic in Africans: Transport Costs on Slaving Voyages." *The Journal of Economic History* 70, no. 4 (2010): 940–63.

Expanded data set. 2008. *Voyages: The Trans-Atlantic Slave Trade Database*. Available online at http://www.slavevoyages.org. (accessed October 2009).

Falconbridge, Alexander. *Account of the Slave Trade on the Coast of Africa.* London: J. Phillips, 1788.

Galenson, David W. *Traders, Planters, and Slaves: Market Behavior in Early English America*. Cambridge: Cambridge University Press, 1986.

Garland, Charles, and Herbert S. Klein. "The Allotment of Space for Slaves Aboard Eighteenth-Century British Slave Ships." *The William and Mary Quarterly* 42, no. 2 (April 1985): 238–48.

Haines, Robin, John McDonald, and Ralph Shlomowitz. "Mortality and Voyage Length in the Middle Passage Revisited." *Explorations in Economic History* 38, no. 4 (2001): 503–33.

Haines, Robin, and Ralph Shlomowitz. "Explaining the Mortality Decline in the Eighteenth-Century British Slave Trade." *The Economic History Review* 53, no. 2 (May 2000): 262–83.

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

Jones, Michael P. "Indicator and Stratification Methods for Missing Explanatory Variables in Multiple Linear Regression." *Journal of the American Statistical Association* 91, no. 433 (1996): 222–30.

Klein, Herbert S. *The Atlantic Slave Trade*. Cambridge: Cambridge University Press, 2010.

https://doi.org/10.1017/S0022050714000357 Published online by Cambridge University Press

Klein, Herbert S., and Stanley L. Engerman. "A Note on Mortality in the French Slave Trade in the Eighteenth Century." In *The Uncommon Market: Essays in the Economic History of the Atlantic Slave Trade,* edited by H. A. Gemery and Jan S. Hogendorn, 239–60. New York: Academic Press Inc., 1979.

_____. "Long-Term Trends in African Mortality in the Transatlantic Slave Trade." In *Routes to Slavery*, edited by David Eltis and David Richardson, 36–48. London: Frank Cass & Co. Ltd., 1997.

Klein, Herbert S., Stanley L. Engerman, Robin Haines, and Ralph Shlomowitz. "Transoceanic Mortality: The Slave Trade in Comparative Perspective." *The William and Mary Quarterly* 58, no. 1 (January 2001): 93–118.

Postma, Johannes. "Mortality in the Dutch Slave Trade, 1675–1795." In *The Uncommon Market: Essays in the Economic History of the Atlantic Slave Trade*, edited by H. A. Gemery and Jan S. Hogendorn, 239–60. New York: Academic Press Inc., 1979.

Richardson, David. "The Costs of Survival: The Transport of Slaves in the Middle Passage and the Profitability of the Eighteenth-Century British Slave Trade." *Explorations in Economic History* 24, no. 2 (1987): 178–96.

Riland, John. *Memoirs of a West-India Planter.* London: Milton, Adams & Co., 1828.

Steckel, Richard H., and Richard A. Jensen. "New Evidence on the Causes of Slave and Crew Mortality in the Atlantic Slave Trade." *The Journal of Economic History* 46, no. 1 (1986): 57–77.

Stein, Robert. "Mortality in the Eighteenth-Century French Slave Trade." *The Journal of African History* 21, no. 1 (1980): 35–41.

Tattersfield, Nigel. *The Forgotten Trade: Comprising the Log of the Daniel and Henry of 1700 and Accounts of the Slave Trade from the Minor Ports of England*, 1698–1725. London: Jonathan Cape, 1991.

Whatley, Warren C., and Rob Gillezeau. "The Fundamental Impact of the Slave Trade on African Economies." In *Economic Evolution and Revolution in Historical Time*: edited by Paul W. Rhode, Joshua Rosenbloom, and David Weiman, 86–110. Palo Alto, CA: Stanford University Press, 2011.

https://doi.org/10.1017/S0022050714000357 Published online by Cambridge University Press