

# Appendix for Pirates of the Mediterranean: An Empirical Investigation of Bargaining with Transaction Costs

Attila Ambrus\*

Eric Chaney†

Igor Salitskiy‡

December 22, 2011

## 1 Data Appendix

### 1.1 Overview and Summary Statistics

Data are drawn from 53 ransom books taken from the *Archivo Histórico Nacional* and the *Biblioteca Nacional de Madrid*. These books constitute the majority of the known surviving records of trips by the Spanish redemption orders to Algiers and Tetuan.

Summary statistics for variables of interest are given in tables one, two of the appendix and table 1 of the main text. Tables one and two detail the archival sources for trips to Algiers, Algeria and Tetuan, Morocco. Both tables one and two give the number of individuals successfully ransomed in each trip, the number of individuals for whom earmarked money appeared in the book, the number of the earmarked individuals who were successfully ransomed and the length of the trip in days.

---

\*Harvard University and NBER.

†Harvard University.

‡Stanford University.

Table 1 of the main text presents individual level summary statistics for rescued captives. The first five columns detail statistics for Algiers, and the last five detail those for Tetuan. Starred categories denote “favored” groups or those giving preference by the ransoming missions.

The first panel details general statistics. These show that captives rescued from Algiers had been in captivity for 6.10 years on average, whereas those rescued from Tetuan had been captive for on average 4 years. The average captive cost 1658 silver *reales* (all prices are deflated to the year 1600) in Algiers and 1973 *reales* in Tetuan.<sup>1</sup> The spread of prices paid was larger in Algiers than in Tetuan.

The following rows detail statistics regarding the amount of earmarked money sent for a captive. These data were drawn from the ransom books and matched by hand as explained in greater detail below. The variable Earmarked is set equal to one if an individual was recorded as having had money sent for the captive’s rescue from home. In Algiers 9% of rescued captives appear as having been earmarked, whereas in Tetuan 11% of the rescued captives were earmarked.

The next two rows detail the variable Moneysent for all individuals who appear in the ransom books as having earmarked money. The first row shows that in Algiers earmarked captives had on average 1224 reales sent to aid in their rescue while in Tetuan the average is 1083. Among the earmarked individuals who were actually rescued, the averages were 1400 and 1103 reales respectively. In total, 2262 individuals appear as having had earmarked money in both Algiers and Tetuan. Of these 2262, 974 were successfully rescued –297 out of 586 earmarked in Tetuan (51% ) and 677 out of 1676 earmarked in Algiers (40%).

The following entries shows that captives were less likely to be rescued in a “bundle” (that is, jointly with other captives) in Algiers than in Tetuan. In addition, 49% of the rescued population in Algiers were from the areas most desired by the redemption team (since the

---

<sup>1</sup>Such ransoms constituted a sizeable outlay for most families. Rodriguez (2007) estimates that an unskilled laborer (in the 15th century) would have needed roughly 25 years to save enough money to pay the average ransom.

majority of alms were collected from Andalusia, New Castile and Old Castile-León) whereas the total in Tetuan is 68%.

The following row shows that captives rescued from Algiers were rescued –on average– after 8.31 days of negotiations, whereas those rescued from Tetuan were rescued after 11.30 days of negotiations.

The ninth row shows that captives owned by the government formed a smaller percentage of the rescued population in Algiers than in Tetuan. Finally, the proportion of rescued captives who were female, children and the average age of rescued captives and their age at capture was roughly the same in Algiers and in Tetuan.

The second panel details the occupation of the rescued population in both Algiers and Tetuan. Occupations were grouped into 10 categories for parsimony (see below for details), and the entries in this panel show that the occupational distribution of the rescued population was similar in both Algiers and Tetuan.

In sum, the liberated populations appear to be roughly similar in both Algiers and Tetuan except for the fact that those rescued from Algiers were in captivity for a longer period than those in Tetuan and were liberated after fewer days of negotiations in the trip in which they were freed.

## 1.2 Data Construction

The “population” of total surviving ransom books was drawn from the catalogs of the *Biblioteca Nacional de Madrid*, the *Archivo Histórico Nacional* and the books used in Friedman (1983) and Martínez (2004). We used all complete books (that is those that did not have missing pages) that provided prices for the majority of captives (those with large numbers of prisoner exchanges (*canjes*) were omitted). Thus, we aimed to obtain the surviving population of ransom books (that were of statistical use).<sup>2</sup>

The variables of interest were constructed from each captive’s ransom entry. As one

---

<sup>2</sup>We did not, however, attempt to obtain the few known surviving books held in archives other than the *Biblioteca Nacional de Madrid* and the *Archivo Histórico Nacional*.

example, we detail Miguel de Cervantes' (the renowned Spanish author) ransom record as given on folios 158 and 159 of legajo 118 in the *Archivo Histórico Nacional*. This entry reads as follows (the values of variables coded in this entry are detailed in bold):

In the city of Algiers on the 19th day of the month of September [of 1580, **time-toagreement=99 days** (first captive was ransomed in this trip on the 12<sup>th</sup> of June 1580)], the father Fray Juan Gil rescued Miguel [**first name**] de Cervantes [**last name**] of Alcala de Henares [**Castile=1**] of 31 years of age [**age=31**] [...] captured on board the galley of the sun, going from Naples to Spain where he was for a long period in the service of his Majesty [**profession=In King's Service**] he was lost the 26<sup>th</sup> of September of the year 1575 [**years captive=5 years, missedtrips=2**]. He was in the power of Husayn Pasha King, his ransom cost 500 gold escudos [=5044 silver reales<sup>3</sup>] [...] he had 300 ducados of earmarked money [**earmarked=1, moneysent=3238 reales**]<sup>4</sup>

The variables used in the data set were constructed from entries similar to the one given above as follows:

**YearsCaptive:** This variable was detailed for 9562 rescued captives (95% of total sample of 10114).

**Price:** While the paid ransom price was given for 10020 of the rescued captives (99%),<sup>5</sup> and was usually quoted in silver reales or silver reales *de a ocho*, at times the prices were quoted in different units (as illustrated above). The most common of these alternative were reales (or reales *de a ocho*) *de vellón* (or billon, an alloy of silver and copper). Escudos, ducados and marvedies appear more rarely.

In general, fluctuating values of these currency units appear to have created some confu-

---

<sup>3</sup>This rate was imputed from the ransom book. For conversion rates see discussion below under the bold heading price.

<sup>4</sup>This rate was imputed from the ransom book. For conversion rates see discussion below under the bold heading price.

<sup>5</sup>We set the price of Christian captives who were exchanged for Muslims to missing.

sion among scholars.<sup>6</sup> For this reason, when making conversions between currency units we preferred to use the (implied) conversion in each book when these were available.<sup>7</sup> If these were not available, the following conventions were used: 1 ducado=375 marvedies, 1 real=34 marvedies, 1 gold coin=8 silver coins, 1 silver peso=8 silver reales and 1 real *de vellón*=0.5 silver reales.<sup>8</sup>

It should be noted that for the vast majority of captives no conversions were necessary. Furthermore, the majority of exchange rates were derived from the books. This suggests that measurement error due to conversions is probably not a major problem.

Finally, all prices were deflated to year 1600 reales using the average of Hamilton's indexes (1934, 1947) for Andalusia, New Castile and Old Castile-León. For the period 1551-1600 see Hamilton (1934, p. 198), for the period 1601-1650 Hamilton (1934, p. 215), for the period 1651-1700 Hamilton (1947, p. 119) and for the period 1701-1750, see Hamilton (1947, p. 139).<sup>9</sup>

**Earmarked:** This variable is set to one if the variable *Moneysent* is greater than 0.

**Moneysent:** This variable was constructed using the section of the ransom books in which the scribe wrote down money received for individual captives.<sup>10</sup> In total, there were 2262 entries of money received for various captives. These captives were then matched by hand (due to orthographic variations, matching using automated algorithms would have led to a substantial number of missed matches).

Of these 2262 individuals with money recorded 974 were successfully matched. Thus of the 10114 captives in the sample, 974 were recorded as having money sent for them and 9140 were not. The remaining 1288 captives who had money sent for them were not rescued.

---

<sup>6</sup>For one example, see the different value of the peso given by Friedman (1983, p. xiii) and Lea (1906, p. 562). It appears that Friedman's conversion rates are from an earlier era than Lea's.

<sup>7</sup>That is, in many books the scribe would at times give the same price in two currency units allowing us to impute the conversion rate between the two.

<sup>8</sup>See Cayón et al. (2005, p. 401-402) and Lea (1906, p. 560-561)

<sup>9</sup>These series were merged by assuming constant prices in the years 1600 and 1601 ; 1650 and 1651 and 1700 and 1701.

<sup>10</sup>We did not include the few captives who gave their own adjutorios in Algiers. This was done because it is unlikely that the corsairs did not know the amount given by these individuals.

**Bundled:** This variable was constructed under the assumption that the scribes wrote the entries of rescued captives in chronological order (which they seem to have done). We construct the variable *bundled* equal to one if the captive has an identical ransom price to that of the captive before or after her in the book.

**Castile:** This variable was constructed using the home town of the captive. It was set equal to one if the captive was from Andalusia, New Castile or Old Castile-León since these were the areas from which the vast majority of the redemptions in the sample had special orders to rescue captives from.

**DaysElapsed:** The scribe often noted the day on which the captive was ransomed. This information, in addition to the date at which the redemption team entered Algiers or Tetuan can be used to calculate the days elapsed since arrival. The variable used, however, calculates the days elapsed since the first agreement (results are similar if one uses the time elapsed since first landing).

**Govt:** This variable is defined equal to 1 if the book states that the captive was owned by a member of the ruling elites in Algiers or Tetuan. It is equal to 0 otherwise.

**Female:** This variable is equal to one if the captive had the following first names: *Ageda, Agueda, Agustina, Aldonza, Ana, Antona, Antonia, Antonina, Barbara, Barbola, Bernarda, Catalina, Caterina, Cathalina, Cecilia, Clara, Constanza, Cristina, Damiana, Dominga, Ducana, Esperanza, Feliciana, Felipa, Francisca, Geronima, Ginana, Ginesa, Gregoria, Guida, Ines, Isabel, Joana, Josefa, Juana, Jusepa, Lucia, Luisa, Madalena, Magdalena, Manuela, Margarita, Maria, Mariana, Marina, Marta, Nicolasa, Pascuala, Paula, Pereta, Petra, Petronila, Polonia, Porcia, Prudencia, Rosa, Rosalia, Sebastiana, Severina, Teresa, Theodora, Theresa, Thomasa, Thomasina, Ventura, Vitoria, Yasimina, Zajeda* or was otherwise designated as female in the book.

**Child:** This variable is equal to one if the captive was less than 16 years old when ransomed.

**Age:** This variable was taken directly from the ransom books and was reported for 9611

captives (95%)

**AgeCapt:** This variable is the difference between Age and YearsCaptive.

**MissedTrips:** This variable was constructed using the trips to the Barbary States performed by the Mercedarian redemption order in Garí y Siumell (1873) as well as the trips in the sample. We used the date of capture and the date of rescue of each captive to compute how many known trips had gone to their point of rescue before they were rescued. We constructed this variable as a robustness check and it is not used in the empirical analysis (since point estimates are generally attenuated (this attenuation, in turn, is likely due to measurement error)).

### 1.3 Occupation

The 10 occupational categories reported in table 3 and used in the empirical analysis were defined grouping the original professional descriptions (which are reported verbatim) as follows:<sup>11</sup>

i. **Fisherman:** *Pescador*

ii. **Soldier:** *Soldado, Soldado (Sargento), Soldado de la Brigada de Lucas Patiño, Soldado de Caballeria de Oran, Soldado de la Artilleria, Soldado de las Guardias Balonas, Soldado de Oran, Soldado de Zeuta, Soldado del Peñon, Soldado del Regimiento de Dragones de Tarragona, Soldado del Regimiento de Lisboa, Soldado del Regimiento de Navarra, Soldado del Regimiento de Suizos de Vesle, Soldado y Marinero, Soldado- Alferes, Soldado- Capitan de Infanteria, Soldado-Alferes, Soldado-Caballero del Habito de Cristo, Soldado-Caballero Hidalgo, Soldado-Capitan, Soldado-Capitan de Infanteria, Soldado-Capitan del Bajel de la Armada Real, Soldado-General, Soldado-Sargento, Soldado-Sargento de Granaderos, Soldado-Subteniente, Soldado-Teniente, Caballero Romano, Alferes del Regimiento de Suizos de Vesle, Artillero de Armada de España, Atalaya de Ceuta, Caballero, Caballero Atajador, Caballero*

---

<sup>11</sup>We experimented with grouping individuals into even finer groups by professions, but given that the empirical results in these finer groups were similar to those presented we used these broader categories for greater clarity and simplicity. The one exception to this are the results presented in section 3.2.2 where we used the fully disaggregated categories to increase power.

*de la Orden de Calatrava, Caballero de la Orden de San Juan, Caballero de la Orden de Santiago, Caballero del Habito de Cristo, Caballero del Habito de Cristo- Capitan, Caballero del Habito de San Juan, Caballero y Alcalde de Ceuta, Cabo de Escuadra de Oran, Capitan, Capitan (Iba de Espia a Reconocer La Fuerza y Diseño de la Armada Francesa), Capitan de Caballos en Flandes, Capitan de una Fragata Española con Nombramiento del Rey, Capitan de una Galeota Española, Capitan y Sargento Mayor, Escucha de Ceuta, Escucha de la Ciudad de Carchuna, Escucha de la Fuerza de Ceuta, Escucha y Almozaden de Ceuta, Guardia, Maestro de Escopeta, Miembro de la Milicia, Sargento del Peñon, Sargento del Regimiento de Navarra, Teniente del Regimiento de Bezle*

iii. **Majesty:** *En Servicio de su Magestad, En Servicio de su Magestad-Marinero, Mensajero del Gobernador, Mensajero en Servicio de su Magestad*

iv. **Shepherd:** *Pastor*

v. **Sailor:** *Marinero, Marinero (Capitan), Grumete, Marinero en Servicio de su Magestad, Marinero En Servicio del Rey, Marinero- Capitan, Marinero-Calafate, Marinero-Capitan, Marinero-Comerciante de Esclavos, Marinero-Piloto, Paje de Nao*

vi. **Peasant:** *Labrador, Labradora*

vii. **Indias:** *En Carrera de Indias, En la Carrera de Indias, En la Carrera de Indias-Marinero, Piloto de la Carrera de Indias*

viii **Cleric:** *Canonigo de la Iglesia de Orense, Canonigo de la Santa Iglesia Catedral de Canarias, Capellan, Clerigo, Clerigo de la Orden de San Agustin, Clerigo de la Orden de San Francisco, Clerigo de Misa, Clerigo Presbitero, Colegial, Diacono Religioso de Nuestra Señora del Carmen, Frayle, Licenciado, Licenciado del Seminario de San Albano en Valladolid, Licenciado en la Iglesia de la Isla Canaria, Licenciado y Capellan, Licenciado Clerigo de Evangelio, Licenciado Subdiacono, Misionario Apostolico Capuchino, Padre de la Santisima Orden de la Trinidad, Presbitero, Presbitero de la Orden de San Basilio, Prior de Masaraque y Beneficiado de la Santa Iglesia de Girona, Religioso, Religioso Capuchino, Religioso de la Orden de Carmelitas, Religioso de la Orden de la Cartuja, Religioso de la*



*Orden de la Santisima Trinidad, Religioso de la Orden de la Santisima Trinidad Descalza, Religioso de la Orden de los Carmelitas Descalzos, Religioso de la Orden de Nuestra Señora de la Merced, Religioso de la Orden de Nuestra Señora de la Victoria, Religioso de la Orden de Nuestra Señora de la Victoria, Religioso de la Orden de Nuestra Señora del Carmen, Religioso de la Orden de Predicadores, Religioso de la Orden de San Agustin, Religioso de la Orden de San Basilio, Religioso de la Orden de San Bernardo, Religioso de la Orden de San Francisco, Religioso de la Orden de San Juan de Dios, Religioso de la Orden de San Pedro, Religioso de la Orden de San Pedro Alcantara, Religioso de la Orden de Santo Domingo, Religioso de la Orden del Carmen, Religioso de Menores Ordenes, de la Orden de los Minimios, Religioso del Habito de San Juan y Comedador de Baldevida, Religioso Dominicco (Orden de Santo Domingo), Sacerdote, Sacerdote de la Orden de la Santisima Trinidad, Sacerdote de la Orden de San Francisco, Sacerdote Presbitero de la Orden de Santo Domingo, Secretario de la Santa Inquisicion, Diacono Religioso de Nuestra Señora del Carmen, Frayle Caballero del Habito de San Juan, Licenciado, Subdiacono, Misionario Apostolico Capuchino, Religioso de la Orden de San Pedro, Religioso de la Orden de San Pedro Alcantara, Monja de la Orden de la Victoria, Monja Profesa de la Orden de la Victoria de Andujar, Monja Profesa de Santa Clara*

ix. **Other Identified:** all other professions.

This category includes professions denoted (again verbatim) as follows (I have grouped the occupations into general categories for ease of exposition): **Mayor:** *Alcalde de Corte de la Real Audiencia de Sevilla y Visitador de la Isla la Española, Alcalde de los Terreros, Regidor Perpetuo de Marbella, Regidor de Madrid; **Barber:** *Barbero; **Caulker:** *Calafate; **Carpenter:** *Carpintero, Maestro De Carpintero, Maestro de Serrar Madera, Tonelero, Astillero; **Surgeon:** *Cirujano; **Merchant:** *Comerciante, Comerciante de Esclavos, Casero de La Bentilla de Nijas, Mercader; **Servant:** *Criado ;* **Slave:** *Esclavo, Esclavo Mulato, Esclavo de Joseph de Mesa (Caballero de La Orden de Calatrava), Mulato Esclavo de Joseph de Mesa (Caballero de la Orden de Calatrava);* **Scribe:** *Escribano de su Magestad, Notario, Veedor*******

*y Contador de la Galera de Santa Agueda, En Servicio del Hijo del Marques de Villena, En Servicio del Marques de Lanzarote, Funcionario de la Corona; Student: Estudiante (Graduado de Grado y Corona), Estudiante (Graduado de Grado y Corona), Estudiante Teologo, Iba a Francia a Aprender Frances; Blacksmith: Herrero; Baker: Panadero; Ship Owner: Patron de Barca, Patron de Fragata, Piloto; Tailor: Sastre; Bullfighter: Torrero, Torrero de Torreblanca*

x. **NI:** if individual's occupation was not identified

## 1.4 Matching Criteria for Failed Negotiations

Captives were matched in section 4.4 footnote 34 as follows: we first matched captives by first and last name only if there was an exact orthographical match. We then dropped all names for which the earliest observed date was a rescue. Then, we dropped all names that appeared in both Algiers and Tetuan. Then we dropped all names that had more than one rescue. Then we dropped all names that had more than 30 years between appearing in the books.

## 2 Additional material to the reduced form analysis: Testing a prediction of an alternative class of bargaining models

An alternative class of models of dynamic bargaining to the ones that we focus on in the main text is the class of *attrition models*, in which the uncertainty is about the transaction costs of the bargaining partners (Milgrom and Weber, 1985).<sup>12</sup> Such models lead to a “war of attrition”, in which eventually one of the bargaining partners gives in and concedes the surplus to be divided from bargaining completely. As we discuss in the main text, we think

---

<sup>12</sup>For an informal discussion of other alternative models of dynamic negotiations, see Kennan and Wilson (1989).

that this model is not a fitting description of the negotiations in our setting. Nevertheless, below we formally test one of the main predictions that can be derived from models of the above type.

The screening and signalling models highlighted in the main text give predictions about settlement rates only under special assumptions. On the other hand, attrition models yield the testable implication that settlement rates are monotonically decreasing (see Kennan and Wilson (1989)), which we confront with our data.

In order to investigate how settlement rates vary as time passes, we limit our analysis to the group of individuals who had “earmarked” money, since we know for sure that the redemption team attempted to rescue all these captives.

The “stock” of individuals at time 0, then, is the sum of all individuals that appear as earmarked in the ransom books (we again exclude trips that lasted more than 100 days since these were abnormal and obscure the graphical presentation). We denote “failure” as being ransomed and observe how this probability of being ransomed (failure) varies over time. If an individual was not ransomed we assume that she was right-censored at the maximum numbers of days elapsed in the trip in which her name appears. We estimate the hazard function at a given period by taking the steps of the Nelson-Aalen cumulative hazard and smoothing them with a kernel smoother.<sup>13</sup>

The plots of this non-parametric estimate of the hazard function are presented in the left hand of figure 1 for both Algiers and Tetuan. Settlement rates were higher in Algiers over the entire period in which the bargaining team was bargaining in both Algiers and Tetuan. Since negotiations in Tetuan lasted longer the bargaining team was able to rescue more of the desired captives than in Algiers. Over time, settlements rate appear to be roughly constant in Tetuan and parabolic (first increasing, then decreasing) in Algiers.

The right hand graph in figure 1 presents non-parametric estimates of the hazard function for all rescued individuals (that is the “stock” of individuals at time 0 is all captives who

---

<sup>13</sup>We use an Epanechnikov kernel and the “optimal” kernel halfwidth using Stata’s “sts graph, hazard” command.

will eventually be rescued) as a robustness check. These estimates generally confirm the qualitative implications of the previous analysis.

To summarize, we do not find evidence for monotonically decreasing settlement rates over time, that would be predicted by models with uncertainty about time costs.

### 3 Structural Analysis: Robustness checks

Here we provide several robustness checks to our main results. First, we extend our specification to estimate the seller's valuation and account for the personal characteristics of captives. In order to avoid multiplying the number of parameters to be estimated, we only allow personal characteristics to shift the distribution of values, but not its variation. We also assume that these characteristics were observed by both sellers and buyers and thus determined different equilibria for different observables. In our empirical analysis such characteristics include age, age<sup>2</sup> and region of origin.

The results of this specification are presented in table 3. According to this specification, the seller's valuation is higher for all professions in Tetuan. Figures on explained variation suggest that for most professions there has been some improvement in predictive power, but it is not dramatic and some changes are actually reversed, even though in theory adding flexibility should always give weakly higher likelihood. This suggests that expanding the dimensionality of our estimation problem makes the maximization procedure less robust.

In the next robustness check we split our sample into two time periods. For Tetuan we used the threshold 1640, because after this year average duration looks higher and more volatile. For Algiers 1680 looks like a turning point for both prices and duration: before this point the trend was downward sloping and after this point it is positive.<sup>14</sup> Results for this specification are shown in table 4. Overall, the qualitative insights for this specification are similar to those in the basic specification. For both periods interest rates are much higher

---

<sup>14</sup>This point in Algiers roughly corresponds to the emergence of Algiers as a center largely independent of Ottoman control. In Tetuan, the threshold seems to roughly correspond to a decline in the military position of this stronghold.

for Algiers. In the earliest period there is some variation in estimated transaction costs, but for the later period transaction costs are always about twice as high in Algiers as in Tetuan.

The third specification we report here is a model which only differs from the base one by assuming a different type of value distribution for the buyer. Assuming normally distributed unobserved value components in the basic model makes the estimation procedure faster and more robust, as more terms can be expressed analytically before reverting to numerical methods. However, this specification has the nonrealistic feature that the buyer's evaluation is not bounded from below. Although the exact distribution of low buyer valuations is immaterial for the estimations, because values below  $b_0$  do not affect equilibrium strategies, we report results from a specification in which the buyer's valuation is assumed to be lognormal, precluding negative valuations. In this specification we disregard information regarding earmarked money. Results for this specification are displayed in table 5. The main results remain intact. Discount factor for all professions are much higher in Algiers. Transaction costs are also higher in Algiers for most professions (they are slightly lower for fishermen), and the mean of value distribution is twice as high for Tetuan for all professions but soldiers. The estimated variations of these distributions are also about the same for the two specification.

The fourth alternative estimation investigates the robustness of the results to the exclusion of all captives who could have been released in bundled negotiations. Recall that we do not have exact information on this dimension, but we can observe whether other captives with similar characteristics were released at exactly the same agreed upon price, suggesting that these captives were released as part of the same negotiations. Excluding these captives reduces our sample size by roughly 50%. The results of this specification are presented in table 6. The results are similar to our main specification.

The fifth alternative estimation, instead of assuming a multiplicative error term in observed negotiation length, assumes an additive one with log-normal distribution, and drops the assumption that there is a minimum length of negotiations  $\Delta_0$ . We maintain the assump-

tion that there is multiplicative error in the price observations, hence the data generating process in this specification is:

$$\begin{aligned}\log(p) &= \log(p(B)) + e_p \\ \log(\Delta) &= \log(\Delta(B, b)) + e_d\end{aligned}$$

where  $p$  is observed price,  $p(B)$  is model prediction,  $e_p \sim N(0, \sigma_p^2)$  is price error,  $\Delta$  is observed duration,  $\Delta(B, b)$  is predicted duration, and  $e_d \sim \log N(\mu_d, \sigma_d^2)$  is duration error, which has log-normal distribution with parameters  $\mu_d$  and  $\sigma_d^2$ . In this specification we have to assume that  $e_p$  and  $e_d$  are independent, because we do not have a closed form specification for their joint density function if they are correlated. Maximum likelihood estimation results for this specification are presented in table 7. Qualitatively our main results stay the same, with the caveat that not only discount rates but transaction costs are significantly larger in Algiers than in Tetuan, for all professions.

As a final robustness check we conduct structural estimation separately for periods of political instability in Algiers separately.<sup>15</sup> Overall, about 25% of our observations in Algiers correspond to such periods. Unfortunately, this additional reduction in the number of observations per subsample does not allow us to estimate the model for Sailors and we proceed only with Fishermen and Soldiers. Our main interest in doing this exercise is in comparing estimated coefficients, especially transaction costs and interest rates, between the periods of relative political stability and instability, as a consistency check for our estimation results. Results for the basic specification on corresponding subsamples are presented in table 8. The last two rows for each profession show the difference in estimated coefficients. For Fishermen, both estimated interest rate and transaction costs are significantly higher for the periods of instability, consistently with our expectations. The effect for Soldiers is not significant, however this could be attributed to relatively small number of observations.

---

<sup>15</sup>We denote a year as one of political instability if there was at least one change in the ruler that year (Stewart 2006, pp. 14-15).

## 4 References

**AHN (Archivo Histórico Nacional):** códices, legajos: 118, 119, 120, 121, 122, 124, 125, 126, 127, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 142, 143, 144, 145, 146, 147, 148, 149

**BNM (Biblioteca Nacional de Madrid):** mss: 2963, 2974, 3549, 3870, 3586, 3587, 3588, 3589, 3590, 3592, 3593, 3597, 3628, 3631, 3819, 3837, 3872, 4405, 4359, 4363, 4365, 4394, 6547, 6573, 7752

**Cayón, A., C. Cayón and J Cayón.** (2005). *Las Monedas Españolas: del Tremis al Euro del 411 a Nuestros Días*. Madrid: Artes Gráficas Palermo.

**Friedman, E.** (1983). *Spanish Captives in North Africa in the Early Modern Age*. Madison: The University of Wisconsin Press.

**Garí y Siu mell, J.** (1873). *Historia de las Redenciones de Cautivos Cristianos*. Barcelona: Imprenta de los Herederos de la Vuida Pla.

**Hamilton, E.** (1934). *American Treasure and the Price Revolution in Spain, 1501-1650*. Cambridge: Harvard University Press.

**Hamilton, E.** (1947). *War and Prices in Spain, 1651-1800*. Cambridge: Harvard University Press.

**Kennan, J. and R. Wilson** (1989): “Strategic bargaining models and interpretation of strike data,” *Journal of Applied Econometrics*, 4, S87-S130.

**Lea, H.** (1906). *A History of the Inquisition of Spain (vol. 1)*. New York: The MacMillan Company.

**Milgrom, P. and R. Weber** (1985): “Distributional strategies for games with incomplete information,” *Mathematics of Operations Research*, 10, 619-632.

**Rodriguez, J.** (2007). *Captives and their Saviors in the Medieval Crown of Aragon*. Washington D.C.: The Catholic University of America Press.

**Stewart, J.** (2006). *African States and Rulers*. Jefferson: McFarland & Co.

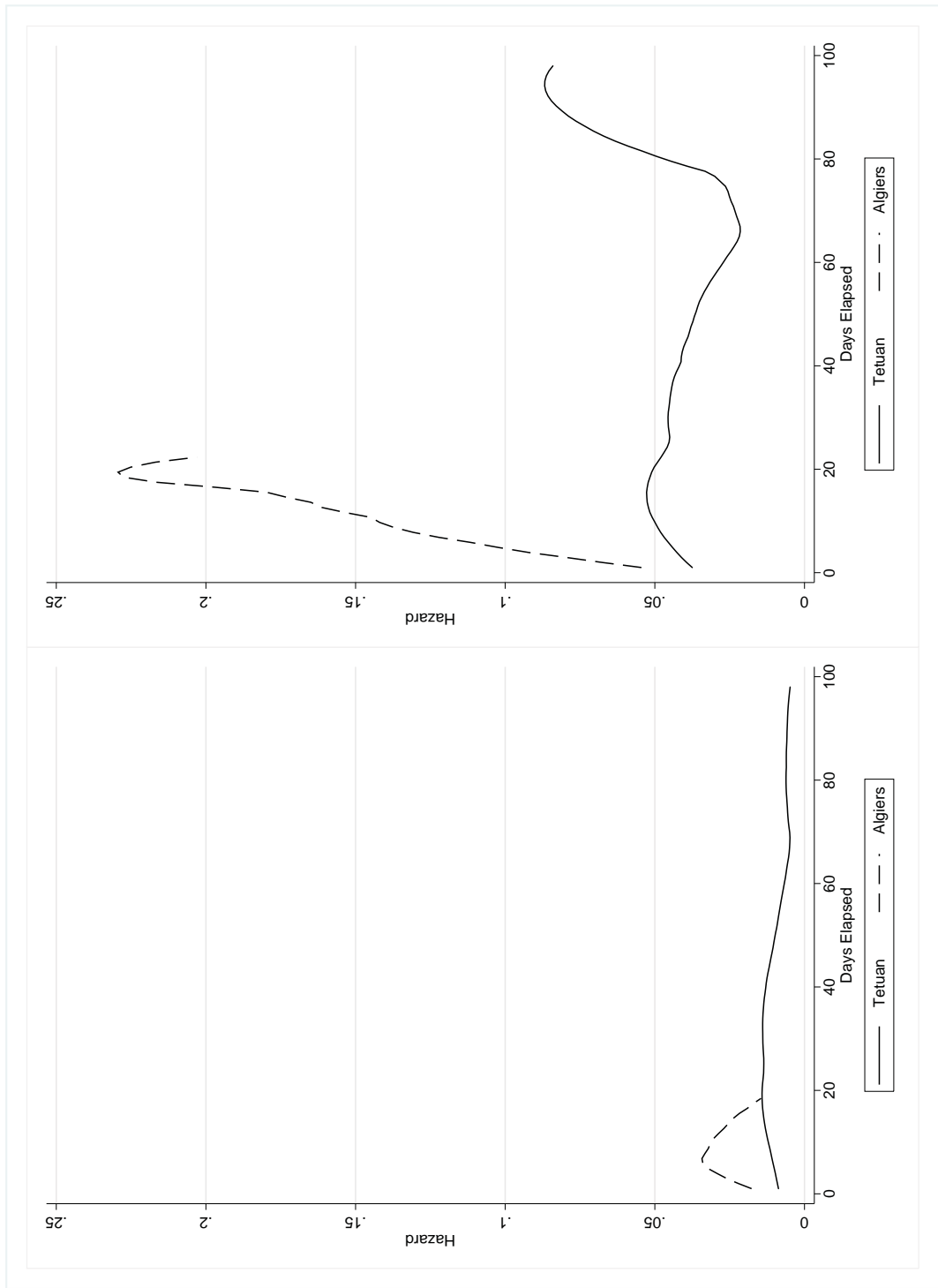


Figure 1: **Settlement Rates for Earmarked and All Rescued Captives**

Graph details non-parametric estimate of the hazard function for all earmarked individuals (left) and all rescued captives (right).



Table 1: **Data Sources (1)**  
Spanish Ransoming Trips to Algiers, Algeria

Year	Archive	Ransomed (Number)	EarMarked (Number)	Ransomed (of EarMarked)	Length (Days)
1575	mss2963	143	-	-	84
1580/1581	l118,l120	165	63	21	293
1582	l119	107	62	21	-
1587/1588	l122	102	36	9	-
1591/1592	l121	120	45	11	-
1618	l125	141	28	16	-
1627	mss3872	143	7	2	-
1642	l133	142	38	23	-
1649	l132	106	15	4	-
1651	mss3597	238	38	15	-
1660	mss4359	368	122	52	-
1662	l139	285	100	45	19
1664	mss4394	262	114	42	-
1667	mss3586	211	124	52	22
1669	mss3593	189	139	44	12
1670	l135	192	106	33	23
1675	mss2974	519	220	115	19
1678	mss7752	448	81	28	-
1679	l146	165	16	8	9
1686	mss4363	320	8	4	20
1690	l145	162	13	7	9
1692	l147	156	34	8	17
1702	mss3587	482	-	-	17
1713	mss3837	197	-	-	22
1718	l148	284	202	95	18
1723	mss3549	424	-	-	21
1724	mss3589	275	-	-	15
1729	l149	272	65	22	-
1730	mss3592	345	-	-	26
1739	mss3590	435	-	-	-
Total(Avg)		7398	1676	677	(38.00)

Archive entries prefaced with l are from the *Archivo Histórico Nacional, códices*. The number after l details the legajo. Archive entries prefaced with mss are from the *Biblioteca Nacional de Madrid*. The number after mss gives the manuscript number. Earmarked individuals had a non-zero amount of money given in Spain for their ransom. Length of negotiations is measured here from the arrival of the redemption team at the corsair stronghold until their departure. (-) denotes missing.

Table 2: **Data Sources (2)**  
Spanish Ransoming Trips to Tetuan, Morrocco

Year	Archive	Ransomed (Number)	EarMarked (Number)	Ransomed (of EarMarked)	Length (Days)
1583	mss3588	87	25	19	284
1609	mss6547	117	4	4	48
1612	mss4405	120	71	6	11
1614	l124	89	-	-	16
1615	mss3870	69	7	2	123
1621	l126	102	5	4	35
1625	l127	50	10	7	13
1633	mss3819	119	-	-	24
1635	mss3628	93	8	6	37
1636	l130	80	-	-	23
1636	l129	73	7	3	26
1639	l131	81	8	6	32
1640	mss6573	219	47	25	30
1645	mss4365	206	66	31	26
1646/1647	l134	123	20	9	37
1648	mss3631	236	82	61	41
1654	l137	126	30	25	-
1656	l136	139	15	5	20
1661	l138	121	-	-	-
1664	l140	79	5	1	23
1668/1669	l142	127	39	18	254
1674	l143	128	61	35	72
1677	l144	132	76	30	134
Total(Avg)		2716	586	297	(62.33)

Archive entries prefaced with l are from the *Archivo Histórico Nacional, códices*. The number after l details the legajo. Archive entries prefaced with mss are from the *Biblioteca Nacional de Madrid*. The number after mss gives the manuscript number. Earmarked individuals had a non-zero amount of money given in Spain for their ransom. Length of negotiations is measured here from the arrival of the redemption team at the corsair stronghold until their departure. (-) denotes missing.

Table 3: Estimates with non-zero seller's valuation and personal characteristics

Location	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$\rho$ (4)	$r$ (5)	$S$ (6)	$c$ (7)	$EV_{duration}$ (8)	$EV_{price}$ (9)	$N$	
<b>Sailors</b>	Tetuan	1165 (168)	1367 (859)	2565 (550)	0.27 (0.21)	0.018 (0.008)	3 (334)	20.98 (5.21)	0.81	0.46	60
	Algiers	427 (129)	17 (523)	2087 (510)	0.35 (0.16)	0.037 (0.009)	36 (222)	15.83 (3.02)	0.86	0.25	71
	Tetuan	944 (194)	1408 (899)	2283 (542)	-0.75 (0.35)	0.027 (0.012)	963 (278)	25.35 (5.25)	0.67	0.29	69
	Algiers	577 (139)	1257 (560)	904 (421)	0.46 (0.11)	0.035 (0.009)	385 (217)	20.12 (5.43)	0.88	0.39	182
<b>Soldiers</b>	Tetuan	506 (87)	1493 (570)	2577 (300)	-0.50 (0.11)	0.025 (0.008)	428 (203)	12.45 (2.81)	0.76	0.35	140
	Algiers	258 (120)	625 (560)	2011 (429)	0.60 (0.10)	0.048 (0.007)	1 (128)	12.48 (3.66)	0.51	0.34	326

Notes:  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales).  $\sigma_v$  is the standard deviation of this distribution (given in constant silver reales).  $\rho$  is the covariance between earmarked and general funds.  $r$  is the interest rate.  $S$  is the seller's evaluation.  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.

Table 4: Estimates by time periods

Location	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$\rho$ (4)	$r$ (5)	$c$ (6)	$EV_{duration}$ (7)	$EV_{price}$ (8)	$N$ (9)	
<b>Panel A: Early</b>										
Sailors	Tetuan	382 (540)	3659 (525)	0.90 (0.46)	0.027 (0.010)	10.50 (8.39)	0.57	0.14	64	
	Algiers	531 (47)	264 (332)	1418 (172)	-0.84 (0.36)	0.024 (0.003)	12.62 (0.89)	0.80	0.17	123
Fishermen	Tetuan	406 (585)	3794 (600)	1 (469)	- (0.008)	0.000 (8.56)	0.63	0.00	39	
	Algiers	390 (41)	50 (284)	1269 (131)	-0.78 (0.65)	0.034 (0.004)	13.14 (1.40)	0.76	0.28	207
Soldiers	Tetuan	1401 (300)	2893 (294)	1123 (466)	0.90 (0.34)	0.009 (5.53)	0.81	0.18	79	
	Algiers	332 (70)	320 (340)	1674 (189)	-0.87 (0.56)	0.046 (0.007)	15.31 (1.92)	0.37	0.31	306
<b>Panel B: Late</b>										
Sailors	Tetuan	651 (147)	229 (1424)	4115 (1415)	-0.85 (0.61)	0.027 (0.008)	17.48 (6.28)	0.63	0.47	29
	Algiers	586 (126)	1687 (1164)	1008 (636)	0.76 (0.43)	0.027 (0.009)	15.82 (3.89)	0.81	0.17	23
Fishermen	Tetuan	473 (117)	2734 (400)	854 (404)	0.45 (0.49)	0.026 (0.006)	12.13 (3.18)	0.48	0.30	110
	Algiers	332 (113)	1778 (582)	2252 (748)	-0.90 (0.24)	0.068 (0.016)	22.45 (6.08)	0.87	0.50	152
Soldiers	Tetuan	429 (94)	760 (1003)	2631 (635)	-0.81 (0.40)	0.024 (0.004)	10.22 (2.37)	0.69	0.38	132
	Algiers	679 (81)	2859 (1029)	1541 (1244)	-0.25 (0.57)	0.030 (0.014)	20.45 (2.90)	0.90	0.20	148

Notes: Panel A provides estimates using the sample before 1640 in Tetuan and before 1680 in Algiers. Panel B uses the sample after these dates.  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales).  $\sigma_v$  is the standard deviation of this distribution (given in constant silver reales).  $\rho$  is the covariance between earmarked and general funds.  $r$  is the interest rate.  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.

Table 5: Estimates using lognormal value distribution

<b>Location</b>	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$r$ (4)	$c$ (5)	$EV_{duration}$ (6)	$EV_{price}$ (7)	$N$ (8)
<b>Sailors</b>								
Tetuan	494 (425)	3767 (393)	664 (832)	0.013 (0.005)	6.23 (7.06)	0.73	0.21	93
Algiers	434 (63)	1107 (355)	2832 (537)	0.034 (0.007)	14.92 (1.63)	0.76	0.21	146
<b>Fishermen</b>								
Tetuan	626 (151)	2912 (342)	3315 (870)	0.035 (0.010)	22.17 (6.10)	0.47	0.43	149
Algiers	359 (54)	1657 (306)	1986 (623)	0.053 (0.009)	18.99 (2.30)	0.74	0.28	359
<b>Soldiers</b>								
Tetuan	621 (203)	1608 (787)	5069 (1409)	0.023 (0.008)	14.17 (4.25)	0.69	0.38	211
Algiers	239 (119)	1573 (774)	4006 (1180)	0.079 (0.015)	19.02 (7.11)	0.39	0.38	454

Notes:  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales).  $\sigma_v$  is the standard deviation of this distribution (given in constant silver reales).  $r$  is the interest rate.  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.

Table 6: Estimates on a sample without suspected bundles

<b>Location</b>	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$\rho$ (4)	$r$ (5)	$c$ (6)	$EV_{duration}$ (7)	$EV_{price}$ (8)	$N$ (9)
<b>Sailors</b>									
Tetuan	1426 (265)	1203 (893)	2261 (670)	-0.82 (0.79)	0.006 (0.003)	9.07 (3.41)	1.01	0.12	40
Algiers	511 (38)	147 (403)	1618 (198)	-0.77 (0.58)	0.024 (0.003)	12.41 (0.90)	0.84	0.19	103
<b>Fishermen</b>									
Tetuan	566 (279)	48 (1075)	3204 (912)	0.77 (0.78)	0.045 (0.028)	25.18 (7.87)	0.43	0.39	70
Algiers	393 (86)	1229 (594)	885 (263)	-0.53 (0.34)	0.034 (0.008)	13.47 (1.94)	0.86	0.23	233
<b>Soldiers</b>									
Tetuan	529 (184)	1258 (1207)	2785 (558)	-0.84 (0.35)	0.027 (0.007)	14.21 (3.97)	0.67	0.36	108
Algiers	365 (53)	55 (292)	1790 (213)	-0.83 (0.15)	0.034 (0.008)	12.38 (1.49)	0.45	0.22	308

Notes:  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales),  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales),  $\sigma_v$  the standard deviation of this distribution (given in constant silver reales),  $\rho$  is the covariance between earmarked and general funds,  $r$  is the interest rate,  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales),  $pr_{termination}$  is the probability the negotiation was terminated.  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.

Table 7: Estimates with lognormal distribution and for additive error in negotiations length

<b>Location</b>	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$\rho$ (4)	$r$ (5)	$c$ (6)	$EV_{duration}$ (7)	$EV_{price}$ (8)	$N$ (9)
<b>Sailors</b>									
Tetuan	458 (97)	3780 (387)	1090 (193)	-0.06 (0.51)	0.014 (0.004)	6.58 (2.04)	0.99	0.32	93
Algiers	381 (66)	364 (1005)	1548 (195)	-0.75 (0.41)	0.025 (0.003)	9.37 (1.74)	0.99	0.19	146
<b>Fishermen</b>									
Tetuan	543 (271)	2692 (446)	1144 (328)	-0.02 (0.48)	0.015 (0.005)	8.37 (2.13)	0.98	0.34	149
Algiers	490 (40)	2952 (830)	1039 (58)	-0.58 (0.20)	0.021 (0.003)	10.26 (1.99)	0.99	0.25	359
<b>Soldiers</b>									
Tetuan	544 (168)	2565 (641)	1266 (315)	-0.48 (0.49)	0.013 (0.003)	7.22 (1.15)	0.99	0.28	108
Algiers	628 (29)	1319 (102)	1060 (48)	0.29 (0.68)	0.027 (0.001)	16.78 (0.60)	0.30	0.08	454

Notes:  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales),  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales),  $\sigma_v$  the standard deviation of this distribution (given in constant silver reales),  $\rho$  is the covariance between earmarked and general funds,  $r$  is the interest rate,  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales),  $pr_{termination}$  is the probability the negotiation was terminated.  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.

Table 8: Estimates during periods of political instability in Algiers

Regime	$\lambda$ (1)	$\mu_v$ (2)	$\sigma_v$ (3)	$\rho$ (4)	$r$ (5)	$c$ (6)	$EV_{duration}$ (7)	$EV_{price}$ (8)	$N$ (9)
Stable	472 (44)	262 (240)	1206 (78)	0.46 (0.09)	0.026 (0.005)	12.48 (1.19)	0.81	0.14	236
Non-stable	359 (80)	1655 (544)	2159 (674)	-0.10 (0.29)	0.063 (0.013)	22.46 (4.14)	0.85	0.51	123
Difference	-113 (91)	1393 (594)	954 (679)	-0.56 (0.30)	0.036 (0.014)	9.98 (4.31)			
Stable	274 (56)	251 (444)	2065 (264)	0.60 (0.11)	0.057 (0.008)	15.66 (1.94)	0.66	0.31	363
Non-stable	248 (104)	265 (1341)	4791 (1606)	0.20 (0.42)	0.044 (0.013)	10.98 (2.66)	0.43	0.39	91
Difference	-25 (118)	14 (1412)	2726 (1627)	-0.40 (0.44)	-0.013 (0.015)	-4.68 (3.30)			

Notes:  $\lambda$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $\mu_v$  is the mean of the distribution of money which could be paid from the general funds for a captive (given in constant silver reales).  $\sigma_v$  is the standard deviation of this distribution (given in constant silver reales).  $\rho$  is the covariance between earmarked and general funds.  $r$  is the interest rate.  $c$  is the monetary equivalent of transaction costs per day (given in constant silver reales).  $EV_{duration}$  gives the percent of the variation in durations that is successfully explained by the model and  $EV_{price}$  gives the percent of variation in prices explained.  $N$  gives the number of observations used in estimation. Standard errors in parentheses.