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Technical Appendix to

JEWISH PERSECUTIONS AND WEATHER SHOCKS: 1100–1800

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Appendix A. Descriptive Statistics

Table A1
Descriptive Statistics: Five-year Data

Variable	Mean	SD	Minimum	Maximum	Observations
Persecution					
Overall	2.242	14.806	0.000	100.000	N = 55,698
Between		3.062	0.000	33.333	n = 933
Within		14.643	−31.091	101.523	T-bar = 59.6977
Expulsion					
Overall	1.409	11.788	0.000	100.000	N = 55,698
Between		2.579	0.000	33.333	n = 933
Within		11.670	−31.924	100.685	T-bar = 59.6977
Lag1Weather					
Overall	−0.054	0.340	−1.278	1.370	N = 55,698
Between		0.099	−0.544	0.452	n = 933
Within		0.330	−1.437	1.257	T-bar = 59.6977
LowAntiquity					
Overall	0.380	0.485	0.000	1.000	N = 55,698
Between		0.409	0.000	1.000	n = 933
Within		0.285	−0.588	1.363	T-bar = 59.6977
LowSuitability					
Overall	0.477	0.499	0.000	1.000	N = 55,698
Between		0.495	0.000	1.000	n = 933
Within		0.000	0.477	0.477	T-bar = 59.6977
LowCapital					
Overall	0.777	0.416	0.000	1.000	N = 55,698
Between		0.378	0.000	1.000	n = 933
Within		0.200	−0.120	1.767	T-bar = 59.6977
LowConstraint					
Overall	0.411	0.492	0.000	1.000	N = 55,698
Between		0.405	0.000	1.000	n = 933
Within		0.294	−0.498	1.398	T-bar = 59.6977
PopDensity					
Overall	11.766	13.001	0.000	329.829	N = 55,698
Between		11.029	0.000	130.915	n = 933
Within		8.032	−88.051	230.363	T-bar = 59.6977

Notes. See text and Appendix C for descriptions of data. Statistics for in-sample cities (cities with Jewish community present).

Table A2

Descriptive Statistics: One-year Data

Variable	Mean	SD	Minimum	Maximum	Observations
Persecutions					
Overall	0.470	6.832	0.000	100.000	N = 276,359
Between		0.701	0.000	10.000	n = 933
Within		6.816	−9.531	100.325	T-bar = 296.205
Expulsions					
Overall	0.285	5.322	0.000	100.000	N = 276,359
Between		0.597	0.000	10.000	n = 933
Within		5.311	−9.716	100.138	T-bar = 296.205
Temperature$_{i,\ t-1}$					
Overall	−0.055	0.342	−1.388	1.370	N = 276,359
Between		0.098	−0.508	0.370	n = 933
Within		0.332	−1.434	1.257	T-bar = 296.205
LowAntiquity					
Overall	0.380	0.485	0.000	1.000	N = 276,359
Between		0.409	0.000	1.000	n = 933
Within		0.285	−0.600	1.376	T-bar = 296.205
LowSuitability					
Overall	0.429	0.495	0.000	1.000	N = 276,359
Between		0.492	0.000	1.000	n = 933
Within		0.000	0.429	0.429	T-bar = 296.205
PopDensity					
Overall	0.777	0.416	0.000	1.000	N = 276,359
Between		0.379	0.000	1.000	n = 933
Within		0.199	−0.126	1.774	T-bar = 296.205

Notes. See text and Appendix C for descriptions of data. Statistics for in-sample cities (cities with Jewish community present).

Table A3

Descriptive Statistics: Grain Prices

Variable	Mean	SD	Minimum	Maximum	Observations
Wheat Price (log)					
Overall	−54.82	98.44	−409.44	650.32	N = 16,171
Between		88.83	−247.94	580.03	n = 108
Within		46.27	−306.95	186.80	T-bar = 149.731
Temperature					
Overall	−0.15	0.48	−2.01	1.47	N = 16,171
Between		0.14	−0.43	0.23	n = 108
Within		0.47	−2.03	1.39	T-bar = 149.731

Note. See text and Appendix C for descriptions of data.

Appendix B. Further Robustness Tests

As we describe in the main article, we run several additional robustness tests on our data. This Appendix provides further details for the most informative of these.

We run the mechanism regressions for soil suitability and state antiquity using the continuous versions of those variables (as opposed to the dichotomous variables we use in our baseline regressions) in Table B1. Interpreting the size and significance of the interactions in Table B1 is non-trivial since it requires visualising these statistics over a range of values for the interacted

Table B1

Continuous Wheat Suitability and Continuous State Antiquity Variable

	Dependent variable: persecutions			
	(1)	(2)	(3)	(4)
Temperature$_{,t-1}$	6.426*	0.575	−0.980	−1.91**
	(3.227)	(2.15)	0.625)	(0.798)
Low Constraints Wheat × *Temperature*$_{,t-1}$	−2.002**	−0.808		
	(0.805)	(0.496)		
Low Constraints Antiquity			−0.00156	0.0407**
			(0.0347)	(0.0184)
Low Constraints Antiquity × *Temperature*$_{,t-1}$			−0.115*	−0.0984**
			(0.0674)	(0.0445)
Controls	Yes	Yes	Yes	Yes
City dummies	Yes	Yes	Yes	Yes
Time dummies	No	Yes	No	Yes
N	55,696	55,696	55,696	55,696
F	7.18	17.60	5.944	5.329
p-values	0.0002	0.0000	0.0004	0.0015

Notes. *p < 0.10, **p < 0.05, ***p < 0.01. Standard errors in parentheses. Controls are the same as in Table 1. Details about our measures of wheat suitability and state antiquity are in the main text.

variable. As such, we follow the suggestion of Brambor *et al.* (2006) and graph the DID regressions (columns 2 and 4) in Figures B1 and B2. The Figures plot out the overall effect of temperature on persecution probability – i.e. $\partial persecution/\partial temperature = \beta + \zeta \times Mechanism.$ The 95% confidence intervals for these Figures are also included and appropriately take into account the covariance between the coefficients on temperature and the interaction term (Brambor *et al.*, 2006). The Figure illustrating the soil quality regressions clearly shows that for higher quality soil (value <4) there is no relationship between temperature and Jewish persecution. However, as we would expect, as soil quality deteriorates (value > 4), the effect of temperature becomes negative and statistically significant. We get similar, though somewhat stronger results using the continuous version of state antiquity (which we recode so that higher values of the variable indicate more recent states).

One potential source of bias in the standard errors of our regressions stems from serial or spatial correlation (Bertrand and Mullainathan, 2004; Conley, 2008). In Table B2, we control for these potential biases using the method suggested by Conley (2008) and implemented in Stata code by Hsiang (2010). We take into account spatial influence of all cities within a 300 km circle surrounding each city. We also assume an AR(2) process. Our estimates are unaffected although our standard errors increase somewhat.

We extracted rainfall data contained in Pauling *et al.* (2006) for our cities between 1500 and 1799.[1] We extracted the data in a very similar way to show how we created the city-year temperature data. Figure C7 illustrates the data grid and contour map we created for summer 1500 showing rain accumulations in centimetres. As a robustness check on our findings, we expect that extreme values of rainfall, like extreme temperature, would lead to lower agricultural output and therefore produce the kind of subsistence crises that made persecutions more likely. The rainfall data largely confirm this hypothesis. Table B3 shows the effect of running our baseline specifications using the log of five-year lag of average rainfall as the variable of interest. Using the sample covering all the years for which rainfall data are available (1500–799), we get mixed support.

[1] We use the series on summer rainfall amounts.

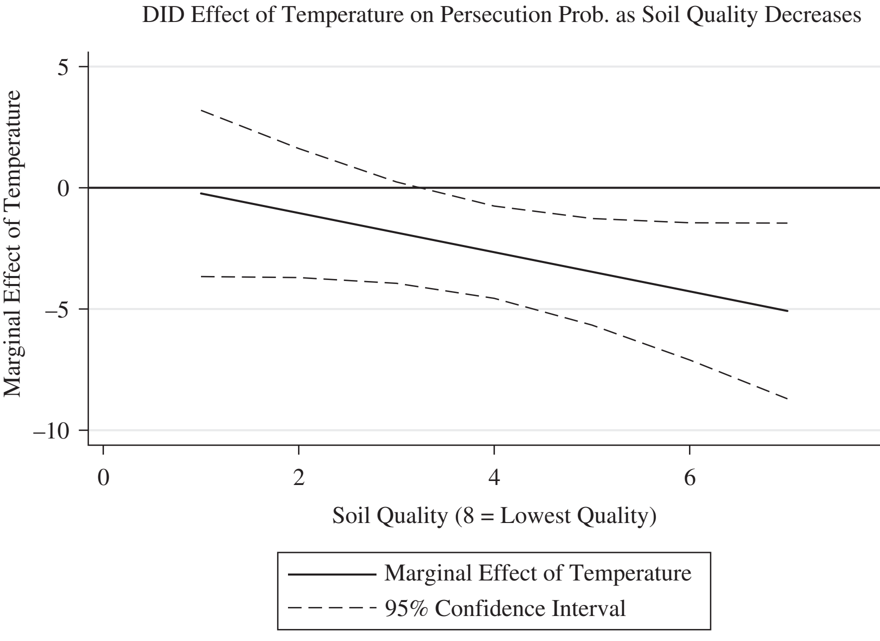


Fig. B1. *The Effect of Colder Temperature in Areas with Lower Quality Soil Using a Continuous Measure of Soil Quality*

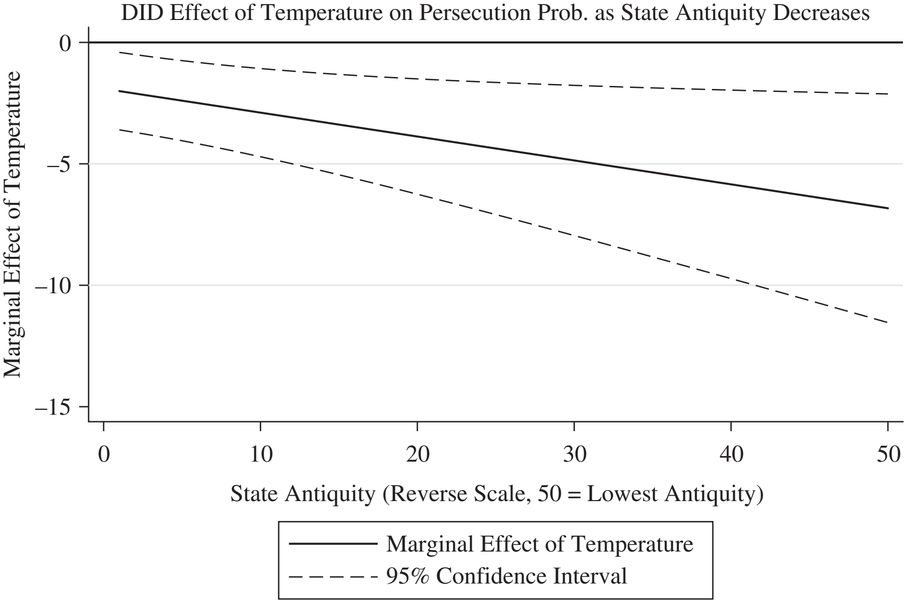


Fig. B2. *The Effect of Colder Temperature in Areas with Lower State Antiquity Using a Continuous Measure of State Antiquity*

Table B2

Mechanism Regressions Controlling for Spatial and Serial Correlation

	Dependent variable: persecutions									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Temperature$_{,t-1}$	−2.52***	−3.19**	−1.22**	−2.53**	−1.38***	−2.20*	−2.76**	−3.59**	−3.07*	−3.30*
	(0.89)	(1.51)	(0.475)	(1.27)	(0.52)	(1.15)	(1.20)	(1.65)	(1.82)	(1.89)
Low Wheat			−0.414	−1.65						
			(0.29)	(1.67)						
Low Wheat × *Temperature*$_{,t-1}$			−2.76	−1.13						
			(1.72)	(0.9)						
Low State Antiquity					0.757	2.09***				
					(0.5)	(0.5)				
Low State Antiquity × *Temperature*$_{,t-1}$					−2.91	−2.34*				
					(1.94)	(1.34)				
Low Constraints							−1.38**	0.321		
							(0.56)	(0.5)		
Low Constraints × *Temperature*$_{,t-1}$							1.28	1.36		
							(1.1)	(0.8)		
Low Capital Protect									−1.50	0.259
									(2.12)	(1.63)
Low Capital Protect × *Temperature*$_{,t-1}$									0.91	0.11
									(1.90)	(1.9)
Temperature$_{,t-1}$ + *Interaction*			−3.98**	3.66**	−4.30**	−4.54**	−1.48***	−2.23*	−2.17***	−3.19**
			(1.71)	(1.74)	(1.93)	(2.12)	(0.54)	(1.27)	(0.79)	(1.33)
Correct for Spatial Dep	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correct for Serial Corr	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	55,698	55,698	55,698	55,698	55,698	55,698	55,698	55,698	55,698	55,698
Adjusted R^2	0.056	0.123	0.057	0.124	0.057	0.126	0.057	0.124	0.056	0.123

Notes. *p< 0.10, **p < 0.05, ***p < 0.01. Coefficients are multiplied by 100. We control for spatial and serial correlation using the method suggested by Conley (2008) and implemented in Stata code by Hsiang (2010). We take into account spatial influence of all cities within a 500 km circle surrounding each city. We also assume an AR(2) process.

Table B3

Baseline Rainfall Regressions

	Dependent variable: persecutions				
	(1)	(2)	(3)	(4)	(5)
$Rainfall_{t-1}$	−2.04***	−0.488	−0.107	−0.417	0.0861
	(0.494)	(0.795)	(0.325)	(0.772)	(0.983)
Pre-1600			32.97***	0.0991	0.0991
			(5.378)	(3.882)	(11.28)
Pre-1600*$Rainfall_{t-1}$			−4.376**	−0.745	−4.429**
			(6.842)	(5.361)	(5.361)
$Rainfall_{t-1}$ + *Interaction*			−5.840***	−0.897	−7.115**
			(1.200)	(1.306)	(2.891)
Controls	Yes	Yes	Yes	Yes	Yes
City dummies	No	Yes	No	Yes	Yes
Time dummies	No	Yes	No	Yes	No
City-specific Intercept	No	No	No	No	Yes
N	23,094	23,094	23,094	23,094	23,094
F	11.15	3.752	16.04	3.696	3.081

Notes.*p < 0.10, **p < 0.05, ***p < 0.01. Standard errors in parentheses. Coefficients are reported with standard errors clustered at the city level. Controls refer to urban population. Columns (1)–(2) report the baseline effect of rainfall on persecution probability. Columns (3)–(5) include an interaction term with a pre-1600 dummy. Column (5) allows each city its own intercept.

The OLS regression in column yields a coefficient of −2.04 which suggests that a one standard deviation in rainfall (0.28) increases persecution probability by about half of a percentage point. However, this coefficient shrinks considerably and loses statistical significance once we introduce city fixed effects and time dummies.

We know from our earlier analysis that the relationship between supply shocks and persecution of Jews weakened over the course of the early modern period as states developed more fiscal and legal capacity. Recognising this fact, we introduce an interaction term for the period before 1600. These are reported in columns (3)–(5) of Table B3. We obtain significantly larger coefficients for years prior to 1600 indicates that the relationship between rainfall and persecutions was indeed stronger in this period. Column (3) suggests that the combined effect of a one standard deviation decrease in rainfall would raise persecution probability by 1.6 percentage points (0.28×5.84). Due to the small number of observations that we have for the period before 1600, and the fact that the time dummies absorb a lot of variation, we do not obtain statistically significant coefficients in our DID regression. However, when we use a flexible specification that allows each city to have its own intercept we do obtain an estimate that is comparable in magnitude to the coefficient that we obtain in the OLS regression.

In Table B4, we run our mechanisms regressions using the rainfall variable during the sixteenth and seventeenth centuries. The results largely mirror what we find using temperature. The DID estimate of the interaction between poor soil quality and rainfall on persecution probability is large and statistically significant. The overall effect of low rainfall on persecution probability ($\partial Persecution/\partial Rainfall$) suggested by the estimates in column (2) is −5.23. In other words, a one standard deviation decrease in rainfall increases persecution probability by 1.5% relative to the baseline probability of 2.2% in areas with low soil quality. In contrast, in areas with good soil quality, the effect of a one standard deviation decrease in rainfall leads only to a 0.45% increase in persecution probability (and this effect is statistically insignificant). The overall effect of the state antiquity variable is similarly large with a one standard deviation decrease in rainfall

Table B4

Mechanism Regressions with Rainfall Data

	Dependent variable: persecutions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Rainfall_{t-1}$	0.674	−1.61	0.968	−0.667	−0.435	−3.22*	−4.29*	−5.79**
	(1.21)	(1.56)	(1.13)	(1.58)	(1.26)	(1.79)	(2.29)	(2.45)
Low Wheat × $Rainfall_{t-1}$	−3.55*	−3.62*						
	(1.98)	(1.96)						
Low State Antiquity			20.7**	20.6*				
			(9.92)	(10.80)				
Low State Antiquity × $Rainfall_{t-1}$			−3.70**	−3.93**				
			(1.78)	(1.95)				
Low Constraints					0.0443	−5.24		
					(11.3)	(12.3)		
Low Constraint × $Rainfall_{t-1}$					−0.138	0.863		
					(2.09)	(2.26)		
Low Capital Protection × $Rainfall_{t-1}$							4.57*	3.75
							(2.50)	(2.42)
$Rainfall_{t-1}$ + *Interaction*	−0.0288*	−0.0523***	−0.0273*	−0.0460**	−0.00573	−0.0236	0.0028	−0.0204
	(0.0160)	(0.0197)	(0.0151)	(0.01832)	(0.0163)	(0.01874)	(0.0107)	(0.0149)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes
N	13,065	13,065	13,065	13,065	13,065	13,065	13,065	13,065
F	7.654	3.243	6.303	3.240	5.035	3.139	7.903	3.306
p-values	0.0001	0.0000	0.0001	0.0000	0.0005	0.0000	0.0000	0.0000

Notes. *p < 0.10, **p < 0.05, ***p < 0.01. Standard errors clustered at the city-level in parentheses. Controls are the same as those employed in Table 2. We do not report coefficients for the effect of Low Capital because of insufficient variation in this variable for the period 1500–799.

leading to a 1.3% increase in persecutions in cities within more recently developed states. Older states, which presumably also possess greater legal and fiscal capacity, exhibit no statistically or economically significant relationship between rainfall and persecutions. Finally, consistent with the temperature mechanisms regressions, rainfall exhibits no significant relationship between capital protection or constraints on the executive. This is, again, in keeping with our overall story that the breakdown in the relationship between supply shocks and Jewish persecution was driven more by increases in state capacity than by constraints on the power of rulers.

Overall, the rainfall analysis supports our baseline analysis using temperature shocks. This is provides us with considerable confidence concerning the validity of our findings as the rainfall data come from a completely different source than our temperature data. In fact, there is very little statistical relationship between the two measures. During the sixteenth and seventeenth centuries, the correlation between rainfall and temperature is only −0.047.

Appendix C. Data

Data on Jewish presence in cities is taken from city entries in the *Encyclopedia Judaica* 2007. The *Encyclopedia Judaica* typically mentions when Jews entered a city, when they were persecuted, when they were expelled, and when they were allowed re-entry. Using this information a database was created of 1,069 cities that had a Jewish presence at some point from 1000 to 1800. Figure 1 plots every city in our full database. In our empirical analysis, we utilise the 933 cities for which we can obtain urbanisation data.

The Existence of a Jewish Community

Our data set includes all cities that are recorded as having a permanent Jewish population in the period under consideration. As we note in the text, we explicitly code whether or not a Jewish community is present for every between 1100 and 1800. We do this on the basis of the information contained in the *Encyclopedia Judaica*. We are able to do this because for many communities the Encyclopedia explicitly mentions the date when a Jewish community is first recorded. For example, in Florence the first Jewish community was officially established in 1437. Alternatively, in other cases the Encyclopedia mentions the first date at for which we know for certain that there is a Jewish community. For example, in the entry for Trier, the Encyclopedia notes that ‘The first definitive evidence for the presence of a Jewish community dates from 1066, when the Jews were saved from an attempted expulsion on the part of Archbishop Eberhard through his sudden death at the altar’ (Encyclopedia Judaica, 2007, p. 143). The entry for Burgus gives 974 as the data in which we know there was a Jewish community. Often the data of first entry is a rough estimate. The York entry records that Jews settled in the middle of the twelfth century. We therefore code a community as present from 1150 onwards. Similarly, we are told that Jews moved to Drogobych, Ukraine to work as contractors in the salt mines in the beginning of the fifteenth century, so a date of 1410 was used.

There are some communities for which the first information we have concerning a community is information on a pogrom. To overcome this problem, we assume that a community has to have been present for either 50 years before the pogrom is mentioned. For example, Jews in Chomutov (Czech Republic) were first mentioned as being massacred in 1421, so the dates 1371 was used as the main date of entry. We also consider 1, 25, 75 and 100 year internals prior to a communities prior to first mention in the Encyclopedia. These robustness checks do not change our baseline reasons and are available upon request.

Figure C1 provides a visual representation of our data. All of the 1,069 cities in our full database possessed Jewish communities at some point between 1100 and 1800. But expulsions could only occur in cities with a Jewish population in that year. A city that had expelled its Jewish population the year previously cannot expel them again unless the Jewish community in question

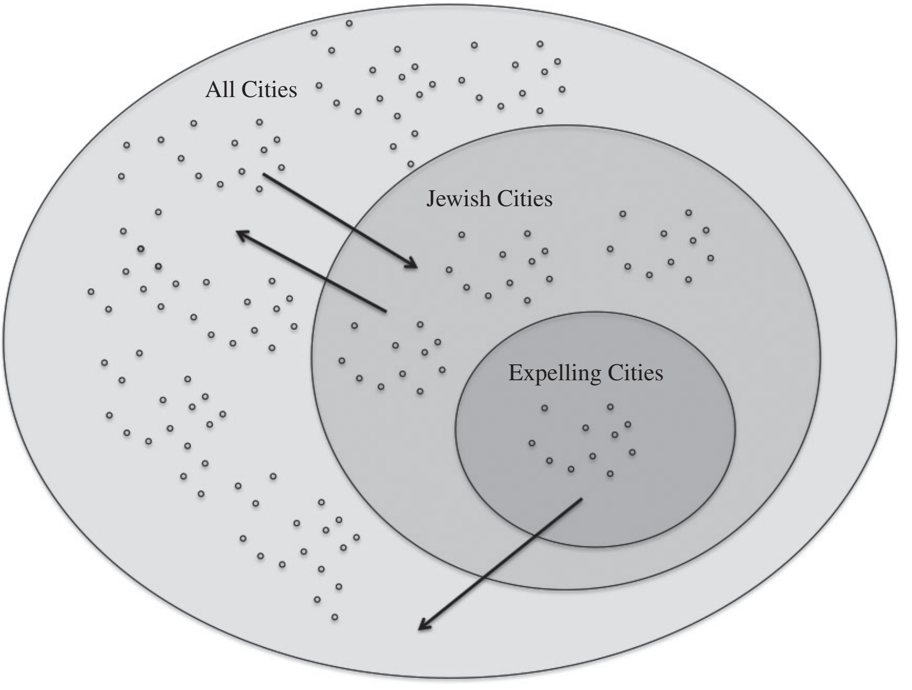


Fig. C1. *Cities in Our Data set*

Notes. All the 1069 cities in our database contain Jewish communities at some point between 1100 and 1800. In any given year, a city either has a Jewish community or not. Only cities with Jewish communities are included in our sample as countries liable to conduct an expulsion.

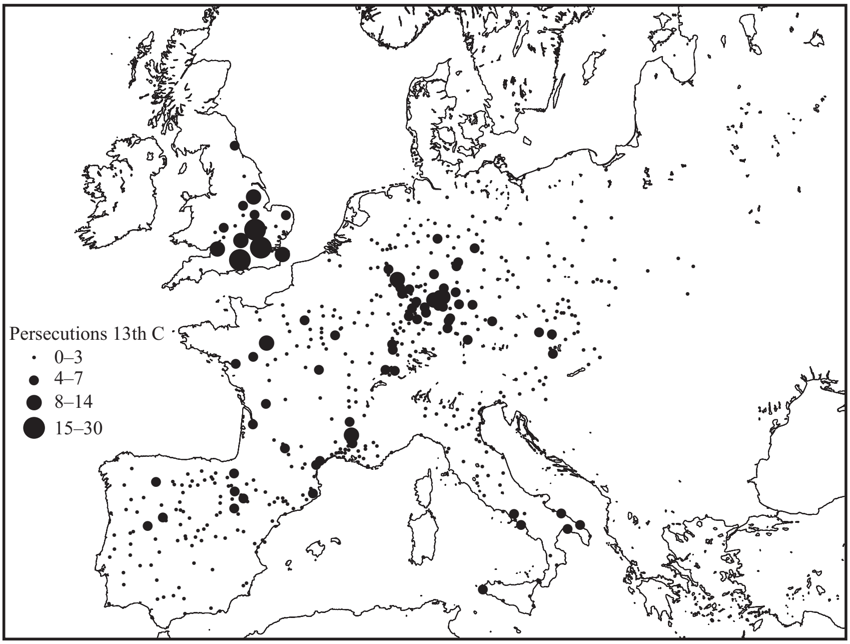
had returned in the meantime. Thus, our regressions use only the sample represented by the two darker sets of cities.

Data on Persecutions

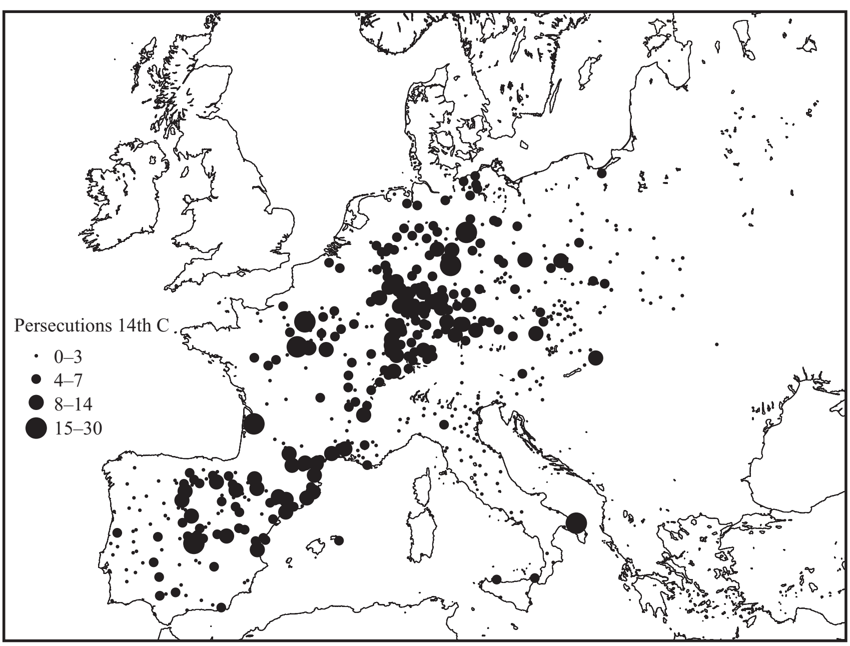
There are 1,366 persecutions in our full database: 785 expulsions and 614 pogroms. We have omitted all instances of persecution that cannot be dated. But we have included the cities in question in the sample if they had a documented Jewish population. The direction of this measurement error biases our coefficients downwards.

For example, Bonn is in our database as it had a Jewish community prior to 1100. This community was expelled and massacred in 1348 but is recorded as having returned to the city by 1381. There was also an expulsion in the fifteenth century that we omit because it is not dated. Occasionally, Jews left a city or a region for voluntary reasons. We have noted this in our database and these do not count such an observation as an expulsion even when the reasons for their leaving often had to do with the imposition of discriminatory taxes on Jews or the threat of popular violence. Figure 1 in the main text shows the distribution of expulsions across the cities in our database.

Figures C2*a* to *f* plot the number of persecutions per century. Our main empirical result is the strong causal link between negative temperature shocks and persecutions in the fifteenth and sixteenth centuries. Figures C2*c* and *d* show that the cities that drive this result are clustered in Spain, Portugal and Germany during the fifteenth century. Persecuting cities cluster in Germany, Italy and to a lesser extent eastern Europe in the sixteenth century.

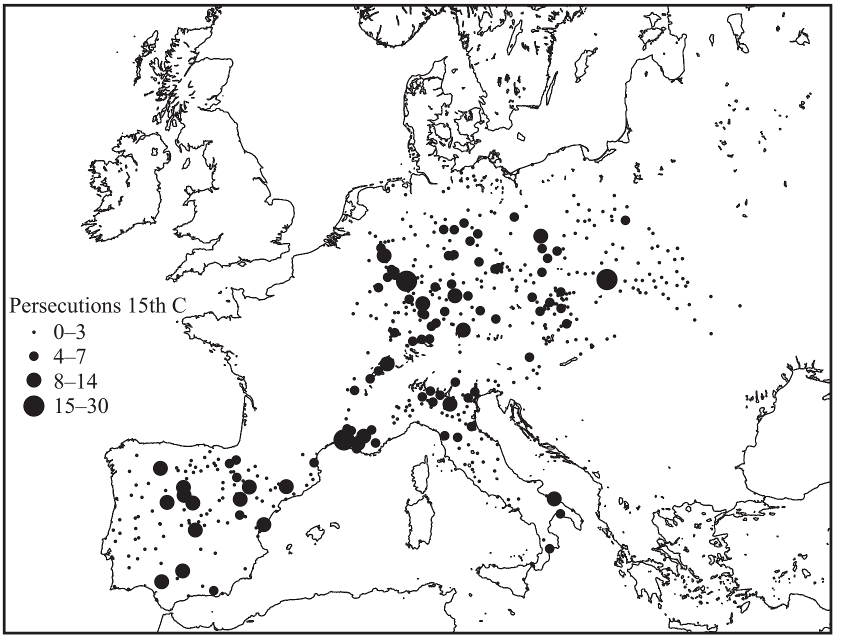


(*a*)



(*b*)

Fig. C2. *(a) 13th Century Expulsions. (b) 14th Century Expulsions. (c) 15th Century Expulsions. (d) 16th Century Expulsions. (e) 17th Century Expulsions. (f) 18th Century Expulsions*



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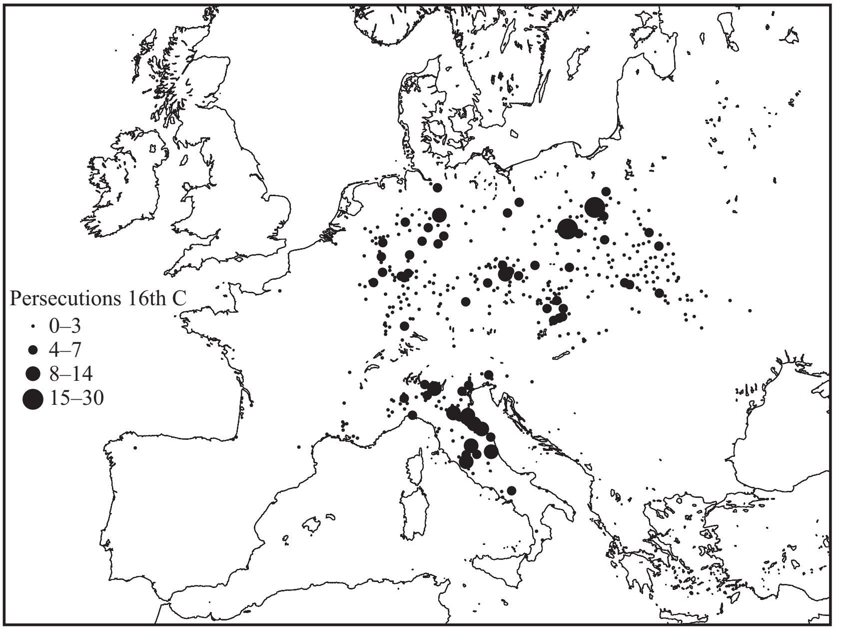
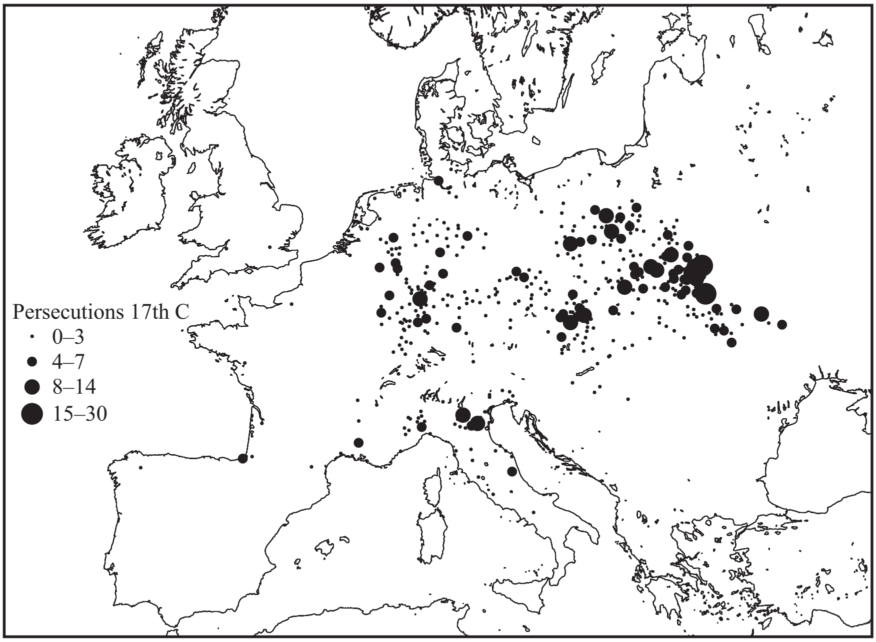


(*d*)

Fig. C2. *(Continued)*



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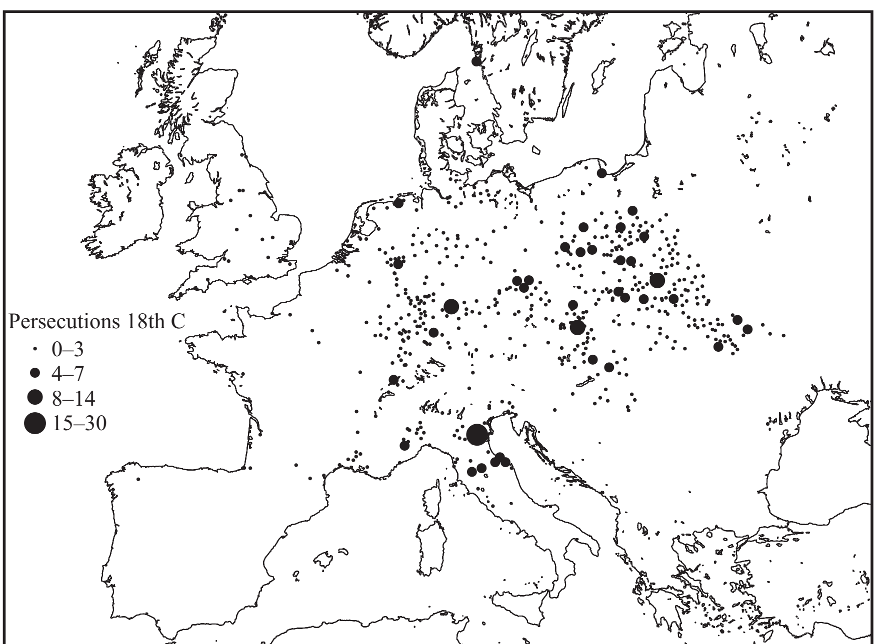


(*f*)

Fig. C2. *(Continued)*

The Decision to Establish a Jewish Community

The majority of Jewish communities in western Europe were established between 900 and 1200. This is before the major period of Jewish expulsions and persecutions. Jewish settlement was largely driven by the expansion of the European economy known as the Commercial Revolution. There is no evidence that the decision to establish a Jewish community in this period was influenced by the likelihood of expulsion or persecution. We therefore treat initial Jewish settlement as exogenous.

There is more concern that Jewish settlement in the period after 1300 was affected by the fear of persecution or expulsion. However, the available historical evidence mitigates this concern somewhat. For example, we know from documentary evidence that the Jews of England settled in France following their expulsion in 1290 as this was the geographically closest and culturally most similar Jewish community (the Jews of England spoke French) despite the fact that Jews in that country had suffered numerous local persecutions and expulsions and would in fact be expelled *en masse* by Philip IV in 1306 (Huscroft, 2006; Mundill, 2010). Similarly, the Jews of France were willing to return to France after this expulsion as they indeed did in 1315 even though they faced the threat of similar events occurring in the future.

This does not mean that Jews were irrational or that they failed to perceive the threat of persecution. On the contrary, they frequently negotiated contracts that guaranteed their protection with secular rulers as a condition of settlement. However, as we argue, the contracts typically proved unenforceable in the face of large negative shocks (such as those associated with bad harvests or the Black Death) (Baron, 1965*a*, 1967*a*). Nor was there any location where Jews could go where they would be free from persecution; persecutions were less common in the Islamic Middle East but they still did take place on occasion (Cohen, 1994). A factor that cannot be discounted was Jewish religious tradition, which encouraged Jews to see the period of exile following the destruction of the Second Temple as a period of necessary and inevitable suffering.

Finally, there were also sound economic reasons for this behaviour. Jewish commercial networks required Jewish communities to be spread across a wide geographical area. This enabled them to diversify across space and smooth idiosyncratic shocks (Botticini, 1997). Moreover, the prohibition of lending at interest meant that the demand for Jewish moneylending services was highest precisely in areas that did not have a Jewish community. This was an important factor in encouraging Jewish communities to spread across western and central Europe.

Conversion

In medieval and early modern Europe, Jewish identity was both a religious and an ethnic identity. In our analysis, we assume that Jewish identity is fixed. In reality of course, Jewish religious, if not ethnic, identity was a choice variable that could respond endogenously to political and economic incentives. In this Section, we argue that treating Jewish identity and fixed in short-term is appropriate.

Jewish religious identity evolved in the long-run in response to economic and political incentives. After Judaism became a literate religion, there is strong evidence suggesting that it only flourished in regions with a commercial economy and some level of urbanisation while it declined in predominantly agrarian economies (Botticini and Eckstein, 2012).

However, there is little evidence that the adherents to Judaism varied in response to short-run political variables. This is unsurprising for several reasons. First, there is a large amount of evidence that suggests that persecuting members of a particular religion tends to strengthen their belief (Stark, 1996, ch. 8).[2] Certainly, the threat of expulsion or persecution clearly limited the attraction of converting to Judaism in the medieval period.[3] But with a few notable exceptions it did not induce Jews to convert to Christianity in large numbers. Monter (1994, p. 6) observes that Islam and Judaism have never 'yielded many voluntary converts to Christianity: the history of futile Christian programmes to convert Jews cannot be treated adequately without superhuman erudition and Voltairean wit'.

Second, converted Jews were often not accepted into mainstream Christian society and faced hostility from both Jewish and Christian communities. A large number of conversions occurred in Spain in the aftermath of the massacres that took place in 1391. These conversions did not end Christian hostility to Jewish converts. Converted Jews – known as conversos – faced persecutions in Toledo and León in 1449, while between 1459 and 1464 there was unrest against conversos in Burgos. In the 1460s, they were attacked in Jaén. Persecutions occurred in Seville, Toledo and Burgos throughout the 1460s while in 1473 conversos were massacred in Cordoba, Montoro, Bujalance, Adamar, La Rabla, Santaella, Ecija, Andújar, Ubeda, Baeza, Almódovar del Caomp and Jaén (Ruiz, 2007, p. 156). As is well known, this persecution of the conversos intensified after the mass expulsion of Jews from the Iberian peninsula at the end of the fifteenth century.

Third, Jews were typically given the option to convert only after or in the aftermath of a persecution of expulsion. Malkiel (2001), e.g. argues that Jewish chroniclers had an incentive to elevate the choice between apostasy and death in a heroic act. However, in instances like the massacres that accompanied the First Crusade in 1096, there is little evidence that this was the case. He suggests that the crusaders murdered Jews because that was their 'primary intention' and not because 'the Jews refused conversion' (Malkiel, 2001, p. 259). The possibility that Jews converted to Christianity in the wake of a persecution or expulsion does not affect our theoretical or empirical analysis. And the evidence suggests that conversions rarely occurred in anticipation of a persecution.

Soil Quality

Our preferred measure of soil quality is wheat suitability from the FAO. The FAO database is constructed using two types of information. Detailed information on the characteristics of 154 crops is compiled to determine what sorts of geographic and climatic conditions are optimal for growing each plant. This information is combined with climatic and geographic data collected on a very disaggregated level. The climate data include measures of precipitation, frequency of wet days, mean temperature, daily temperature range, vapour pressure, cloud cover, sunshine, ground-frost frequency and wind speed. The geographic data include information on soil types and slope characteristics. The FAO combines these data to construct potential yields for each crop in each grid cell under different levels of inputs and management. We assume a 'moderate' level of inputs to wheat cultivation. This is consistent with farmers who produce primarily for home consumption but with some market orientation. Figure C3 shows the resulting suitability of wheat cultivation across Europe. We extract the wheat suitability for each of our cities using geospatial software and create a dummy variable equal to one if a city has an agricultural sector that is either moderately or significantly constrained in its wheat cultivation. This is the main variable 'Low Wheat' that we use in our regressions.

[2] This is what one would expect from the economics of religion literature, notably Iannaccone (1992).

[3] While the Church taught that Jews should be tolerated as 'witnesses,' Christians who converted to Judaism were typically treated as heretics and executed.

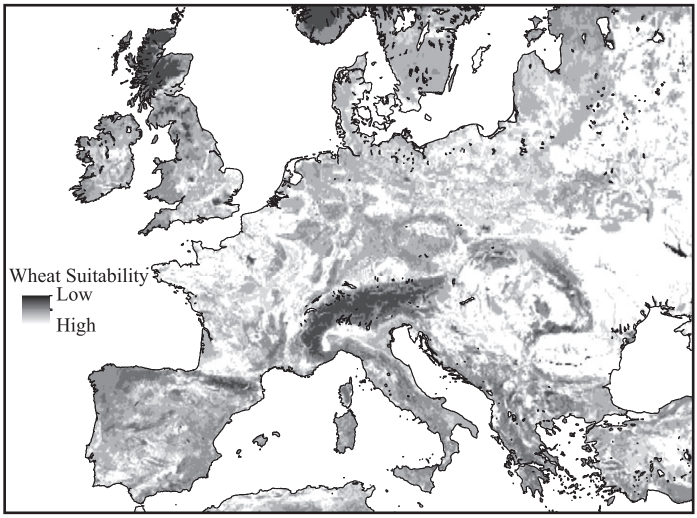


Fig. C3. *Wheat Suitability*
Notes. A lighter shade indicates that the soil is more suitable for wheat cultivation.
Source. Fischer *et al.* (2002).

Urban Density

Our urban density variable is based on the Bosker *et al.* (2013). Figure C4 shows the location of the eighteenth century Bosker *et al.* cities relative to all of our Jewish cities. The Bosker *et al.* cities are shown as open circles whereas the Jewish cities are points. The weakest coverage of Bosker *et al.* cities is in eastern Europe, particularly, Lithuania and Ukraine.

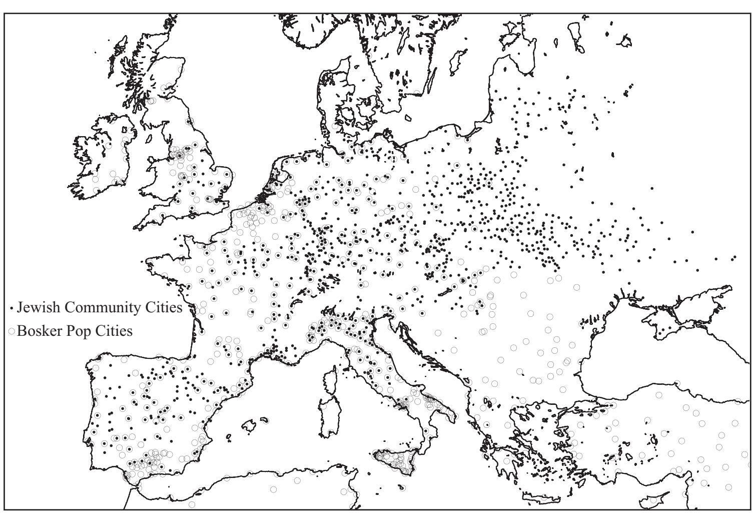
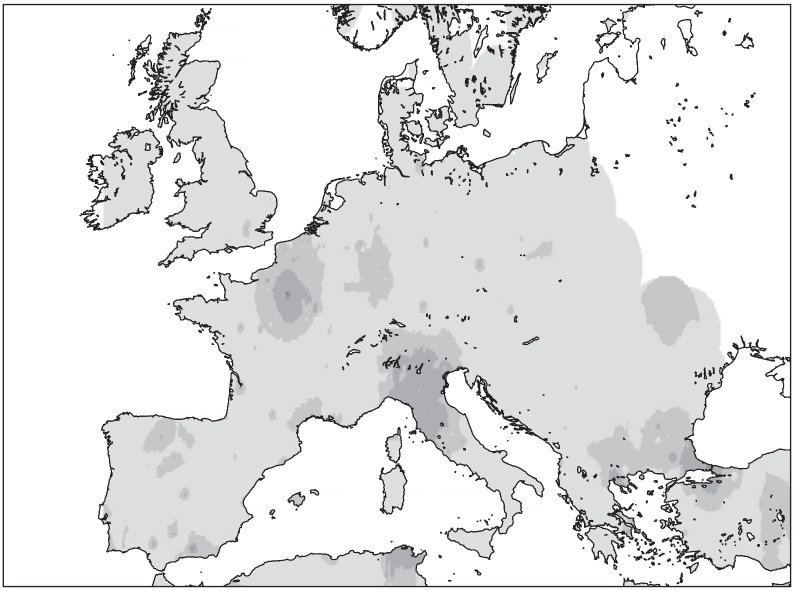
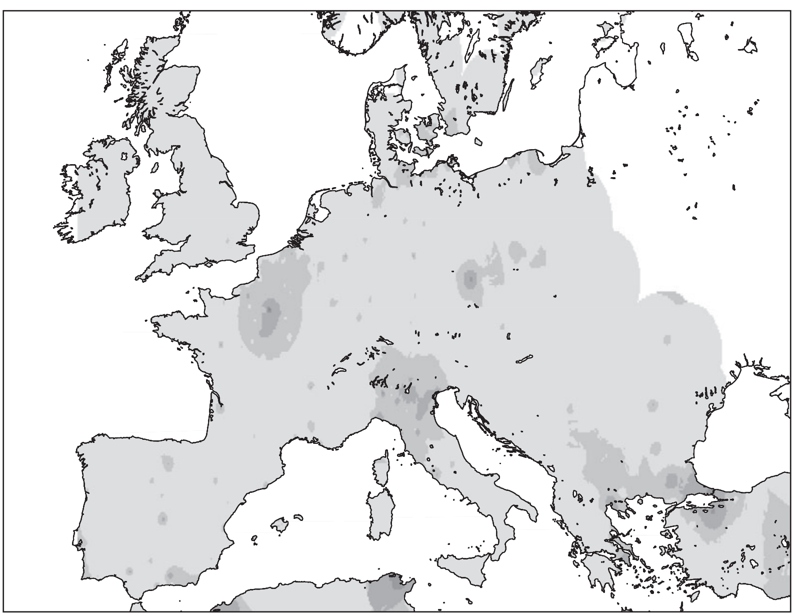


Fig. C4. *The Distribution of Bosker et al. (2013) Cities and Jewish cities*
Notes. Open circles represent Bosker *et al.* cities. Points represent Jewish cities in our database.
Source. Encyclopedia Judaica (2007); Bosker *et al.* (2013).

We use geospatial software to create a heat map for every century based on population of all Bosker *et al.* cities with populations greater than 5,000. Each point on the map is assigned a population number based on the inverse distance-weighted value of all Bosker *et al.* cities within 1 degree of the point (about 100 kilometres depending on the latitude of the point). The maps for each century are reproduced below as Figures C5*d* to *f*.

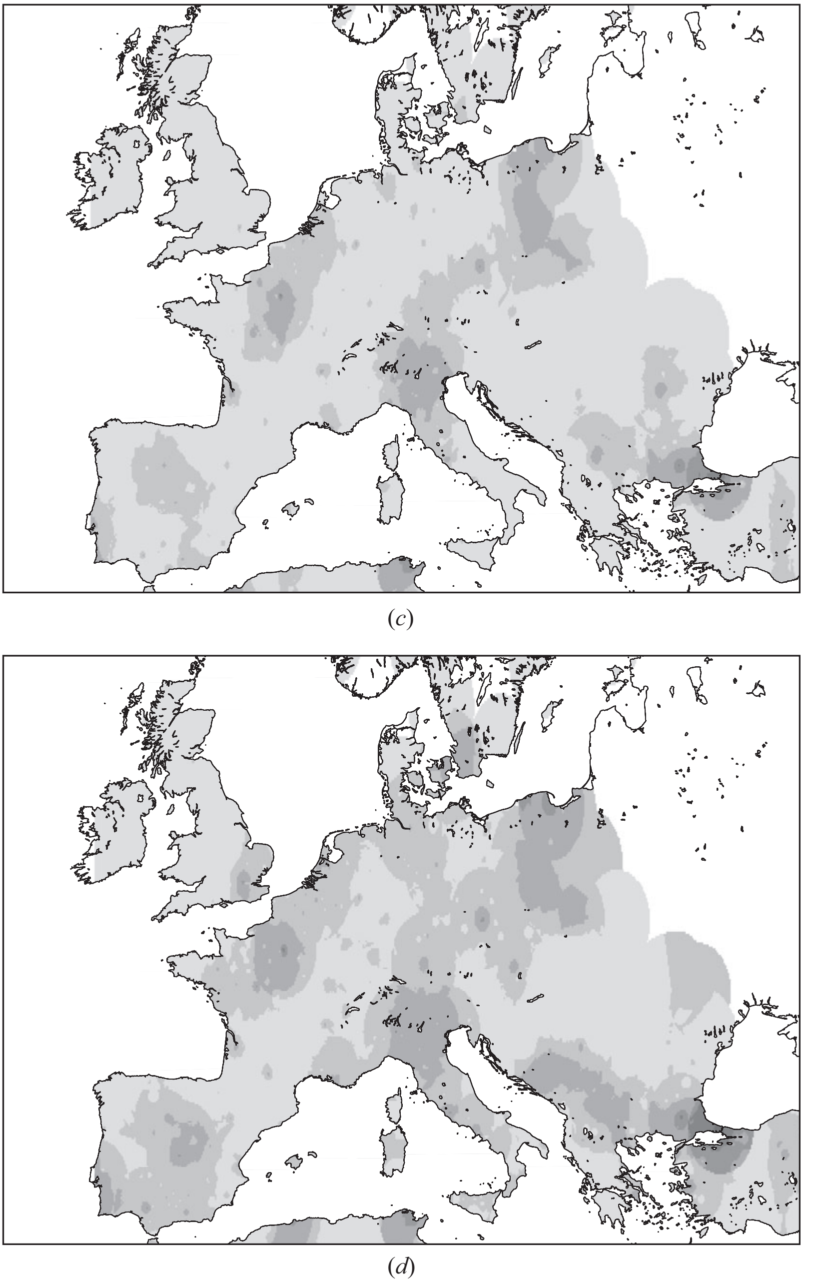


(*a*)



(*b*)

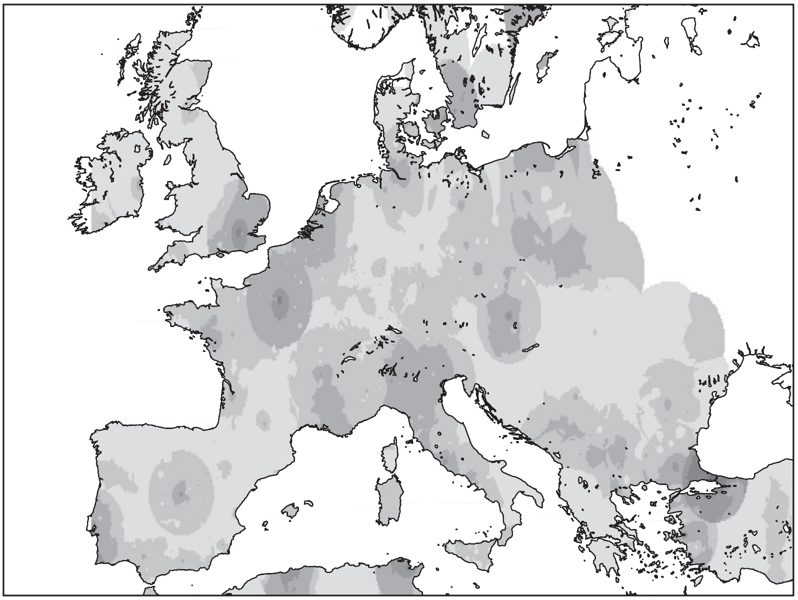
Fig. C5. *(a) 13th Century Urban Density. (b) 14th Century Urban Density. (c) 15th Century Urban Density. (d) 16th Century Urban Density. (e) 17th Century Urban Density. (f) 18th Century Urban Density*



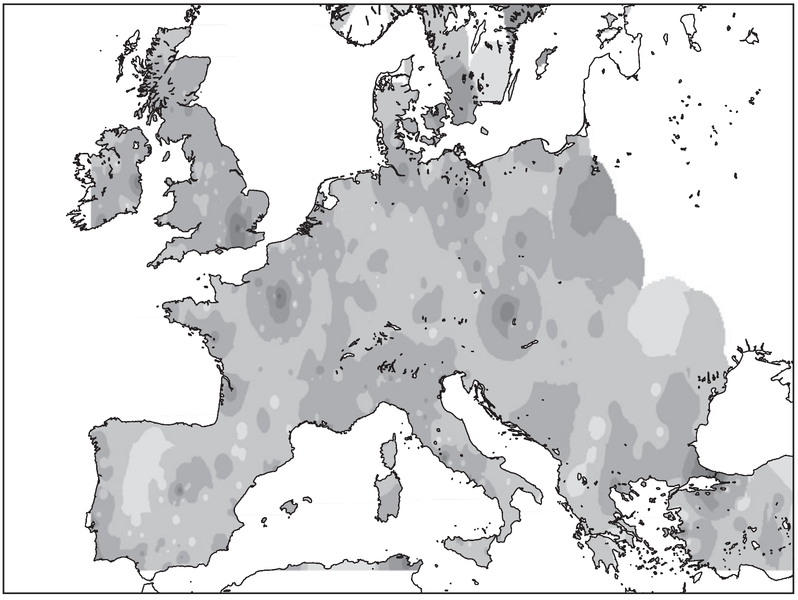
(*c*)

(*d*)

Fig. C5. *(Continued)*



(*e*)



(*f*)

Fig. C5. *(Continued)*

Temperature Data

We use the temperature data of Guiot and Corona (2010) as our main variable of interest. The process for creating the city-level temperatures was as follows: First, we created a thirty-two point grid of temperatures on the map of Europe for every year between 1100 and 1799. An example of this grid for 1100 is reproduced in Figure C6 as the dark red circles. We then used geospatial software to fill in the temperature at all the points on the map using the inverse distance-weighted average of the temperature of the surrounding twenty-four grid points. Figure C6 shows the resulting heat map of temperature deviations for 1100. Finally, we extracted the temperature for each of our 1,069 cities for each of the 700 years in our data set.

Temperature is an important determinant of agricultural production. According to Porter and Gawith (1998), the optimal temperature for wheat cultivation over the course of the growing season is between $17--23°C$ (Porter and Gawith, 1998, p. 25).

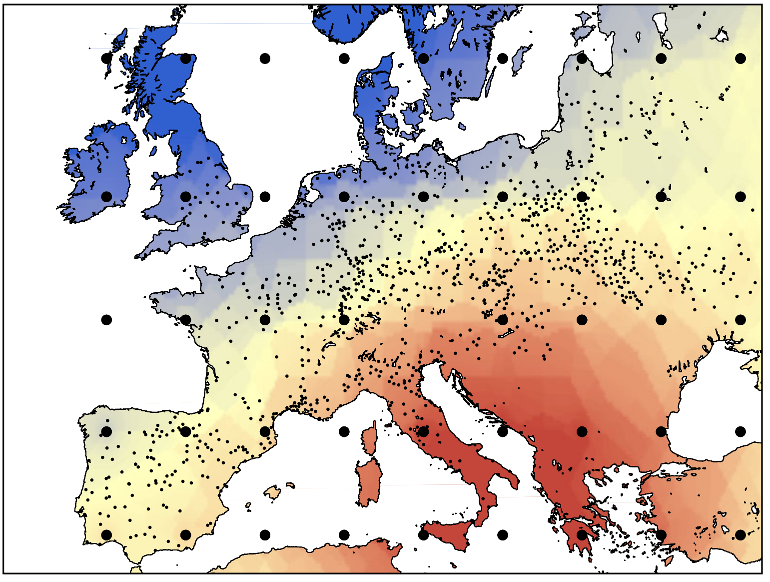


Fig. C6. *Distribution of Jewish Cities*

Notes. The distribution of Jewish cities, cities overlaid with the Guiot and Corona (2010) temperature grid and the corresponding heat map of average temperature during the growing season in 1100.

Rainfall Data

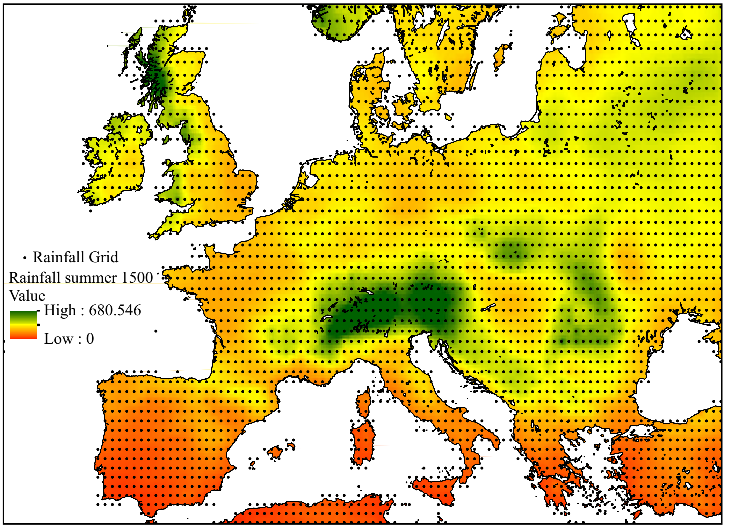


Fig. C7. *Rainfall in Summer 1500*

Agricultural Production and Prices

Our wheat prices series come from Allen-Unger database[1]. This data set contains grain prices series for 98 European cities. Figure C8 shows the location of these cities, though not all cities are in the panel for the entire period. The average price of wheat across all in-sample cities between 1100 and 1800 is shown in Figure C9. It clearly shows the effect of the Black Death in the second

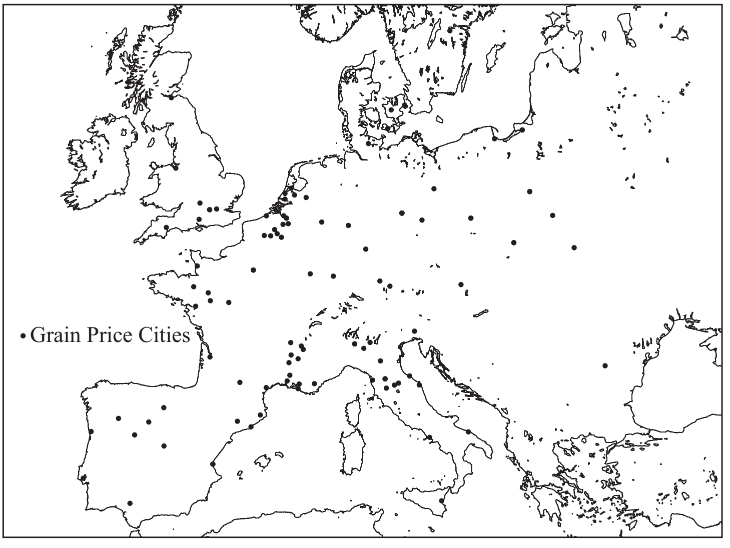


Fig. C8. *Grain Price City Locations*

Source. Allen-Unger database.

[1] The Allen-Unger Global Commodities database is available at http://www.gcpdb.info/.

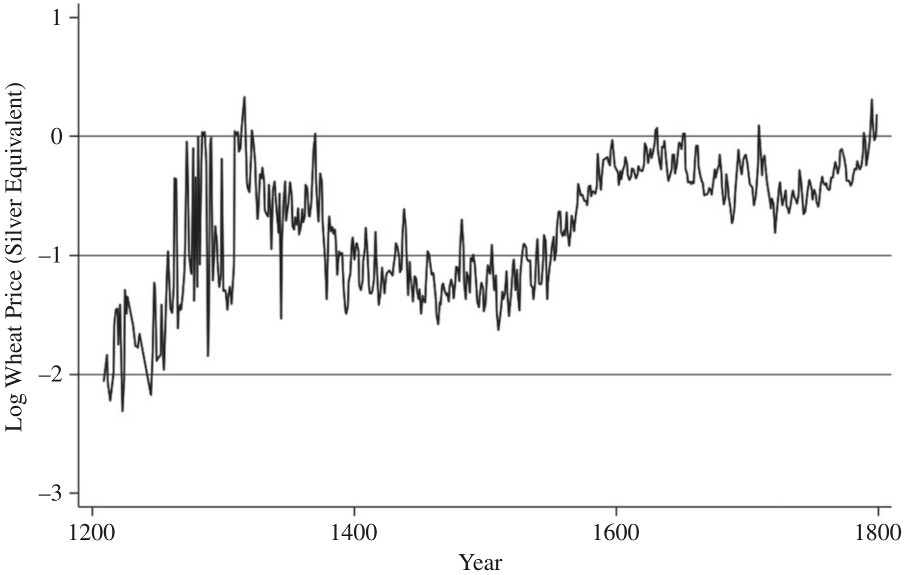


Fig. C9. *Grain Price Time Series*

Source. Allen-Unger database.

half of the fourteenth century as well as the effect of silver imports from the New World during the sixteenth century.

Appendix D. Additional Historical Evidence and Discussion

In the main text, we provide an example of a negative temperature shock leading to harvest failures and popular unrest and ultimately to violence against Jewish communities. Here we can provide more detail on several other examples that illustrate the causal mechanisms we identify in our empirical analysis.

The Black Death

A large number of expulsions and persecutions accompanied the Black Death (1348–50) (Cohn, 2007; Voigtländer and Voth, 2012). The fact that the Black Death triggered antisemitic violence is entirely consistent with our hypothesis.

The 1340s were in fact a period of warm summers. However, the years 1348–50 saw 'three very rainy summer seasons. As a result, hunger was rife in Europe, and poverty spread extensively throughout the society. The frightful scenes of the 'Black Death' were preceded by the phenomenon of drought and the distress of famine. There were places, in Breslau in Germany, for example, where Jews were killed not by the plague, which had not yet reached there, but as a result of starvation, for hungry people in their distress turned upon the Jews' (Breuer, 1988, p. 140).

Jews were blamed for the plague across Germany. Both the Pope and the Holy Roman Emperor spoke against this libel and the Emperor tried to protect Jews where and when he was able – less out of sentiment but because he viewed them as an economic asset. Charles IV protected Jews in Prague and in other areas where his authority was strong but elsewhere he was prepared to let his subjects burn Jews.

> When the plague was at its height and the bands of flagellants were sweeping across the country, he sold or transferred the holdings of the Jews, if and when they should be killed, to

> the cities and nobles who saw fit to support him. In exchange for all of these payments, the Jews could expect one thing: that the king, the nobles and the city councils who had benefited from their monies would protect them. Undoubtedly, they were legally and morally obligated to do so and there is no reason to doubt that they would indeed have preferred to protect the lives of their Jews in order to continue to benefit from their money. However, under the circumstances we have described, it appeared that they would not be successful, they decided to turn the destruction of the Jews to their best advantage (Breuer, 1988, pp. 146–7).[4]

The worst massacre was in Strasbourg where 2,000 Jews were burned to death. In Brandenburg, where Louis I was faced with a rebellion, initial attempts to protect Jews from accusations of well-poisoning 'broke down under the frenzy of the populace, whose good will the embattled margrave could not afford to lose' and in 1351 Louis allowed Jews to be burnt in Königsberg (Baron, 1965*a*, p. 211). The massacres and expropriations more or less wiped out the Jewish communities in the Electorate.

The Armleder Massacres

One example comprises the series of persecutions that occurred in Alsace and Franconia between 1336 and 1339 and that are known to historians as the Armleder persecutions. They began when Arnold von Uissigheim, a knight turned highway robber, instigated an 'economically motivated social uprising' that turned against the Jews (Levenson, 2012, p. 188). He led a group of peasants with leather patches affixed to their arms and he became known as Rex Armleder. Uissigheim was arrested and executed by Count Gottfried of Hohenlohe. But other individuals took up the cause and the massacres continued across Bavaria and Alsace until 1338, destroying more than 100 Jewish communities (Rubin, 2004, pp. 55–7).

Historians propose various explanations for the massacres. One contemporary explained that Uissigheim's brother had been killed by Jews. Others attributed it to resentment against usury. In some areas, antisemitism had been stirred up by prior allegations of host desecration. However, these events are also highly consistent with our theoretical framework.

As Figure D1 illustrates, the Armleder massacres occurred during a period of particularly cold temperatures. The town of Kitzingen saw its Jewish community massacred during this episode and is in our data set. The average temperature deviation in Kitzingen from 1100 to 1339 was 0.059 with a standard deviation of 0.16. The two coldest five-year periods were between 1325 and 1335, which were two standard deviations below the mean. While temperature from 1335 to 1339 improved, it was still three quarters of a standard deviation below average.

Political scientists have argued that a band of weak political authority created by the dismemberment of the Carolingian empire at the Treaty of Verdun in 843 shaped European history throughout the medieval and early modern period. In particular Stasavage (2011) argues that the lands known as Lotharingia, which lie between the historical boundaries of France and Germany, were areas of weak state authority and fragmentation. The Armleder massacres thus occurred in a region where γ_t was low.

The Haidamack Massacres

While persecutions and expulsions of Jews became less and less common in western Europe after 1600, they continued to take place in eastern Europe where the Polish state remained weak. The Haidamack Massacres refers to a series of pogroms that occurred throughout the eighteenth century in Poland and Ukraine.

[4] Charles IV subsequently forgave the perpetrators of the massacres, noting 'that the populace had been "animated by vulgar prejudice, bad advice, and reprobate feelings" when it attacked Jews and thus caused much damage to the royal Treasury, he nevertheless accepted the regrets and satisfaction offered him by the city elders' (Baron, 1965*a*, pp. 158–9).

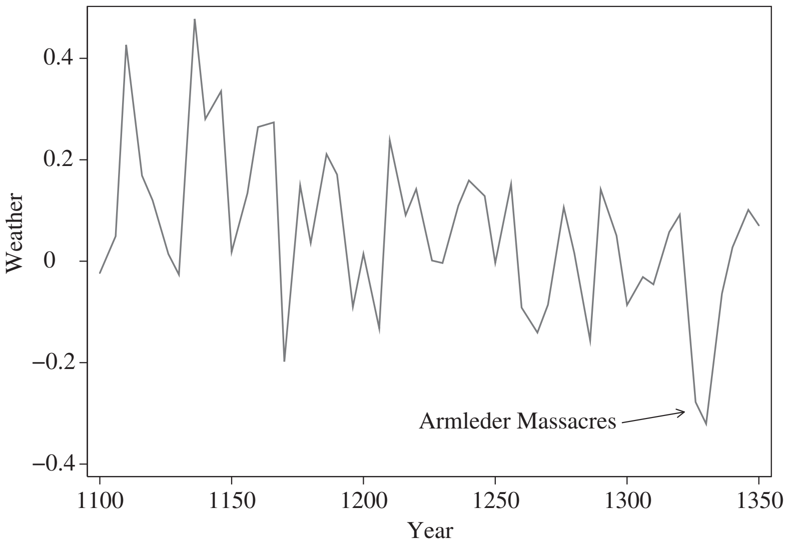


Fig. D1. *Temperature Deviations (Five-year Averages) in Kitzingen 1100–350*
Notes. The Armleder pogroms (1336–8) followed a period of extremely cold temperature in Alsace and Franconia.

Figure D2 shows the temperature deviations for Zbarazh from 1100 to 1800. The Figure depicts that a period of extremely cold temperature occurred at the turn of the eighteenth century. The first massacres occurred in Belaya Tserkov and Satanov in 1703, and in Zbarazh and Izyaslav in

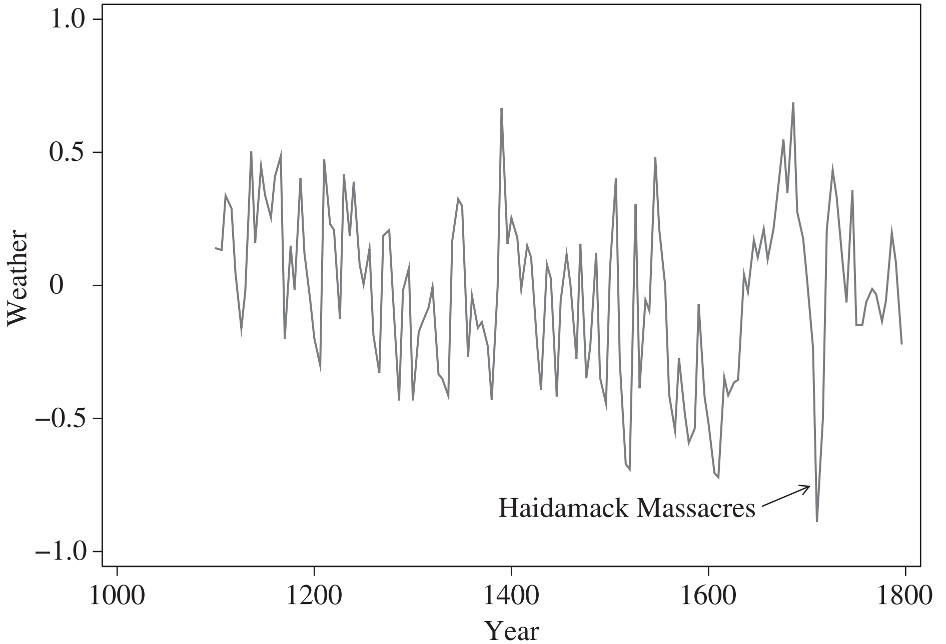


Fig. D2. *Temperature Deviations (Five-year Averages) in Zbarazh, Ukraine 1100–350*
Notes. The Haidamack Massacres began in the early eighteenth century during a period of cold temperature.

1708. The worst killings occurred in 1734, 1750 and 1768. Hence the timing and location of the Haidamack massacres is highly consistent with our theory and overall argument.

National Expulsions

There are five 'national' expulsions in our database:

(*i*) England 1290;
(*ii*) France 1306, 1394;
(*iii*) Spain 1492; and
(*iv*) Portugal 1497.

Rulers conducted national level expulsions for a range of reasons including the need for immediate revenue. The French king Philip IV (1285–314) decided on a policy of expulsion as an expeditious way of getting his hands on as much Jewish wealth and property as possible.[5] He realised that

> '[i]t would take too many administrators and petty officials to organise the arrest of French Jews and confiscate all of their property, and most importantly, their loan records. At any point in the process, problems could arise which would translate to less revenue for the king. Local officials could quietly confiscate Jewish moveable property themselves, selling it off for their own profit. Or they might agree to accept bribes in return for allowing Jews to leave with at least some of their goods. Jews in close relationship with nobles, and government officials, might possibly hear of the plan and arrange to leave before it was carried out, or hide their valuables. Finally, the townspeople could discover that the Jews were being expelled and preempt the confiscation, taking for themselves Jewish property and the records that revealed their own indebtedness' (Taitz, 1994, pp. 220–1).

In so doing, he sacrificed a long-run revenue stream and therefore made the French crown permanently poorer (Jordan, 1989).[6]

State Capacity

Figure D3 depicts tax revenues per capita from Karaman and Pamuk (2013). It shows the dramatic rise in fiscal capacity that took place in the leading western European states from around 1600 onwards.

[5] According to one historian: 'During the period 1301–6, the king imposed similar taxes on the Jews of Normandy as elsewhere in France. The war against the Flemish was renewed in 1302 and resulted in the imposition of new taxes on the entire population ... the seizure of Jewish goods, the detention of the Jews and their expulsion from France in the summer of 1306 are events manifestly connected with this situation. On June 21, just two weeks after the statement on sound money, the king sent letters to his officials all over France secretly directing 'the accomplishment of the mission the king charged them with *viva voce*'. The following month was marked by detention and seizure. A contemporary chronicler writes that the confiscators left the Jews only the clothes they were wearing, that their apparel and furniture were sold for very little, and that cartloads of silver and gold from their houses were brought to the king day and night. On August 17, the king ordered that treasure found in Jewish houses belonged to him, threatening the usual penalties for those who ignored the order' (Golb, 1998, pp. 536–7).

[6] Mechoulan (2004) demonstrates that at a discount factor equal to the prevailing 12% interest rate this decision may well have been the correct one for Philip IV, given the political and fiscal situation he faced. Subsequent expulsions followed this pattern and involved some form of expropriation with minor variations. In 1492, the Jews of Spain were allowed to take their private possessions with them but forbidden from taking gold, silver or minted coins while their communal property was distributed to local town councils (Beinart, 2002, pp. 55–6).

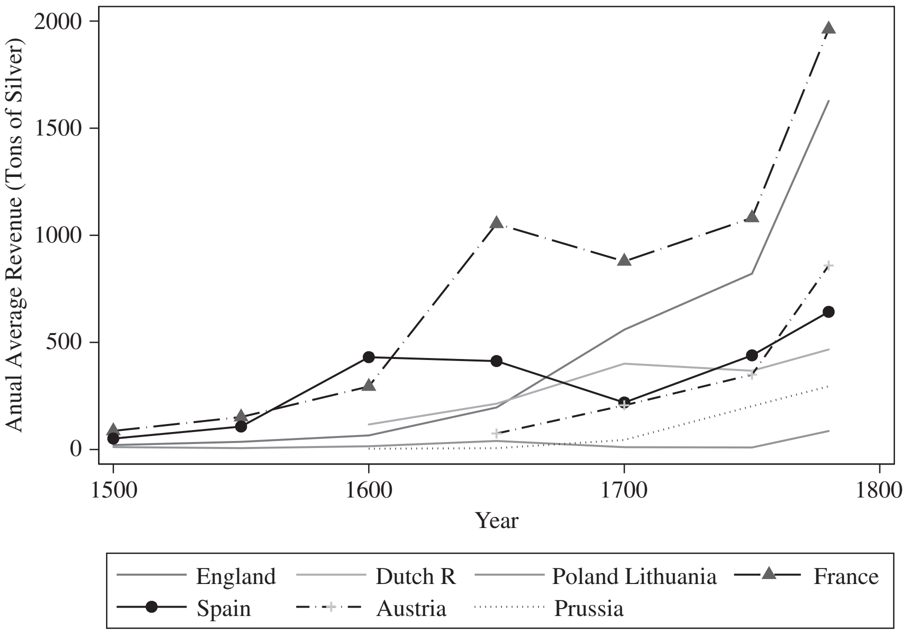


Fig. D3. *State Capacity*
Notes. Karaman and Pamuk (2013) based on data from the European State Finance Database.

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