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Economic Determinants of Witch Hunting*

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Abstract

We adopt a q-model of investment to give insights into the economic conditions that allowed witch hunting to flourish in early modern Europe. Using data from Bavaria, the southern English county of Essex, and Scotland, econometric investigation reveals that hunting activity was highly responsive to income shocks with a grain price elasticity of persecution of between 0.5 and 0.8. Cultural and social considerations have hitherto often been regarded as explaining the phenomenon of witch hunting. But the article shows that despite these differences, the three regions displayed similar hunting propensities. Furthermore, econometric allowance for non-income hunting motivations strengthens the article's argument for the importance of economic factors in reaching a full understanding of discrimination and persecution.

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1 Introduction

Witch hunts or the social process leading to it is one of the unresolved puzzles of pre-industrial history. Why did people accuse their neighbours of a crime potentially leading to execution? In fact, the belief in witchcraft and witch hunting are not exclusively historical phenomena. Especially in the poorest and most slowly developing region of the world, Sub Saharan Africa, there are still outbreaks of violent witch hunts.[1] A common observation of reporters is that the number of witch accusations increases with economic problems and the prevalence of AIDS. For example, in Zimbabwe the number of accusation became particularly dramatic during the last years of economic decline. The regions facing the most serious deterioration of economic and health conditions are the ones with the highest persecution rates. Can this link between economic pressure and persecution activity help to explain the witch hunts in 16th Century Europe?

An obvious difference to the European Witch Hunt is that in general, the modern cases are unorganized, illegal persecutions. The institutionalized witch hunt in early modern Europe occured during a relatively short period, and was regionally concentrated. It has been estimated that about 75% of the total persecutions occured in an area covered by Germany, France, Switzerland and the Low Countries, with Germany as the centre at the end of the 16th Century.[2] Common to both the European hunt and the modern cases in Africa is the belief in the existence of harmful magic:[3] "*Sorcery, by*

[1]See the web sites of the United Nations (http://www.un.org/) and Amnesty International (http://www.amnesty.org/) for examples.

[2]Estimates of the number of victims vary considerably. Levack (1995, p.24-25) estimates a total of about 110,000 trials and 60,000 executions for the early modern period in Europe.

[3]Modern belief in witchcraft is by no means restricted to developing countries. To give some examples: for the United States, Newport and Strausberg (2001) report an increase of the percentage of people believing in witches from 14 per cent in 1990 to 26 per cent in

general agreement, can cause illness in man or beast, even death in extreme cases; it can cause bad weather, destroy fertility in plants or in humans" (Monter, 1969, p.viii). This is an important precondition: without this belief, neighbours would be reluctant to participate in a hunt, to accuse a witch or to testify (see e.g. Levack, 1995, p.161).

Besides the existence of harmful magic, there is a second element in the witchcraft concept developed in early modern Europe: "*A witch was a person of either sex (but more often female) who could mysteriously injure other people.* [...] *It was only in the late Middle Ages that a new element was added to the European concept of witchcraft* [...]. *This was the notion that the witch owed her powers to having made a deliberate pact with the Devil*" (Thomas, 1971, p. 520, 522). This second element, the pact with the devil, which became the central aspect of witchcraft as a crime during the 15th Century, triggered the persecution propensity of the authorities.[4] In fact, Levack (1995, p.28) points out that without the persons in control of the legal machinery being convinced of the existence of an "*organized, conspirational sect of Devil-worshippers*" as an explanation for the increasing political, economic, and social tensions in Europe at that time,[5] the witch-hunt would

2001. For Germany, the Allensbach Institute for Demography reports a similar increase from 8 per cent in 1956 to 16 per cent in 1989 (Allensbacher Berichte, 1989/No.20, Table 1). See also Blécourt (1999) for an overview on 20th Century witch beliefs in Europe, and Muchembled (1991, p. 281-293) for an example of the development of the witch concept from the early modern period to 20th Century in rural France.

[4] "*Neighbours of witches were generally much more concerned about the misfortunes that they thought they had suffered as a result of a witch's magical power that they were about the witch's alleged dealings with the devil*" (Levack, 1995, p.10). See also Muchembled (1991, p.191-210, *Absence du Diable, Presence du Malheur*).

[5] Maxwell-Stuart (2001, p. 60-61) lists the following factors explaining this phenomenon: "*Climate change starting in the 1560s; economic difficulties brought about by crop failures and the effects of war; religious divagation leading to increased and rigourous disciplining of people by both ecclesiastical and secular authorities to enforce acceptance and strict observation of reformed religion, whether Catholic or Protestant: widespread belief that the world was entering its final phase and that the last battle with Satan was joined or*

not have taken place.

Given the two components of the European witchcraft concept, there are two interesting "stylized facts" to be found in the literature: (1) the frequency of witch trials does not follow a smooth time path but fluctuates; (2) the number of executions is about half the size of the number of accusations.[6] We propose an economic explanation of the first fact, using a model building on the second observation. Why was the execution rate not higher? Although in most cases, persecution pressure came from individuals, the magistrates decided whether to actually persecute or not (Levack, 1995, p. 170/171), a decision in which cost considerations must have played an important role. First of all, there were considerable direct costs of persecution.[7] Secondly, the magistrates faced indirect costs - the danger to their families or themselves being persecuted, psychological costs, like doubts about the guilt of the accused, and the concern about the implications of the hunt for social and political stability (Levack, 1995, p. 182). This cost-benefit analysis is the main building block of the model in Section 2. The role of the local magistrate in the model is also motivated by the changes in the legal system in Europe after 1550: almost everywhere, secular courts became in charge of the jurisdiction over witchcraft, and the local and regional courts enjoyed a high degree of independence from central authorities (Levack, 1995, p. 69). In this framework, we demonstrate how income shocks create persecution cycles. Section 3 contains a test of the empirical implications using a count data

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about to be joined - all these produced a general climate of anxiety in which persecution of anyone deemed to be a cause or a possible cause of increasing that anxiety was likely to be triggered."

[6]The execution rates varied from a very low number in Finland (16 per cent) to a very high one in Pays de Vaud (90 per cent), concentrating around 40 to 50 per cent (Levack, 1995, Table 1, p. 23).

[7]Larner (2000, p. 116) states that in Scotland, "*[D]isposing of a witch was nearly always an expense to the local authority rather than a source of revenue*".

model with time series from three European regions: Bavaria, the southern English county of Essex, and Scotland. To measure economic pressure, we use grain price data for the observation period and region under analysis.[8] Section 4 contains a discussion of the results, and Section 5 concludes.

2 Model

The choice of persecution activity is modelled based on a q-model of investment.[9] Consider a magistrate with infinite lifespan (e.g. a dynasty), who maximizes the present value of his profits

$$\begin{aligned} &\max_{H(t)} \int_0^\infty e^{-rt} \left(R\left(P(t), Y\right) - H(t) - C\left(H(t)\right)\right) dt; \\ &\text{s.t.} \\ &\dot{P}(t) = H(t) - \delta P(t), P(0) \geq 0 \text{ given,} \end{aligned} \tag{1}$$

where r denotes the rate of time preference, reflecting for example the probability of losing office. The magistrate cannot influence aggregate income Y, which is given and e.g. subject to climatic shocks. The revenue function is given by $R\left(P(t), Y\right)$, where $P(t)$ is the number of people investigated, or people whose character is publicly known.[10] One could think of this number as representing the public good "security": the more people know about their neighbours, the safer they feel. In case it turns out that the neighbour is a

[8] See Section 3 and the Data Appendix for details.

[9] See e.g. Romer (1996, p.345-384), Barro and Sala-i-Martin (1995, p.119-125).

[10] $0 \leq P(t) \leq POP$, where POP is the total "relevant" population, characterizeed by the following facts: for most European countries, the proportion of accused female witches was higher than 75 per cent (Table 3, p.134 Levack, 1995). The percentage of accused witches significantly older than 50 varied between 50 and 90 per cent (Levack, 1995, Table 4, p.142). There is also some evidence that marital status mattered, i.e. unmarried women were more likely to be accused. In addition, it seems to be the case that most of the accused witches came from the lower levels of society (Levack, 1995, p. 141-152).

witch, appropriate steps can be taken. In the case the neighbour is found not guilty, a source of uncertainty is removed.[11] This security generates a more friendly climate towards the magistrate, and his revenue increases. On the other hand, it could also reflect the disciplinary function of witch hunts, which would have a positive effect on the magistrate's revenue.[12] These mechanisms work under the condition that the people in the community believe that there are witches who cause economic damage.

If an improvement of economic conditions is interpreted as the consequence of a decrease in witchcraft activity, the policy instrument "hunting" loses its power if income increases. Therefore, the revenue function satisfies

$$R_P > 0; R_Y > 0; R_{P,P} < 0; R_{Y,Y} < 0; R_{P,Y} < 0.$$

The number of people investigated changes over time: it increases with persecution activity $H(t)$ ($H(t) \geq 0$), and decreases at the rate δ ($0 \leq \delta \leq 1$), which can be seen as the rate at which people forget about the characteristics of their neighbours, or, in other words, the persistence of witch beliefs.[13]

Witch hunting causes direct cost, which is modelled by the term $H(t)$ in the profit function (after normalising the price of witch hunting activity to one). Besides the direct cost, there is also an adjustment cost component

[11] This is the reason why in the empirical part, we analyze the number of accusations and not the executions.

[12] A good illustration for the importance of the interaction between public pressure and the authorities' willingness to persecute is the example of the period 1651 to 1659 in Scotland. With the arrival of the English judges during the English occupation, the number of cases was dramatically reduced: "*English good sense prevailed over Scottish superstition*" (Larner, 2000, p.75). But after 1657, the number of cases increased again. Larner (2000, p.75/76) speculates whether the judges had 'gone native', or whether it was more likely that the public pressure was so strong that they had to react.

[13] "*While the initial outbreak may have been caused by other factors, this outbreak educated both rulers and populace in the likelihood of witch conspiracies, and tainted the friends and relatives of those who were accused with a reputation which was readily revived when required*" (Larner, 2000, p. 196).

$C(H(t))$ to be taken into account, with

$$C(0) = 0; C_H(H) > 0; C_H(0) = 0; C_{H,H} > 0. \tag{2}$$

The adjustment cost component reflects the reluctance of the magistrate to start a persecution, which could get out of control, and the difficulty of stopping it. Setting up the current-value Hamiltonian for the magistrate's problem, one obtains

$$\begin{aligned}\mathcal{H}\left(P(t), H(t)\right) = &\left(R\left(P(t), Y\right) - H(t) - C\left(H(t)\right)\right) + \\ &+ q(t)\left(H(t) - \delta P(t) - \dot{P}(t)\right),\end{aligned} \tag{3}$$

where q is the shadow price of P. Applying the maximum principle leads to the following set of first-order conditions

$$q(t) = 1 + C_H(H(t)); \tag{4}$$

$$\dot{q}(t) = (r + \delta)q(t) - R_P\left(P(t), Y\right); \tag{5}$$

$$\dot{P}(t) = H(t) - \delta P(t), \tag{6}$$

and

$$\lim_{t \to \infty} e^{-rt} q(t) P(t) = 0. \tag{7}$$

The interpretation of q in equation (4) is straightforward: marginal cost of witch hunting equals marginal benefits, which, in turn, equal the shadow price of people investigated. Equations (5) and (6) are the equations of movement for the number of people investigated and q, and equation (7) is the transversality condition. Because of the assumptions in equation (2), it is possible to write hunting activity as a function of q. From equation (4) we obtain

$$H(t) = g(q(t)), \tag{4'}$$

with $g_q > 0$ and $g(1) = 0$. In the stationary state, we have

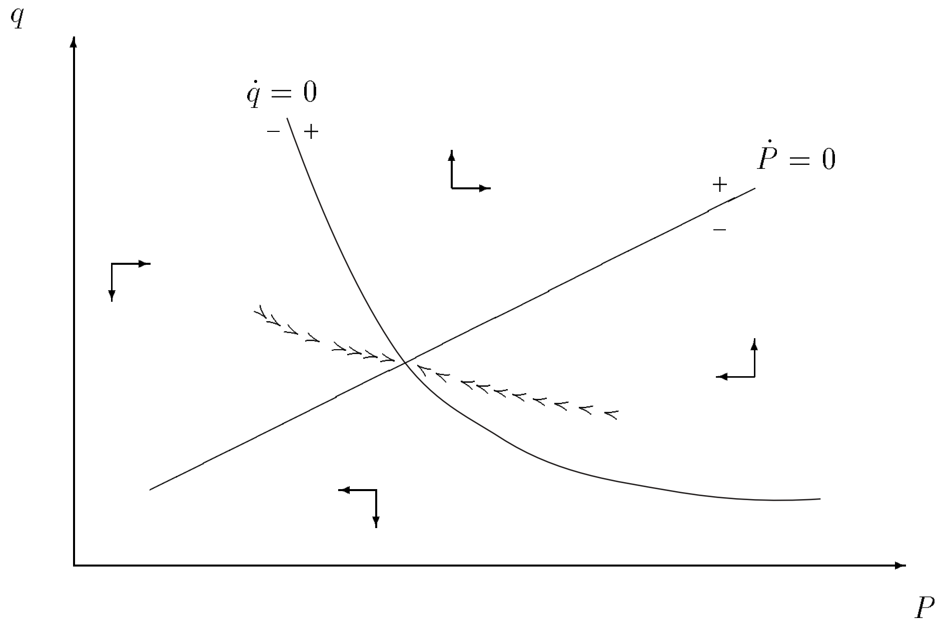
$$\begin{aligned} \dot{P} = 0 &: g(q^\star) = H^\star = \delta P^\star; \\ \dot{q} = 0 &: (r + \delta) q^\star = R_P\left(P^\star, Y\right). \end{aligned} \tag{8}$$

In steady state, hunting activity H must be exactly high enough to compensate for the decrease in the number of people for whom the characteristics are known (δP). In addition, the present value of the marginal revenue must be equal to the shadow price of people investigated. Linearising the system of differential equations in q and P around the steady state and calculating the determinant of the Jacobian matrix $\mathbf{J}$, it turns out that the system produces a stable saddle path:

$$|\mathbf{J}| = \begin{vmatrix} \dot{P}_P & \dot{P}_q \\ \dot{q}_P & \dot{q}_q \end{vmatrix} = \begin{vmatrix} -\delta & g_q \\ -R_{P,P}\left(P^\star, Y\right) & r + \delta \end{vmatrix} < 0. \tag{9}$$

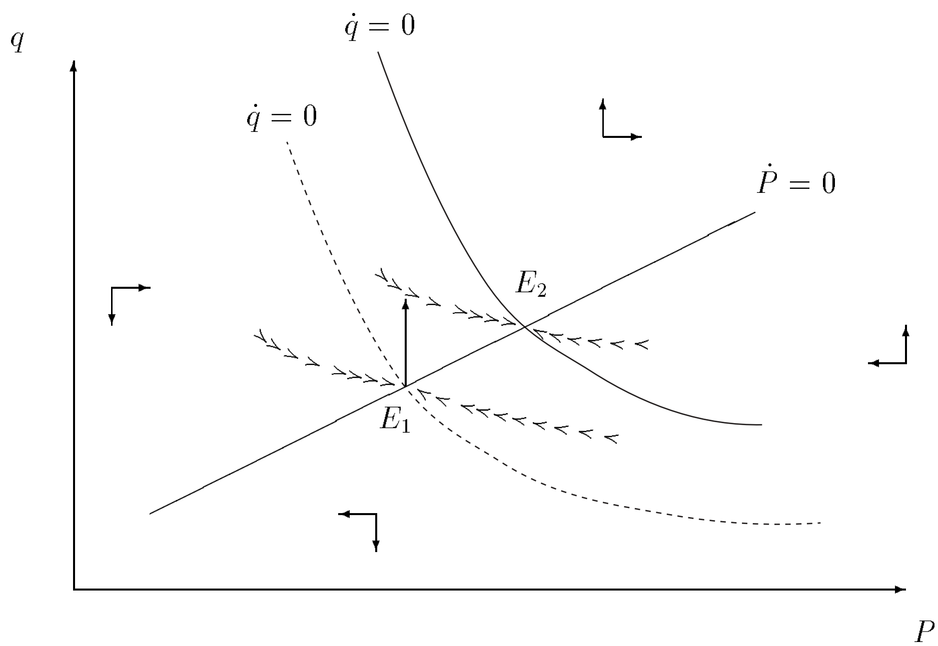
As illustrated in Figure 1, the $\dot{P} = 0$ curve is upwards sloping in P with slope $\frac{\delta}{g_q} > 0$. As it can be seen from equation (9), P increases above the curve, while it decreases below. Above the $\dot{q} = 0$ curve, which has a negative slope $\frac{R_{P,P}}{r+\delta} < 0$, q is increasing, while it decreases from points below the curve.

Figure 1: Phase Diagram



Consider now the climatic deterioration during the Little Ice Age, leading to a series of harvest failures, which would decrease income over a very long period. In Figure 2, this is reflected by an upwards shift of the $\dot{q} = 0$ curve. The sudden increase in the value of people investigated will lead to an increase in hunting activity. The system will then evolve along the new stable path towards the new equilibrium E_2, which is characterised by a higher level of P and q, which implies a higher hunting activity (equation $4'$). Permanent economic recovery, on the other hand, will lead to lower levels of P, q, and H.

Figure 2: Permanent and Temporary Income Shocks



A temporary decrease in income will lead to a jump of q on the new stable path. Once the shock dies out, the old stable path leading to E_1 is again the relevant one. Another interesting implication of the model is the impact of a change in either the time preference of the magistrate (or a change in political stability): if r increases, there will be both a downwards shift and a decrease in the slope of the $\dot{q} = 0$ curve. Hence, we would expect that during periods when political instability is high (e.g. a war), or when there is a reason for an increase in time perference (e.g. a plague), witch hunting activity to be low. These implications are in line with the literature: Thomas (1971) and Macfarlane (1999) point out that plagues did not lead to an increase in persecution intensity. This fact is generally true for Europe, and Levack (1995) explains it by the well known epidemic spread of the desease, which could not be attributed to local witches. Another explanation is the low social class of the victims of a witch hunt, which makes it difficult to connect them to a large scale disaster (Klaits, 1985, p.29).[14] For Germany, it has been argued that the Swedish occupying forces during the Thirty Years War prevented further accusations, and that the war itself kept the people from accusing so that "*peace-time pursuits like witch-hunting simply stopped*" (Monter, 1976).

3 Data and Econometric Method

To test the empirical implications of the model, we compare three European regions with different characteristics and different persecution levels, from the geographic center (Bavaria) and the periphery (Essex, Scotland) of Europe. Bavaria is an example of a catholic region with high persecution intensity. For the period 1586 to 1730, Behringer (1997, p.68/69) estimates 4000 cases, with 1000-1500 victims. Essex is a protestant region with a relatively low hunting intensity (314 people persecuted at the Essex Assize and Quarter Session courts between 1560 and 1680, Macfarlane, 1999, p. 23). The persecution intensity in Scotland was comparably high, with about 3000 accusations, and over 1000 executions in the period 1560 to 1760 (Larner, 2000, p. 62/63). The literature explains regional differences in persecution intensity mainly with social and cultural factors, and with differences in the legal system, especially the importance of the pact with the devil in the legal definition of witchcraft and the use of torture in the criminal law procedure (Levack 1995, Chapter 7, Klaits 1985, Chapter 6).[15] In addition, the inde-

[14] "*There were orthodox views about what caused the spread of plague and smallpox; witchcraft tended to be used as an explanation for individual misfortunes and illnesses for which no standard explanation was at that time available*" (Larner, 2000, p.82).

[15] To explain the difference in the level of witch-hunting between Essex and Scotland, Levack (1995, p.200-202) lists (among other causes) the almost complete absence of the

pendece of local courts was crucial. Another important factor was the degree of religious zeal, the active participation in either Reformation or Counter-Reformation.[16] We demonstrate that although these factors are central when explaining the intensity of persecutions, they do not lead to differences in the importance of economic determinants of fluctuations in persecution intensity.

We assess the influence of grain prices p_t as a measure of economic pressure on fluctuations in the number of accusations per year a_t.[17] Since we analyze time series of count data, we use a Poisson regression model as a starting point, allowing for autoregressive feedback.[18] The conditional density is specified as Poisson,

$$\text{Prob}(A_t = a_t | p_t, a_{t-1}) = \frac{e^{-\lambda_{t|t-1}} \lambda_{t|t-1}^{a_t}}{a_t!}, \tag{10}$$

i.e. the probability that the number of accusations is equal to a_t is conditional on the grain price in log levels and the number of accusations in the previous

pact with the devil in the accusations and the absence of torture in Essex.

[16]Witch hunting in Germany has been put in context with the confessional bifurcation that took place in the 16th Century, especially with the Catholic reaction to the spread of Protestantism (Trevor-Roper, 1990). For example, Midelfort (1972) shows that catholic areas in Germany displayed a higher probability of accusations than protestant territories. However, a direct link of persecuting Protestants in Catholic areas has been rejected or constrained to a few exceptional cases (Volk, 1882; Renczes, 1990). For Scotland, it has been argued that the active role of the clergy in the legal procedure is seen as an important cause of the relative high number of trials (Larner, 2000).

[17]For Bavaria, we use grain prices from Ausgburg and Munich (Elsas, 1936, 1940, 1949). In Scotland, intensive hunts took place in the eastern part (Fife, Lothians and Borders, Larner (2000, p. 81)) Therefore we use grain price series from Edinburgh and Fife as economic indicators (Gibson and Smout, 1995). The data situation for Essex allows us to use the grain price index in Bowden (1967, 1985) and a real wage index provided by Wrigley and Schofield (1989). A detailed description of the price data and the data on hunting activity can be found in the Data Appendix.

[18]For the following, see King (1988, 1989); Cameron and Trivedi (1998).

period. The conditional mean $\lambda_{t|t-1}$ follows

$$\begin{aligned}\lambda_{t|t-1} =& \mathrm{E}\left[a_t | p_t, a_{t-1}\right] = \exp\left(\beta \ln p_t + \rho \ln a_{t-1}\right) = \\ &= p_t^{\beta} \left(a_{t-1}\right)^{\rho}.\end{aligned} \tag{11}$$

Hence, both β and ρ can be interpreted as elasticities of the conditional mean with respect to price changes and changes in the number of accusations in the previous year. If we want to use the conditional mean defined in equation (11), we have to rescale the number of accusations so that the lowest count is greater than zero. The following transformation is a possibility:

$$a_{t-1}^{\star} = \max\left(c, a_{t-1}\right);\; 0 < c < 1;\; acc_t = 0, 1, 2, \ldots \tag{12}$$

To estimate the parameter c, we rewrite the conditional mean as

$$\begin{aligned}\lambda_{t|t-1} &= \exp\left(\beta \ln p_t + \rho \ln a_{t-1}^{\star\star} + \rho \left(\ln c\right) d_t\right); \\ a_{t-1}^{\star\star} &= \begin{cases} a_{t-1} & \text{and } d_t = 0 \text{ if } a_{t-1} > 0; \\ 1 & \text{and } d_t = 1 \text{ if } a_{t-1} = 0; \end{cases} \\ c &= e^{\frac{\rho(\ln c)}{\rho}}.\end{aligned} \tag{13}$$

To address the issue of overdispersion, we also present the results for a Negative Binomial Regression Model (Negbin).

4 Results

Figure 3 summarizes the main empirical results from Tables 1-4 in the Appendix. The basic model is the same for all three regions, i.e. changes in the expected value of the number of accusations are explained by changes in the grain price level. Dummy variables take into account variation in witch hunting due to war, plague, or panics discussed in Section 2.[19]

We find a significant impact of price changes on the number of accusations in all three regions: the grain price elasticity of accusations ranges from 0.49 in Bavaria to 0.81 in Essex, the Scottish result lies in between this range (0.69).[20] The 95 per cent confidence intervals of the grain price elasticities in the right graph of Figure 3 overlap. This shows that although the regions under analysis have very different characteristics, the regional spread of this parameter which is central to our model is remarkably small.

The graphs on the left of Figure 3 provide a visual impression on the impact of war, plague, and panics on the accusation probabilities in the Negbin models.[21] The model predicts that a magistrate with an increasing rate of time preference reduces hunting activity. To illustrate this point, we plot the probability density functions for the model conditional on a "normal" period (solid curves), and on periods where we would expect the rate of time preference to be higher (short dashes). In the Bavarian case, such a period is

[19]The parameters of the dummy variables cannot be interpreted as elasticities, but, using the transformation $e^{\beta} - 1$, where β is the respective parameter, allows to interpret them as rates of change, comparing the situation where the dummy variable is active with the situation where it is inactive (Halvorsen and Palmquist, 1980).

Note that in the case of Bavaria and Essex, we introduced additional dummy variables accounting for region specific characteristics. To control for price changes which contemporaries saw as clearly not attributable to the influence of witches, we added dummy variable to the Bavarian model to account for the *Kipper und Wipper* inflations in 1618-1623, 1659-1667, and 1676-90. For Essex, the dummy variable *qual* allows to correct for fluctuations due to extensive loss of records in 1595-1600, 1604-06, and 1620-40 (Macfarlane, 1999, p.28).

[20]The result for Bavaria is based on Munich prices. For Augsburg prices, we get 0.40 (Table 1). The elasticities for Munich prices are higher, probably because the price is more representative for the situation in the region due to the size of the market. Note that the price elasticity for Essex is imprecisely estimated relative to the other regions.

[21]The mean is conditional on the average log price level (Bavaria: Munich rye prices, Essex: grain price index; Scotland: Edinburgh wheat prices); we assume that the number of accusations in the previous year is zero ($acc_{t-1} = 0, d_t = 1$).

characterized by the Thirty Years War.[22] For Essex, we plot the probability density function for the plague period,[23] and in Scotland it is the period of the English occupation 1651-60 and after the Act of Union 1707.[24] The data support the implications of the model: the probability density functions shift to the left. To illustrate the impact of a panic, we also plot the probability densities conditional on periods with panic trials (long dashes). In each of the regions, there is a remarkable shift of the distribution to the right.[25]

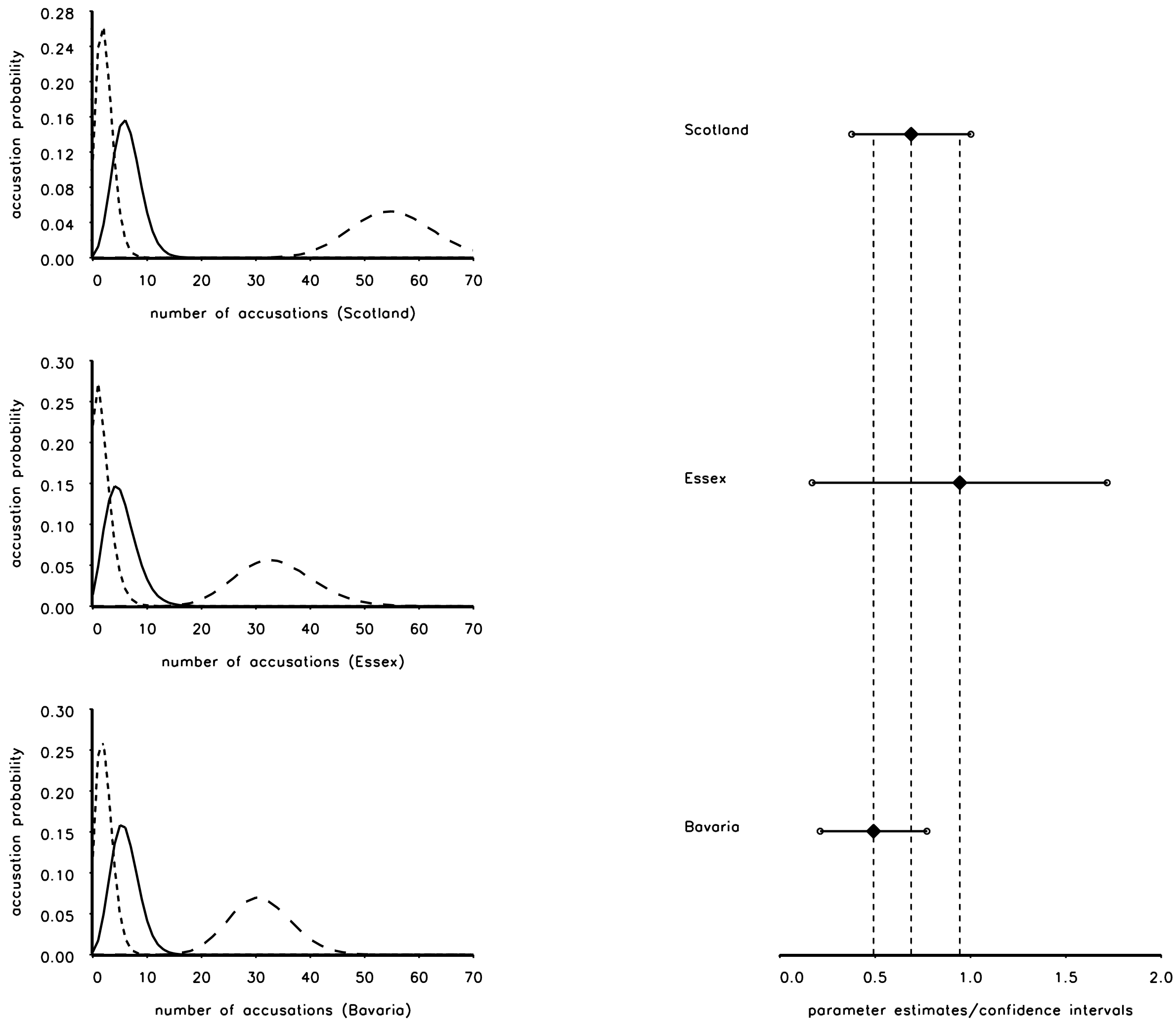
[22]We take into account the influence of the main military events during the Thirty Years War by introducing a dummy variable for the periods 1625-26 and 1632-37. During this time predicted accusations decrease by 40-70 per cent (Table 1).

[23]The Civil War (1641-1649) had no significant impact on persecution intensity, but the plague 1597-1599 did: the expected value of accusations predicted by the model is reduced by 60 per cent (Table 2). An explanation for the insignificant impact of the Civil War is the timing: it takes place almost at the end of the witch-hunting period, when the level of accusations was already low. In Bavaria, the war period/Swedish occupation is characterized by an overall upward trend in the number of accusations.

[24]During this period, the number of cases is reduced by about 65 per cent (Tables 3 and 4). As in the case of Essex, war (1639/40, 1645, 1679-1684, and the Jacobite rebellions 1715, 1719, and 1745/46) does not have a significant impact on persecution intensity. One might speculate that since war is more frequent in Scotland than in the other two regions, the influence is neglegible. In addition, the the period of the bubonic plague 1644-1649 (Flinn, 1977, Part 3, ch. 4) does not have a significant impact on the number of accusations (Tables 3,4). This is also true for the plague in Bavaria (1602, 1621-35, 1648/49, and 1713, Kisskalt 1953).

[25]Panics are exceptional outbreaks of hunting activity, and often attributable more to the prosecutors involved, and not to other causes. During the 1590 panic in Bavaria, the models predict an increase in the number of accusations of 400-500 per cent, compared to a "normal year" (i.e. no war, no plague, Table 1). In the case of Essex we correct for the impact of two unusual outbreaks in 1582 and 1645. These exceptional years increased the expected value of accusations by about 500 per cent (Table 2). For Scotland, we introduce a dummy variable for the five national panics 1590/91, 1597, 1629/30, 1649, and 1661/82 (Larner, 2000, Appendix I, p. 204-205). During the panics, the model predicts an increase in the number of cases of about 700 per cent (Tables 3, 4).

Figure 3: Summary of Results



Notes:
Scotland: Edinburgh wheat prices (1560-1599 and 1621-1670, Negbin); Essex: grain price index (1560-1675, Negbin); Bavaria: Munich rye prices (1550-1700, Negbin).
In the left column, accusation probabilities are displayed for the three regions. The solid curves indicate the densities for normal periods (no war/plague/occupation), short dashes represent occupation/war (Scotland, Bavaria) and plague (Essex) periods, and long dashes the panic periods.
The graphs in the right column contain the estimates for the price elasticities of persecution, together with 95 per cent confidence intervals.

The next interesting result is the feedback parameter ρ (Tables 1-4). It measures the elasticity of accusations with respect to changes in the number of cases in the previous year. For Bavaria and Scotland, this parameter is significantly positive and less than one per cent. This outcome points towards contagion effects and the persistence of witch beliefs, though the impact dies out over time. The lagged number of accusations has no influence on the conditional mean of the Essex hunts. This is in line with Macfarlane's observation that for this region, persecutions were not directly interconnected (Macfarlane, 1999, p.30).

In the case of Essex, we also analyzed the impact of changes in the real wage provided by Wrigley and Schofield (1989). Since food accounted for 80 per cent of the basket of consumables (Wrigley and Schofield, 1989, p. 312), the real wage elasticity in Table 2 has the expected negative sign. However, the impact is stronger than for the grain price: an increase in the real wage by one per cent leads to a decrease in the number of accusations by almost two per cent. Although fluctuations in food prices dominate the real wage, taking into account the other components of the basket of consumables gives a broader picture of changes in economic conditions.

In addition, the data situation for Essex allows to test another interesting hypothesis. For post-Reformation England, Thomas (1971) and Macfarlane (1999) have argued that the inability to keep up the old system of dealing with poverty via personal charity (Slack, 1988) created a conflict between long-held values and actual behaviour.[26] This conflict led to the increase in

[26]"*The great bulk of witchcraft accusations thus reflected an unresolved conflict between the neighbourly conduct required by the ethical code of the old village community, and the increasingly individualistic forms of behaviour which accompanied the economic changes of the sixteenth and seventeenth centuries.* [...] *It would certainly be wrong to think that there were no such difficulties and conflicts in the medieval village. But such tensions as there were then had to find some other outlet, for, as we have seen, it was only the*

persecutions. Once a public charity system was in place replacing the old informal institutions, the accusations decreased again. We test this explanation in two ways. First, we check whether, after a series of unsuccessful attempts in the 16th Century, the development of the Old Poor Law in the statutes of 1598 and 1601 had a significant impact on the number of accusations. Although the implementation of the law was not frictionless (Slack, 1988, p.113-137), this important step towards a public welfare system should have relieved pressure by re-assigning the responsibility for the poor to the local authorities. We model the implementation of the Poor Law by a dummy variable which takes the value one after 1601. A second way to look at the issue is to use the dependency ratio provided by Wrigley and Schofield (1989, p.447, Table 10.6).[27] If the number of people dependent on the income earner increases, the scope for redistribution via personal charity will be lower. This situation might make it necessary to turn down a neighbour asking for help, the typical situation leading to an accusation.[28] The results in Table 2 provide impressive evidence for this explanation. The elasticity of accusations with respect to the dependency ratio is about 5 per cent, and the implementation of the Poor Law leads to a reduction in expected accusations of over 60 per cent.

Reformation which, by taking away the protective ritual of Catholicism, made witchcraft appear a serious danger to ordinary people" (Thomas, 1971, p.670).

[27]They calculate the dependency ratio as the number of people aged 0-14 years and over 60 years per 1000 persons aged 15-59 years.

[28]"[...] *the most common situation of all was that in which the victim* [...] *had been guilty of a breach in charity or neighbourliness, by turning away an old woman who had come to the door to beg or borrow some food or drink, or the loan of some household utensil*" (Thomas, 1971, p. 660-661).

5 Conclusion

When looking at the impact of economic conditions on witch hunting activity, the literature comes to mixed conclusions, and stresses the importance of cultural and social determinants. Behringer (1997) argues that in Bavaria, hunger crisis years were important for increasing the propensity of people to persecute witches, but cautions against a monocausal interpretation. Analyzing regional witch-hunting data for the southern English county of Essex, Macfarlane (1999, p.147-157) concludes that economic factors did not play a prominent role in explaining the persecutions. He finds no evidence on the impact of population pressure or fluctuations in the emerging cloth industry on the frequency of accusations. Based on the results in Larner (2000), Maxwell-Stuart (2001, p. 55) states that Scotland is an example for a region without correlation between natural desasters and persecution of witches.

An econometric analysis of data from these regions demonstrates that in fact, there is a significant relationship between economic pressure and witch hunting activity. The results of the empirical exercise are in line with the main implications of our theoretical model, which explains fluctuations in hunting activity with cost-benefit considerations of the authorities. We find that the grain price elasticity of persecution varies between 0.5 and 0.8. This is a very small range, given the different characteristics of the three regions under analysis. Allowance for non-income hunting motivations like war and epidemics strengthens our argument for the importance of economic factors in reaching a full understanding of discrimination and persecution.

Appendix

A Tables

Table 1: Results for Bavaria (1550-1700), Grain Prices (Logs)

Augsburg	Poisson Model		Negbin Model	
	Estimate	Standard Error	Estimate	Standard Error
Constant	-0.389	1.610	-0.542	0.366
$GRAIN_t$	0.360	0.222	0.398	0.053
INF_t	-0.204	0.268	-0.175	0.161
WAR_t	-1.545	0.671	-1.037	0.504
$PANIC_t$	1.816	0.456	1.639	0.448
$PLAGUE_t$	0.515	0.566	0.197	0.384
ρ	0.246	0.104	0.219	0.075
d_t	-0.438	0.475	-0.382	0.237
λ			2.738	0.200
Log-Likelihood		31.935		37.392
N		151		151
Munich	**Poisson Model**		**Negbin Model**	
	Estimate	Standard Error	Estimate	Standard Error
Constant	-1.662	1.658	-1.246	1.014
$GRAIN_t$	0.534	0.231	0.491	0.140
INF_t	-0.198	0.271	-0.167	0.230
WAR_t	-1.576	0.707	-1.000	0.480
$PANIC_t$	1.773	0.424	1.645	0.418
$PLAGUE_t$	0.522	0.613	0.208	0.393
ρ	0.268	0.100	0.238	0.077
d_t	-0.364	0.471	-0.332	0.245
λ			2.713	0.202
Log-Likelihood		32.080		37.400
N		151		151

Notes:
$GRAIN_t$: log price level in Augsburg and Munich; INF_t: inflation dummy (1618-1623, 1659-1667, and 1676-90), WAR_t: war dummy (1625-26, 1632-37); $PANIC_t$: corrects for the extreme witch hunt in 1590; $PLAGUE_t$: plague dummy ((1602, 1621-35, 1648/49, and 1713); ρ: feedback parameter; d: see equation (13); λ: dispersion parameter in the Negbin model.

Table 2: Results for Essex (1560-1750)

Grain Price Index	Poisson		Negbin	
	Estimate	Standard Error	Estimate	Standard Error
Constant	-36.564	12.315	-34.631	11.11
$GRAIN_t$	0.577	0.332	0.806	0.347
$PANIC_t$	1.883	0.447	1.847	0.547
WAR_t	0.61	0.391	0.336	0.484
Poor Law	-1.026	0.244	-1.061	0.269
$PLAGUE_t$	-1.329	0.503	-1.039	0.474
$\ln DR_t$	5.127	1.878	4.619	1.669
ρ	-0.035	0.192	0.033	0.179
d_t	0.199	0.373	0.312	0.354
$qual_t$	-0.617	0.274	-0.623	0.247
λ			0.654	0.235
Log Likelihood		1.116		1.413
N		116		116

Real Wage	Poisson		Negbin	
	Estimate	Standard Error	Estimate	Standard Error
Constant	-18.207	15.54	-8.68	13.663
RW_t	-1.286	0.638	-1.77	0.58
$PANIC_t$	1.962	0.434	1.998	0.485
WAR_t	0.653	0.371	0.417	0.418
Poor Law	-1.125	0.228	-1.184	0.236
$PLAGUE_t$	-1.51	0.493	-1.268	0.454
$\ln DR_t$	4.115	1.994	3.129	1.762
ρ	0.003	0.203	0.096	0.186
d_t	0.262	0.39	0.418	0.362
$qual_t$	-0.679	0.281	-0.713	0.253
λ			0.62	0.244
Log Likelihood		1.1251		1.42
N		116		116

Notes:
$GRAIN_t$: grain price index (logs); RW_t: Real Wage; $PANIC_t$: corrects for the extreme hunts 1582 and 1645; WAR_t: Civil War 1641-1649; Poor Law dummy: active after 1601; $PLAGUE_t$: plague dummy (1597-1599); $\ln DR_t$: log of dependency ratio; ρ: feedback parameter; d_t: see equation (13); λ: dispersion parameter in the Negbin model.

Table 3: Results for Scotland (1560-1760), Oats Prices (Logs)

Edinburgh	Poisson		Negbin	
	Estimate	Standard Error	Estimate	Standard Error
Constant	0.547	0.497	1.215	0.365
$GRAIN_t$	0.978	0.271	0.666	0.204
WAR_t	-0.477	0.359	-0.105	0.214
$PANIC_t$	2.276	0.318	2.139	0.348
$PLAGUE_t$	-0.130	0.384	-0.195	0.408
OCC_t	-0.251	0.527	-1.031	0.267
ρ	0.232	0.101	0.208	0.104
d_t	-1.196	0.469	-0.445	0.277
λ			3.054	0.199
Log Likelihood		44.865		50.917
N		201		201
Fife	**Poisson**		**Negbin**	
	Estimate	Standard Error	Estimate	Standard Error
Constant	0.614	0.429	1.197	0.388
$GRAIN_t$	1.038	0.258	0.751	0.224
WAR_t	-0.457	0.383	-0.120	0.292
$PANIC_t$	2.326	0.301	2.168	0.324
$PLAGUE_t$	-0.250	0.381	-0.236	0.317
OCC_t	-0.263	0.519	-1.028	0.272
ρ	0.234	0.092	0.209	0.098
d_t	-1.220	0.456	-0.484	0.300
λ			3.032	0.195
Log Likelihood		44.997		50.921
N		201		201

Notes:
$GRAIN_t$: wheat prices (logs), WAR_t: corrects for war periods (1639/40, 1645, 1679-1684, and the Jacobite rebellions 1715, 1719, 1745/46); $PANIC_t$: corrects for panic trails (1590/91, 1597, 1629/30, 1649, 1661/82); $PLAGUE_t$: plague dummy (1644-1649); OCC_t: active during English occupation 1651-1660 and after 1707; ρ: feedback parameter; d_t: see equation (13); λ: dispersion parameter in the Negbin model.

Table 4: Results for Scotland (1560-1760), Edinburgh Wheat Prices (Logs)

	Poisson		Negbin	
1560-1670	Estimate	Standard Error	Estimate	Standard Error
Constant	0.323	0.624	1.137	0.374
$GRAIN_t$	0.920	0.275	0.587	0.172
WAR_t	-0.542	0.333	-0.122	0.489
$PANIC_t$	2.273	0.318	2.175	0.357
$PLAGUE_t$	-0.090	0.400	-0.231	0.367
OCC_t	-0.272	0.530	-1.056	0.267
ρ	0.207	0.103	0.192	0.098
d_t	-1.199	0.460	-0.418	0.263
λ			3.047	0.210
Log Likelihood		44.991		50.922
N		201		201
1560-1599,	Poisson		Negbin	
1621-1670	Estimate	Standard Error	Estimate	Standard Error
Constant	0.156	0.689	0.980	0.351
$GRAIN_t$	1.030	0.303	0.689	0.156
WAR_t	-0.560	0.339	-0.093	0.063
$PANIC_t$	2.234	0.312	2.165	0.336
$PLAGUE_t$	-0.086	0.397	-0.193	0.368
OCC_t	-0.302	0.505	-1.036	0.266
ρ	0.197	0.098	0.181	0.099
d_t	-1.283	0.473	-0.431	0.284
λ			3.158	0.212
Log Likelihood		49.743		56.129
N		180		180

Notes:
$GRAIN_t$: wheat prices (logs), WAR_t: corrects for war periods (1639/40, 1645, 1679-1684, and the Jacobite rebellions 1715, 1719, 1745/46); $PANIC_t$: corrects for panic trails (1590/91, 1597, 1629/30, 1649, 1661/82); $PLAGUE_t$: plague dummy (1644-1649); OCC_t: active during English occupation 1651-1660 and after 1707; ρ: feedback parameter; d_t: see equation (13); λ: dispersion parameter in the Negbin model.

B Data

Behringer (1997) presents evidence on witch trials in the Southern part of today's Bavaria. Since witch activities were considered to be capital crimes, their persecution was in the responsibility of the various states. The number of accusations increased over the 16th Century: in 1562/63, the first serious persecutions took place, a smaller one in 1570 and a larger one in 1575, almost immediately followed by the 1578-81 hunt. The "large panic trial" started in 1568/7, with the absolute peak in 1590. Between 1587 and 1630, there were almost never less than 10 women accused in the territories under analysis. During the Swedish invasions persecutions declined. The period from 1650 to 1700 is characterised by strong one-year peaks in 1673, 1680 and 1694. To estimate the impact of economic conditions on hunting activity, we analyze the impact of grain prices on the Augsburg and Munich grain markets (Elsas, 1936, 1940, 1949). The market conditions in these two cities can be regarded representative for the region under analysis.

The data for Essex are from Macfarlane (1999) for the observation period 1560-1675. Between 1560 and 1579, Macfarlane (1999, p. 28, Table 3) reports 52 cases for the Essex Assizes. This number increases in the period 1560-1599 to 111, and falls to 44 in 1600-1619 and 25 in 1620-1639. During 1640-1659, there is again an increase (63), and after 1660, the number of cases falls to 12. Two unusual outbreaks occur in 1582 and 1645. To measure economic conditions, we use the grain price index in Bowden (1967, 1985, Table I). The calculations are based on the harvest year (e.g. harvest year 1620: September 1620 - September 1621).[29] To make use of the rich data sets available for England in this period, we also test the impact of the real wage

[29]Since the indictment numbers come from the Trinity and Hilary assizes, the relevant grain price is from the year before.

index estimated by Wrigley and Schofield (1989, p.642-644, Table A9.2).

The Scottish data are from the Scottish Witchhunt Data Base,[30] the observation period is 1560-1760. The witch hunts started with the Witchcraft Act in 1563, which made witchcraft a capital crime (until 1735).[31] The majority of cases are concentrated in the period between 1590 and 1662. Larner (2000) distinguishes 5 peaks of persecution waves: the first two, 1590/91 and 1597 are characterized by the strong support of the Scottish king James VI. The peak in 1629/30 coincides with the continental panic, and the peaks in 1649 and 1661/62 are characterised by the peak in the Convenanting influence and the Restoration. After 1662, witch hunting activity decreased. In the 18th Century, only a few cases can be found. Regional price series are available from Gibson and Smout (1995). Intensive hunts took place in the East of Scotland (Fife, Lothians and Borders, Larner (2000, p. 81)). Therefore, we took grain prices (oats and wheat) from Fife and Edinburgh.[32] To account for missing values, we interpolate the data by estimating a VAR in levels. We re-write the VAR in state space form and apply the Kalman filter to derive the likelihood (Harvey, 1992). This allows us to estimate the parameters of the model and the missing observations simultaneously.[33] To make sure that the results presented above are not due to the interpolation method, we present two sets of results for the Edinburgh wheat price (Table 4), where the second set leaves out the period with missing price data (1600-1620).

[30]Scottish Witchhunt Data Base, version 1.5. The data base is an extension of the work by Black (1938) and Larner *et al.* (1977). We are very grateful to Stuart Macdonald for providing us with the data.

[31]For the following, see Larner (2000, p. 60-68).

[32]Oats: Edinburgh: 1645-1760; Fife: 1640-1760 (Gibson and Smout, 1995, Table 3.2); Wheat: Edinburgh: 1556-1678 (Gibson and Smout, 1995, Table 2.3); 1626-1760 (Gibson and Smout, 1995, Table 3.8).

[33]For a similar procedure, see Froot *et al.* (2001).

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