ELITES, WEATHER SHOCKS, AND WITCHCRAFT TRIALS IN SCOTLAND

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Abstract. I find that favourable temperatures predict more witchcraft trials in Early Modern Scotland (1563-1727), a largely agricultural economy. During this time, witchcraft was a secular crime, and it was incumbent on local elites to commit resources to trying witches. My main empirical specification survives various robustness checks, including accounting for outliers. Turning to mechanisms, I find that positive price shocks to export-heavy, taxable goods predict more witch trials, while price shocks to Scotland's main subsistence commodity, oats, do not. This is consistent with the explanation that as elite income increased, more resources were devoted to witchcraft prosecutions; I cite anecdotal evidence that a different proceeding, sexual trials in Aberdeen, experienced a similar trend.

Fair is foul, and foul is fair.

- William Shakespeare, Macbeth

1. Introduction

Today's wealthiest countries have strong fiscal and legal state capacity (Dincecco and Katz, forthcoming). Centralized states are associated with beneficial outcomes: less poverty (Michalopoulos and Papaioannou, 2013), more stability (Blattman and Miguel, 2010; Besley and Persson, 2011), and better public goods provision (Acemoglu et al., 2014; Dell, 2017). Indeed, the correlation between high living standards and various state capacity measures is well established (Johnson and Koyama, forthcoming).

Yet there is a deleterious, and even dark, side to state capacity. Lowes et al. (forthcoming) show that centralized political institutions can crowd out norms of rule-following, hence weakening good customs and incentivizing bad ones, like cheating. More disturbing, however, is the idea that state capacity can mould the conditions required for organized genocide, such as in Rwanda (Heldring, 2017). In Rwanda's case, state planning and resources were required to carry out persecutions against Tutsis.

In this paper, I use data from Early Modern Scotland to examine a particular type of persecution, made possible through strong legal state capacity: witch hunts, which were motivated by a genuine belief that witches are evil. Scottish law, which made witchcraft a

secular crime in 1563, de facto required local elites to commit resources to trying witches. When these resources were more ample, witchcraft prosecutions increased. Consistent with this, and given that Scotland was an agricultural economy, I find that favourable (warmer) temperatures predict more trials. This is robust to county-specific time trends, different specifications, placebo tests using forward lags, and accounting for outliers.

Turning to mechanisms, I document secondary historical evidence that Scottish elites derived income from export-heavy, taxable commodities such as herring and wool. Using this as a guide, I find that positive price shocks to herring and wool predict more trials. As a falsification, I find that shocks to Scotland's main subsistence commodity, oats, do not predict trials, since this crop was not a major source of elite income. I provide historical evidence that these patterns were not due to greed, since witchcraft suspects had little valuable property, and trials were costly.

My paper proceeds as follows. In Section 2, I review related literature, and demonstrate my study's contribution. In Section 3, I provide historical background. In Section 4, I describe my empirical strategy and data in order to identify the causal impact of shocks on witch trials. Section 5 provides my results, along with robustness checks and mechanisms. In Section 6, I conclude.

2. Related Literature

My study investigates the idea that economic shocks cause violence, and thus follows an important literature in this vein (Hsiang et al., 2013; Collier and Hoeffler, 2004; Miguel et al., 2004). In particular, Bazzi and Blattman (2014) have stressed the need for case study evidence in order to disentangle underlying mechanisms. By examining witchcraft trials in Early Modern Scotland, I focus on a single case study, and am therefore able to uncover mechanisms that drive the link between temperature shocks and witch trials, while limiting confounding factors. This is an important contribution, since economic channels that drive conflict and violence are still ill understood, though recent research has made progress in this direction (Dell, forthcoming; Fetzer, 2014; Dube and Vargas, 2013).

The debate over these channels is long-lasting. Dube and Vargas (2013) use data on Colombian conflict in the 1990s and early 2000s to identify two widely-discussed mechanisms: the opportunity cost effect, and the rapacity effect. The former effect states that when the *value* of being violent rises, relative to other activities, then violence itself increases (Besley and Persson, 2011; Dal Bo and Dal Bo, 2011; Angrist and Kugler, 2008). For example, if agricultural wages decline, then farm workers are more likely to join guerrilla squads. The rapacity effect, and its analogue the state prize effect, claims an opposite impact: higher income means that there is more to fight over (Hirshleifer, 1991; Grossman, 1999). If, say, oil prices rise, then paramilitaries are more likely to attack oil fields and kidnap oil executives. Although I find that positive environmental shocks predict more witch trials, this is not due to a rapacity effect. Rather, it is due to the ability of local elites to finance a trial.

The papers closest to mine in subject matter are Oster (2004), Miguel (2005), Johnson and Koyoma (2014), and Leeson and Russ (forthcoming). Oster uses time series data to document a negative relationship between air temperatures and witch trials in Early Modern Europe, and argues that poor economic conditions prompt such trials. Unlike Oster, I focus on a single case study, Scotland, which had more centralised institutions than the rest of Europe for prosecuting witches. I uncover a completely different result: positive economic shocks predict *more* witchcraft trials. I also provide empirical evidence for an explicit mechanism driving this result.

Miguel's (2005) study of Tanzania suggests a similar story as Oster's: when rainfall is low, people kill unproductive members of society by blaming them for witchcraft. Tanzania, however, does not have the legal institutions that Scotland had for dealing with witchcraft accusations. Witch killings in Tanzania are much more decentralised, and are often carried out by family or community members without judicial restraint. In Scotland, sizable costs were incurred to ensure that legal procedure was carried out before a witch was executed, and it is not at all clear that Scottish witches were economic burdens.

Johnson and Koyama (2014) investigate witchcraft trials in France between 1550 and 1700, and argue that increases in fiscal capacity strengthened rule of law, reducing the number of

witchcraft trials. Scottish trials were different from France's in this regard, since Scottish trials were more centralised, and followed rather strict judicial guidelines. At any rate, I am interested in an entirely different question: whether economic shocks caused witchcraft trials.

Leeson and Russ's (forthcoming) study examines witch trials across Europe, and finds that non-market competition between Catholics and Protestants account for much of the variation in trials. Unlike Leeson and Russ, who find that income does not matter for predicting witchcraft trials, I find that it does, at least in Scotland. Leeson and Russ's general explanation does not account for Scotland's peculiarities, and indeed, they do not claim to have disproven the weather explanation. My explanation, moreoever, does not contradict theirs; it is possible that both religious competition and funding for trials mattered.

Because most Scottish witch suspects were women, I make a contribution to the literature on violence against women.[1] Estimates find that intimate partner violence, and sexual violence against women, cost as much as $4.49 trillion per year, or 5.3% of world GDP (Fearon and Hoeffler, 2014). Causes of domestic violence, in particular, have been well-studied and include women's household bargaining power (Doss, 2013; Bloch and Rao, 2002) and emotional cues that prompt male spouses to act aggressively (Card and Dahl, 2011). In Early Modern Europe, women were viewed as inferior and corruptible beings, more naturally prone to witchcraft than men, which caused them to be hunted as witches (Rowlands, 2013). I find that weather shocks can precipitate these acts of violence.

I contribute to the literature on historical witchcraft trials by using a panel dataset to study the impact of temperature on Scottish trials. Historians have postulated a number of factors that contributed to witch trials, including changing religious values (Levack, 2006), state expansion (Larner, 1981), and patriarchy (Apps and Gow, 2003). I offer another explanation: the costs of financing a trial must be sufficient.

Finally, a growing literature in economics has examined persecutions (Jha, 2013; Voigtlander and Voth, 2012; Waldinger, 2010) . For instance, Anderson et al. (forthcoming) find

[1]Roughly 85% of Scottish witch suspects were women.

that bad weather shocks predict more Jewish expulsions from European cities between 1100 and 1800. The authors claim that these expulsions are driven by political economy concerns, as local rulers scapegoat Jews for economic woes. My story is also a political economy one, driven by the ability of local elites to finance a trial.

3. Historical Background

The Protestant Reformation consolidated itself in Scotland in 1560, when Edinburgh's Parliament formally rejected papal authority. Prior to the Reformation, witches were, at worst, seen as beings to be appeased, not persecuted. The Reformation changed this with its insistence on deliberate eradication of evil, thus making witchcraft a secular crime in 1563 with the Scottish Witchcraft Act (Cowan, 2008). The cultural reasons behind this are beyond this study's scope, though other authors have covered this in detail (Goodare, 2013; Roper, 1994; Smout, 1973).

Historical evidence suggests that central authorities, especially the Privy Council in Edinburgh, were able to exert some influence over proceedings, so that no local trials occurred without first going through Edinburgh.[2] Local authorities were indeed content to have their trials sanctioned by central bureaucracy. According to a number of scholars, central control over witchcraft prosecutions was an important part of state building in Early Modern Scotland, a country that was otherwise difficult to govern (Dillinger, 2013; Larner, 1981).

There were five stages of witch hunts (Goodare, 2002):

(1) A witch is identified locally.
(2) Evidence is gathered through local kirks (churches) and elites.
(3) The Privy Council or parliament in Edinburgh reviews the evidence, and grants permission to local elites and witch hunters to set up a 'commission of judiciary' to try the accused.
(4) The commission tries the witch.
(5) The convicted witch is executed.

[2]Treason was the only other crime to enjoy such a level of central oversight (Larner, 1981).

The bulk of expenses for the trial was incurred locally. The Privy Council was very interested in ensuring that proper judicial procedure was carried out, in order to prevent witch trials from descending into decentralised and unregulated lynchings.

The first stage, the identification of a witch, happened locally.[3] A triggering event, such as a death in the family, would incite Scottish people to accuse neighbours of witchcraft. It usually took years before a neighbour's accusation of witchcraft would result in a formal complaint, a pattern consistent with the rest of Europe (Briggs, 1998). Another way to identify a witch was for already accused witches to name their co-conspirators, although such evidence was given less weight.

In the second stage, a confession was sought, and this stage often involved torture. Sleep deprivation was commonly used, and was very effective in obtaining confessions, since it led to hallucinations (Dudley and Goodare, 2013). This stage might involve local kirk (church) officials, who otherwise had a very limited role in witchcraft prosecutions. Local officials and elites had to ensure that the evidence collected during this stage was suitable for Edinburgh's vetting.

The third stage involved acquiring Privy Council or parliament's permission to set up a commission of judiciary, composed of local elites (lairds, burgesses, justices, etc.) to try a witch. As Levack (2008) says,

> Most cases... were adjudicated by local authorities who petitioned the privy council or parliament for permission... These local commissioners then assembled an assize (jury) to determine innocence or guilt, which in most cases turned out to be the latter. (p. 4)

It was at this stage that the central government in Edinburgh got involved in local affairs. However, besides granting permission, the Privy Council and parliament usually did not intervene directly in local trials.

The trial itself, the fourth stage, relied on four types of evidence: confessions, neighbours' testimony, other witches' testimony, and The Devil's Mark. This last proof, either a visible

[3]An important exception, the 1590 North Berwick trials, started when King James accused witches of trying to sink his ship. However, even these trials relied on local identification of suspected witches.

blemish or insensitive spot on the body, was discovered by court examiners or professional witch-prickers. It was a sign of a witch having made a Satanic pact.[4] Once witchcraft was established, the witch was strangled at the stake until dead, and her body was subsequently burned.

To attain a more concrete analysis, I cite Paterson (2013), who uses case study evidence from Scottish witchcraft prosecutions to examine trial expenses. In 1596, when a day-labourer's wages were 40 pence per day (Gibson and Smout, 1994), it cost £20 to imprison a witch in Aberdeen.[5] This paid for the accused's sustenance, as well as the costs of extracting a confession. Elites paid the amount; as Paterson documents, the bill was laid upon a laird's estate, a burgh council composed of merchant elites, or a town council comprised of local elites and magistrates. Although a witch's property was sometimes seized to pay part of the trial costs, most witches had little valuable property, and the bulk of expenses were paid by local elites.

The last Scottish witchcraft trial was in 1727, and witchcraft was removed from secular criminal offenses in 1736. Historians investigating the decline and end of Scottish witch hunting have concluded that lawyers became less convinced about the validity of evidence in witchcraft cases: confessions under tortures were seen as questionable, and witch-pricking for the Devil's Mark was exposed as fraudulent (Wasser, 2008; Levack, 2008).

An example of a specific witchcraft trial helps to elucidate specifics. I take this case study from Larner (1981), who describes the stories of two women, of uncertain age, tried and executed for witchcraft in the town of Dumfries, in 1671. One of them, Janet Macmurdoch, had several accusors, including John Moor of Barlay, whose accusations dated from 1665, over Macmurdoch's unpaid rent. When John Moor impounded Janet's livestock, she cursed him, allegedly causing his child to subsequently die. Another accusor, John Murray of Laik, accused Janet of evil actions she committed in 1664, and Jean Sprot, another plaintiff, was cursed by Janet in the same year, causing Jean to suffer a strange disease. Clearly, it took a long time for accusations to come to fruition, in the form of a formal trial.

[4]The pact was sexual in nature, culminating in a witches' orgy.
[5]There were 240 pence in one Scottish pound.

The jury consisted of small lairds and grand tenants, men of prominence, from a ten-mile radius around Dumfries. This assize had to travel over rough terrain, in order to preside over Janet's trial. This pattern reflects Scotland's rural character at the time: as Larner (1981) says, there were scattered villages instead of nucleated towns, a trend different from England's. On May 18, 1671, Janet Macmurdoch was executed, and her body burned.

4. Data and Empirical Strategy

4.1. **Empirical Strategy.** To test for the effects of temperature on witchcraft trials, I estimate the following specification:

$$Witch\ Trial_{i,t} = \beta Shock_{i,t} + \delta_i + \eta_t + \epsilon_{i,t}. \tag{1}$$

Here, $Witch\ Trial_{i,t}$ is either a dummy for whether or not a trial occurred, or a count for the number of witchcraft trials in county i in year t.

$Shock_{i,t}$ is simply a temperature shock, where temperature is measured as a deviation from an average over the period 1961-1990. In my specifications, I use either a three-year, five-year, or ten-year moving average for temperature. The reason I use moving averages is because historians have documented that it took a long buildup for witchcraft suspicions to become full-blown accusations - sometimes as long as twenty years (Larner, 1981). To examine mechanisms related to agricultural commodities, I use $Suitability_i \times Price_t$ for the shock, where $Suitability$ is county i's suitability for the particular commodity, while $Price_t$ is its price on world markets in year t.

δ_i and η_t are county and year fixed effects, respectively. I use these to control for omitted heterogeneity at the level of counties and time periods. I also report county-specific trends for robustness. The equation is estimated using OLS, and I cluster standard errors by county.

My identification strategy is based on the fact that temperature and world commodity prices are exogenous from a single county's point of view. A negative coefficient on β implies that the shock negatively predicts unrest, while a positive coefficient β means that the shock

positively predicts unrest. In northern Europe, unlike tropical zones such as Africa, higher temperature are better for agriculture.

4.2. **Data.** I acquire witchcraft trial data from the Survey of Scottish Witchcraft, which is available through the University of Edinburgh. The database was derived from previously existing printed data, and was enhanced through extensive archival research. Not all of those who were tried were executed: of the 305 cases we know the outcome for, 205 were executed, 52 were acquitted, and the rest were banished. However, while this sample gives an execution rate of 67%, the Survey's researchers believe that the actual execution rate was much higher, since this sample mostly comprises trials at Edinburgh's justiciary court, which followed judicial procedure more rigidly than the vast majority of courts. The Survey offers wide coverage of the year and county of witchcraft trials, for 3,098 witch suspects. For additional documentation, please see the Survey's website.[6]

Weather data for this period are scant, and the only panel data available for Europe are from Guiot and Corona (2010). These authors collect data from proxy sources, including ninety-five tree ring series, sixteen indexed climate series based on archives, ice-core series, and pollen series to construct grids of reconstructed growing-season (April to September) temperature for Europe from 900 AD to today. I use geospatial software to match counties with their nearest grid points. The measured temperatures are based on deviations from the 1961-1990 average.

There is substantial evidence that warmer temperatures in northern Europe are better for agriculture (Olesen and Bindi, 2002). Studies of Early Modern northern Europe have shown that warmer temperatures predict lower wheat prices (Waldinger, 2014) and greater grain yield (Holopainen and Helama, 2009). Parry (1975), in particular, examined cereal cultivation in south-east Scotland from the late Middle Ages to the the eighteenth century, and found that colder temperatures substantially reduce yields. It is therefore a sound assumption, for my analysis, that warmer temperatures improve agricultural conditions.

[6]http://www.shca.ed.ac.uk/Research/witches/

Scottish counties during this period look very different than they do today. Because no digital map of Early Modern Scottish counties is easily available, I constructed a map based on *The Atlas of Scottish History to 1707*. This gives me borders of counties that existed from 1563 to 1727, the years of my analysis.

In my specifications, I always control for population density, since this could impact trials. These data are from the History Database of the Global Environment (HYDE), and are available for the years 1500, 1600, 1700, 1710, 1720, and 1730.[7] HYDE data are based on historical sources of population numbers. Because there are gaps in my data, I linearly interpolate between years, within counties, to construct a balanced panel.

Price data, in real amounts, are from the Allen-Unger database. These data were collected by Robert C. Allen and Richard W. Unger based on various sources, and contains the price of commodities in grams of silver per litre. I examine three commodities in my analysis: wool, herring, and oats. None of the price data come from Scotland, but rather from important trading posts and cities from around the world, like Massachusetts, London, and Paris. Based on the *Atlas of Scottish History to 1707*, I located and mapped Scotland's eight major trading ports: Leith, Glasgow, Bo'ness, Dundee, Ayr, Aberdeen, Burntisland, and Inverness. I then located the Allen-Unger location that is closest to Scotland in that particular time period, and used the commodity price from that port.

For wool, there is only one port for this period, "England." Herring price data are from Antwerp, "England," Frankfurt, Linkoping, and London. There are gaps in the herring price data, which I used linear interpolation to fill.

For oats, I use the price for London from 1550 to 1565, "Southern England" from 1566 to 1702, and Coutances for 1702 onwards.[8]. I also use oats price data with Gibson and Smout's (1994) price series for Scotland, which contains oats prices for Fife. Although oats prices from other regions are also available, Fife has the widest coverage. The correlation between

[7] http://themasites.pbl.nl/tridion/en/themasites/hyde/

[8] There is a gap in this data for the year 1582, for which I use the oats price from Antwerp

the Allen-Unger oats price, and that from Gibson-Smout, is 0.2872, with corresponding p-value 0.0058. I can thus say that the two price series for oats are well-correlated with each other.

Suitability for growing oats is from the *Food and Agriculture Organization*'s Global Agro-Ecological Zones (GAEZ) database. I use the values for rainfed, low input oats suitability, and merge this with my map of Scotland. Because oats suitability may not identify where oats were actually grown historically, I also use cropland usage data from the History Database of the Global Environment for the year 1500. For pasture land, I acquire data from Ramankutty and Foley (1999), which helps me to identify the suitability for herding sheep. Finally, for herring, I use information from Rorke's (2005) article on the Scottish herring trade from 1470 to 1600; instead of a continuous suitability measure, I use an indicator, since Rorke describes whether or not a region caught herring for export.

County-level fixed effects mean that I do not need to control for time-invariant county characteristics. However, I interact variables, such as distance from Edinburgh and justices of the peace, with my shock to test for heterogenous responses of trials to weather shocks. These are above-median indicators. For example, if distance from Edinburgh is greater than median, I code this as a 1, and as a 0 otherwise. I acquire justices of the peace data from the *Atlas of Scottish History to 1707*; this is the average number of justices over the period 1587 to 1663, when data is available.

Summary statistics for my dependent variables, shocks of interest, and county characteristics are shown in Table 1. I also provide a map of the total number of witchcraft trials over this period in Figure 1. As can be seen, Edinburgh and East Lothian (Haddington) had the most intense witch-hunting. In Figure 2, I plot time series data for witch trials and temperature in Edinburgh county.

5. Results

5.1. **Main Results.** In Table 2, I report my main results for witch trials from 1563 to 1727, using three different moving averages for 3 years, 5 years, and 10 years. As can

be seen, positive shocks to temperature predict more trials. For example, in column (2), a standard deviation increase in temperature causes a 0.06 standard deviation increase in trials. In column (5), a standard deviation increase in temperature causes a 0.14 standard deviation increase in the probably of a trial, or 4.06%. All regressions control for county-level population density, which might also predict trials.

These effects can be favourably compared to Hsiang et al's (2013) meta-analysis of the literature on climate and conflict, which finds that a standard deviation increase in temperature causes a 4% median increase in interpersonal violence, and a 14% increase in intergroup violence, across studies. Hsiang and his coauthors classify Tanzanian witch killings as "Personal Violence and Crime," and claim that these median figures are substantial, lending support to my results on Scottish witch trials.

5.2. **Robustness.** It is possible that I am not accounting for time-varying, county-specific factors that might affect witchcraft prosecutions. I thus repeat the analysis using county-specific time trends in Table 3. The results are still positive, large, and generally significant: for example, in column (6), a standard deviation increase in temperature (10 year MA) causes a 0.19 standard deviation increase in the probability of a trial, or 5.63%.

In Table 4, I conduct additional robustness checks by changing the empirical specification. In Columns (1)-(3), I run a logistic regression analysis, and in columns (4)-(6), I use $ln(trials + 1)$ as my dependent variable. Results are still large and significant.

As an additional check, I exclude trials prior to 1610. This is for two reasons. First, King James set off a national witch panic in 1590 when he accused witches of trying to kill him by sinking his ship. Thus, witch trials in 1590 were not due to local factors. Furthermore, Goodare (2002) claims that autonomous local trials, without central approval, occurred prior to 1610. These trials were conducted in regality courts, private courts that landlords held to settle disputes, and so were not as costly as establishing a commission of justiciary. Results are shown in Table 5. The results are significant, and larger than before, as I would expect. For example, in column (1) a standard deviation increase in temperature (3 year

MA) causes a 0.11 standard deviation increase in trials. Favourable weather continues to cause more witchcraft trials.

Furthermore, it is possible that political events in the 1650s to 1660s are driving these results. As I discuss later, this period involved English occupation of Scotland, and it is possible that lairds were forced to demonstrate subservience to their English overlords by, among other tasks, trying witches.[9] I therefore repeat the analysis in Table 2, by excluding the 1650s and 1660s from my analysis. The results, reported in Table 6, remain large and significant. For instance, in column (6), a standard deviation increase in the temperature shock causes a 5% increase in witch trials.

My crucial identifying assumption is that weather is unrelated to unobservables that could bias my estimates. To determine if this is in fact the case, I perform a placebo test in Table 7, replacing current moving-average weather shocks with future moving-average weather shocks (one year forward). If my identification is sound, then there is no reason that future weather should predict current witch trials. As my results show, there is no significant relationship between witch trials and future weather, and the coefficient estimates are smaller than those for my main results. For example, in column (2), a standard deviation increase in the five-year moving average predicts only a 0.01 standard deviation increase in trials. Compare this to column (2) in Table 2, with a 0.06 standard deviation increase in trials predicted. This supports my identification strategy.

An alternate explanation for these patterns is greed: namely, witchcraft suspects had possessions that neighbours and the Crown wished to seize, and these possessions increased in value during beneficial years. There were a handfull of cases like this - notably, there were seven high-status women who were accused by heavily indebted men with property disputes (Yeoman, 2002). However, most such prosecutions failed, and the vast majority of witchcraft suspects were low-status women with no valuable property. Of the 316 witch suspects in my dataset whose socioeconomic status is known, only 9 are classified as either "Lairds/Baron" or "Nobility/Chiefs". Given the time and resources it took to try witches, historians do not

[9]Indeed, my data show that 384 witches were tried in the 1650s, and 647 in the 1660s, for a total of 1,031.

believe that witchcraft trials were driven by greed (Goodare, 2010). Early Modern Scots, including educated elites, believed strongly in witchcraft, and were willing to take concrete measures to extirpate evil.

In Table 8, I briefly consider simple lagged temperature shocks, since my hypothesis depends crucially on the buildup of elite resources prior to a trial. In other words, elites need to accumulate resources over time in order for trials to occur, while there is unsatisfied demand. Although only column (4) in Table 4.7 is significant, all specifications yield positive and large coefficients. For example, column (2) shows that a standard deviation increase in temperature causes a 0.08 standard deviation increase in trials.

My hypothesis of a supply-side constraint is further demonstrated through a political incident: the 1660 end of Republican occupation of Scotland. After the English republicans left Scotland to its own devices, there was an outbreak of witchcraft trials. According to my data, only 2 trials were held in 1660. From 1661-1662, there were 612 witches prosecuted. Although this was a political event, it nonetheless supports my resource constraint theory of Scottish witch trials.

I have documented a robust relationship between beneficial temperatures and witchcraft prosecutions. This fits well with the observations that local elites required resources to conduct witchcraft prosecutions. It also supports my theoretical prediction that years of higher income should experience more trials.

5.3. **Compliers.** In Table 9, I interact the 5 year moving average weather shock with various compliers. First, I examine whether distance from Edinburgh had an impact. Those wishing to try a witch had to seek the Privy Council or parliament's permission in Edinburgh; in my model, this proxies for a higher marginal cost of conducting a trial. Indeed, I find that a greater distance from Edinburgh (higher than median) attenuates the impact of the shock on trials.

I then determine whether having more justices of the peace has an impact. Data on justices of the peace is available for every county except Cromarty, and therefore my sample size is slightly smaller. More justices of the peace implies a lower marginal cost of conducting a

trial, since there is some legal state capacity available to try a witch. Indeed, this amplifies the impact of the shock.

To get a sense o the marginal benefit of prosecuting a witch, I use the intuition that during times of national political crisis, the marignal benefit increases - it is dangerous to let witches roam during these times. I use Levack (2008) to identify five periods of political instability: In 1590-91, James I was fending off a series of rebellions; In 1597, there was a large-scale quarrel between church and the state; In 1643-44, a radical group of presbyterians, the covenanters, consolidated political power in Scotland; In 1649-50, some covenanters fought English military efforts to occupy Scotland; Finally, in 1661-1662, the covenanters were displaced by royal power. I code each of these years as a '1', and a zero otherwise, and then interact this with the weather shock. Clearly, times of crisis exacerbate the impact of this shock on trials. This corresponds to an increase in the marginal benefit, leading to more witch trials.

Finally, I examine distance from the nearest trade port. Counties further from trading ports have less access to alternate sources of income. If this is greater than median, I indicate this as a '1', with a zero otherwise. This is intended to capture y, the value of income. According to my model, the smaller this income is, the less likely a trial is to occur. Indeed, a higher distance from a port attenuates the impact of the shock on witch trials, lending support to my hypothesis.

5.4. **Mechanisms.** Because local elites, such as lairds and burgesses, were responsible for the time and money involved in carrying out witch trials, I expect that positive shocks to their income would lead to more witchcraft trials. Specifically, shocks to export-heavy, taxable commodities like herring and wool should have an impact on trials, while shocks to Scotland's main subsistence commodity, oats, should have no effect.

Historical evidence states that local elites derived income not only from peasant rents, but also from exports. Customs duties were levelled on goods exiting Scotland, helping to fill the coffers of burgesses and lairds through customs farming. Evidence from Gowrie and Aberdeen also suggests that tenants paid landlords rents in the form of surplus agricultural

produce, which landlords then sold to merchants to buttress their income (Young, 2007; Whyte, 1986). Furthermore, many elites (burgesses) of royal burghs and burghs of barony were themselves merchants, who relied on export income to exert local political and economic power (Brown, 1992; Smout, 1973). Based on data from the *Atlas of Scottish History to 1707*, I was able to identify two of the most common exports: wool, and herring. Based on a 1614 survey of exports from the *Atlas*, wools and wool products composed about 15% of total exports, while herring composed 13% of total exports. Fells (timber) is the only commodity that comprises a larger percentage of exports (21%), but based on customs receipts from 1595 to 1599, wool and herring were taxed at a higher rate than fells. I therefore focus on wool and herring as examples of export-heavy, taxable commodities.

Scotland's main subsistence commodity, oats, was not exported much at all. Oats comprise 0.4% of total exports, based on the 1614 survey. Oats' short growing season combined with their nutritious content made them a staple diet among Scots (Smout, 1973). Therefore, although it was an important crop, oats do not contribute significantly to elite income, and therefore should not impact witch trials.

My reduced form relationship between weather and witch trials requires some discussion here. Warm temperatures in Scotland were important for growing oats, but also for producing wool and catching herring. Veterinary studies show that sheep shear better when temperatures are warm, and they can die or fall ill under inclement conditions (Glass and Jacob, 1991; Torell et al., 1969). With regards to herring, a common method of storage at the time was salting (Rorke, 2005), which works better under warmer temperatures. It is also more likely for fishing boats to sail when the weather is good.

In Table 10, I show the regressions for wool/herring price shocks and witch trials. Total witch trials is the outcome variable. Clearly, higher prices of both commodities lead to more trials. For example, in column (1), a standard deviation increase in the wool price shock (3 year MA) increases trials by 0.15 standard deviations. In column (4), a standard deviation increase in the herring price shock (3 year MA) increases trials by 0.10 standard deviations.

In Table 11, I regress witch trials on oat price shocks. In columns (1)-(3), I interact the world oats price with the FAO data for oats suitability. There is no significant effect, although the coefficient estimates' sizes are comparable to those for herring and wool. In column (3), a standard deviation increase in the oat price shock reduces trials by 0.13 standard deviations. The coefficient estimates are negative, which could suggest the following story: peasants who grow and sell oats blame witches when oat prices are low. Although this is plausible, there is no historical evidence to support it, and at any rate, the coefficients are insignificant: even if peasants complain about witches, elites need the resources to prosecute. In columns (4)-(6), I interact the world oats price with HYDE data for cropland usage, and again find an insignificant impact, although it is now positive, further indicating that the oats price does not robustly predict trials. The effect is still sizable - for instance, in column (4), a standard deviation increase in the oats shock predicts a 0.09 standard deviation increase in witchcraft trials - however, given the overall insignificance, and the fact that this insignificance is robust across specifications, I can conclude that oats shocks do not predict witch trials. In columns (7)-(9), I use Gibson and Smout's (1994) oats price data for Fife, and again find an overall insignificant effect. However, in column (9), the 10-year-moving-average is slightly significant, and the coefficient estimate is large: a standard deviation increase in the shock reduces trials by 0.18 standard deviations. Nonetheless, the overall impact of oats prices on trials appears insignificant.

There is, additionally, anecdotal evidence that spending on other public goods increased following favourable weather. The town of Aberdeen, for example, was unique in its retention of a large Justice of the Peace Court, which tried crimes like fornication and adultery. Running the court was fairly expensive and, according to DesBrisay (1986),

> The forces of nature could clearly influence the court's work: in 1697, when... poor weather and serious food shortages led to disease and high mortality, the justice court sat only thirteen times... it seems likely that backlogs of cases occasionally built up. (p. 81)

It therefore makes sense that witch trials would increase following favourable temperature.

6. Conclusion

Persecution of populations is not always a disorganised, unruly affair. Events like the Khmer Rouge killings, East Timorese massacres, and Rwandan genocide were all planned and organised by elites. Similarly, Early Modern Scottish witchcraft trials required local elites' time and material resources.

In this paper, I have shown that positive weather shocks caused more witchcraft trials in Early Modern Scotland. During such good times, local elites had more resources to devote to witch prosecutions. Consistent with this, I find that positive price shocks to export-heavy, taxable commodities, herring and wool, caused more trials, while shocks to oats, Scotland's main subsistence commodity, did not.

A further question raised by this paper is that of policy: namely, how can we prevent persecution, when elites finance it? Based on my findings, the answer might be to target the export of goods that elites derive wealth and power from.[10] Indeed, such sanctions are used against states like North Korea and Iran ostensibly for this purpose (Elliot, 1998; Marinov, 2005). An Early Modern 'omnipotent economic planner' wishing to limit witchcraft trials would therefore sanction the export of wool and herring from Scotland. Although such a thought exercise risks overgeneralising, especially since actors may react unexpectedly to sanctions, the policy implications are worthy of future research.

[10]This abstracts from general equilibrium concerns. Sanctions can, after all, harm even persecuted populations by denying them of food, medicine, and income.

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TABLE 1. Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Main Results					
Witch Trials Count	5,610	0.55	4.16	0	116
Witch Trials Dummy	5,610	0.10	0.30	0	1
Temperature (3 year MA)	5,610	0.16	0.42	-1.11	1.83
Temperature (5 year MA)	5,610	0.16	0.35	-0.81	1.73
Temperature (10 year MA)	5,610	0.16	0.29	-0.55	1.30
Population Density	5,610	4,008	11,028	18.36	93,331
Commodity Price Shocks					
Suitability × Price Wool (3 year MA)	5,610	8.78	3.25	0.78	16.74
Suitability × Price Wool (5 year MA)	5,610	8.78	3.17	0.81	15.98
Suitability × Price Wool (10 year MA)	5,610	8.77	3.05	0.88	15.26
Suitability × Price Herring (3 year MA)	5,610	0.64	1.01	0	3.96
Suitability × Price Herring (5 year MA)	5,610	0.63	1.01	0	3.90
Suitability × Price Herring (10 year MA)	5,610	0.62	0.99	0	3.68
Suitability × Price Oats (3 year MA)	5,610	0.02	0.005	0.009	0.04
Suitability × Price Oats (5 year MA)	5,610	0.02	0.005	0.01	0.04
Suitability × Price Oats (10 year MA)	5,610	0.02	0.005	0.01	0.03
Compliers					
Distance from Edinburgh: above median	34	0.5	0.5	0	1
Times of crisis: indicator	5,610	0.05	0.23	0	1
Justices of the Peace: above median	33	0.48	0.5	0	1
Distance from a Port: above median	34	0.5	0.5	0	1

FIGURE 1. Total Number of Witchcraft Trials, 1563-1727

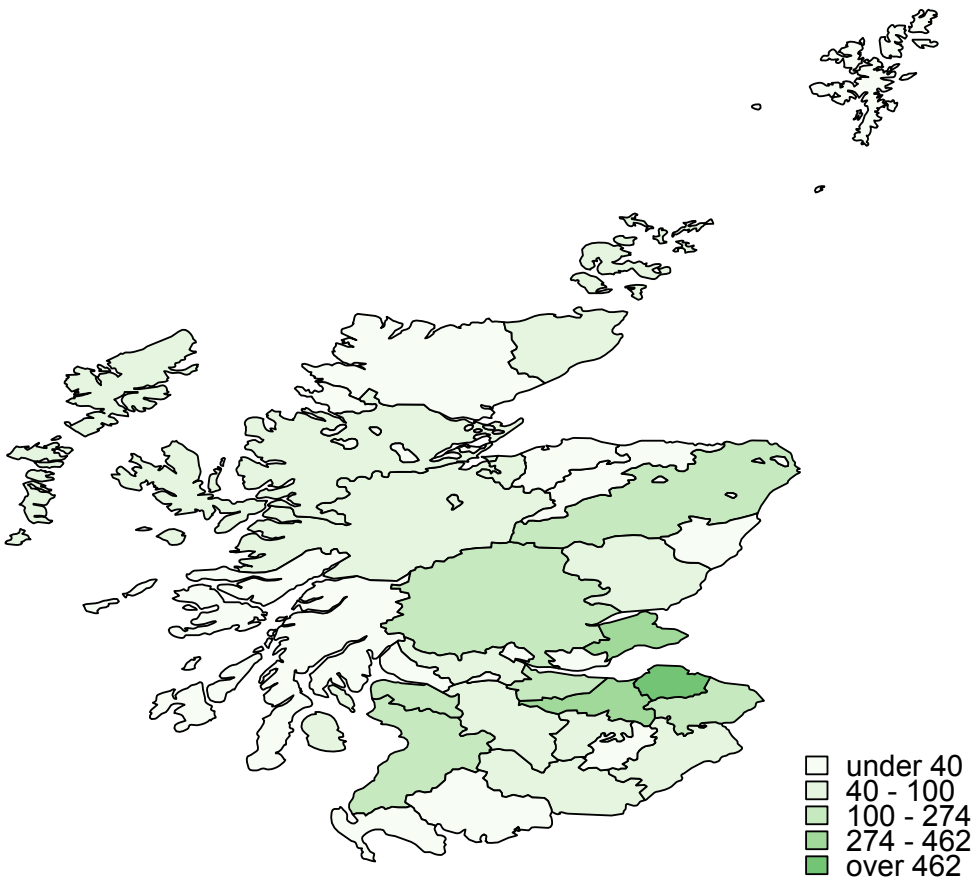

FIGURE 2. Witch Trials and Temperature (5-year MA) in Edinburgh, 1563-1727

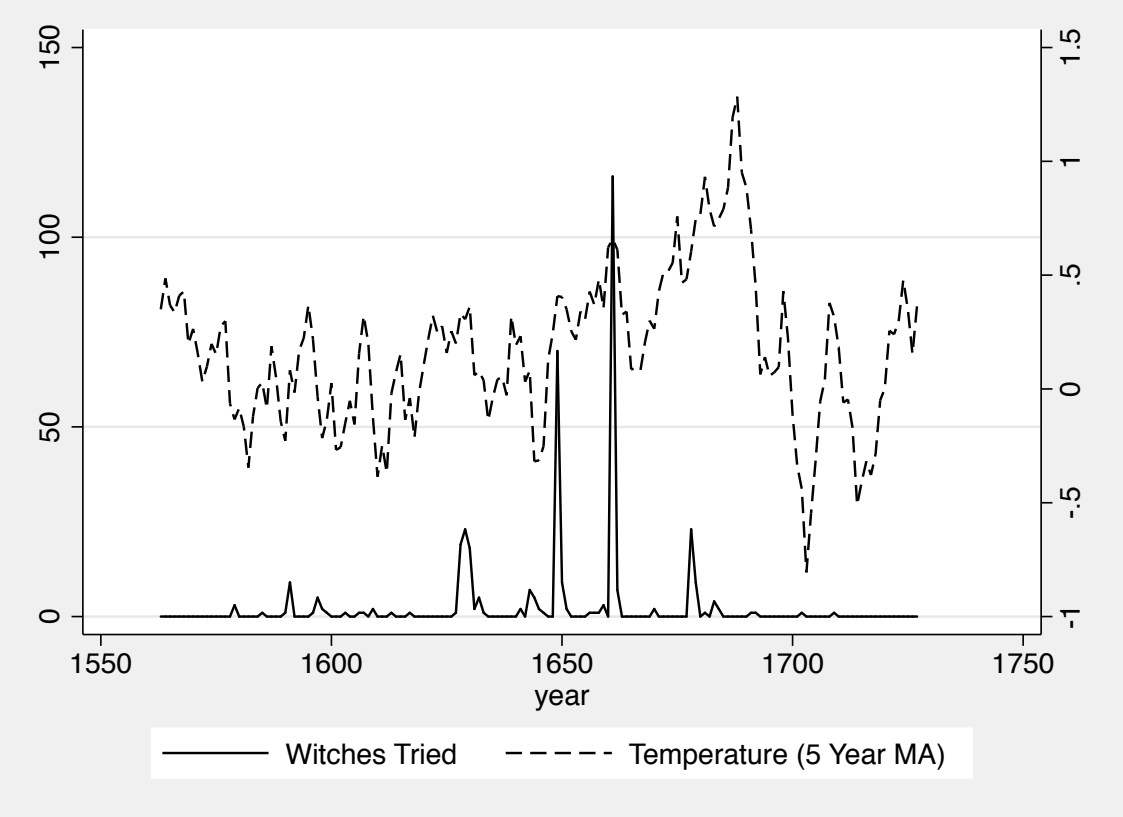

TABLE 2. Effect of Temperature Shocks on Witchcraft Trials

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Count	Count	Count	Dummy	Dummy	Dummy
Temperature (3 year MA)	.548			.104**		
	(.504)			(.046)		
Temperature (5 year MA)		.711**			.116***	
		(.341)			(.040)	
Temperature (10 year MA)			.805			.161**
			(.499)			(.071)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 3. Main Results with County-Specific Trends

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Count	Count	Count	Dummy	Dummy	Dummy
Temperature (3 year MA)	.619			.110**		
	(.571)			(.049)		
Temperature (5 year MA)	.	.850**			.126***	
		(.374)			(.036)	
Temperature (10 year MA)	.		.962			.194**
			(.601)			(.084)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County-Specific Trends	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 4. Main Results: Different Specifications

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Dummy	Dummy	Dummy	*ln*	*ln*	*ln*
Temperature (3 year MA)	.012*			.149*		
	(.008)			(.076)		
Temperature (5 year MA)	.	.024***			.176***	
		(.009)			(.061)	
Temperature (10 year MA)	.		.004			.220**
			(.011)			(.101)
Robustness Check:	Logit	Logit	Logit	Dep Var	Dep Var	Dep Var
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 5. Excluding Years Prior to 1610

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Count	Count	Count	Dummy	Dummy	Dummy
Temperature (3 year MA)	1.12**			.196***		
	(.545)			(.059)		
Temperature (5 year MA)	.	1.30***			.228***	
		(.413)			(.059)	
Temperature (10 year MA)	.		1.50***			.290***
			(.526)			(.095)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	4,012	4,012	4,012	4,012	4,012	4,012

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 6. Excluding the 'Turbulet' 1650s to 1660s

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Count	Count	Count	Dummy	Dummy	Dummy
Temperature (3 year MA)	.276			.091*		
	(.282)			(.077)		
Temperature (5 year MA)		.539*			.114**	
		(.312)			(.042)	
Temperature (10 year MA)			.773*			.173**
			(.451)			(.073)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	4,896	4,896	4,896	4,896	4,896	4,896

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 7. Future Weather Shocks (One Year Forward) and Current Witch Trials

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Count	Count	Count	Dummy	Dummy	Dummy
Temperature (3 year MA)	-.277			.048		
	(.297)			(.068)		
Temperature (5 year MA)	.	.158			.085	
		(.415)			(.061)	
Temperature (10 year MA)	.		.417			.120
			(.404)			(.071)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 8. Effect of Temperature Shocks on Witchcraft Trials: One Year Lags

	(1)	(2)	(3)	(4)
Dependent variable:	Count	Count	Dummy	Dummy
Temperature	.093	.524	.067	.123**
	(.372)	(.367)	(.055)	(.060)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Counties	34	34	34	34
No. of observations	5,610	4,012	5,610	4,012

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 9. Compliers

Dependent variable: witch trials	(1)	(2)	(3)	(4)
Temperature (5 year MA)	.194***	.198	.270	2.045**
	(.052)	(.539)	(.216)	(.804)
Temperature × interaction	-.060***	.813*	10.09*	-1.043**
	(.021)	(.472)	(5.42)	(.482)
Interacted variable:	*Distance from Edinburgh*	*Justices of the Peace*	*Political Crises*	*Distance from a Port*
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Counties	34	33	34	34
No. of observations	5,610	5,445	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 10. Effect of Wool and Herring Shocks on Witch Trials

	(1)	(2)	(3)	(4)	(5)	(6)
Price Shock:	Wool	Wool	Wool	Herring	Herring	Herring
3 year MA	.198**			.019**		
	(.092)			(.009)		
5 year MA	.	.186**			.018**	
		(.087)			(.008)	
10 year MA	.		.236**			.015**
			(.103)			(.007)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.

TABLE 11. Effect of Oats Shocks on Witch Trials

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3 year MA shock	-.013			.011			-.0006		
	(.011)			(.013)			(.0006)		
5 year MA shock	.	-.012			.008			-.0004	
		(.010)			(.011)			(0.0004)	
10 year MA shock	.		-.011			.008			-.001*
			(.009)			(.011)			(.0006)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Counties	34	34	34	34	34	34	34	34	34
No. of observations	5,610	5,610	5,610	5,610	5,610	5,610	2,890	2,822	2,652

Standard errors, clustered at the county level, are reported in parentheses.
Significance levels are ***< 0.01, **< 0.05, and *< 0.1.
All regressions control for population density.