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ABSTRACT

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1. Introduction

In April 1780, Pantaléone Terrier was prosecuted for food theft after she stole two *bichets* of buckwheat flour, worth approximately three *livres*, from a miller in Moûtiers.[1] Terrier declared that she had decided to steal the flour because she was "in great a misery, my husband being sick and unable to work ever since All Saints' Day, and having two children suffering from hunger". Considering that the plaintiff had refused to sell her flour on credit and that "A man driven by misery and hunger to commit petty theft of food is less guilty than if he was driven by cupidity", the judge decided to dismiss the charges against Terrier and released her from custody.[2] Fifty years earlier, Pierre Lavin, a day labourer from the province of Chablais, was less fortunate. In March 1734, "Due to all the harvest having failed over the last year in his homeland, he had no choice but to leave to beg for food here and there". He migrated to France but was later arrested in Beaujeu, near Lyon, and condemned for begging and petty theft by the French constabulary.[3] Lavin's experience suggests that seasonal migration could represent an efficient coping mechanism against income shocks, but only if one had the ability to secure a job and stable earnings.

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[1] One *bichet* of flour was roughly equivalent to 10 kg, while the average income of a farming household amounted to £200 a year during the 18th century. The fundamental accounting currency in the duchy of Savoy during the second half of the 18th century was the *Livre de Savoie* (hereafter £), which was pegged on the *Lira piemontesi*. See online Appendix A.2 for more details.

[2] Archives départementales (hereafter Arch. dép.) Savoie, 2B 10702, Pantaléone Terrier.

[3] Arch. dép. Rhône, 7 B 21, Procédure contre Pierre Lavin.

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This article sheds light on the effect of economic conditions on the occurrence of property crimes and violent crimes by exploiting within-province variations in weather-induced negative income shocks in Savoy from 1749 to 1792.[4] Specifically, I use the spatial heterogeneity in the migration pattern between lowland and upland communities to show how seasonal migration constituted an efficient buffer against weather-induced income shocks.[5] Indeed, migrant labour brought in remittances, which not only supplemented communities' resources but also temporarily relieved impoverished households of the burden of feeding these workers.

I assemble a new data set on the occurrence of property crimes and violent crimes between spring 1749 and summer 1792 at the provincial level. I combine these data with reconstructed seasonal temperature data and population census data, as well as information on the average migration rate, annual wheat prices, grape harvest dates and annual wine prices. I document how weather shocks translated into transitory negative income shocks for local communities. I show that warmer temperatures were associated with earlier grape harvest dates (GHD) and lower wine prices. This fact is consistent with previous findings in the literature (Daux et al., 2012; Meier et al., 2007), and can be explained by the fact that temperatures and growing season length are a critical aspect for the cultivation of winegrapes. They have a major impact on grape ripening and fruit quality: warmer temperatures quicken vegetative growth and increase ripening potential. Warmer temperatures were also associated with higher wheat prices.[6] Since bread made up the bulk of the Savoyard consumption basket where vegetables, fruits and livestock products only marginally supplemented diets (Nicolas, 1979), variations in grain prices had a larger impact on household real income than did those in wine prices.

The first part of the empirical analysis explores the effect of weather shocks violent crime and property crime rates. In the face of an economic downturn, a rise in food prices, joblessness and/or the inability to secure financial resources, individuals may turn to illegal income-generating activities. In other words, these individuals who lack economic resources may have greater incentives to commit crime (Becker, 1968).[7] In line with the proposed theory, I find that transitory negative income shocks associated with weather shocks significantly increased the occurrence of property crimes, but significantly decreased that of violent crimes. Specifically, a one standard deviation increase in temperature raised the property crime rate by 6.9%, but decreased the violent crime rate by 8.7%. The drop in real income caused by temperature shocks may explain the negative relationship between warmer temperature and violent crime rates. Despite lower wine prices, alcohol consumption, a major criminogenic trigger, is likely to have declined as households' income decreased.

The second part of the empirical analysis focuses on the role of seasonal migration in the mitigation of weather shocks. Freedman et al. (2018) show that, among immigrants in the United States, the likelihood of committing income-generating crimes is higher when they are prevented from participating in the local labour market. The case of Pierre Lavin, arrested and condemned for begging, is certainly not representative of the fate of most Savoyard migrants. Many contemporaries and scholars have, in fact, highlighted that seasonal migration constituted a significant source of income for local communities – from £25 to as much as £100 per migrant (Grillet, 1807; Guichonnet, 1945; Verneilh-Puiraseau, 1807). Seasonal migration offered a viable alternative to crime for generating income and, therefore, reduced the expected returns to property crimes. This may, in turn, have diminished the incidence of such crimes during transitory economic shocks. Drawing on data from Becchia et al. (2012), I exploit spatial variations in seasonal migration rates to show that, indeed, such labour movements reduced the need to steal to survive, and was an efficient strategy to mitigate the negative effect of weather shocks. Historical evidence thus suggests that the cash inflow generated by seasonal migrants, as well as the temporary relief of Malthusian constraints, helped alleviate the impact of adverse weather shocks. Further, I provide evidence that seasonal migration mitigate the effect of weather shocks on crimes directly related to material deprivation – theft of edible products.

Related literature My work relates to the literature on linkages between weather variability, agricultural risks, vulnerability and migration (Falco et al., 2018; Feng et al., 2010; Jha et al., 2018; Marchiori et al., 2012). Ratha (2005) emphasises the positive effects of remittances: they represent a net fiscal gain for countries of origin, provide currency for importing scarce inputs, and can serve as a buffer against negative income shocks in migrants' home countries. Yang and Choi (2007) show that, in Filipino households with overseas migrants, remittance inflows from overseas replace up to 60% of exogenous declines in income. Focusing on internal migration in Tanzania, Kubik and Maurel (2016) find that weather shocks are an important migration driver through their effect on agricultural income.

Additionally, my findings build on and advance the historical literature on seasonal migration (Fontaine, 1998; 2003; Siddle, 2000; Viazzo, 1989). For instance, Lorenzetti (2003) emphasises that the conjunction of a strong demand for labour in urban areas and the necessity of buying not locally available food best explains migratory movements in the Insubric valley.[8] Siddle (1997) suggests that the deployment of successful migration networks in the Alps contributed to sustain the flows of migration remittances and savings, and helped mountain communities to prosper.

[4] During the 17th century and the first half of the 18th century, Savoy was occupied on many occasions by foreign troops. In 1749, a seven-year rule of the Holy Roman Empire ended, and for the next 40 years, Savoy was not involved in any military conflict. Political and judicial institutions were thus very stable over this period.

[5] Hereafter, I use *Savoy* to refer to the duchy of Savoy, whereas I use *Savoie* for the province constituting part of the duchy. Chambéry was the capital city of both the duchy of Savoy and the province of Savoie.

[6] This result is also in line with previous findings in the literature (e.g. Franck and Galord, 2017; Jia, 2014).

[7] Specifically, Becker (1968) suggests that individuals weigh the benefits and costs of committing a crime, such that any change in the relative gains and the level of crime deterrence can have an impact on the incidence of misconduct.

[8] A more traditional view holds that mountain communities used emigration mostly to ease pressure on subsistence and escape Malthusian positive checks, but does not generally consider pull factors (e.g. Dupâquier, 1988, pp. 99–143; Poussou, 1970).

The findings in this paper also contribute to a prior literature that examines the determinants of interpersonal conflicts. More specifically, this article relates to lines of research that analyse the direct effect of temperature (heat) on violence. For instance, Mares (2013) analyses the level of violent crime rates in Saint-Louis between 1990 and 2009, and finds that a one degree increase toward a warmer temperature is associated with a one percent increase in violent crimes. Using Finnish data spanning 1996–2013, Tiihonen et al. (2017) find similar results, whereas Harp and Karnauskas (2018) and Schinasi and Hamra (2017) show that, in line with the routine activities theory, the relationship between mean heat daily heat index and violent crimes is particularly significant during cold months.[9]

Finally, this article relates to lines of research that analyse the effects of weather on economic activity which, in turn, can influence the propensity for property and violent crimes.[10] For instance, Axbard (2016) studies how climate-induced changes in income opportunities for Indonesian fishermen affect the number of piracy attacks. An improvement in fishing conditions significantly increases the income of fishermen while the level of sea piracy is significantly reduced. In particular, Axbard shows that the effect of negative income shocks is smaller in areas with many alternative legal income opportunities consistent with the fact that opportunity costs drive, at least partially, the relationship between transitory negative income shocks and crimes. Blakeslee and Fishman (2018) and Dix-Carneiro et al. (2018) respectively analyse the effect of adverse weather conditions and trade shocks on crime rates, and show that the reduction of agricultural income and labour market earnings results in significantly higher crime rates in India and Brazil.

In 19th-century Bavaria, negative transitory income shocks associated with adverse weather conditions resulted in a significant increase in property crimes and significantly fewer violent crimes (Mehlum et al., 2006). In particular, Mehlum et al. posit that the decline in violent crime rates was driven by a reduction in alcohol consumption. Many historians of crime have, in fact, related alcohol consumption and drunkenness to violent behaviour. Because alcohol lowers inhibitions, impairs a person's judgement and may exaggerate the offence taken, an increase in alcohol consumption could lead to a surge in violent crimes (Brennan, 1988; Greenshields, 1994; Lecoutre, 2010). Further empirical evidence from 19th-century Prussia (Traxler and Burhop, 2010) and 19th-century France (Bignon et al., 2017) support this underlying mechanism. Traxler and Burhop assemble data on beer production, rye prices, seasonal rainfall and crime in 19th century Prussia, and demonstrate that beer consumption had a strong and highly significant impact on violent crimes. In particular, they show that rainfall shocks, a proxy for negative transitory income shocks, had no impact on violent crime once they account for beer consumption. Bignon et al. (2017) use geographical variations in the timing of the phylloxera crisis to identify the effect of negative income shocks on property and violent crime rates. In wine growing areas, contagion by phylloxera resulted in a significant decrease in wine production, and represented a strong exogenous income shock. On average, property crime rates subsequently increased by 18%, while violent crime rates decreased by 12%.

The remainder of the article is organised as follows. Section 2 provides historical background and discusses how seasonal migration helped to mitigate the effects of weather shocks. Section 3 reports data sources and the dataset construction, and provides descriptive statistics. Section 4 presents the estimation strategy, quantifies the effect of weather shocks on the incidence of crimes, and considers a number of robustness checks. Section 5 concludes.

2. Historical background

2.1. Savoy during the 18th century

In 1720, the Treaty of The Hague ended the War of the Quadruple Alliance, and attributed Sardinia to the Duke of Savoy, with the royal title. The newly-formed Kingdom of Sardinia encompassed Aosta Valley, Nice, Oneglia, Piedmont, Sardinia and Savoy. Savoy, itself composed of six provinces and two bailiwicks, was then an administrative division of the new political entity (see online Appendix Fig. D.1). In 1749, a seven-year rule of the Holy Roman Empire came to an end, and Savoy was not occupied until the invasion of French revolutionary troops in September 1792.[11]

Institutionalised in the mid-16th century, the Senate of Chambéry, a court of appeal, was the main ruling institution in the duchy until the creation of intendants at the turn of the 18th century. Within each province, there was a court of first instance, or *judicature-mage*. The head judge (*juge-mage*) had pre-eminence over other local judges and was responsible for ruling criminal cases of £2000 or less.[12] Judges were required to resolve cases within 3 months of their issue and to prioritise criminal over civil court cases (*Loix*, Articles 1 and 4, Title XVI).[13]

[9] See Miles-Novelo and Anderson (2019, pp. 37-40) for a recent literature review on heat stress and violent crimes.

[10] More broadly, this paper relates to the decades-long literature on business cycles and crime (e.g. Arvantes and Defina, 2006; Bell et al., 2018; Draca et al., 2013; Mocan and Bali, 2010).

[11] French troops entered Chambéry on 23 September. The *Réunion de la Savoye à la France* decree was ratified by the Convention on 27 November 1792.

[12] For an overview on the functioning of local justice during this period, see Dullin (1915, pp. 7-44). For a detailed account of the evolution of the senate and its criminal policies from the 16th century onward, see Laly (2010; 2012, ch. 2). For a general description of Savoy prior to the 18th century, see Laly (2012, ch. 1).

[13] In 1770, the *Loix et constitutions de Sa Majesté le roi de Sardaigne*, also called the Royal Constitution, (hereafter *Loix*) stipulated in its Article 5, Title II, Livre IV, that "All information and acts necessary to the proceeding of criminal trials will be written by a clerk or their substitute who should be notaries [...] or anyone else as long as he is a notary [...] and swears an oath of secrecy and exactitude". Other edicts required judges to send a quarterly summary of their activities to the intendant general in Chambéry, to ensure they were working effectively (Laly, 2013, pp. 95–101).

Table 1
Demographic structure and agricultural production of Sainte-Foy-Tarentaise, 1756.

Demographic structure		Agricultural production[b]		
Population	1204	Rye	6624	*bichets*
Number of families	276	Wheat	400	*bichets*
Number of men	493	Beans	500	*bichets*
Number of women	711	Barley	800	*bichets*
Number of migrants[a]	≈100	Hay	7500	quintals
		Nuts	150	*bichets*

[a] The city council reported that "About hundred men, either peddlers or chimney sweeps, migrate every to France between late September and the beginning of the summer". In 1761, the population included 142 children younger than five and 1075 individuals older than five.

[b] The city council further reported that "The inhabitants do not cultivate other crops excepted a lots of potatoes (or *truffes*) and straws, which I did not bother to mention". In 1761, the inhabitants owned 1171 cows (and the like) as well as 713 ewes. The *bichet* of Sainte-Foy-Tarentaise is a unit of capacity for grains equal to 15.5 l for wheat and 10.3 l for oats.

Source: Arch. mun. Sainte-Foy-Tarentaise, Réponse à l'intendant Agiono, État de la communauté de Sainte-Foy, 1756.

The duchy of Savoy was a land of contrasts. In the north and the west, areas with high population densities and a rain-fed agrarian economy centred on the production of grains. In the east, the mountainous mass precluded the intensive cultivation of grains, and instead pasture-based livestock production took on a more central position in the agricultural mix. During the first half of the 18th century, numerous institutional and tax reforms contributed to the standardisation of financial practices, the unification of bureaucracy, the purge of some seigniorial institutions, and the creation of local intendants in each province (Storrs, 2009; Symcox, 1983).[14]

Meanwhile, there was little innovation in agriculture (Nicolas, 1978), and in fact, total agricultural output stagnated and could barely sustain population increases. Yields remained static during this period and close to subsistence level, leaving local communities vulnerable to adverse weather conditions.[15] A Harsh climate and the lack of activity during winter, particularly, in hilly areas, pushed many inhabitants to seasonally migrate and seek work outside the duchy. Migration not only offered the opportunity to earn an additional income, but also temporarily reduced population pressure. Several estimates suggest that migrants numbered as many as 30,000, or about 10% of the total population, by the end of the 18th century (Bruchet, 1894, p. 256).

2.2. Climate, weather variability and agricultural production

Located in the Western Alpine region, the duchy of Savoy had a continental climate with harsh winters (snow and prolonged frost), and warm, dry summers. By the mid-18th century, Savoy was a rural rain-fed agrarian economy with relatively low agricultural productivity by European standards.[16] Seed-yield ratio averaged 4.6:1 for wheat and 3:1 for rye (Crook et al., 2004).[17] Yields in viticulture were also relatively low, 15 to 25 hectolitres per hectare; often insufficient to meet local demand, and sometimes even to provide a living for local producers.

Pastures typically occupied 50% of the agricultural area, meanwhile arable land 30%, of which one third was dedicated to wheat, and about 5% to grapes (Gex, 1943; Guichonnet, 1955; 1969; Nicolas, 1978; Vion, 1956). Table 1 provides an overview of the socio-economic structure of a typical mountainous parish, where we observe a predominance of rye and hay to feed livestocks. The provinces of Genevois, Maurienne and Faucigny produced enough grains to export a small surplus in the neighbouring regions. On the contrary, the province of Savoie needed to annually import between 8000 and 12,000 hectolitres of grains from the nearby city

[14] Intendants were responsible, among other things, for the collection of taxes and the maintenance of public infrastructure, such as roads and dikes. They also sent monthly reports on the social and economic situations in their province to the intendant general in Chambéry, who could then take measures to better cope with sources of distress (Esmonin, 1960; Verdo, 2012).

[15] To reduce competition from French products, agricultural and industrial tariffs were raised in the aftermath of the Spanish occupation. Bigot de Sainte Croix (1877, pp. 64-6), then French ambassador in Turin, remarks that the tariffs on basic goods were too high and impeded trade. Tochon (1871, p. 66) claims that they were detrimental to the population, as staple prices and wine prices were left more vulnerable to weather whims. In accounts of his travel to Italy in the 1760s, Richard (1766, p. 87) similarly points out that depreciation of foreign currencies and high tariffs severely impeded the foreign trade in the Sardinian Kingdom. For further discussion of the volume and composition of trade in Savoy, see Nicolas (1978, pp. 93-104).

[16] Nicolas (1978, pp. 686-91) reports that the average wheat yield was about 4.5 to 6 hectolitres per hectare during the 18th century. For an extensive description of the agricultural situation and related practices, see Costa de Beauregard (1774), Tochon (1871), and Verneilh-Puiraseau (1807, pp. 421-72).

[17] Arch. dép. Haute-Savoie, 1 C 4 178, pièce 18, État des récoltes tel qu'il a été envoyé à Saint-Julien. For the early 19th century, Verneilh-Puiraseau (1807, pp. 424, 470-1) indicates that the seed-yield ratio averaged 4-5:1 for wheat, 5-6:1 for rye and 15-20:1 for potatoes.

of Belley or the province of Dauphiné in France (Nicolas, 1978, pp. 95–6).[18] Moreover, much of the annual variations in crop yields depended on year-to-year weather fluctuations.

In general, wet summers were detrimental to harvest quality, as the high moisture content of the grains made its storage harder (Brunt, 2004). Wet and cold summers also meant that grapes did not mature as they should, diminishing yields compared to normal years. By contrast, a warm and early spring fostered the development of grains and meant an earlier harvest – the usual harvest time for wheat and rye ranged from early July to early August (Collomb, 1977, p. 37, Daquin, 1787, p. 32, Verneilh-Puiraseau, 1807, pp. 170–1, 422). Early harvests had the advantage of reducing the risk of catastrophic damage to crops from hailstorms, and preventing mature crops from drying and rewetting due to rainy spells (Le Roy Ladurie, 2006; Pfister and Brázdil, 2006). However, warmer temperatures also resulted in lower numbers of formed grains and weight, which in turn reduced wheat yield.[19]

Several episodes of adverse weather conditions occurred between 1749 and 1789. Becchia et al. (2012) review the historiography of climatic conditions in Savoy, and note that a series of dry summers occurred in 1754, 1762, and 1766–7, and that repeated droughts hampered agricultural output in the 1770s and 1780s, increasing the environmental pressure over a growing population.[20] To this regard, the intendant of Genevois revealed that, in 1770, the harvest fell short of an average one-fifth or less for one-fourth of the parishes. In another two-thirds of the 170 parishes, the harvest levels ranged from one-third to two-thirds of a normal year.[21]

2.3. Institutional relief, migration and crime

Weather-induced agricultural failures had a strong effect on household real incomes and living standards. Because food crops were more widely consumed than wine in the Savoyard household, the net income effect of warmer temperature on household budget tended to be negative.[22] Ruff (1984, pp. 142-8) shows that deprivation was a major driver of thefts in early modern France. In particular, wheat price movements deeply affected the poorest, and correlate with the rate of theft. Elevated food prices made it more difficult for many households to meet their minimum subsistence needs, leaving thievery as the only solution for survival. Using various population censuses, Nicolas (1978) finds that between 8 and 13% of the households were recorded as poor during normal years, but these numbers significantly inflated in times of food shortage.

Local populations and authorities used various strategies to mitigate the negative effects of weather shocks. For instance, in June 1759, the province of Chablais experienced an episode of drought followed by continuous rains in July and August. In September, the intendant noted that peasants had reaped only half of a normal grain harvest. Apple and pear trees had given no fruit, and there were very few cherries and plums.[23] Later that year, the king granted a £90,000 tax exemption to reduce “the extreme misery of the peoples”, and an additional £40,000 to support poor relief (Nicolas, 1978). Generally, while the system of relief provided by municipal and state authorities worked well, it was insufficient to cover all the needs of the population.[24]

Beyond tax exemption and poor relief, in response to weather shocks and in an effort to maintain their living standards, local communities also resorted to other strategies, including occasional smuggling, thefts and seasonal migration. During the second half of the 18th century, seasonal migration involved between 20,000 and 30,000 individuals, i.e. about 10% of the total population or one-third of the able-bodied young men (Bruchet, 1894, p. 256; Letonnelier, 1920; Pérouse, 1930; Verneilh-Puiraseau, 1807, pp. 394-6).[25] Paris, Lyon, Northern Italy and South Germany were the preferred destinations. Maistre et al. (1992, pp. 26) estimate that, during the 18th century, merchants amounted to at least 15% of the migrants. The bulk of individuals migrating seasonally was composed of workers in the building industry, metal artisans, agricultural labourers, servants and other unskilled occupations. Attracted by the opportunities of expanding towns, some stayed for good.[26]

In Saint-Maxime-de-Beaufort, seasonal migration involved 7.8% of the population in 1757 and 11.7% in 1787. In Nancy-sur-Cluses, there were 45 absentees out of 376 inhabitants in 1780 (Maistre and Maistre, 1986, p. 16). In Saint-Jean-de-Maurienne and Saint-Sorlin d’Arves, seasonal migrants respectively totalled 11.4 and 11.25% of the population in 1773 and 1789

[18] Introduced in the 1730s, potatoes and maize were already consumed in the 1740s. Their cultivation considerably expanded after the repeated episodes of food distress in the early 1770s (Ferrand, 1979, pp. 692–4; Nicolas, 1978). In 1787, the doctor Daquin (1787, pp. 33-8) reported that potato harvests were plentiful, and “so precious for people in the countryside that there is no peasant who does not cultivate them, and they are basically the main food of the city’s commoners”. In the province of Faucigny, potatoes represented almost one-fourth of total agricultural production in 1789, and, in the province of Chablais, the intendant noted that potatoes constituted “most of the food of a large number of peasants, in particular in mountainous areas”. Arch. dép. Haute-Savoie, 1 C 99, pièce 99, lettre du 26 janvier 1789.

[19] Recent studies show that the net effect of warming is associated with net yield reductions: a one degree increase in temperature reduces yields by 5 to 10% (Tack et al., 2015; Uprety and Reddy 2016, pp. 45–54).

[20] Similarly, wet summers in 1749, 1751, 1756–9, and 1770 led to repeated poor harvests. Meanwhile, a series of long and cold winters occurred between 1766 and 1774, in 1778 and 1780, and again in 1788 and 1789, and resulting in repeated and significant fluctuations in grain prices.

[21] Arch. dép. Haute-Savoie, 1 C 4 178, pièce 6, État général de la qualité de la récolte de l’année 1770.

[22] See the online Appendix B for a more detailed discussion of living standards during the 18th century.

[23] Arch. dép. Haute-Savoie, 1 C 2 72, pièce 13, État de la récolte en Chablais en 1759.

[24] The online Appendix B further describes the set of actions undertaken by public authorities and assistance institutions to attenuate transitory poverty shocks.

[25] Lorenzetti (2003, p. 370) reports that 25 to 30% of adult males practised seasonal migration in the Italian Alps.

[26] In Bordeaux, a large number of *frotteurs* (furbishers) were from the parish of Sainte-Foy-Tarentaise in Savoy. In 1770, forty of them wrote to the city council toreport one of their fellow colleagues, Maurice Blanc, after he repeatedly committed theft. The plaintiffs asked for his expulsion from Bordeaux to preserve the reputation of the migrant community as honest workers. Arch. dép. Gironde, 12 B 339 (as cited in Poussou, 1978, Annexes III, pp. 692–5).

Table 2
Cash inflow and outflow in Sainte-Foy-Tarentaise, 1756.

Sources of income	£	Sources of expenditure	£
Migrants income	8000	State taxes[a]	6865
Livestock sales	3500	Salt tax	3000
Cheese and butter sales	800	Rye purchases	2120
Cloth sales	130	Wine and other crops purchases	1000
Lace sales	150		
Other textiles	400		

[a] State taxes include the *taille*, which was levied on people and their real estate; extraordinary taxes; and taxes on bridges and highways (*Ponts et chaussées*).
Source: Arch. mun. Sainte-Foy-Tarentaise, Réponse à l'intendant Agiono, État sur l'argent qui entre et sort annuellement, 1756.

(Pérouse, 1930, p. 40). Other medium-sized towns like Boëge, Flumet, Sallanches, and Samoëns had similar levels of seasonal migration. In contrast, the extent of such movements from the lowland cities was considerably lower. About 5% of the population of Aix-les-Bains migrated every year, 3% in Annecy, and 1% in Thonon-les-Bains (Bouverat, 2013; Viallet, 1993).[27] While there was a continuous flow of workers from the upland valleys towards the plains in search of seasonal employment, urban dwellers more rarely migrated, and these structural differences in migration rates remained relatively stable over the pre-industrial period.[28]

The seasonal migration of young men might have *de facto* contributed to a direct reduction of violent and/or deviant behaviour in provinces of emigration. Indeed, public houses were a common location for alcohol consumption, and contributed to the structuring of individual social relations. The ill treatment of women by drunken men and/or the murder of a rival or an acquaintance in a fight were not unusual events. Lecoutre (2010) describes the typical drunkard as a peasant or craftsman between the ages of 20 and 34, drinking in public houses every evening, even on Sundays. That said, seasonal migration may also have had an indirect positive income effect on violence, leaving the overall net effect unclear.

Another plausible mechanism through which migration may influence crime propensity is the inflow of remittances and the transitory reduction of the Malthusian constraint. If poverty and need drove some of the migration flow, seasonal and commercial emigration also responded to other dynamics. Many migrants belonged to wealthier social groups, were well integrated in their local communities, and used remittances to pay family taxes, local debts or purchase of grains (Fontaine, 2003; Maistre et al., 1992; Siddle, 1997; Viazzo, 1989). For instance, in Magland in the province of Faucigny, the three hundred seasonal migrants usually returned home with about £200 in profits per capita. This extra income allowed the community, which grew only one-third of the grains it consumed, to pay for additional the £37,000 in grains required to sustain a living. Similarly, in Sainte-Foy-Tarentaise, seasonal migrants earned £8000 a year, which represented 60% of the total cash inflow of the parish; one quarter of this was devoted to the acquisition of grains (Table 2). Meanwhile, migrants from Nancy-sur-Cluses earned, on average, a net income of £100 in 1758 (Maistre and Maistre, 1986, p. 16).[29]

A back-of-the-envelope calculation suggests that 25,000 seasonal migrants could have brought as much as £2.5 million per year back to their parishes, enough to buy the equivalent of 200,000 *coupes* of wheat or 300,000 *coupes* of rye. In 1789, the intendant of Genevois observed that four *coupes* of wheat were sufficient to feed an individual for a year, meaning that seasonal migration could have helped to nourish as many as 50,000 inhabitants; note that the total population of the duchy of Savoy was approximately 350,000 inhabitants in 1776 (Rousseau, 1960, p. 46).[30] Migrant cash flows were, however, used to cover other expenditures, such as state taxes, such that the overall effect on poverty reduction was likely somewhat smaller.

3. Data

By 1749, there were six provinces in the duchy of Savoy, each corresponding to an independent judicial division, or *judicature-mage*. My sample comprises of offenders who committed at least one property crime and/or violent crime between spring 1749 and summer 1792 in one of these six provinces. I use year-on-year seasonal temperature variations at the province level to identify the effect of adverse weather conditions on the likelihood of committing crimes. I digitised and geo-referenced the map drawn by Cary (1808, p. 17) to create a digital vector data set that reproduces the administrative borders of Savoy during the 18th century. I use this

[27] In 1789, there were 2175 seasonal migrants out 64,372 inhabitants in the province of Genevois. Arch. dép. Haute-Savoie, 1 C 4 178, pièce 8, État comparatif des productions année commune tant en bled que menu bled, 1789.
[28] For an overview of migration patterns across the Alps, seeMathieu (2009, pp. 123-7). For a general discussion of push and pull factors and their impacts on migration patterns in early modern Europe, see Lucassen (1987).
[29] In Ugine, a town of 2000 inhabitants, annual remittances amounted to approximately £4000 (Devos and Grosperrin, 1985). Verneilh-Puiraseau (1807, pp. 394-6) instead reports a lower estimate of 25 to £30 per migrant.
[30] The *coupe* of Annecy is a unit of capacity for grains equal to 88.86 l for wheat. Online Appendix B contains a detailed discussion of living standards during the 18th century. Arch. dép. Haute-Savoie, 1 C 4 178, pièce 8, État comparatif des productions année commune tant en bled que menu bled, 1789.

Table 3
Summary statistics.

Statistic	*N*	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Crime data							
Crime rate per 100,000	1044	7.08	8.81	0	1.7	9.9	100
Violent crime rate per 100,000	1044	3.77	6.17	0	0	5.5	73
Property crime rate per 100,000	1044	3.31	5.07	0	0	4.9	67
Weather data							
Temperarature anomalies	1044	0.12	0.97	−3.49	−0.50	0.76	3.11
Precipitation anomalies	1044	−0.47	2.15	−9.61	−1.68	0.64	9.87
Temperarature (°C)	1044	5.88	5.96	−5.70	1.34	10.34	17.30
Precipitation (mm)	1044	314	110	32	241	395	614
Grape harvest date[a]	174	43	8	19	37.2	49	59
Socio-economic data							
Seasonal migration rate	6	0.090	0.046	0.036	0.059	0.121	0.155
Prices data							
Annecy wheat prices (ag/l)	76	0.68	0.17	0.42	0.55	0.81	1.16
Chambéry wheat prices (ag/l)	73	0.74	0.19	0.42	0.57	0.83	1.20
Annecy red wine prices (ag/l)	49	0.84	0.27	0.36	0.72	0.90	1.63
Population data							
Population in 1719	6	49,724	29,190	26,123	32,831	55,958	104,022
Population in 1758	6	49,070	24,449	28,124	32,182	59,109	91,443
Population in 1776	6	58,708	31,197	33,682	36,632	68,227	114,917
Population in 1793	6	66,770	39,207	37,863	39,757	80,556	136,650

[a] Grape harvest date is expressed as the number of days after 31 August.

data set to compute the average seasonal temperature anomalies in each province before matching them with crime data and data on seasonal migration rates. Table 3 reports descriptive statistics at the province level for the dependent and independent variables used in my empirical analysis. The respective data sources are discussed in the following sections.[31]

3.1. Crime data

The Savoyard judicial archives include approximately 36,000 criminal procedures spanning the 16th, 17th and 18th centuries. Each criminal procedure details the criminal charge, the trial record and the judgement. In this paper, I draw on a smaller sample from these archives comprising 11,617 criminal procedures covering the three centuries created by local archivists.[32] which allows to assemble a data set on the location, date of the event, course of action, and actors involved in any property or violent crime occurring between spring 1749 and summer 1792.[33] Property crimes include acts such as burglary, larceny, highway robbery and theft. Violent crimes include events like homicide, assault, insults and threats.

Overall, I collected data from 2169 procedures that involved 3975 offenders. Violent crimes constitute 52% of all reported crimes, which is previous historiography estimates.[34] Additionally, I collect population data at the province level for various years from archival sources and secondary literature and linearly interpolate for missing values.[35]

For each province, I construct a measure of *Total crime* as the ratio of offenders in all criminal procedures per 100,000 inhabitants. Then, I disaggregate criminal procedures by type of criminal offence and create two additional variables: *Violent crime* and *Property crime*. Fig. 1(a) and (b) present the distribution of property crimes and violent crimes over time. For both figures, annual variations are important and can be related to weather conditions, as discussed in Section 2.2. In general, the forms of theft reported in judicial records varied in style and purpose, as did the scope of the objects stolen including, among other things, money, food, animals, clothes,

[31] All necessary files to replicate all tables and figures of the main text of this article and the Online Appendix are available in Chambru (2020).

[32] Arch. dép. Savoie, B0, Procédures civiles et criminelles, directes ou en appel, 1559 à 1792. Arch. dép. Savoie, 2B, Procédures civiles et criminelles, appels et directes, (1424–1792). Before being classified and referenced, criminal procedures were preserved in undefined bags. To create the sample, the archivists selected a random sample of bags, but there is no way to guarantee their representativeness. For a more detailed discussion of the representativeness of the sample, see Laly (2010, pp. 910-12). For a detailed description of the judicial archives, see Claus (2013).

[33] Social status, city of birth and place of residence of the criminal are also sometimes included in the records.

[34] Ruff (1984, p. xix) shows that, throughout the 18th century, violent crimes constituted 58% of the total reported crime in the *Sénéchaussée* of Bazas and 52% in the *Sénéchaussée* of Libourne. In Périgueux, 416 of the 976 cases (42.6%) brought before the local court between 1720 and 1790 were related to theft (Cameron, 1981, p. 179). Guichetau (2008, p. 340) analyses 381 criminal procedures from the *présidial* courts in Nantes between 1760 and 1790. 51.7% of the prosecutions related to violent crimes. In Languedoc, property crimes represented between 51 and 58% of the total reported crime during the second half of the 18th century (Castan, 1977, p. 198). In Normandy, 53% of the criminal procedures analysed by Gégot (1966, p. 105) dealt with property crimes.

[35] Population data for 1793 are from the Cassini website (http://cassini.ehess.fr), while those for 1783 and 1719, are respectively, from Rousseau (1960) and Nicolas (1978, p. 12). Meanwhile, population data for 1776 and 1756–8 are from archival sources. Arch. dép. Savoie, C 433, Récapitulation des Consignes du Sel des Provinces du Duché de Savoye pour L'année 1776. Arch. dép. Savoie, C 434, Paralelle du denombrement des personnes, Bestiaux, et de la Taxe en Sel relative au denombrement.

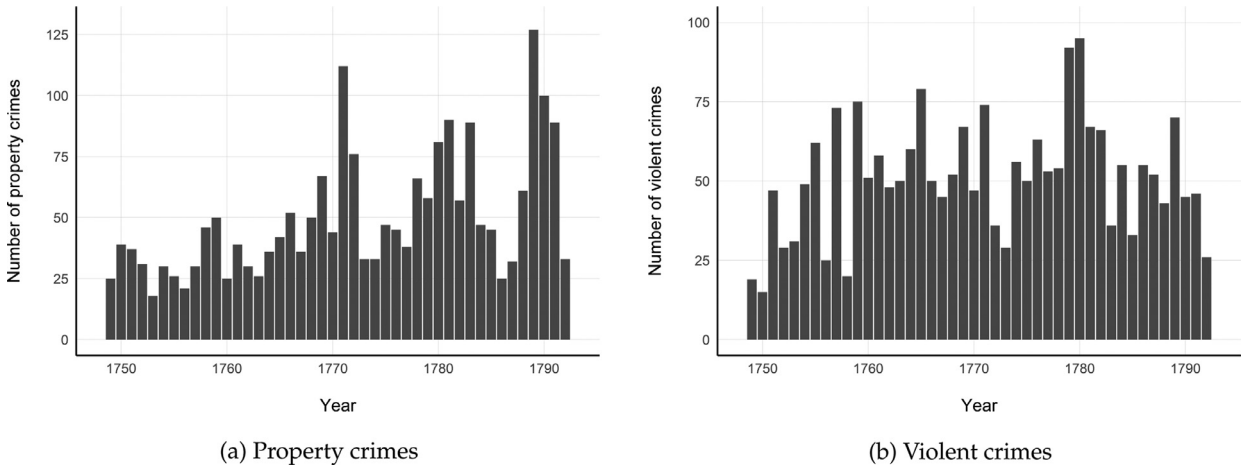


Fig. 1. Number of crimes in Savoy, 1749–92. *Sources:* See Section 3.1.

handkerchiefs and furniture. I make use of this information to create a sub-category of crime, *Theft of edible products*, indicating any event in which food was stolen. The judicial records do not, however, always state the exact object of theft and hence potential variations in the level of reporting could mean some bias in this variable. I consequently only use the latter to supplement the baseline estimates, where I suggest that an increase in property crimes induced by weather shocks was partially driven by the need to survive.

One caveat of using criminal procedures to capture interpersonal conflict lies in their plausibly biased representativeness. For instance, changes in state capacity and the ability to enforce the law due to external events, such as wars or weather-induced income shocks, may have affected the government's ability to carry out judicial activities. Yet, from 1749 to 1792, the political situation was relatively stable, no foreign troops were stationed in the Savoyard territory, and Savoy was not involved in any war, thus reducing the risk of bias due to political turmoil or violence against foreign soldiers. Moreover, because criminal cases had priority over civil cases, it is unlikely that capacity constraint influenced the number of judged cases (see Section 2.1). In addition, judicial spendings were only a tiny fraction of the state budget and studies on its functioning report no sign of exceeding the system's capacity during the 18th century (Briegel and Milbach, 2013; Laly, 2012). Online Appendix Figure D.2 shows that the total number of crimes varied greatly from one year to another. Notably, there were spikes in 1771 and 1789, two years with notoriously extreme weather, reducing the concern that adverse events might have influenced the number of treated cases. Another issue is that, in early modern Europe, a proportion of crimes did not come before the courts, but were dealt with on an infrajudicial level, either by arrangements or retribution (Garnot, 2000; Ruff, 1984). There is no reason, however, to believe that homicides, for instance, were reported less frequently in years with bad weather. A final concern is that changes in the nature of the judicial law and the functioning of the courts over time might have influenced the level of reporting. However, the short time span of my sample and the stability of judicial practices during the first half of the 18th century reduce this concern (Laly, 2010).

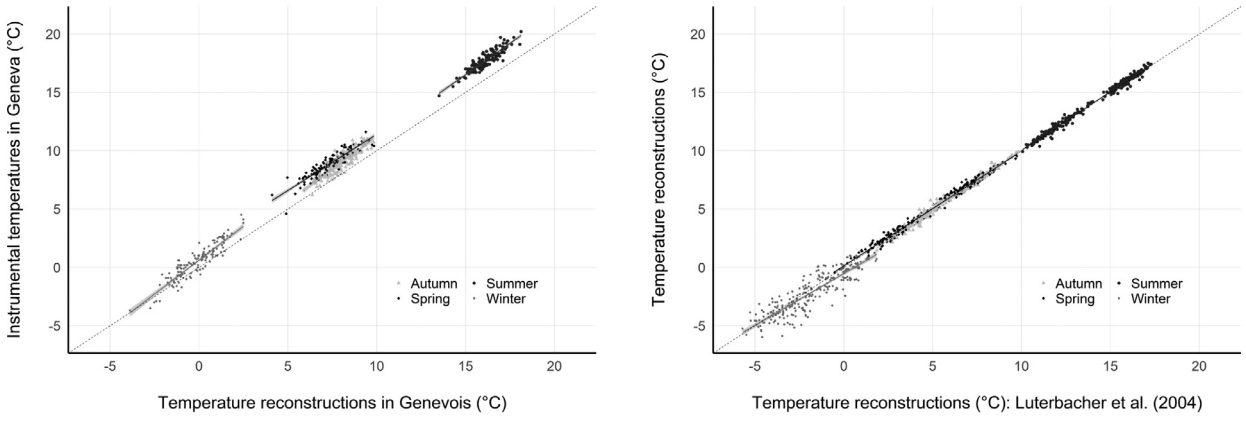
3.2. Weather data

The historical weather data are taken from the European Seasonal Temperature and Precipitation Reconstruction (ESTPR) database, which provides gird cell of 0.5 × 0.5 degree resolution, each containing yearly seasonal observations covering the period of study (Luterbacher et al., 2004; Pauling et al., 2006).[36] Values are interpolated for each grid node from a number of homogenised instrumental data series, reconstructed sea-ice and temperature indices derived from documentary records, and several seasonal temperature reconstructions from ice cores and tree rings.[37] I aggregate these weather data at the province-season-year level by weighting each grid value that intersects a polygon (province) by its relative share in the total area of the given polygon. I then calculate the weighted mean seasonal temperature and precipitation for each set of province *i*, season *s*, and year t. Finally, I calculate the seasonal standardised temperature deviation from the long-term mean (1500–1600) for each of the six provinces:

Compared to instrumental weather data, interpolated data might be subject to measurement error and other biases. To assess the reliability of temperature reconstructions, I compare the ESTPR data set to three other sets of temperature data. Fig. 2(a) shows that there is a strong correlation between instrumental temperature data in Geneva and temperature reconstructions in the neighbouring

[36] Approximately 2000 square kilometres at the latitude of Chambéry. The total land area of the duchy of Savoy was about 10,500km^2 in 1789.

[37] The ESTPR data set is the only paleoclimatological source offering similar spatial and temporal coverage, and is widely used in the literature (e.g. Ashraf and Michalopoulos, 2015; Grosfeld et al., 2020; Jedwab et al., 2019; Pei et al., 2013). Chimani et al. (2013) provide newer estimates of temperature grid data for the Greater Alpine Region, but cover 1780–2008.



(a) Seasonal temperatures in the province of Genevois, 1760–1900

(b) Seasonal temperatures in Savoyard provinces, 1749–92

Fig. 2. Comparisons of temperature reconstructions with other data set. *Sources:* Temperature data in Geneva (Auer et al., 2007). Temperature reconstructions in the European Alps (Casty et al., 2005).

province of Genevois.[38] Second, I compare seasonal temperature data from the ESTPR database with independent temperature reconstructions in the European Alps (Casty et al., 2005) and find a strong correlation rate between the two series (Fig. 2(b)), consistent with broader comparisons in the literature.[39]

$$Temperature_{ist} = \frac{T_{ist} - \overline{T}_{is}}{SD(\overline{T}_{is})}$$

where T_{ist} is the value of the seasonal temperature in province i during season s of year t. $\overline{T}_{is}$ is the long-term mean (1500–1600) of the seasonal temperature in province i, and $SD(\overline{T}_{is})$ is the standard deviation of the long-term mean of the seasonal temperature in province i.[40]

I further compare temperature reconstructions with documentary records of grape harvest dates (GHD) in the provinces of Chablais and Maurienne (Nicolas, 1978, pp. 584–5; Tissot, 1887, pp. 320–2).[41] GHD are closely related to spring and summer temperatures, and therefore provide a reliable proxy for reconstructing weather conditions in the past: on average, the variation in GHD is about 10 days for 1° C variation in the growing season temperature (Chuine et al., 2004; Etien et al., 2009; Le Roy Ladurie and Rousseau, 2011; Meier et al., 2007). I first compare Savoyard GHD with series from French Jura (Daux et al., 2012) and neighbouring Switzerland (Meier et al., 2007) in order to assess their reliability. These two regions are close to Savoy and have similar weather patterns, such that GHD should, on annual basis, be parallel to one another. Fig. 3(a) reports the correlation matrix of these series and indicates that those for Savoy are strongly correlated with the GHD series of Switzerland and French Jura. Savoyard GHD are thus reliable indicators of summer temperatures condition during the 18th century. Fig. 3(b) shows the scatter plot of the temperature variable derived from the ESTPR database against the GHD: the higher the temperature anomalies, the warmer the temperature during the summer, and the earlier the grape harvest. Overall, these results suggest that temperature variables derived from paleoclimatological data are a reliable estimate of past weather conditions.

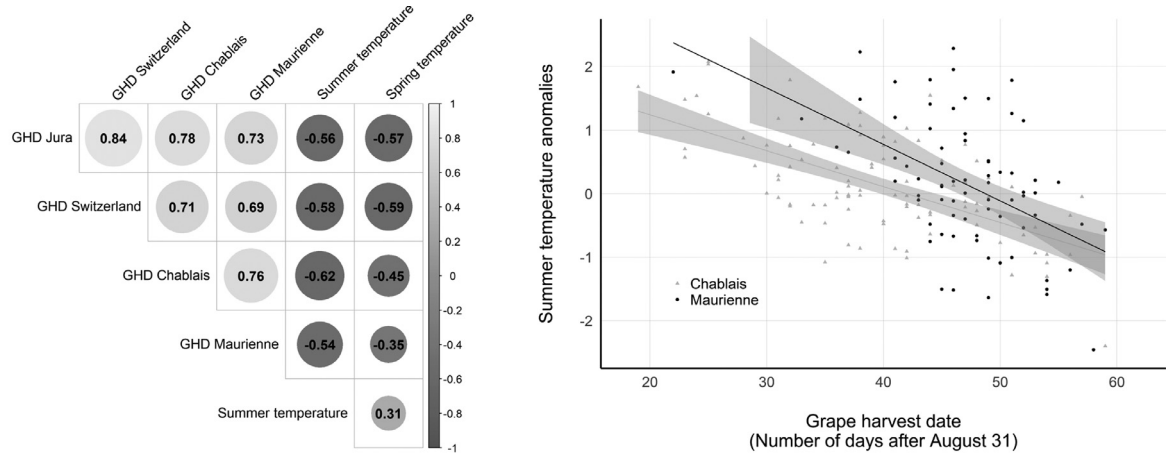
I also construct two additional measures of weather shocks so as to capture only extreme events. I create a dummy variable, *Droughts*, equal one if the seasonal temperature deviation is at least one standard deviation larger than the long-term mean, and zero otherwise. Similarly, to capture extremely wet seasons when floods were more likely, I create a dummy variable, *Floods*, equal one if the seasonal precipitation deviation is at least one standard deviation larger than the long-term mean, and zero otherwise.

[38] I derive seasonal temperature data in Geneva between 1760 and 1900 from the HISTALP project (Auer et al., 2007): www.zamg.ac.at/histalp. The city of Geneva was not part of the duchy of Savoy, but it was located 40 km north of Annecy, the capital city of the province of Genevois. These data were not used in the reconstruction by Luterbacher et al. (2004).

[39] For instance, Casty et al. (2007, p. 795) use independently reconstructed gridded temperature data and find an overall 0.95 correlation rate with temperature data from Luterbacher et al. (2004).

[40] Online Appendix Figs. D.5 and D.6, respectively display the distribution of seasonal standardised temperature deviation and the distribution of seasonal standardised precipitation deviation between 1749 and 1789.

[41] Nicolas uses vintage bans in Montmélian and its surroundings to build a series spanning 1713–90. Montmélian is a town located 15 kilometres south of Chambéry. Tissot reports GHD from 1688 to 1790 in Thonon-les-Bains in the province of Chablais.



(a) Correlation matrix of GHD series, 1688–1790

(b) Temperature and GHD in Savoy, 1688–1790

Fig. 3. Comparisons of temperature reconstructions with GHD. *Sources:* GHD in Jura (Daux et al., 2012). GHD in Switzerland (Meier et al., 2007). GHD in Chablais (Tissot, 1887, pp. 320–2). GHD in Maurienne (Nicolas, 1978, pp. 584–5).

3.3. Socio-economic data

Migration data Data on the average rate of seasonal migration at the province level was collected from Becchia et al. (2012). During the 18th century, the administration also carried out, for military purposes, enquiries regarding the number of males over the age of 13 in every parish. A few of these documents (*consigne des mâles*) survived for the years 1726, 1758 and 1776, where for each individual, name, age, occupation and the place of residence (including abroad) is recorded. The migration estimates derived from these documents are consistent with those from other sources, including enquiries carried out by the administration to evaluate the magnitude of migration across several towns in Savoy (Depoisier, 1858; Guichonnet, 1945; Letonnelier, 1920). A potential concern is that the level of seasonal migration varied from one year to another across provinces depending, among other things, on local economic conditions. Historical evidence, however, show that seasonal migration patterns were quite stable over time.[42]

Prices data I use data on wheat prices in early October, right after the harvests, in the markets of Annecy (1717–92) and Chambéry (1717–89) to approximate annual changes in living standards (online Appendix Fig. D.7).[43] In Table 4, I show the correlation between wheat prices and the standardised temperature deviation during the summer in the provinces of Genevois and Savoie (columns 1 to 3). Warmer temperatures are positively correlated with higher wheat prices, supporting the idea that temperature shocks often resulted in negative transitory economic shocks that could, in turn, influence the incidence of crime.

Mehlum et al. (2006) argue that higher rye prices were concomitant with higher beer prices, leading to less alcohol consumption, and reducing the incidence of violent conflicts. Every year, in early December, the city council of Annecy would set the price of a jug of locally produced wine, based on information it gathered about the outcome of the grape harvest.[44] I collect these prices from the registers of the Annecy city council deliberations to investigate the effect of temperature shocks on the price of wine (1741–89). Columns 4 and 5 of Table 4 report the correlation between summer temperature shocks in the province of Genevois and the price of red wine in Annecy, and show that warmer temperatures had a negative effect on wine price levels. This result is consistent with the fact that warmer temperatures foster the development of wine grapes and positively affect their harvests, as reflected earlier by GHD. However, the share of wine in the consumption basket was relatively small compared to crops, such that the overall effect of temperature shocks on living standards was likely negative.

4. Empirical strategy and results

4.1. The impact of temperature shocks on violent and property crimes

I begin by examining whether changes in year-to-year seasonal temperature influence property crime rates and violent crime rates in Savoy from spring 1749 to spring 1792. I estimate a reduced-form model of the form:

$$Crime_{ist} = \beta_1 \, Temperature_{its} + \delta_i + \theta_t + \epsilon_{ist} \tag{1}$$

[42] I discuss this issue in greater details in Section 4.2.

[43] Annecy: monthly average wheat prices, for the four October markets. Arch. mun. Annecy, HH2, Mercuriales 1629–1789. Chambéry: wheat prices on 29 September (*Saint-Michel*). Arch. dép. Savoie, 189Edépôt 1265–94, Arch. mun. Chambéry, Registre de la Grenette.

[44] Arch. mun. Annecy, BB 45 à 55, Registre des délibérations de la ville d'Annecy.

Table 4
The impact of temperature shocks on wheat and wine prices in Savoy, 1717–92.

	Log of wheat prices (ag/l)			Log of wine prices (ag/l)	
	(1)	(2)	(3)	(4)	(5)
Temperature	0.013	0.031	0.032	−0.061	−0.077
	(0.010)	(0.014)	(0.014)	(0.033)	(0.033)
	[0.208]	[0.023]	[0.020]	[0.062]	[0.019]
Temperature *t-1*		0.053	0.053		−0.075
		(0.014)	(0.013)		(0.033)
		[0.0001]	[0.0001]		[0.023]
Spring temperature	Yes	Yes	Yes	Yes	Yes
Spring temperature *t−1*	No	Yes	Yes	No	Yes
Province FE	No	No	Yes	No	No
Observations	149	149	149	49	49
R^2	0.013	0.172	0.198	0.071	0.171

Notes: OLS estimations. Robust standard errors and p-values in parentheses and brackets respectively.
In columns 1 to 3, the dependent variable is the log of wheat prices in grams of silver per litre in province *i* during after harvest time (Autumn) in year *t* (1717–92). In columns 4 and 5, the dependent variable is log of red wine prices in grams of silver per litre in the city of Annecy in year *t* (1741–89). The independent variable Temperature is the summer temperature deviation from the long-term seasonal mean (1500–1600) in province *i*, divided by its standard deviation. The other independent variables are defined accordingly. Province FE is a set of province fixed effects.

where $Crime_{its}$ is the log of the *Total crime* rate in province *i* in season *s* in year *t*. Accordingly, *Violent crime, Property crime*, and *Theft of edible products* denote the log of the crime rate for each category of criminal offence.[45] $Temperature_{its}$ is the seasonal standardised temperature deviation from the long-term mean (1500–1600) in province *i* during season *s* in year *t*. δ_i are province fixed effects that account for time-invariant province characteristics, such as altitude, land characteristics, and distance to markets. θ_t are year fixed effects, and account for time-variant characteristics that may affect all provinces at the same time. Standard errors are clustered at the province level. Because my data set includes only six provinces, I estimate the p-value of the coefficients of interest from the wild cluster bootstrap-t procedure (Cameron et al., 2008). The β_1-coefficient captures the effect of temperature shocks on the incidence of crimes.

Table 5 presents the main results. In column 1, I report the estimate from pooling together all crime categories into a single category, *Total crime*. The estimated coefficient is statistically non-significant, which is not surprising given that in theory temperature shocks had an opposite effect on violent crime rates and property crime rates. Column 2 reports the coefficient of the effect of *Temperature* on violent crime rates. The coefficient is negative and statistically significant, indicating that there were considerably fewer violent crimes during economic downturns. Previous empirical studies suggest that transitory poverty shocks temporarily reduced the level of alcohol consumption, which in turn diminished the frequency of violent crimes (Bignon et al., 2017, p. 37; Traxler and Burhop, 2010, pp. 11–13). In Section 3.3, I showed that warmer temperatures were correlated with lower wine prices and resulted in a positive income effect. Yet, warmer temperatures were also correlated with higher wheat prices, leading individuals to spend a greater share of their total income on staple crops rather than alcohol consumption (substitution effect). Moreover, increases in crop prices affected all members of the household, whereas a decline in wine prices affected only the adult members of the household. That means that the welfare gain (income effect) was likely to be smaller than the welfare loss (substitution effect) induced by increases in crop prices. Overall, the reduced-form effect of temperature shocks on violent crimes was negative in 18th-century Savoy.[46]

The results presented in column 3 suggest that warmer temperatures had a positive and statistically significant effect on property crime rates. A one standard deviation increase in temperature increased the incidence of property crimes by 6.9%.[47] Adverse weather conditions reduced the prospects of the next harvest and increased pressure on current staple prices. This in turn created situations of economic stress for more vulnerable individuals.[48] This is consistent with the fact that weather-induced economic shocks were a source of economic deprivation that led some individuals to commit crimes to survive (Bignon et al., 2017; Mehlum et al., 2006). In columns 4 to 6, I further refine the *Temperature* variable by attributing more weight to cells that have higher agricultural suitability. Shocks that affect areas with greater agriculture potential may comparatively be more detrimental to the local population than those

[45] The crime rate is calculated as the ratio of offenders per 100,000 inhabitants (see Section 3.1).
[46] Note, however, that the worst shocks, i.e. those associated with famine, may have increased violent crimes (e.g. Alfani, 2011, pp. 30–1). While such a result would not be in line with temperature-aggression hypothesis, the low temporal granularity of the temperature data prevents inferring any reliable conclusions.
[47] Blakeslee and Fishman (2018, pp. 765-7) find an effect of similar magnitude in contemporary India.
[48] For more further discussion of this mechanism, see Labrousse (1933), Goubert (1960), and Nicolas (1978).

Table 5
The impact of temperature shocks on crime rates in Savoy, 1749–92.

	Total crime	Violent crime	Property crime	Total crime	Violent crime	Property crime
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature	−0.020	−0.087	0.068			
	(0.052)	(0.039)	(0.039)			
	[0.707]	[0.027]	[0.080]			
Weighted temperature				−0.018	−0.085	0.070
				(0.053)	(0.040)	(0.037)
				[0.733]	[0.035]	[0.060]
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1044	1044	1044	1044	1044	1044

Notes: The sample is a balance panel of provinces covering 1749–92. Panel linear estimations with province fixed effects and year fixed effects. Cluster bootstrapped standard errors (Cameron et al., 2008) and p-values in parentheses and brackets respectively.
In columns 1 and 4, the dependent variable is the log of total number of crimes per 100,000 inhabitants in province *i* during season *s* in year *t*. In columns 2, 3, 5 and 6, the dependent variables are defined accordingly for violent and property crime. In columns 1 to 3, the independent variable Temperature is the seasonal temperature deviation from the long-term seasonal mean (1500–1600) in province *i*, divided by its standard deviation. In columns 4 to 6, the share of each cell in the mean seasonal temperature of province *i* is weighted by the share of the cell's soil suitability to grow wheat in the total soil suitability of province *i*. Weighted temperature is then defined accordingly. Province FE is a full set of province fixed effects. Year FE is a full set of year fixed effects.

occurring in areas less suitable for agriculture.[49] Results remain stable across all specifications. In online Appendix E, I perform additional robustness exercises to show that baseline results do not depend on the construction of the independent variable.

4.2. The role of seasonal migration

Was seasonal migration an efficient buffer against weather shocks? In Section 2.3, I provide historical evidence that seasonal migration contributed to the mitigation of weather shocks through two channels: remittances and the reduction of Malthusian constraints. To investigate whether temperature shocks affected crime rates differentially in provinces where average seasonal migration was high, I use the following specification:

$$Crime_{ist} = \beta_1 Temperature_{its} + \beta_2 Temperature_{ist} \times Migration_i + \delta_i + \theta_t + \epsilon_{ist} \quad (2)$$

where $Crime_{its}$, $Temperature_{its}$, δ_i, and θ_t are defined as in Eq. (1). $Migration_i$ is a measure of seasonal migration in province *i* defined as: (i) *migration dummy*, a dummy variable equal to one if the seasonal migration rate in province *i* is higher than the mean migration rate in the duchy of Savoy, and zero otherwise; (ii) *migration rate*, a continuous variables equal to the seasonal migration rate in province *i*. β_2 is the coefficient of interest and indicates the differential effect of temperature shocks between provinces with high migration rates, and those with low rates.

Table 6 presents these results. Estimates with the variable *Migration dummy* compare provinces with high seasonal migration rate to those low seasonal migration rate, while estimates with the variable *Migration rate* indicate the relative effect of higher seasonal migration rate. If, as suggested in previous empirical studies, the decline in violent crimes is driven by a relative decrease in purchasing power, then one should expect the coefficient *Temperature* × *Migration* to be positive in columns 3 and 4 of Table 6. That it is negative indicates that the effect of welfare gains linked to seasonal migration was smaller than that of a temporary reduction in the criminogenic population. Columns 1 to 3 of Table 7 report the effect of temperature shocks and migration on a subset of violent crimes: physical violence committed against individuals, excluding homicide. The results are in line with the previous findings and suggest that seasonal migration did not have a positive effect on the level of violence.

In Section 2.3, I provide narrative evidence to show that remittances derived from migrant labour were a valuable resource for such provinces. Parishes, such as Maglans and Sainte-Foy-Tarentaise, relied on migrant cash inflows to acquire large quantity of grains to sustain their population (Table 2). In column 5 of Table 6, the coefficient associated with the interaction term between temperature and the dummy variable that indicates whether seasonal migration is structurally high in the province is negative and statistically significant. The magnitude of the effect of seasonal migration is substantial, since it completely offsets the negative effect of temperature shocks on property crime rates. According to the estimates presented in column 5 of Table 6, seasonal migration was an efficient coping strategy to reduce the impact of weather-induced income shocks. Recall that the back-of-the-envelope calculation

[49] To do so, I use the crop suitability index (value) estimated for intermediate input level rain-fed wheat from the Global Agro-Ecological Zoning (GAEZ).

Table 6
The impact of seasonal migration.

	Total crime		Violent crime		Property crime	
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature	0.045	0.144	−0.044	0.008	0.115	0.190
	(0.029)	(0.030)	(0.026)	(0.047)	(0.024)	(0.030)
	[0.115]	[0.00001]	[0.087]	[0.862]	[0.00001]	[0.000]
Temperature × Migration dummy	−0.198		−0.129		−0.143	
	(0.034)		(0.057)		(0.046)	
	[0.000]		[0.025]		[0.002]	
Temperature × Migration rate		−0.018		−0.011		−0.014
		(0.004)		(0.006)		(0.005)
		[0.00001]		[0.066]		[0.003]
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1044	1044	1044	1044	1044	1044

Notes: The sample is a balance panel of provinces covering 1749–92. Panel linear estimations with province fixed effects and year fixed effects. Cluster bootstrapped standard errors Cameron et al. (2008) and p-values in parentheses and brackets respectively.
In columns 1 and 2, the dependent variable is the log of total number of crimes per 100,000 inhabitants in province *i* during season *s* in year *t*. In columns 3 to 6, the dependent variables are defined accordingly for violent and property crime. In columns 1 to 6, the independent variable Temperature is the seasonal temperature deviation from the long-term seasonal mean (1500–1600) in province *i*, divided by its standard deviation. Migration dummy is a binary variable equal to one if the average seasonal migration rate in province *i* is above the Savoyard mean, and zero otherwise. Migration rate is a continuous variable equal to the rate of seasonal migration in province *i*. Province FE is a full set of province fixed effects. Year FE is a full set of year fixed effects.

Table 7
The impact of seasonal migration on physical violence and petty theft of food.

	Physical violence against persons			Theft of edible products		
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature	−0.067	−0.034	0.011	0.034	0.056	0.098
	(0.040)	(0.021)	(0.047)	(0.018)	(0.019)	(0.027)
	[0.099]	[0.101]	[0.822]	[0.064]	[0.004]	[0.0003]
Temperature × Migration dummy		−0.099			−0.066	
		(0.065)			(0.019)	
		[0.131]			[0.001]	
Temperature × Migration rate			−0.009			−0.007
			(0.007)			(0.002)
			[0.202]			[0.0001]
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1044	1044	1044	1044	1044	1044

Notes: The sample is a balance panel of provinces covering 1749–92. Panel linear estimations with province fixed effects and year fixed effects. Cluster bootstrapped standard errors (Cameron et al., 2008) and p-values in parentheses and brackets respectively.
In columns 1 to 3, the dependent variable is the log of total number of physical violence against persons (exlcuding homicide) per 100,000 inhabitants in province *i* during season *s* in year *t*. In columns 4 to 6, the dependent variable is the log of total number of thefts of edible products per 100,000 inhabitants in province *i* during season *s* in year *t*. In columns 1 to 6, the independent variable Temperature is the seasonal temperature deviation from the long-term seasonal mean (1500–1600) in province *i*, divided by its standard deviation. Migration dummy is a binary variable equal to one if the average seasonal migration rate in province *i* is above the Savoyard mean, and zero otherwise. Migration rate is a continuous variable equal to the rate of seasonal migration in province *i*. Province FE is a full set of province fixed effects. Year FE is a full set of year fixed effects.

in Section 2.3 suggests that migrants cash inflows helped sustain a significant share of the population, particularly as this inflow ended up in provinces with high migration rates. In column 6, the estimated coefficient for the interaction term *Temperature* × *Migration rate* is equal to −0.014 and statically significant at 1%. A one percentage point increase in the seasonal migration rate reduced the impact of temperature shocks on property crime by 1.4%.

It is, however, difficult to identify the exact underlying mechanism. The effect may be driven by the fact that provinces with higher seasonal migration rates benefitted from cash inflows, faced temporarily lower population pressure, or that a portion of their most

criminogenic population, i.e. young able-bodied men who constituted the bulk of criminals in 18th-century Europe, was temporarily absent (Lecoutre, 2010; Ruff, 1984). If the reduction in property crime rates in provinces with high seasonal migration rates was driven by the departure of migrants, the share of young men among offenders in the winter season should have been lower than during the rest of the year. Online Appendix Figure D.4 presents the age distribution of offenders involved in property crimes throughout the year and specifically during winter, when seasonal migrants were absent. The age group 21–35 represents 50 and 61% of the offenders respectively, thus excluding the possibility that the mitigation effect of seasonal migration is driven by a composition effect.

Table 7 reports the coefficient estimates of the effect of temperature shocks on the rate of property crimes that involved the theft of edible products. This specific type of property crime may likely have been be more directly related to hunger, and could, in turn, provide additional evidence on the underlying mechanism in the relationship described above. Column 4 reports the results from estimating Eq. (1), while columns 5 and 6 report estimated coefficients from Eq. (2). In all columns, the coefficient on *Temperature* is positive and statistically significant, suggesting that temperature shocks had strong impact on the level of property crime rates that involved the theft of edible products. This result confirms the idea that when provinces were subjected to adverse weather conditions, economic deprivation was one of the main factors behind the increase in property crime rates. The coefficient associated with the interaction term in columns 2 and 3 yields results that are qualitatively similar to my baseline findings (Table 6). In provinces with higher shares of migrant labour, seasonal migration allowed for both an inflow of remittances as well as a temporary alleviation of Malthusian pressure, significantly improving lives of individuals who did not migrate, and enabling them to better cope with transitory economic shocks. This may, in turn, have decreased the necessity of stealing to survive. Given the limitations relative to the construction of the theft of edible products variable (see Section 3.3), this evidence is merely suggestive, but it is in line with previous empirical evidence in the literature (Axbard, 2016; Bignon et al., 2017).

Levels of seasonal migration may have varied from one year to another across provinces depending, among other things, on local economic conditions. One concern is that using the average rate of migration at the provincial level may fail to capture changes in the intensity of migration and/or shifts in their geographical pattern. If the migration rate was higher than the average during economic downturns, then its potential mitigating effect on crime rates may be over-estimated. Conversely, its effect could be under-estimated during a non-crisis year, leaving the overall direction of the bias undetermined. Another concern is that the relative importance of migration across provinces may have changed over time due to variations in the timing of exposure to strong weather shocks. Two factors assuage the concerns described above. First, the most important weather shocks were of regional, if not continental, dimension during the second half of the 18th century. This means that all provinces were contemporaneously adversely affected by the worst weather shocks in the early 1770s and in the 1780s. Second, historians have shown that the pattern of seasonal migration was highly persistent over time in that it required structured (village) networks and a degree of specialised knowledge (Bruchet, 1897; Guichonnet, 1945; Letonnelier, 1920; Siddle, 1997). Workers from one village often migrated to a same area year after year and specialised in one of the following occupations: mason, charcoal burner, pedlar, or agricultural labourer. It is therefore unlikely that a negative transitory shock completely disrupted the structural differences across provinces in terms of seasonal migration movements.

5. Conclusion

A recent trend in the literature has consistently demonstrated the existence of a significant relationship between weather variations, economic shocks and interpersonal conflicts. To his regard, I link temperature data with economic variables and crime data to examine the effect of temperature shocks in the context of early modern Savoy. I also investigate the role of seasonal migration, in an effort to ascertain whether such movements were effective in alleviating the impact of negative economic shocks. Overall, I show that temperature shocks had a positive and significant effect on property crime rates and a negative impact on violent crime rates. Previous findings in the literature have also suggested that there is a positive relationship between alcohol consumption and violence. I show that while temperature shocks were associated with lower wine prices in the province of Genevois, their net welfare effect was negative given the relatively greater share of crops in the household consumption basket. Additionally, I provide qualitative and quantitative evidence suggesting that seasonal migration weakened the link between temperature shocks and property crimes. Together with poor relief and state interventions, seasonal migration increased local communities' resilience against weather shocks and sustained population growth during the 18th century.

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Declaration of Competing Interest

The author declares that he has no relevant or material financial interests that relate to the research described in the article.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.eeh.2020.101353.

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