Let the Punishment fit the Crime: Self-Governed Communities in Southeastern Spain

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Abstract

The standard crime and punishment literature predicts that it is optimal for the ruler to use the maximum punishment available in case a crime is committed. However, empirical studies show that punishments are, in general, smaller than the maximum punishment available. The usual explanation is that punishment is costly (i.e. maintaining the prisons, guards, etc). However, we do not observe the maximum punishment rule even in cases in which punishment is costless (i.e. traffic fines). Moreover, punishments depend on the characteristics of the accused (i.e. teenagers receive lower punishments than adults for the same crime). However, the literature finds that the business cycle and the crime rate is uncorrelated. Hence, we need to explain why, imposing the maximum punishment is not optimal and why the punishments change with some observables and not others.

I use a novel data set from a self-governed community of farmers in $19^{th} - 20^{th}$ centuries Spain. In this data, the maximum punishment available is only rarely used, although punishment is costless. Also, punishments are affected by observables characteristics. In my data, there no correlation between the punishment and the business cycle.

I propose a model that can explain the lack of maximum punishment, even when the punishment is costless. The model also gives an intuitive explanation for progressivity on the punishment. Finally, the model predicts that punishments (and crime rates) could be cyclical or counter-cyclical, depending on the parameters. I use the data to estimate and test the model.

Keywords: Economic History, Law and Economics, CPR, Self-Governed, Optimal Contracts

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1 Introduction

On October 2^{nd} 2009, The Council of Good Men (the Water Tribunal in Murcia) was inscribed on the Representative list of the Intangible Cultural Heritage of Humanity by the United Nations. The Water Tribunal in Murcia is an institution that has been active, and it is still active, since the 13^{th}century. The "Council" is made of elected members among the farmers in the community. The "Council" is responsible, among other duties, for providing justice when conflicts between the farmers arise. Most of these conflicts relate farmers irrigating without the right to do so and, hence, reducing the available water for irrigation for other farmers.

The Water Tribunals in the city of Mula has a similar structure. There is, however, an important difference. In Murcia, as in many other towns in the region, water was allocated using fix quotas (*tandas*).[1] In Mula (and Lorca) water was allocated using a public auction. Hence, by using the prices paid in the auction we can have a precise sense of the value of the water stolen. Also it is interesting that, while in Murcia all the farmers have water property rights, in Mula and Lorca some farmers have no water rights (they have to buy the water during the periodic auctions).

The Water Tribunal of Mula consists of seven members, which are elected among the water-owners every year on December 26^{th} and their appointment lasts for two years. In odd years, four members are elected and in even years three members are elected. This means, that any given year there are three (four) members of the Council in their first term and four (three) members in their second term. After the election is held, the members of the Council elect a President (among them) who will serve for one year. The President then appoints a Vice-president and a Treasurer (among) and a Secretary (outside the Council). The role of the Council is to pass sentence about issues affecting the water irrigation system as well as disputes between the farmers. No appeal to another court is possible.

The irrigation system consist on a Dam on the nearby river, a main channel that brings the water from the Dam to the city and countless smaller channels and sub-channels that connect the main channel with the individual plots. The old Dam (*El Gallardo Dam*) was built around the 9^{th} century by the Arabs and it was used until 1931 when the new Dam (*De La Cierva Dam*) was finished. The main channel that goes from *El Gallardo Dam* to the city where the plots are was also built in the 9^{th} century and is still being used today. [Ostrom (1990)], p 69, noticed how remarkable the achievements of these communities are:

> For at least 550 years, and probably for close to 1,000 years, farmers have continued to meet with others sharing the same canals for the purpose of specifying and revising the rules that they use, selecting officials, and determining fines and assessments.
>
> Water was never abundant in this region, conflict over water has always been just beneath the surface of everyday life, erupting from time to time in fights between the irrigators themselves, between the irrigators and their own officials, and between groups of irrigators living in the lower reaches of the water systems and their upstream neighbors. Despite this high potential for conflict - and its actual realization from time to time - the institutions devised many centuries ago for governing the use of water from these rivers have proved adequate for resolving conflicts, allocating water predictably, and ensuring stability in a region not normally associated with high levels of stability.

In this environment it is fairly easy to steal water: one just has to open the gate next to his own parcel and the water will flow in. The technology for detection of crime also is very effective: irrigation is done by

[1] Notice that Murcia is the name of both the region and the capital of the Region.

"flooding" your parcel, hence it is easy to detect who stole water just by identifying a "flooded" parcel. Given this environment one would expect fines to be high, to prevent the stealing of water; if fines are low, one would expect high crime rates. However, as [Ostrom (1990)], p 75, noted (citing [Glick (1967)], p56), "the actual fines assessed were very low (a few pennies at the most) and also variable, depending on the gravity of the offense, on general economic conditions, and probably on the individual's ability to pay".

However, both Ostrom and Glick get the causality wrong. They assigned the reason for the low fines to be due to the need to minimize conflicts between the officials and the farmers. "Because the fines actually assessed were kept relatively low, the guards did not deeply antagonize the farmers". However, as I will show later, the reason why the fines were very low has do to with insurance. As it was recognize in private correspondence between Glick and Ostrom: "The fines for cheating are set low enough so that if you really need some more water it's worth the fine". Of course, as I will show, this is only true for first-time offenders, not for recidivists. If the reason why the fines were low was to reduce conflict between the guards (that were farmers themselves) and the farmers, all fines should be low, not just fines for first-time offenders. However, in this case, the system will not be sustainable, because all farmers will find it profitable to steal almost every season. But, as Ostrom noticed, there was a "remarkable conformance rate".

During the trials, the judges have full discretion about the amount of the fines, up to a maximum established in their Ordinances (25 *pesetas* in the case of Mula). Empirical evidence shows that most of the fines were negligible (average of 5 *pesetas*) or zero. In most sentences, the accused just has to repay the value of the water stolen and sometimes also a small fine. To get a sense of the magnitude of these fines notice that the daily wage for an unskilled worker during this period was 5 pesetas. Hence, the maximum amount corresponds to a weekly wage.

Some historians such as [Anderson and Mass (1978)] and [Glick (1967)] have pointed out the progressiveness of the system. A farmer caught once (stealing water) will be mildly punished. If the same farmer is caught again, he would receive a much severe punishment. The punishment might be a high fine or even the inability to irrigate for one month. In Mula the fines for recidivists are always $20 - 25$ *pesetas*.

Standard Law and Economics literature, since Becker's seminal work ([Becker (1968)]), concludes that the best way to prevent crime is by using the maximum punishment available to the ruler. This view assumes that the only objective of society is to minimize crime. This point of view is too simplistic and does not fit in the real world: traffic fines are not huge, nor do we think that death penalty should be applied to every crime. Moreover, there are cases in which the law explicitly establishes no penalty in case of extreme need (in Germany the law establishes that it is not a crime to steal food if you cannot buy it).

Since the technology to write and apply the law is imperfect, there will be instances in which an innocent man is found guilty. It could be because the law itself is imperfect and cannot predict all contingencies: the law says that stealing is a crime, even if it is stealing to prevent your child from starvation, but a judge would hardly punish such an action. It could also be that the evidence is strong, but not perfect, against the indicted; hence, there will always be a small chance that she is innocent nonetheless. As I will explain later, given the technology for crime detection in this environment, it is safe to assume that the imperfection comes from incomplete laws (incomplete contracts) and not from imperfect observability of the crime.

I assume that rather than minimize crime the ruler is facing a trade-off between minimizing type I and type II errors. The community cannot write a law so specific to account for all possible contingencies that can affect a particular case. Hence, it allows discretion to the judge to impose a fine base on his criterion. The judge will observe every particular case and assign a greater or lower punishment based on the damage caused by the crime and the benefits the crime reported to the accused.

In this environment, the optimal mechanism exhibits progressiveness: small fines for first offenders and big fines for recidivists. It also predicts small fines simultaneously with low crime rates. The intuition is that when caught stealing, although the fine is small, the farmer loses the option value of stealing "for free" in the future when he might really need the water. The intuition here is the same as a yellow card in a soccer game: a yellow card is innocuous, unless you get a second yellow card, which means you are out of the game.

This paper belongs to a bigger project that studies the evolution and survival of the irrigators communities in Southeastern Spain (see [Donna and Espin-Sanchez (2011)] and [Espin-Sanchez (2012)]). This project is also related to the literature about institutions and how a change in institutions could affect economic outcomes such as the crime rate.

2 Case Study

> "*A majoribus tradita, et apud nos deposita* - Recibida de nuestros mayores y conservada entre nosotros", ("Received from our elders, and preserved among us"), Epigraph of the Preamble of the Ordinances of Mula, 1853.

In this section, I discuss the situation in Mula and the particular characteristics of the situation before, during and after its transition from a market institution to a non-market institution for water allocation. Geographical, historical and social conditions at the time the Christians conquered the Kingdom of Murcia, may have had an important impact on the way these institutions where originally set up. There is evidence of experimentation with other systems and some towns did, indeed, switch back and forth from a market to a non-market system before the 15^{th} century (see [Rodriguez-Llopis (1998)]).

2.1 Environment

In this area, the exploitation of the farm is made at the individual or family level (more than 90% of the parcels are smaller than 1ha). None of the plots are big farms (all owners have less than 5ha and most less than 1ha). The first explanation that comes to mind is that the technology/environment here makes the moral hazard problem so important that a bigger exploitation scale would not be profitable, even though it would alleviate the problems derived from the water scarcity. The same argument appears in [Hoffman (1996)].

2.1.1 Geography and weather

The coastal strip of southeast Spain is the most arid region of all continental Europe due to the "Foehn Effect"[2]. It is located right to the west of the mountain chain Prebaetic System, which includes the *Mulhacén* (the second highest mountain in Europe). The annual rainfall is less than 300 mm. The rainfall frequency distribution is skewed. The majority of years are dryer than the yearly average. The summers are dry with a secondary winter minimum appearing; Autumn is the only relatively wet season. However, in rainy days, in 70% of the cases, less than 1 mm falls and in 90%, less than 10 mm. The number of torrential rain days is not very high but when they occur, they can reach high intensities (for examples, 681 mm of water fell in Mula on one day, October 10^{th} 1943, while the yearly average is 320 mm). Insolation is very high, more than 3000 hours of solar exposure per year, the highest figure in Europe. Arid conditions are found in relation to the marginal situation of southeast Spain to the circulating air movements found in the occidental Mediterranean area and to the Atlantic-origin storms.

[2] A Foehn wind is a type of dry down-slope wind which occurs in the lee downwind side of a mountain range. It is a rain shadow wind which results from the subsequent adiabatic warming of air which has dropped most of its moisture on windward slopes see orographic lift. As a consequence of the different adiabatic lapse rates of moist and dry air, the air on the leeward slopes becomes warmer than equivalent elevations on the windward slopes.

2.1.2 History and Origins

After the fall of the Caliphate of Cordoba in 1031, the Kingdom of Murcia passed under the successive rules of the powers seated variously at Almería, Toledo and Seville. In 1172 it was taken by the Almohades, and from 1223 to 1243 it briefly served as the capital of an independent kingdom.

The Castilians, with forces led by King Alfonso X, took the city at the end of this period of autonomy, whereupon large numbers of immigrants from north northern Spain resettled the town. As with much of the Spanish Reconquest, these Christian populations were brought to the area with the goal of establishing a Christian base here, one that would be loyal to the Crown of Castile and whose culture would supplant that of the subjugated Moorish peoples. In 1296, control over Murcia and the surrounding region was transferred to the Kingdom of Aragon and, in 1304, was finally incorporated into Castile under the Treaty of Torrellas.

Every king since Alfonso X has respected the customs that farmers have in Murcia and in every town of the region. He also gave them the right to self-govern as "farmers' communities". It is worth noticing that the ruler opinion, for this particular situation, was that it is better to let the people make their own economic decisions and charge a (somewhat) low distorting tax, rather than appropriate the rights of exploitation and create a monopoly.

After the capital city (Murcia) surrendered to the Christians there were still three fortresses in the kingdom to be considered: Mula, Lorca and Cartagena. The leaders of these cities claimed rebellion and did not accept the terms of surrender agreed in the capital. Soon the Christian army was at the gates of Mula (the closest city to Murcia among the three) and the place was taken by force. After this victory the remaining cities of Lorca and Cartagena surrendered without resistance. This event had as a consequence that stronger reprisals were taken against the (mostly Muslims) citizens of Mula, which increased the local demand for new Christians colons. Hence, the new Christian settlers in Mula had to start *tabula rasa* and made new institutional arrangements.

The need for more Christians induced families from other parts of the peninsula, mainly from the kingdoms of Castile and Aragon, to migrate to Mula. The *Concejo* (City Council) would give every family a piece of land (*parcela*) and a quota on the water of the river (*tanda*). However, by the 15^{th} century, ownership of water and land was dissociated. Land could be bought and sold. Water property rights were also bought and sold. Owners of water property rights will get together and sell the water to the farmers using public auctions.

The water-owners (Waterlords) were clearly different persons than the land-owners (farmers). A well functioning cartel was established. The Waterlords themselves began to run the auctions. In the 18^{th} century this cartel was made formal and legal and received the name "*Heredamiento de Aguas*". The land-owners were small proprietors, with family-size plots, who created their own association, *"Sindicato de Regantes"*. The aim of this association was, for one side, to regulate themselves and settle disputes that arose between neighbors. Also, this association was created to keep balanced the power in the market for water.

2.1.3 The production system

I refer here to the traditional production system, present in the southeast of Spain from 13^{th} century until the last third of the 20^{th} century. As reported by [Anderson and Mass (1978)], in each of the two systems for allocating the water (*quotas* and *auctions*), the production structure is based on small (family-size) units. Since the land is owned individually but the water irrigation system (the river, the dam and the channels) have to be managed jointly, these farmers had to create an institution to manage the common resource.

However, in neighboring areas the structure is radically different. Powerful landowners hire seasonal workers to work in large estates and pay them wages just above their survival needs. These large estates are used to grow cereals and are not irrigated. The production function is different: scale effects are important (hence the big estates), the crop is homogeneous (cereals) and, thus, there is no need for specific human capital investment or proper incentives for effort: quantity is easy to verify and contract, quality not so much. The argument for the optimality of the contract on land is consistent with [Hoffman (1996)].

The goods produced in the *huertas* are also different than in the large estates. *Huertas* produce mainly vegetables and fruits. They were also the main producers of white mulberry leafs during the silk boom in the 19^{th} (and 16^{th}) century as well as saffron and other high quality products. However, large estates produce mostly grain and fodder. Olives and grapes (wine) are produced in both systems.

The first thing to remark is that *huertas* produce goods that are heterogeneous in quality, while large estates produce homogeneous goods that bring low profit per acre. The former products (citrus, peaches, etc) are very sensitive to weather conditions and require constant and close attention. Also, products cultivated in *huertas* required a high level of specific human capital. Tasks like pruning, fertilizing, selective harvesting (and seeding) or animal caring require a level of specific human capital higher than average. This accumulation of human capital will take several years and is transmitted mainly from father to son. However, tasks like reaping are easily learned and poorly paid.

All the attributes mentioned in the previous paragraphs are determined by technological constraints. What about the economic structure? Goods that are heterogeneous in quality, for which production a high level of specific human capital is needed and which are subject to shocks and specific needs only observed by the farmer, have a severe moral-hazard problem in a principal-agent setting. Monitoring cost are prohibitively high. [Morilla-Critz, Olmstead and Rhode (1999)] showed that "whereas wheat required about 9 man-hours of labor per acre in 1939, lemons required 286". The optimal mechanism in this environment will be to "sell" the firm to the agent. [Garrido (2011)] and [Calatayud and Garrido (2011)] show that this was indeed the case in eastern Spain. They also show that all the contracts in this type of environment require that the farmer owns the land or that the farmer has a long-term contract with the Landowner with compensation for all the improvements, which is roughly equivalent to the farmer owning the land.

In a static environment, the wage-worker will not pay much attention in taking care of the crop. He will have incentives to report bad weather and will not work as much as needed in some circumstances. All those problems could be solved by some incentives mechanisms, such as a piece wage instead of an hourly wage, adjusting the payment to some quality measure if needed. However, any of those mechanisms is unlikely to solve the problem of investment in specific human capital or the selective harvesting (and seeding) issue. Moreover, any other specific investments will only be carried out if the farmer can get the entire surplus produced by the investment, such as experimenting with new crops/methods or irrigating at night.

3 Model

> "If , though unjust, I acquire the reputation of justice, a heavenly life is promised to me", Plato, The Republic.

Here I present a simple model that can explain the main features of the data. This simple version is static, so it can not take into account progressiveness. However, it can easily be extended into an infinite-periods model. A dynamic version of this model will imply progressiveness because the judge can update his beliefs about the farmer's type base on previous periods. I also consider here a situation with only one farmer, and one judge. This is without loss of generality, since we can consider every farmer/trial independently. In the cases in which the number of offenses provides information about the state we just have to reinterpret the public signal.

We have a farmer i with expected utility function:

$$U_i\left(r_i, \theta_i, \gamma\left(R\right), F\left(R\right), w\right)$$

where $r_i \in \{r_H, r_L\}$ is the individual state of the farmer (the amount of rain he have received in his plot can be High or Low), $\theta_i \in \{\underline{\theta}, \overline{\theta}\}$ is the type of the farmer (he can be either honest ($\theta_i = \overline{\theta}$) of dishonest ($\theta_i = \underline{\theta}$)), $R \in \{H, L\}$ is a public signal about the individual state of the farmer (the amount of rain in the town can be High or Low), $\gamma(R) \in [0,1]$ is the probability that a farmer is caught is he steals water, $F(R) \in [0, \bar{F}]$ is the fine imposed on the farmer if caught stealing water and $w \in \{0, W\}$ is the amount of water (if any) stolen by the farmer. The type θ_i will only affects the utility of the farmer when he steals water and is convicted.[3] That is, the utility of two farmers that receive the same amount of rain and do not steal water is the same, regardless of their type.

I interpret water stealing as stealing the water from the dam or from the channel, so that the social cost is shared equally among all farmers. The case when the farmer steals from another farmer is analogous, but the loss for the community is different. Without loss of generality and due to the interpretation of the parameters in the model we have: $r_H > r_L$ and $H > L$.

In this model, we can interpret r_i as the amount of rain received by the farmer. The farmer is the only one that observes r_i. Although rainfall is public knowledge, the way each farmer can use the water is not. Some farmers may have plots in slope, so they can not fully take advantage of all the water. Maybe a farmer was sick the day of the rainfall and could not go to the plot to plow and manage the water. One can think of R as rainfall, which is publicly observed, and r_i as the usage of that rainfall. Hence, the informativeness of R on r_i.

There is public signal R, observed by both, the judge and the farmer, that is correlated with the individual state as follows:[4]

$$P(r_i = r_L / R = H) = q_H$$

$$P(r_i = r_L / R = L) = q_L$$

Also, the prior probability of being honest $\pi \in (0,1)$ is common knowledge. Without loss of generality we normalize the most informative signal R_L, hence $q_L \geq q_H$. That is, it is more likely that the farmers receives low water when the water in the town is low than when the water in the town is high.

We have:

$$U_i(r_i, \theta_i, \gamma(R), F(R), w) = \gamma(R)\, u(r_i + w, \theta_i, F(R)) + [1 - \gamma(R)]\, u(r_i + w, \theta_i, 0)$$

where $u(\cdot,\cdot,\cdot)$ is the Bernoulli utility function. A different interpretation of the utility function is this case is the usability (or marginal returns) derived from every unit of water stolen. A higher θ_i does not necessarily mean a lower feeling of shame but rather a better technology when stealing the water. This could be because the farmer has many sons that can help him irrigate within a short period of time or the shape and location of the farmer's plot are such that he can make a better use of the water stolen.[5]

[3]The model does not make distinction of the case in which the honest farmer suffer whenever he steals the water ("self-ashamed") and the case in which the farmer suffer only if he is caught and convicted ("social-ashamed"). Since the probability of being caught is virtually equal to 1 and I do not have information on cases in which a farmer stole water but was not caught, I cannot identify one case from the other.

[4]This generalization includes other modeling choices as special cases:

- $q_H = q_L = \frac{1}{2}$; in this case the signal is uninformative. This is the case in most of the existing literature that does not take into account the possibility of public signals about the criminal type.
- $q_H = 1 - q_L = 0$; in this case the signal reveals the type perfectly. This is an implicit assumption in Beckerian models in which the trial will determine (without error) whether the defendant is guilty or not.

[5]In one of the trials, the method to "steal" the water was particularly innovative. The defendant tell his three children to "swim" in the channel right next to his plot, and do so in such a way that the channel was block. The water then, overflowed the channel and spill over the defendant's plot.

We need some restrictions in the parameter space to make the problem interesting. Let $u(\cdot,\cdot,\cdot)$ be the Bernoulli utility function for a given final payoff. I assume that $u(\cdot,\cdot,\cdot)$ is strictly increasing and concave in its first term, strictly decreasing in its third term and has a negative cross-derivative between the second and third term:

- $u_1(\cdot,\cdot,\cdot) > 0$: This assumption implies that the farmer receives a positive utility from water, whether it is stolen or not.
- $u_{11}(\cdot,\cdot,\cdot) < 0$: This assumption implies that, although the farmer receives a positive utility from water, he does so at a diminishing rate. This is equivalent to the assumption that water produces diminishing marginal returns.
- $u_2(\cdot,\cdot,\cdot) \leq 0$: This assumption implies that honest farmers will suffer more from stealing water than dishonest farmers.
- $u_2(\cdot,\cdot,0) = 0$: This assumption implies that honest and dishonest have the same utility when they do not receive a fine from stealing water..
- $u_3(\cdot,\cdot,\cdot) < 0$: This assumption implies that the farmer receives a negative utility from the punishment he receives.
- $u_{23}(\cdot,\cdot,\cdot) < 0$: This assumption implies, although the farmer receives a negative utility from the punishment, an honest farmer receives a greater disutility from the same punishment.

This last assumption means that an honest farmer suffer when he is caught stealing, while a dishonest farmer does not. Another possible assumption would be to assume that an honest farmer suffer when he steals water, whether he is caught or not, while a dishonest farmer does not. Both assumptions are not distinguishable within this model and the data available. The reason is that we do not observe situations in which farmers steal water but are not caught. In any case, given the technology of the setting, we can expect that virtually all crimes are detected.

3.1 The Farmer's problem

I will now make some assumptions about the parameter space in order to make the problem interesting.

Assumption 1: Any farmer will find it profitable to steal water if she had received Low rain:[6]

$$u(r_L, \theta_i,) < u\left(r_L + W, \theta_i, \overline{F}\right), \forall R, \theta_i$$

Assumption 2: It is optimal that any farmer steals water if she had received Low rain:[7]

$$u(r_L + W, \theta_i, F(R)) - u(r_L, \theta_i, F(R)) \geq P_R(W), \forall F(R), \theta_i$$

where $P_R(W)$ is the social value of W units of water when the public signal is R, i.e. $P_R = q_R u(r_L + W) + (1 - q_R) u(r_H + W)$. One can interpret the public signal as the proportion (rather than the probability) of farmers that received Low rain. Hence, the social value $P_R(W)$ equals the average utility that an amount of W of water adds.

Assumptions 1 and 2 are less restrictive that they seem. If we take $u(x, \theta_i, F(R)) = ln(x) - \theta_i F(R)$ and $r_L = 0$ we have $u(r_L) = -\infty$. In this case both assumptions are trivially satisfied when. Moreover, this decision

[6]A sufficient condition for Assumption 1 is $u(r_L) < u(r_L - \bar{F} + w)$.
[7]A sufficient condition for Assumption 2 is $u(r_L + w) - u(r_L) \geq w$.

is socially optimal. In the Low rain state a farmer would die if he does not receive extra water for his crops. This is an undesirable outcome and thus non socially optimal.

The timing of the game is as follows:

- At $t = 0$, nature draws $\{r_i, R\}$. The farmer observes $\{r_i, R\}$.
- At $t = 1$, the farmer chooses w.
- At $t = 2$, the judge observes R and chooses a policy function $\{F(R)\}$.
- At $t = 3$,
  - if the farmer has chosen $w = W$, he is caught with probability $\gamma(R)$, in this case his utility is:

$$U_i(r_i, \theta_i, \gamma(R), F(R), W) = u(r_i + W, \theta_i, F(R))$$

  - if the farmer has chosen $w = W$, he is not caught with probability $[1 - \gamma(R)]$, in this case his utility is:

$$U_i(r_i, \theta_i, \gamma(R), F(R), W) = u(r_i + W, \theta_i, 0)$$

  - if the farmer has chosen $w = 0$, he cannot be caught, his utility is then:

$$U_i(r_i, \theta_i, \gamma(R), F(R), 0) = u(r_i, \theta_i, 0)$$

The farmer would get a different utility depending on whether he steals water or not. Hence, we have:

- If the farmer does not steal water:

$$U_i(r_i, \theta_i, \gamma(R), F(R), w = 0) = u(r_i, \theta_i, 0)$$

- If the farmer steals water:

$$U_i(r_i, \theta_i, \gamma(R), F(R), w = W) = \gamma(R)\, u(r_i + W, \theta_i, F(R)) + [1 - \gamma(R)]\, u(r_i + W, \theta_i, 0)$$

Hence, the farmer will steal water if and only if:

$$\gamma(R)\, u(r_i + W, \theta_i, F(R)) + [1 - \gamma(R)]\, u(r_i + W, \theta_i, 0) \geq u(r_i, \theta_i, 0)$$

Notice that, taking θ_i and $\gamma(R)$ as given, the judge can change $F(R)$ so that the farmer find it profitable to steal water when $r_i = r_L$ and not to steal water when $r_i = r_H$. This is the *first-best* outcome. This result is due to the concavity of the Bernoulli function with respect to water. However, the judge does not know θ_i, hence, in general, the *first-best* outcome is not attainable.

3.2 The Judge's Problem

The objective function of the judge is simple. He wants to punish the farmer if he steals water when $r_i = r_H$ and not punish him when $r_i = r_L$. This is the social optimum. The main problem here is that the judge does not observe the actual (individual) state of the farmer r_i, only an imperfect signal (R) about it. One can interpret this signal as the rainfall in the town. R is positively correlated with the rainfall in the farmer's plot r_i, but not perfectly. Other factors such as the slope of the plot or whether the farmer was actually on the field during and after the rain may affect rainfall's productivity. If we consider a case with asymmetric farmers, with other characteristics observed by the judge, then the public signal is still a sufficient statistic for all relevant information observable by the judge.

3.2.1 Honesty is Observable

In the case in which honesty is observable the judge only have to define a punishment contingent on the state of the world and the honesty $F(R, \theta_i)$. According to the judge's problem, the judge only has to choose the punishment so that a farmer in need of water $r_i = r_L$ will find it profitable to steal the water while a farmer that does not need the water $r_i = r_H$, will not. Hence, the optimal punishment should satisfy:

$$u(r_L + W, \theta_i, F(R, \theta_i)) \geq u(r_L, \theta_i, 0)$$

$$u(r_H + W, \theta_i, F(R, \theta_i)) < u(r_H, \theta_i, 0)$$

We can rewrite this conditions as:

$$u(r_L + W, \theta_i, F(R, \theta_i)) - u(r_L, \theta_i, 0) \geq 0 < u(r_H, \theta_i, 0) - u(r_H + W, \theta_i, F(R, \theta_i))$$

If the judge does not want to charge the farmer too much, specially if the farmer is a poor one, the would choose the minimum punishment $F(R, \theta_i)$ that satisfies this condition. Thus the judge will choose the punishment $F(R, \theta_i)$ that solves $u(r_L + W, \theta_i, F(R, \theta_i)) \geq u(r_L, \theta_i, 0)$. Since $u(\cdot, \cdot, \cdot)$ is concave in its first argument, a sufficient condition for such a punishment to exist is that $u(\cdot, \cdot, \cdot)$ is linear in its third argument.[8] A simple example of this case is:

$$u(r_L + W, \theta_i, F(R, \theta_i)) = (r_L + W)^{\alpha} - \theta_i F(R, \theta_i)$$

with $\alpha \in (0, 1)$. In this example, the optimal punishment should satisfy: $(r_L + W)^{\alpha} - \theta_i F(R, \theta_i) = (r_L)^{\alpha}$. Hence, the optimal punishment will be:

$$F(R, \theta_i) = \frac{1}{\theta_i} \left(\frac{r_L + W}{r_L} \right)^{\alpha}$$

Notice that the punishment is this case does not depend on the public signal. The reason is that the judge can fully separate the honest type and the dishonest type, by imposing a different punishment to each of them. The optimal punishment is increasing in the amount of water stolen W, is decreasing in the honesty of the farmer θ_i and is decreasing on the amount of rain received by the farmer in the bad state r_L. This last result might seem counter-intuitive: the punishment is lower in those cases in which the farmer need less water; in those cases in which the gains from stealing water are smaller. The reason for that is that, as long as r_L is sufficiently lower than r_H, it is optimal that the farmer steals water. However, since the gains of stealing water are smaller when r_L is greater, the judge need to impose a smaller punishment when r_L is greater.

[8] In general a sufficient condition is that $u()$ is "more concave" in its first argument than in its third argument.

3.2.2 Individual State is Observable

In the case in the judge knows the rain in the farmer's plot, but not whether the farmer is honest or not. In this case, the judge can make the fine conditional on the individual state, i.e. $F(R, \theta_i) = F(r_i)$. This case is equivalent to have a perfect public signal, i.e. $q_L = q_H = 1$. The judge only has to make sure that all individuals steal water when $r_i = r_L$ and nobody steals water when $r_i = r_H$. The second condition is trivially satisfied by imposing a sufficiently high fine when $r_i = r_H$, i.e. $F(r_H) = \overline{F}$. The first condition will be satisfied if:

$$u(r_L + W, \theta_i, F(r_L)) \geq u(r_L, \theta_i, 0)$$

holds for all θ_i. In the example this implies $(r_L + W)^\alpha - \theta_i F(r_L) \geq (r_L)^\alpha$. This condition should be satisfied for both types, thus, we need it to be satisfied with equality for the honest type $\theta_i = \overline{\theta}$ and satisfied with inequality for the dishonest type $\theta_i = \underline{\theta}$. We have then:

$$(r_L + W)^\alpha - \underline{\theta} F(r_L) > (r_L + W)^\alpha - \overline{\theta} F(r_L) = (r_L)^\alpha$$

Hence, the optimal punishment will be:

$$F(r_L) = \frac{1}{\overline{\theta}} \left(\frac{r_L + W}{r_L} \right)^\alpha$$

Notice how different are the predictions of the model from the previous case. Now the punishment when the rain is high is the maximum punishment, and we will never observe a farmer stealing in this case, in equilibrium. When the rain in his plot was low, we will observe a punishment that depend on the rain received in the bad state. The optimal punishment is increasing in the amount of water stolen W, is decreasing in the honesty of the most honest farmer $\overline{\theta}$ and is decreasing on the amount of rain received by the farmer in the bad state r_L. This last result might seem counter-intuitive: the punishment is lower in those cases in which the farmer need less water; in those cases in which the gains from stealing water are smaller. The reason for that is that, as long as r_L is sufficiently lower than r_H, it is optimal that the farmer steals water. However, since the gains of stealing water are smaller when r_L is greater, the judge need to impose a smaller punishment when r_L is greater.

3.2.3 Honesty is Unobservable

In the case in which "honesty" is not observable, the punishment can only depend on the public signal, i.e. $F(R, \theta_i) = F(R)$. Now the judge has to impose a punishment without knowing both the real need of water of the farmer, nor his honesty. Given the public signal R the farmer will be honest with probability π. Depending on the parameters the judge may want to impose a fine such that all types of farmers steal for all realizations R, that no farmer steals in any realization of R or, more interestingly, that farmers steal when $R = L$ and they do not steal when $R = H$. This will imply:

$$u(r_H + W, \underline{\theta}, F(R)) < u(r_H, \underline{\theta}, 0)$$

$$u(r_L + W, \underline{\theta}, F(R)) \geq u(r_L, \underline{\theta}, 0)$$

$$u\left(r_H + W, \overline{\theta}, F(R)\right) < u\left(r_H, \overline{\theta}, 0\right)$$

$$u\left(r_L + W, \overline{\theta}, F(R)\right) \geq u\left(r_L, \overline{\theta}, 0\right)$$

Notice that, because the honest type suffer more from stealing than the dishonest type, we have $u\left(r_L + W, \overline{\theta}, F(R)\right) < u\left(r_L + W, \underline{\theta}, F(R)\right)$, thus the second equation is redundant. Using the same reasoning we have $u\left(r_H + W, \overline{\theta}, F(R)\right) < u\left(r_H + W, \underline{\theta}, F(R)\right)$, thus, the third equation is also redundant. Hence, $F(R)$ should satisfy:

$$u\left(r_H + W, \underline{\theta}, F(R)\right) < u\left(r_H, \underline{\theta}, 0\right)$$

$$u\left(r_L + W, \overline{\theta}, F(R)\right) \geq u\left(r_L, \overline{\theta}, 0\right)$$

However, now honesty is not observable. So it is not guaranteed that there exist a punishment $F(R)$ such that both equations are satisfied. In the example these equations equal:

$$(r_H + W)^\alpha - \underline{\theta} F(R) < (r_H)^\alpha$$

$$(r_L + W)^\alpha - \overline{\theta} F(R) \geq (r_L)^\alpha$$

Combining both inequalities we have:

$$\frac{(r_L + W)^\alpha - (r_L)^\alpha}{\overline{\theta}} \geq F(R) > \frac{(r_H + W)^\alpha - (r_H)^\alpha}{\underline{\theta}}$$

This inequality will be satisfy when the difference between r_L and r_H is big, when the amount of water stolen W is bit and when $\overline{\theta} \simeq \underline{\theta}$, i.e. when the honest and dishonest are types similar.

In the previous conditions do not hold, the inequality will not hold. Hence, in this case, the first-best cannot be achieved in this case. If the judge imposes a fine that is too small, dishonest types will steal when $r_i = r_H$, which is suboptimal. It the judge imposes a fine that is too high, honest types will not steal when $r_i = r_L$, which is also suboptimal. Hence, the judge must decide between these two cases.

If the judge imposes a high fine, $F(R) > \frac{(r_H+W)^\alpha - (r_H)^\alpha}{\underline{\theta}}$, then both types will not steal when $r_i = r_H$, which is optimal. However, the dishonest type will steal when $r_i = r_L$ if

$$\frac{(r_L + W)^\alpha - (r_L)^\alpha}{\underline{\theta}} \geq F(R)$$

If this condition hold, we have that both types will not steal when $r_i = r_H$ and the dishonest type will steal when $r_i = r_L$, which is optimal. In this case, the outcome will be inefficient only when the farmer is honest and receives low rain, i.e. $\theta_i = \overline{\theta}$ and $r_i = r_L$, which happens with probability $q_R \pi$ when the public signal is R. In this case, the judge will impose a fine that is no greater than $\frac{(r_L+W)^\alpha - (r_L)^\alpha}{\underline{\theta}}$.

If this condition does not hold, this means that the fine is deterring all farmers from stealing at all times. Since we observe some crimes in the data, and the fines are actually quite low, I do not think that this is a relevant case. The judge would choose to impose a low fine, so as to allow some of the farmers to steal water when $r_i = r_L$.

If the judge imposes a low fine, $F(R) \leq \frac{(r_L+W)^\alpha - (r_L)^\alpha}{\overline{\theta}}$, then both types will steal when $r_i = r_L$, which is optimal. However, the dishonest type will steal when $r_i = r_H$ if:

$$F(R) \leq \frac{(r_H + W)^\alpha - (r_H)^\alpha}{\underline{\theta}}$$

If this condition hold, we will have that both types will steal when $r_i = r_L$ and the honest type will not steal when $r_i = r_H$, which is optimal. In this case, the outcome will be inefficient only when the farmer is dishonest and receives high rain, i.e. $\theta_i = \underline{\theta}$ and $r_i = r_H$, which happens with probability $(1 - q_R)(1 - \pi)$ when the public signal is R. In this case, the judge will impose a fine $F(R)$ equal to: $\frac{(r_L+W)^\alpha - (r_L)^\alpha}{\bar{\theta}}$.

3.3 Dynamic Model

For simplicity I will describe the dynamics as a two period model. The qualitative results will also hold in more general case with a finite or an infinite (discounted) horizon. The situation here is the same as described in Section (3), but we have now two periods. The model can be solved using backward induction. At $t = 2$ the state space of the public signal is $RR^{'} \in \{HH, HL, LH, LL\}$. Let y_R^t be equal to 1 if the farmer was caught in period t and the public signal at time t was equal to R, then $y_R^t \in \{0, 1\}$. Moreover we have $\left(y_R^1, y_{R'}^2\right) \in \{(1,1), (1,0), (0,1), (0,0)\}$. However, we are only interested in the cases $\left(y_R^1, y_{R'}^2\right) = (1,1)$ and $\left(y_R^1, y_{R'}^2\right) = (0,1)$, because in cases $\left(y_R^1, y_{R'}^2\right) = (1,0)$ and $\left(y_R^1, y_{R'}^2\right) = (0,0)$ the agent was not caught (hence, not punished) in the second period. We cannot say anything about the dynamics of the punishment in the these other cases. Hence, we are interested in:

- $\left(y_R^1, y_{R'}^2\right) = (1,1)$ implies that the agent have been caught twice. This is the most interesting case and I will focus on it.
- $\left(y_R^1, y_{R'}^2\right) = (0,1)$ implies that the agent was not caught in the first period, but it was caught in the second period. The interpretation about the prior believes should be taken into account when we talk about this updating process.[9]

Let define the posterior probability:

$$\sigma_{RR'} \equiv Pr\left(r_i^2 = r_L^2 | RR^{'}\right)$$

This is the probability that the farmer is in need of water in the second period, conditional on the public signal being equal to R at $t = 1$ and equal to $R^{'}$ at $t = 2$, given that the farmer was caught at $t = 1$. In the same way we can define:

$$\tau_{RR'} \equiv Pr\left(r_i^2 = r_L^2 / RR^{'}\right)$$

At $t = 2$ the problem here is similar to the problem in Section (3). The only difference here is that the prior probability is different. Before we have that the probability that the farmer was in need of water was $q = q_R$ and now we have $q = \sigma_{RR'}$ or $q = \tau_{RR'}$, depending on whether the farmer is a first offender or not. Hence, I can focus the analysis on how these prior probabilities are ranked (if they can be rank) and use the results from the previous section.

From Bayes rule it is straightforward to show the following results:

- $q_{RL}^2 < q_{RH}^2$: Regardless of the state at $t = 1$, the probability that the farmer is of bad type is higher when $R^{'} = H$, if the farmer was caught in both periods.
- $q_{Ls'}^2 < q_{HR'}^2$: Regardless of the state at $t = 2$, the probability that the farmer is of bad type is higher when $R = H$, if the farmer was caught in both periods.

[9] In particular, if the prior believe comes from a situation in which the farmer has not been caught for an infinite number of periods, then there should be no update.

- $p^2_{RL} > p^2_{RH}$: Regardless of the state at $t = 1$, the probability that the farmer is of bad type is higher when $R^{'} = L$, if the farmer was not caught in the first period.

- $p^2_{LR'} > p^2_{HR'}$: Regardless of the state at $t = 2$, the probability that the farmer is of bad type is higher when $R = L$, if the farmer was not caught in the first period.

Using the previous results one can show the following rankings:

- $q^2_{LL} < q^2_{LH}, q^2_{HL} < q^2_{HH}$

- $p^2_{LL} > p^2_{LH}, p^2_{HL} > p^2_{HH}$

We cannot conclude anything about the rankings of q^2_{LH}, q^2_{HL} and p^2_{LH}, p^2_{HL} without further assumptions.

3.4 Empirical Predictions

This section is intended as a summary of results if we use the static model. When the difference between r_L and r_H is big, when the amount of water stolen W is bit and when the honest and dishonest are types similar ($\overline{\theta} \simeq \underline{\theta}$), then the judge can impose a system of fines that achieves the *first-best* outcome: farmers steal water if and only if it is optimal to do so.

If these conditions are not met, then the judge should decide between two *second-best* punishment schemes.

- If the judge imposes a high punishment, the inefficient outcome will happen with probability $q_R\pi$ and the loss will be that of an honest farmer not being able to irrigate when $r_i = r_L$ (type I error).

- If the judge imposes a low punishment, the inefficient outcome will happen with probability $(1-q_R)(1-\pi)$ and the loss will be that of a dishonest farmer stealing water when $r_i = r_H$ (type II error).

The results imply that the farmer is more likely to impose a high-punishment scheme, when both q_R and π are low. A low q_R means that $r_i = r_L$ is very unlikely to happen. This also means that the judge is more likely to impose a high-punishment scheme when $R = H$ (remember that $q_L \geq q_H$).

A low π means that the farmer is very likely to be a dishonest farmer. Notice that this effect is important when talking about recidivists. π is the prior probability that a farmer is dishonest. However, given the structure of the game, conditional on being convicted in a previous period, the judge will update his beliefs about the farmer. More specifically, the farmer will assign a lower (than π) probability of being honest to a farmer that is being convicted in the past. This effect rest on the previous result that the pool of farmers that steal water always contains dishonest farmers in a proportion greater than π.

In general, it is hard to make more specific empirical predictions, without knowing the parameters of the model, that is without knowing what is the relevant punishment scheme. However, we can make more general predictions that will hold under any punishment scheme:

- Observables characteristics that are correlated with the probability that a farmer is dishonest should be taken into account when deciding the punishment.

- The punishment for a first-time offender will not be equal to the maximum punishment.

- Recidivists will receive a greater punishment than first-time offenders:

  - The greater the probability that a farmer is dishonest, the greater the optimal punishment will be.
  - A recidivist farmer has a greater probability of being dishonest than a first-time offender.

4 Data

Following the French influence, during the mid 19^{th} century, the local irrigators communities in Mediterranean Spain made their previously informal arrangements formal.[10] Along the same line, they begin to keep exhaustive track of all the decisions made within the community. Hence, there is extensive information about the trials and punishment inflicted for this period.

In the local archive of Mula there is a complete track of all the trials that took place from 1851 until 1948. The trials after 1948 were performed by regular judges and hence, are not of interest here.[11] The information in the trials includes the name of the offender (and whether he was refereed as a "Don"), the name of the plaintiff (either a farmer or a guard, and whether he was a "Don"), the name of the judges, the verdict, the amount of the fine (if any) and the amount of the indemnification (if any). The information also includes whether the report was made by a farmer (private vs. private) or by a guard (public vs. private).

The qualification as a "Don" is important in this context. A "Don" is someone who belongs to the aristocracy, who has university degree, who is a civil servant of high rank or in general someone who has a lot money and does not "need" to steal water. In most instances in the trials it was not the "Don" who physically stole the water but rather a tenant of his land or some of his servants.

If the report was made by a farmer, this implies that the water was stolen from him. If the report was made by a guard, this implies that the water was stolen from the community (directly from the main channel). There are also some instances in which the report is made by a farmer, but he does not accuse any farmer in particular, only a lack of water in his turn (private vs. public). In this case, the *Heredamiento*, or the guard on duty at the specific time/place, is responsible for the loss.

The data on the trial consists on 282 trials over 97 years, 2.82 trials per year. Of those 282 trials, 174 resulted in a positive sentence (the accused was found guilty), 1.79 positive sentences per year. This implies that 61.70% of the trials ended with a positive sentence. Table (1) shows some summary statistics. The local Ordinances established that the fine for any violation would be 25 *pesetas*. However, the judge can lower the fine if he consider it necessary. In practice that means that the judge can impose any sentence between 0 and 25 *pesetas*.[12] To get a sense of the magnitude of these fines notice that the daily wage for an unskilled worker during this period was 5 pesetas. Hence, the maximum amount corresponds to a weekly wage.

I also use data on the average price paid for the water in the week previous to the trial. The data in this paper comes from all water-auctions in Mula from 1851 through 1948.[13] Although the process of allocating water in Murcia has varied slightly over the years, its basic structure has remained, essentially, unchanged since the 15^{th} century. Land in the region is divided into *regadío* (irrigated land) and *secano* (dry land). Irrigation is only permitted in the former. A channel system allows water from the river to reach all *regadío* lands.[14] The fundamental reason for this division is that *regadío* are fertile lands that are close to rivers and, thus, allow a more efficient use of scarce water in the region. Since it is forbidden to irrigate lands categorized as *secano*, only the farmers that own a piece of *regadío* land in Mula are allowed to participate in the auction.

The mechanism to allocate water to those farmers is a sequential English-auction. The auctioneer sells by

[10] The first (modern) civil code in Spain was written in 1846.

[11] The local archive in Murcia contains information from 1848 until today. The local archive in Lorca contains information from 1785-1961.

[12] We have, however, in the data two instances in which the judge impose a fine greater than 25 pesetas. In one of them, a miller was found guilty of stealing water twice the same week, hence the sentence was 50 pesetas. In another case, five men, all of them "Don", were found guilty of a plot of blocking the main channel and also cheating in the auction: one of the bid for several units in a row and then, the others used this water for irrigation, which was forbidden. In this case the average fine was 65.2, after taken into account the several charges and fines that each of them faced.

[13] Data available in the historical archive of Mula goes back until 1803.

[14] The channel system was expanded from the 13^{th} to 15^{th} century, as a response to the greater demand for land due to the increase in population. The *regadío* land's structure has not change since the 15^{th} century.

auction each of the units sequentially and independently of each other. He keeps track of the name of the buyer of every unit and the price paid by the winner. The basic selling unit is a *cuarta* (quarter), the right to use 3 hours of water for irrigation. Water storage is done in the *De La Cierva* Dam. Water flows from the dam through the channels at approximately 40 l/s. During the sample period auctions were carried out once a week, every Friday.

4.1 Data-Summary Overview

I combine data from different sources. To get a sense of the industry context during the period under analysis, I present a brief description for the region's demographics, agriculture production and weather.[15] Murcia's population share in Spain was around 3% during the period. As a municipality, Mula comprised 2% of Murcia in 1954, ranking Mula 20*th* in terms of population. The three main citrus fruits produced in the area are apricot, lemon and peach. Murcia's share of these crops was 50% (2.3 million), 44% (1.5 million) and 42% (4.3 million), respectively, in terms of total Spain's total production of these fruits for the year 1962. *Regadío* land in Murcia constitutes 4% (70,000 ha.) of Spain's.

Auction data, is obtained from the historical archive of Mula.[16] I complement auctions data with daily rainfall data for Mula and monthly price indexes for Spain, which I obtain from the *Agencia Estatal de Metereologia*, AEMET (which is the National Meteorological Agency), and the *Instituto Nacional de Estadística de España*, INE (which is the National Statistics Institute of Spain), respectively.

Mediterranean climate rainfall occurs mainly in spring and autumn. Peak water requirements for the products cultivated in the region are reached in spring and summer, between April and August. During this period more frequent irrigation is advisable because it is in this period where citrus trees are more sensitive (in terms of quality of production) to water deficits.

Weather is important for the analysis as it is a determinant of seasonality. The coastal strip of southeast Spain is the most arid region of all continental Europe due to the *Foehn Effect*[17] and because of its location: right to the west of the mountain chain *Sistema Penibetico*, which includes the *Mulhacén* (the second highest mountain in Europe). Although annual average rainfall is 320 mm, rainfall frequency distribution is skewed, making the majority of years dryer than this yearly average. Aridity during the summer is especially acute. Autumn is the only relatively humid season. The number of days when torrential rain occurs is not particularly high, but when such rain occurs it is substantial.[18] Potential evaporation is four or five times higher than rainfall and the number of arid months vary from 7 to 11 in the sample. These arid conditions found in southeast Spain are related to the circular air movement in the occidental Mediterranean area and to the Atlantic-origin storms.

I further augment the data with individual characteristics of the farmers' land, which I obtain from the 1954/55 agricultural census.[19] This census was conducted by the Spanish government to enumerate all cultivating soil, producing crops and agricultural assets available in the country. Individual characteristics for the farmers' land (potential bidders which I match with the names in the auctions data) include the type of land and location, area, number of trees, production and the price at which this production was sold in the census

[15] These descriptive statistics are obtained from *Population* and *Agricultural Census* from the *National Statistics Institute* of Spain (INE) (available online at http://www.ine.es/inebaseweb/treeNavigation.do?tn=201299&tns=199923#199923).

[16] From the section *Heredamiento de Aguas*, boxes No.: HA 167, HA 168, HA 169 and HA 170.

[17] A *foehn* wind is "a type of dry down-slope wind that occurs in the lee (downwind side) of a mountain range. It is a rain shadow wind that results from the subsequent adiabatic warming of air that has dropped most of its moisture on windward slopes. As a consequence of the different adiabatic lapse rates of moist and dry air, the air on the leeward slopes becomes warmer than equivalent elevations on the windward slopes" (obtained from: http://en.wikipedia.org/wiki/Foehn_wind).

[18] As an example, on October 10th 1943, 681 mm. of rain water were measured in Mula, more than twice the yearly average for the sample.

[19] Detailed census data is also obtained from the section *Heredamiento de Aguas* in the historical archive of Mula, box No. 1,210.

year. Figure (1) shows a sample card for one farmer from the census data.[20] It can be seen in Table (1), that *Land Extension*, *Number of Trees* and *Kg sold* vary considerably across farmers.

Table (2) shows some summary statistics of the variables used in the estimation in Section (5). "Guilty" is a dummy variable that equals 1 if the defendant was found guilty during the trial. "Fine" is the amount of fine imposed if the defendant was found guilty. The fine should be pay to the treasurer of the Community. The variable "Indemnification" refers to the amount that the defendant should pay as indemnification, that is the value of the water stolen.

"Low Rain" is a dummy variable that equals 1 if during the year of the crime the rain was lower than average and 0 otherwise. "Victim is 'Don"' is a dummy variable that equals 1 if the victim of the crime is an individual (not the community) and this individual is refereed as a "Don", and 0 otherwise. "Defendant is 'Don"' is a dummy variable that equals 1 if the defendant/accused of a crime is an individual (not a guard) and this individual is refereed as a "Don", and 0 otherwise.

"Price of Water" is a continuous variable that refers to the average price of the water sold during the week that the crime occurred. It is remarkable that there was an auction only 181 weeks out of the 282 in which there was a crime reported. The remaining 101 weeks there was no auction because there was not enough water stored in the dam. "Auction" is a dummy variable that equals 1 if there was an auction in the week that the crime was committed or 0 otherwise. Notice that "Price of Water" and "Auction" are collinear, thus I cannot use both of them in the same regression. "Public" is a dummy variable that equals 1 if the water was stolen from the community (from the main canal), and 0 otherwise. "Private" is a dummy variable that equals 1 if the water was stolen from an individual farmer. "Private" and "Public" are not collinear since there are other crimes, mainly by millers. "Recidivist" is a dummy variable that equals 1 if the crime was performed by a farmer that has committed a crime in the past.[21]

5 Empirical Results

In this section I show the main empirical results of the paper. The sample size here is small, so I cannot estimate the parameters of the model structurally. I leave this for future research, when a more comprehensive data set, including data on trials in other cities like Lorca or Murcia, is available. Also, it should be taken into account that the low significance of some of the results responds more to the small sample size rather than being irrelevant. It should be emphasized, however, that the magnitude of the estimates is very big. Hence, we will expect the same results to hold, and with the same magnitude, if we were using a bigger data base.

5.1 Probability of being found Guilty

The model displayed in Section (3) has very specific predictions about how observable characteristics at the time of the trial affects the probability of being guilty or not. Given the sample size I show also regressions using a selection of the relevant variables rather than using all of them at the same time. Table (3) shows several regressions using a Logit model (I also estimate a Probit model, for completeness).

[20] One nice feature of this data is that every individual record (card) contains information on any plot owned by the farmer, both in the *huertas* and in other places. Information on whether a farmer owns another plot of land not allowed for irrigation is important as it is the farmer's outside option (for other sources of income) in case he does not buy water at a given auction during a specific period.

[21] There is a case in which the same name appears twice. However, both crimes are 29 years apart. The name is Antonio García Zapata. Antonio is the second most common name in the sample and García and Zapata are the two most commons last names. Hence, it is unlikely that both crimes were committed by the same person, but even it they were, 29 years should be enough for everyone to forget the previous crime. I treat this case as a first-time offender.

We can see in Table (3) that when the crime happen during a dry season, the defendant is more likely to be found guilty. The table shows marginal effects. The effect of "Low Rain" is very big: about 10-13% increase in the probability of being found guilty. This could be due to a higher monitoring level $\gamma(R)$ during a dry season. During a dry season farmers might be paying more attention to the amount of water received and making sure that they have witness in case they note insufficient water. In many cases, the trial is suspended/close due to lack of witness in the side of the accuser. Notice, however, that this effect goes away when we introduce the price of water in the equation (columns (4) and (6)). This might be due to several reasons. The more important is that the price of water is highly correlated with the rain. Also the price is more volatile than the rain. Hence, introducing the price of water in the equation will cause the coefficient on "Low rain" to vanish, without adding any additional predictive power. This is the main reason I am more comfortable with the regressions using the Auction dummy (columns (5) and (7)).

It is interesting to notice that the dummies referring to the wealth of both the defendant and the victim are not very significant and are very small, while, as we will see later, the punishment is very sensitive to those variables. This is consistent with [Garrido (2011)], who looks at Victorian London crime data. Although, the results are small and insignificant (except for column (4)) the sign are what we would expect if the effect is not zero. When the victim is a "Don" the social damage is small, because the "Don" can "afford" to buy water in the next auction, and is unlikely to be cash-constraint. On the other hand, and for similar reasons, when the defendant is a "Don" the probability that he is in need of water is smaller than if it was a regular farmer. Nonetheless, as shown below, most of the effect is transmitted through a greater fine, and not a greater probability of being Guilty.

Columns (4) and (6) show a lower number of observations because the price is not recorded in times when there was no auction. Technically, this is equivalent to an infinite price, so we cannot use any estimation to compute the price when is missing. Hence, it is wiser to use a dummy variable to capture this effect and be able to use all the data. Moreover, the effect of prices is tiny and insignificant. This effect is consistent with the literature that there is no clear relation between crime rates and the business cycle. The effect of the Auction dummy is not very significant (maybe due to the small sample size) but we should take it into account because of its size. It implies that if there was not an auction during the week previous to the trial, the defendant is about 10% less likely to be Guilty. This is again consistent with the idea that you do not want to punish farmers that steal because of need: if there was no auction, the only way to obtain water was to steal it from the main channel.

Finally, Table (3) shows how the probability of being accused of stealing water from the main channel (public) or from another farmer (private) changes. Remember that both dummies are deviations from the default case, which comprises mostly millers interfering with the water flows to enhance the power of their water mills. Hence, when comparing the difference in probability from stealing from the main channel or from another farmer we should subtract both coefficients. The combined effect is then more than 20% (columns (6) and (7)).

5.2 Fine

As predicted by the model, and anticipated in the previous Sub-Section most of the effect of the optimal punishment will go through the fines. The judge has total freedom to impose any fine he thinks appropriate between $0-25$ *pesetas*. Thought this section one should keep in mind that in some cases the fine imposed is 0 and that the average fine is 3.63 pesetas, so that the results in Table (5) are huge.

As before, we observe an important effect of weather on the punishment but it is not always significant. The effect is slightly smaller than 3 pesetas which means that fines are 50% bigger when the trial happens during a dry season. As before this effect vanishes when we introduce the price of water (columns (4), (6), (9) and (11)). Also as before, the effect of the price of water is tiny and insignificant, except when we introduce in the equation also the variable Recidivist (column (9) and (11)), in which case the effect becomes significant but still tiny.

The effect of the identity (Don) of the victim and the accused is clear and strong. When the victim is a "Don", the offender gets a really mild punishment, a reduction of more than 80%. It is true that the effect halves when we include other variables regarding the identity of the victim ("Private" and "Public" on column (12)), but it is still important in size. When the defendant is a "Don", the fine is three times bigger than if not. The effect is also smaller when we include other information regarding the defendant in the equation ("Recidivist" on column (12)), but it is still significant and big. This idea is also present in [Garrido (2011)] and reflect the idea that wealthy people should receive a greater punishment for the same crime because "they should know better" than the peasants.

Crimes committed in weeks in which there was no auction are also very mildly punished. The effect is a reduction on $6.5-7$ *pesetas* (from an average of 3.6) and is consistent in size and significant across different specifications. The punishment are smaller when the defendant stole the water from the main channel than when it stole it from another farmer. This effect reflect the idea that stealing from another farmer (not a Don) is more damaging than stealing from the main channel. If the judge want to minimize conflict between farmers, fines should be greater when farmers steal from each other than when they steal from the main channel. The net effect between public and private varies across specifications but is always big $3-6$ *pesetas*.

Finally, as the model predicts, the biggest effect comes from recidivists defendants. Recidivists are fined between $10-15$ *pesetas* more for the same act. Moreover, the raw data shows that all recidivists received a fine of 20 or 25 *pesetas*. Remember that 25 *pesetas* is a weekly wage for this period, thus the size of these fines are important, while the fines for first time offenders are very small or zero. Hence, although the effects of the other variables are important, they are of second order when compared with the effect of Recidivism.

5.3 Indemnification

The indemnification is different than the fine. The fine has a punitive goal, to deter farmers from stealing, and goes always to the community. The indemnification goes to the farmer from whom the water was stolen or to the community if the water was stolen from the main channel. The indemnification is an estimate of the value of the water stolen. Sometimes the judge will not set the monetary amount but just the quantity of water stolen (measured in *cuartas*) and decree that the indemnification will be the equal to the amount of water stolen at the average price during the last auction. Hence, we should interpret the results in Table (6) as a measure of the value of the water stolen, rather than as a measure of the punishment.

It is interesting to note that now the variables relating external conditions, like weather and prices, are less significant than in Table (5). Rain effect is of similar size as before, but is much less significant. But the (lack of) effect of the water prices is remarkable since the variable indemnification is a direct function of water prices: indemnification is just the product of the quantity of water stole (measured in *cuartas*) and the price of the water in the last auction before the trial. Hence, one might expect a greater effect. This insignificant effect suggests that the adjustment is through quantities not prices. In other words, farmers steal (relatively) more water when the price is low than when the price is high. This way the indemnification that they will have to pay is virtually constant regardless of the prices of water.

The effect of individual characteristics is consistent with the model. Individual characteristics of the defendant (whether he is a "Don" or a recidivist) play no role on determining the indemnification. The indemnification is not a punishment, just a way to compensate the losses suffered by the victim. However, individual characteristics of the victim (whether he is an individual and in this case a "Don") have a huge impact on the indemnification. When the victim is a Don, the indemnification is huge, it is so big that it overcompensate the negative effect on the fine (see Table (7) for the net effect).

However, remember that we cannot take this as an implication for causality. Remember that the indemnification is not chosen by the judge to balance type I and type II errors or any optimization problem, it is just a mechanical computation based on the water stolen (reported by witness) and the price of water (which is recorded). A likely explanation is that farmers, knowing that they will get a lower fine when stealing from a "Don", will steal more water when they can steal from a "Don" than when they cannot. Remember that farmers can only steal from a neighbor farmer who is irrigating down the channel, so the choice of whom to steal is restricted. The same explanation applies to the case when farmers steal from the main channel.

6 Concluding Remarks

I have proposed a simple model that can explain some of the empirical puzzles associated with Becker's seminal paper about crime and punishment. The first puzzle is the lack of empirical support for the "maximum punishment is optimal" principle. Empirical literature has shown that maximum (available) punishment is rarely or ever used in practice. The first response to this puzzle was the idea that punishments are costly. Hence, a lower (than maximum) punishment is optimal in this case. Although this argument might seem reasonable in cases where the punishment is imprisonment, when the punishment is a monetary fine this argument make no sense, since fines of every amount have the same implementation costs at the margin.

A second issue that arises here is the progressivity of the legal system. Little attention has been given to this issue and never jointly with the low punishment phenomenon. A possible explanation for both issues is to assume that there are two (unobservable) individual characteristics that affects crime. One components is temporary, although is correlated with the environment. The second component is permanent or persistent. It is this second component that explains the optimality of progressivity. Without the temporary component the optimal policy will be life sentence, since the probability that the accused is a criminal equals 1. Without the structural component, criminal histories would not matter, hence there should be no progressivity in the punishment. It is the combination of both components that gives us the legal system that we see in the real world.

This case study looks like a controlled experiment because there is only one single crime to be examined: water stealing. There are also easily verifiable/quantifiable degrees of the crime: external characteristics like rainfall, water prices and the amount of water stolen; internal characteristics about the victim and the defendant. Hence, the results derived from this study are robust to misinterpretation.

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A Tables and Figures

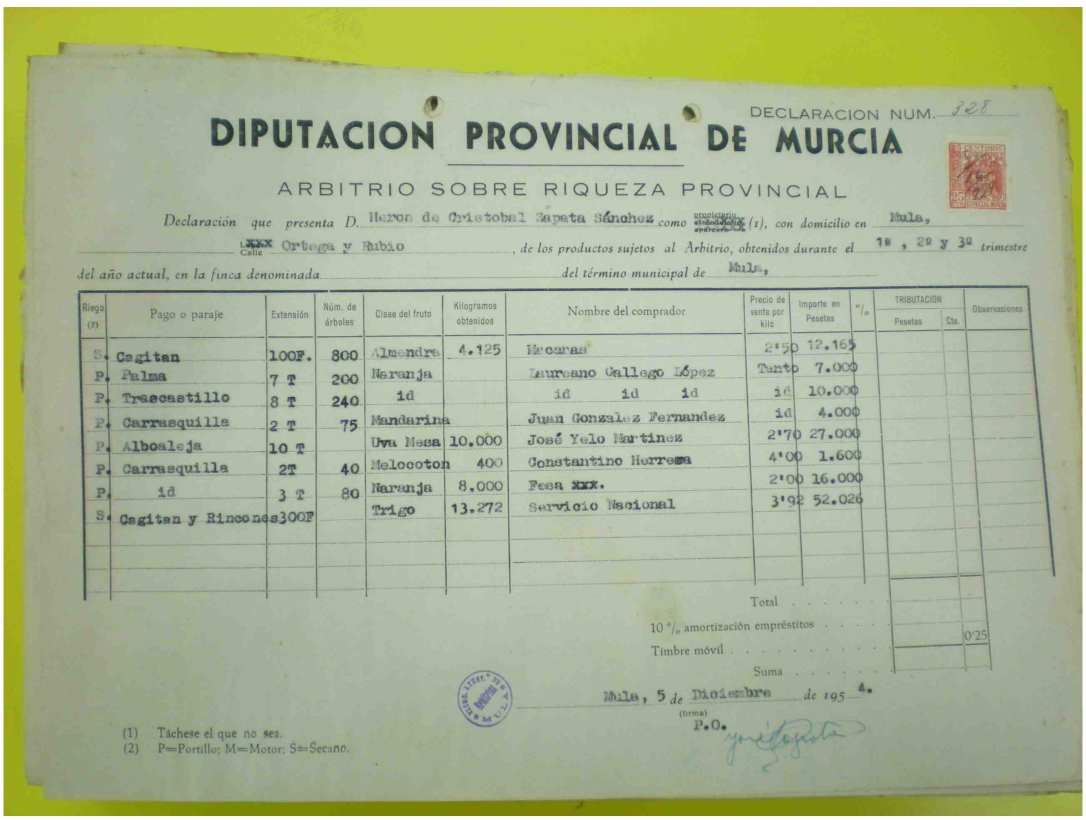
Table 1: Summary Statistics of the Agricultural Census 1954.

Variable	Mean	SD	Min	Max	Obs
Land Extension	5.54	32.24	.25	900	819
Kg Produced	5,569.70	10,003.76	0	110,000	1,000
Number of Trees	161.49	493.45	1	12,300	946

Table 2: Summary Statistics of the Trials.

Variable	Mean	SD	Min	Max	Obs
Guilty	0.6170	0.4869	0	1	282
Fine	5.7651	8.9468	0	65.2	174
Indemnification	9.2610	25.4359	0	240.75	174
Low Rain	0.6418	0.4803	0	1	282
Victim is “Don”	0.2553	0.4368	0	1	282
Defendant is “Don	0.1525	0.3601	0	1	282
Price of Water	29.008	25.9941	0.0212	112.84	181
Auction (Dummy)	0.6418	0.4803	0	1	282
Public	0.4645	0.4996	0	1	282
Private	0.4184	0.4942	0	1	282
Recidivist	0.0402	0.1971	0	1	174

Figure 1: Sample of individual data obtained from the Agricultural Census


DECLARACION NUM. 328

DIPUTACION PROVINCIAL DE MURCIA

ARBITRIO SOBRE RIQUEZA PROVINCIAL

Declaración que presenta D. Heros de Cristobal Zapata Sánchez *como* propietario (1), *con domicilio en* Mula, Calle Ortega y Rubio, *de los productos sujetos al Arbitrio, obtenidos durante el* 1º, 2º y 3º *trimestre del año actual, en la finca denominada* ... *del término municipal de* Mula,

Riego (2)	Pago o paraje	Extensión	Núm. de árboles	Clase del fruto	Kilogramos obtenidos	Nombre del comprador	Precio de venta por kilo	Importe en Pesetas	°/°	Tributación Pesetas	Cts.	Observaciones
S.	Cagitan	100F.	800	Almendra	4.125	Mecaras	2'50	12.165				
P.	Palma	7 T	200	Naranja		Laureano Gallego López	Tanto	7.000				
P.	Trascastillo	8 T	240	id		id id id	id	10.000				
P.	Carrasquilla	2 T	75	Mandarina		Juan Gonzalez Fernandez	id	4.000				
P.	Alboaleja	10 T		Uva Mesa	10.000	José Yelo Martinez	2'70	27.000				
P.	Carrasquilla	2T	40	Melocoton	400	Constantino Herrera	4'00	1.600				
P.	id	3 T	80	Naranja	8.000	Fesa XXX.	2'00	16.000				
S.	Cagitan y Rincones	300F		Trigo	13.272	Servicio Nacional	3'92	52.026				

Total . . . . . .

10 °/° amortización empréstitos . . . .

Timbre móvil . . . . 0'25

Suma . . . . . .

Mula, 5 de Diciembre de 1954.

(firma)

P.O.

(1) Táchese el que no sea.

(2) P=Portillo; M=Motor; S=Secano.

Table 3: Probability of being Guilty (Logit).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low Rain	**0.128**		**0.128**	0.008	0.109	-0.0174	0.0945
	(2.11)		**(2.09)**	(0.10)	(1.74)	(0.22)	(1.49)
Victim is "Don"		-0.056	-0.060	0.002	-0.058		
		(0.83)	(0.88)	(0.03)	(0.84)		
Defendant is "Don"		0.058	0.049	**0.176**	0.055		
		(0.72)	(0.61)	**(1.98)**	(0.68)		
Price of Water				-0.000		0.000	
				(0.05)		(0.31)	
Auction (Dummy)					0.091		0.083
					(1.46)		(1.31)
Public						-0.088	-0.097
						(0.75)	(1.03)
Private						0.131	0.103
						(1.12)	(1.07)
N	282	282	282	181	282	181	282

Marginal Effects. t-stats in parenthesis. Regressions also use a constant. Bold when p-value<0.05.

Table 4: Probability of being Guilty (Probit).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low Rain	**0.128**		**0.128**	0.008	0.108	-0.014	0.095
	(2.11)		**(2.10)**	(0.10)	(1.73)	(0.17)	(1.50)
Victim is "Don"		-0.056	-0.060	0.000	-0.058		
		(0.83)	(0.88)	(0.00)	(0.84)		
Defendant is "Don"		0.058	0.050	**0.175**	0.057		
		(0.72)	(0.62)	**(1.97)**	(0.71)		
Price of Water				-0.000		0.000	
				(0.00)		(0.29)	
Auction (Dummy)					0.091		0.082
					(1.45)		(1.30)
Public						-0.089	-0.098
						(0.75)	(1.04)
Private						0.131	0.103
						(1.12)	(1.07)
N	282	282	282	181	282	181	282

Marginal Effects. t-stats in parenthesis. Regressions also use a constant. Bold when p-value<0.05.

Table 5: Amount paid as a Fine (OLS).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low Rain	2.682		2.260	0.663	2.890	0.141	2.468		0.336	2.722	0.341	2.799
	(1.48)		(1.30)	(0.65)	(1.73)	(0.14)	(1.43)		(0.42)	(1.61)	(0.43)	(1.68)
Victim is "Don"		**-4.471**	**-4.501**	**-2.175**	**-4.188**						-0.324	-2.298
		(2.33)	**(2.35)**	**(2.00)**	**(2.28)**						(0.31)	(1.03)
Defendant is "Don"		**7.330**	**7.122**	**4.790**	**7.495**						2.084	**5.600**
		(3.36)	**(3.26)**	**(3.77)**	**(3.58)**						(1.96)	**(2.54)**
Price of Water				0.0004		0.026			**0.034**		0.023	
				(0.02)		(1.49)			**(2.39)**		(1.52)	
Auction (Dummy)					**-6.629**		**-6.878**			**-6.637**		**-6.598**
					(3.99)		**(4.08)**			**(4.02)**		**(4.05)**
Public						**-3.537**	-4.289		**-3.608**	-3.182	**-3.206**	-1.789
						(2.38)	(1.64)		**(2.99)**	(1.23)	**(2.38)**	(0.63)
Private						1.946	2.464		0.842	2.834	0.440	1.320
						(1.34)	(0.95)		(0.71)	(1.12)	(0.37)	(0.51)
Recidivist								**13.82**	**15.02**	**11.40**	**14.59**	**10.61**
								(3.32)	**(7.60)**	**(2.90)**	**(7.33)**	**(2.71)**
N	171	171	171	116	171	116	171	171	116	171	116	171

t-stats in parenthesis. Regressions also use a constant. Bold when p-value<0.05.

Table 6: Amount paid as an Indemnification (OLS.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low Rain	2.329		2.458	3.477	2.856	3.814	4.366		3.835	4.337	4.575	3.399
	(0.55)		(0.64)	(1.08)	(0.74)	(1.16)	(1.07)		(1.16)	(1.06)	(1.43)	(0.86)
Victim is "Don"		**25.21**	**25.18**	**20.51**	**25.38**						**13.69**	**20.86**
		(5.93)	**(5.92)**	**(5.95)**	**(5.96)**						**(3.30)**	**(3.92)**
Defendant is "Don"		-1.378	-1.605	-7.328	-1.369						-3.075	1.288
		(0.29)	(0.33)	(1.82)	(0.28)						(0.73)	(0.25)
Price of Water				0.092		0.065			0.0655		0.0686	
				(1.50)		(1.11)			(1.12)		(1.13)	
Auction (Dummy)					-4.187		-2.527			-2.555		-3.845
					(1.09)		(0.63)			(0.64)		(0.99)
Public						**17.26**	**17.77**		**17.26**	**17.65**	8.974	5.837
						(3.48)	**(2.87)**		**(3.47)**	**(2.81)**	(1.67)	(0.86)
Private						-2.888	-0.476		-3.005	-0.519	-2.959	-1.421
						(0.60)	(0.08)		(0.61)	(0.08)	(0.62)	(0.23)
Recidivist								-8.987	1.596	-1.322	-0.660	-4.497
								(0.91)	(0.20)	(0.14)	(0.08)	(0.48)
N	171	171	171	116	171	116	171	171	116	171	116	171

t-stats in parenthesis. Regressions also use a constant. Bold when p-value<0.05.

Table 7: Total amount paid: Fine plus Indemnification (OLS).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low Rain	5.011		4.718	4.140	5.746	3.955	6.834		4.171	7.058	4.916	6.498
	(1.13)		(1.12)	(1.28)	(1.38)	(1.17)	(1.55)		(1.25)	(1.60)	(1.52)	(1.44)
Victim is "Don"		**20.74**	**20.68**	**18.34**	**21.19**						**13.37**	**18.56**
		(4.44)	**(4.43)**	**(5.31)**	**(4.61)**						**(3.18)**	**(3.22)**
Defendant is "Don"		5.952	5.517	-2.538	6.126						-0.991	6.888
		(1.12)	(1.04)	(0.63)	(1.17)						(0.23)	(1.21)
Price of Water				0.0922		0.091			0.099		0.092	
				(1.50)		(1.52)			(1.68)		(1.49)	
Auction (Dummy)					**-10.82**		**-9.404**			**-9.192**		**-10.44**
					(2.60)		**(2.19)**			**(2.13)**		**(2.49)**
Public						**13.73**	**13.48**		**13.68**	**14.46**	5.768	4.048
						(2.70)	**(2.02)**		**(2.72)**	**(2.14)**	(1.06)	(0.55)
Private						-0.942	1.988		-2.163	2.315	-2.519	-0.100
						(0.19)	(0.30)		(0.44)	(0.35)	(0.52)	(0.02)
Recidivist								4.832	**16.62**	10.08	13.93	6.114
								(0.46)	**(2.02)**	(0.98)	(1.73)	(0.61)
N	171	171	171	116	171	116	171	171	116	171	116	171

t-stats in parenthesis. Regressions also use a constant. Bold when p-value$<$0.05.