# *The Economics of Draft Animal Choice in Italian Agriculture: a Principal-Agent Approach to the Adoption of an Early Form of Capital**

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## 1. Introduction

The conventional wisdom about institutional arrangements in Italian agriculture during the nineteenth and twentieth centuries holds that they were exploitative and inefficient. Many early writers referred to Italy's tenure arrangements as backward, and blamed them for the poverty of the Italian countryside (Sereni 1946, 1947; Gramsci 1950). In this context, terms such as 'inefficient' or 'backward' are used to describe institutional arrangements resulting in sub-optimal allocative decisions, particularly in relation to factor proportions. Underlying the conventional wisdom is a belief that traditional peasant societies followed rules which defy analysis with the tools of modern economic theory. In a word, tradition holds sway over optimization.

In this paper we challenge the conventional wisdom on the inefficiency of Italian farming systems by focusing on the allocation of a major form of agricultural capital in peasant society, draft animals. We contend that the geographic distribution of draft animals in Italian agriculture at the beginning of this century can be explained first by the physiological characteristics of the animals themselves and second by the different tenure systems in the various provinces of Italy. We argue that, when landlords supplied draft animals, their choice depended on which animal could best

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resist abuse and neglect from workers who did not have a direct, vested interest in preserving its capital value. Thus we observe mules and oxen (the two most abuse-resistant animals in use in Italy) primarily associated with sharecroppers and wage workers. We conclude that agency problems induced landlords to chose one particular draft animal over another. This behaviour is evidence that the Italian agricultural system was, in fact, not inefficient or backward, but rather a smoothly functioning system subject to certain non-removable constraints. In addition, our findings are consistent with earlier work on U.S. agriculture in which a similar argument was made for the use of mules in the U.S. South. Just as in Italy's case, agency concerns motivated draft-animal choice.

In the remainder of the paper we present first a review of the literature on Italian farming (section II). In section III, we describe the physiological characteristics of draft animals in use in Italy, and in section IV we discuss data sources. Section V reports the results of our regression analysis. A brief conclusion follows in section VI.

## 2. Tenancy and Agriculture in Early XXth Century Italy

Two main facts stand out from an examination of the Italian economy at the beginning of the XXth century. The first is that Italy was fundamentally an agrarian economy. In spite of manufacturing growth rates between 5 and 8 per cent from the mid-1890s on (ISTAT 1957, Fenoaltea 1983, Toniolo 1990), in 1911 agriculture still accounted for 55.5 percent of the active labour force and 46 per cent of GDP (ISTAT 1976, SVIMEZ 1961). The second fact is the 'dualistic' character of the Italian economy, with a relatively rich industrial North and a poor agrarian South. In 1914, the five northern regions had a per capita income two and one-half times the South's, and per-capita income in the three richest regions was 4.3 times higher than in the three poorest. Similarly wide gaps in labour productivity existed between the North and the South (Galassi and Cohen 1992, p. 157, Zamagni 1978, pp. 194-9).

Sharp regional differences and the persistence of a large agrarian sector have constituted the main themes of modern Italian economic and social history, and the interpretation offered by Gramsci (1950) and particularly by Sereni (1946, 1947) is important to our present purposes. In their view, the political unification of Italy in the mid-XIXth century was an 'incomplete revolution' in that it failed to seize the opportunity presented by the collapse of the old regime in order to reform tenure relations in the countryside. By that time, 'modern' agrarian institutions had made significant inroads only in the North, where the pre-conditions were set for agricultural growth and eventually industrial development. On the contrary, in central and southern Italy, 'feudal residues' discouraged productivity-enhancing investments and kept the peasantry in a state of poverty and subjection to rural lords. This model was challenged by Romeo (1959) and Gerschenkron (1962), who argued that the kind of institutional reforms being advocated - the creation of a landowning

peasantry as had happened in France in 1789-92 - would not have helped development and industrial growth. Both Romeo and Gerschenkron, however, sidestepped the related problem of why particular forms of tenurial arrangements existed in different areas of the country, and whether any of them were inefficient. As the issue of efficiency in tenancy systems is central to our paper, it is worthwhile discussing these arrangements in some detail.

The conventional wisdom holds that pre-1914 rural Italy can be divided into three areas, [see Figure 1 for a map of Italy's 16 regions and 69 provinces in 1911]. In the North (Piedmont, Liguria, Lombardy, Venetia, most of Emilia), farming was a market-oriented business run by landowners with salaried workers, or by capital-rich tenants paying fixed rents. Small-scale farms predominated only in the mountainous areas. Share-croppers were common in some areas in the North (Venetia, parts of Emilia), but were usually reasonably well-off peasants who could supply their own draft animals and tools (Poni 1982). The same could not be said of central Italy (Tuscany, Marches, Umbria, parts of Latium), where share-cropping was by far the most common tenurial arrangement. Here share-croppers were usually poor and unable to supply anything more costly than a simple hoe. Farms were small and very intensively cultivated, but little machinery, other than wine and olive presses, was present because landlords tended to over-use labour as it only cost them a fraction of its marginal product. Further down, roughly from the plains around Rome south, large latifundia were leased by an indolent and absentee aristocracy to middlemen who then sublet to small peasants or hired landless labourers at peak times. Agriculture in the centre and South was thus starved of capital, as evidenced by its low productivity and the primitive level of techniques in use. Whatever surplus farming did produce was squandered by landlords in conspicuous consumption in the towns. Hence, the conventional story goes, the backwardness of Italy's economy, and in particular the poverty of the South.

Modern research has cast a great deal of doubt on the conventional wisdom. Recent works (Bevilacqua 1990, Lupo 1990) have shown that both landlords and peasants in the South were willing to innovate and take risks under the right conditions, introducing new crops and adjusting their crop mix when the market provided adequate incentives. More importantly, the view of tenurial arrangements as "feudal residues" has been seriously undermined. The institutions of rural Italy have been reassessed by Cohen and Galassi in a series of papers approaching tenure choice as an agency problem under objective constraints (1990, 1992, 1994). Their examination of factor proportions and productivity for sharecropping areas in central Italy suggests that share tenancy did not lead to excessive labour use, and that productivity differences had more to do with the environment in which farmers were operating than institutional problems. Further, a cost-benefit analysis of a capital-investment project on a sharecropped farm has revealed that delayed mechanization in central Italy was due not to tenure

**TABLE 1 - Breakdown by tenure arrangement of the Italian agricultural labour force, 1911**

| | Owner Operators | Fixed Rent Tenants | Sharecroppers | Wage Workers |
|---|---|---|---|---|
| North | 25.3 | 12.0 | 15.4 | 44.1 |
| Centre | 11.6 | 2.7 | 45.7 | 34.6 |
| South | 14.6 | 7.0 | 7.7 | 64.4 |
| Italy | 18.8 | 8.4 | 17.8 | 50.2 |

Source: MAIC (1913a), *Censimento* I.

arrangements but to relative factor prices (Galassi 1995). But the more interesting part of their reassessment relates to the South.

As we said, the conventional view of the South is of a land dominated for the most part by large estates worked by wage labour. A superficial reading of the 1911 Census seems to support the view of the South as a land of wage workers (see Table 1). However, using the report of a 1907 Parliamentary Commission, Galassi and Cohen (1994) discovered contractual arrangements of much greater variety and intricacy. They argue that complex tenancy relationships in the South represented quite rational responses by landlords and tenants to the problems of high-income variance, incomplete or non-existent credit and insurance markets, and supervision-intensive cash crops (that is, crops whose output was extremely sensitive to the quality of labour inputs). Southern tenure systems were organized broadly along two main lines. In areas where cereals predominated, fixed-rent or wage-labour contracts were in force. Where vines and olive trees were important, some form of share contracts was used. What is striking about the South, however, is that the same individual farmer was, at different times of the year, wage worker and share cropper, all the while having at times a small plot of his own. The results of the 1911 Census, a predominance of wage workers in the South, are thus easy to explain: when the data were collected (mid-June), the wheat harvest was about to begin and most farmers were in fact working at that moment as wage labourers.

Briefly, then, the analysis suggests that Italian tenurial arrangements in the years before the First World War constituted rational responses to the non-removable constraints faced by farmers. In the North, where the climate allowed farmers a wider range of crop and livestock choice, diversification was effective as a risk-management technique. Small-scale credit was also easier to come by, and evidence suggests that in general crop yields in Northern Italy were less variable than in the hot and dry Centre and South (Galassi and Cohen 1994). Reasonably predictable yields meant that problems of moral hazard encountered elsewhere were less pressing in the North. Low

risk and weak agency problems not surprisingly were associated with fixed rent or wage contracts. Similar motivations explain why fixed rent and wage contracts in the South were linked with grain growing, except that greater exogenous risks there forced farmers to diversify by entering into multiple contracts. Share tenancy in the centre and South was associated with tree crops, while in the North share-croppers were more often farmers who had access to some non-tradeable input. The difference between the sharecropped farms in the centre and the crop-specific share contracts common in the South can also be explained as diversification, as in the riskier environment of the South sharecroppers preferred to farm scattered plots rather than take on a single farm as in the centre.

The tendency in modern research has been to re-evaluate tenurial systems in Italian farming, showing that sound economic reasons existed for the diffusion of different arrangements. The brief outline presented in this section does not do full justice to the issue, but is adequate for our present purposes of examining the link between tenure and draft-animal choice.

### 3. Draft Animals Used in Italian Agriculture

In Italy, as in most countries, several different types of draft animals were used to pull ploughs, haul equipment and carry the produce to market. The main types used in Italian farming were the ox, horse, mule and donkey. Table 2 shows the percentage breakdown by headcount of each type used in the three broad areas into which Italy is traditionally divided. Most of these animals were used for similar tasks, but it must be noted that each type has some particular characteristics of significance to our analysis. In this section we will discuss the various innate similarities and differences between these four types of animals and how, given these traits, each animal could be used to its maximum efficiency.

The first distinction to be made among these four types of animals is that the ox comes from a different genealogical background than the other three. Like all bovines, the ox has a completely different digestive structure, as well as different hoof characteristics, different gait, speed of work and rest

**TABLE 2 - Breakdown of draft animals used in agriculture, 1908 (%)**

| | Oxen | Horses | Mules | Donkeys |
|---|---|---|---|---|
| North | 56 | 27 | 05 | 12 |
| Center | 46 | 19 | 06 | 28 |
| South | 18 | 21 | 20 | 40 |
| Italy | 38 | 23 | 12 | 27 |

Source: (MAIC 1910)

requirements, compared with equids such as the horse or the mule. The ox is part of the ruminant family[1] which means that digestion takes place in four stomachs rather than in just one, as is the case with most animals. The first stomach (rumen) contains several micro-organisms which allow oxen to breakdown and digest fibre, something which non-ruminants cannot do.[2] Breaking fibre down allows oxen and other cattle to survive on much cheaper foodstuffs (hay, grass and corn stalks) without the need to supplement them with concentrated rations such as corn or oats (USDA 1984). Oxen consequently were rarely fed high-protein diets which, as discussed below, often lead to founder (laminitis) or colic in horses. In general, when left to forage on their own or under the feeding practices in place before the large feed-lots of the last fifty years,[3] oxen were easily cared for and their feed requirements made it quite difficult to induce digestive or physiological damage.

Other peculiarities of cattle are that they ruminate[4] while lying down, which can be something of a hindrance when the animal is working. While oxen can physiologically ruminate while standing, the process goes much more smoothly if lying down. Disturbing the process of rumination can cause serious damage to an ox (Haynes 1978, pp. 26-7). Another important characteristic of cattle is that their systems of stomachs allows them to digest mouldy hay easily, something that can be fatal in horses because of their different digestive tracts. Therefore, feeding oxen requires less care than feeding horses.

As for the ability to work in hot conditions, each type of animal has its own way of coping with high temperatures and work. While almost all animals sweat, the horse is the domesticated animal that sweats the most, followed by the donkey, and then cattle. With increased sweating ability comes increased ability to resist heat stress. Thus, in this regard the horse has a decided advantage in hot climates (McDowell 1980, p. 470). While under extreme conditions horses may have trouble, as a rule they have several

[1] Other ruminants include sheep, goats and deer.

[2] For a good textbook discussion of the digestive differences between bovines and equids see Haynes 1978, pp. 15-31.

[3] The recent feeding practice among cattle farmers of feeding high-protein diet to speed the rate of growth has brought on a new problem called "grain overload" in which the rumen cannot digest the high levels of sugar and starch generated by the high levels of corn or oats and the bovine's stomach swells grossly out of proportion and can easily lead to death if not treated immediately. This practice of feeding highly concentrated rations is, however, a fairly recent phenomenon and did not affect draft oxen in earlier days to any great extent.

[4] The process of rumination occurs when the animal's stomach forces portions of its contents back into the mouth for further mastication. In lay terms this is when a cow is lying down "chewing its cud". Rumination takes place from between 15 to 20 times per day (Fraser 1980, p. 164).

defence mechanisms to help them cope with moderate to hot temperatures.[5]

Bovines rely less on sweating and more on other means of cooling themselves. Cattle will, for example, increase their respiration rate by a factor of five when over-heated or working, which in turn rapidly increases the rate of heat loss. In contrast, horses and most other animals cannot increase their respiration rate to the extent cattle or sheep can (McDowell 1980, p. 470). In addition oxen can adapt to a warm environment thanks to their generally lighter hair coat that lies parallel to the skin. This allows light to be reflected and convection to occur as cooling air easily moves over the hair coat. Equine hair, being attached perpendicularly to the body like human hair, does not lie as close to the body. This traps air and reduces heat loss.

The final point to make regarding oxen is in their work habits. As described below, horses can literally be worked to death. Oxen, however, will simply stop working when exhausted: they are in a sense a self-monitoring type of capital (Klinkenberg 1993, p. 89).

Within the equid family it is important to discuss the differences between horses, mules and donkeys.[6] Both horses and donkeys are reproducible equid species, whereas the mule is the hybrid cross between a male donkey and a female horse. As a hybrid, the mule possesses qualities not found in either the horse or the donkey.

Mules, like oxen, simply cease working once tired. The stubbornness popularly associated with them is the result of the mule's fearing for its safety which results in an unwillingness to perform some task it feels may cause it harm. Horses, on the contrary, can be more easily coaxed into performing tasks that hybrids would not carry out. For example, when working in a field on a hot day, the mule will stop work when it is tired, at which time it is nearly impossible to start it working again. Horses will not stop when tired and can literally work themselves to death.[7]

This self monitoring on the part of the mule carries over into the consumption of food and water. After a long day working, horses will tend to eat or drink as much as is put in front of them. Mules, however, will consume only safe amounts. In the normal course of feeding these animals,

[5] See also Kauffman (1993a, pp. 338-9) for a discussion of heat resistance among horses and mules.

[6] For a complete discussion of the differences between horses and mules see Kauffman 1993b, pp. 1-8.

[7] Interestingly, mules do have something of an "over-ride" mechanism. It has often been argued that mules will work harder and longer when led by a female horse (mare) with a bell around her neck, known as a "bell-mare". Mules would follow their bell-mare just as a flock of sheep would follow the one with the bell around its neck, the bell-wether. Because the mare could be coaxed into extra work, the entranced mules could also be conned into added work as long as they were following their bell-mare (Clutton-Brock 1992, pp. 49-50).

large amounts of feed may be placed in front of mules and they will make it last for several days, whereas horses will consume it as quickly as possible (Anderson and Hopper 1917, p. 289). Severe problems can arise in horses if such an irregular consumption of food or water occurs. Horses have an inherently delicate digestive system, which is susceptible to such potentially fatal or debilitating afflictions as colic or laminitis (founder). Colic is a generic term for abdominal pain which can be the result of a number of causes - one of the most common being irregular or improper feeding. When a horse colics, it lays on the ground and rolls about. The danger arises if the horse twists its intestines, ultimately leading to death in a matter of hours. Laminitis is caused by a build-up of toxins in the blood from excessive or irregular doses of high protein from large amounts of grain (corn or oats). This disease ultimately manifests itself by rotating the coffin bone in the hoof and the loss of the entire hoof. The animal is thereby rendered lame for life and in nearly every case must be destroyed.

Unfortunately, less is known about the donkey than is known about either bovines, horses or mules. Donkeys are pure-bred equids, so in that sense they are similar to the horse. However, unlike the horse, their origins are traced primarily to the desert regions of the world (Clutton-Brock 1992, pp. 62-3). Biological selection of donkeys in these regions resulted in their being more resistant to heat stress than the horse.

In terms of being able to withstand adverse conditions, from changes in feeding times and feed types to overwork, temperature fluctuations, and human abuse, the animals rank as follows. Both mules and oxen will withstand difficult conditions as well as neglect and thus are the most resistant work animals. Horses are the most delicate and susceptible of the four animals we are considering, as they have a low tolerance for variations in feed and will work at any pace set by the driver, which if not monitored can lead to over-exhaustion. The donkey falls in between these two categories because of its similarities to the horse in its proclivity for colic and founder, yet its desert origins make it hardier and more resistant than the horse to excessive heat levels. Thus we would expect mules and oxen to be entrusted to workers who do not own the animals: wage workers and sharecroppers. We would expect horses to be used by owners and fixed-rent tenants, that is, individuals who have the greatest incentive to preserve the capital value of the most delicate of the draft animals. As donkeys are not as abuse-resistant as oxen or mules, but more resistant than horses; we would expect them to be used in a variety of instances depending on both the severity of the principal-agent problem in each particular situation and on the relative prices in a particular area.

## 4. The Data

In this section we turn to the data used in testing our hypothesis that draft animal choice can be analyzed as an agency problem. Three sources of data

have been used: the 1908 livestock census (MAIC 1910) for draft animal information, the 1911 population census (MAIC 1913a) for demographic and tenure data, and the annual publications of the Ministry of Agriculture (MAIC 1912, 1913b) for data on land characteristics (mountains, hills), crop mix and output. Of these three sources, the first two require some discussion.

We begin by focusing on the 1911 Census. The data were collected during the first two weeks of June 1911 by Ministry of Agriculture staff following a standardized procedure that ensured consistent answers over the entire country (MAIC 1916) - indeed the already-mentioned problems with the overestimation of wage labourers in the South were the direct result of applying to southern farming a taxonomy derived from observations in the rest of Italy. The results for the countryside were broken down by age, gender, and type of contract used. We have transformed the raw data reported in the Census returns into man-year equivalents by multiplying them by the age-and gender-specific coefficients calculated by Serpieri for Italian farming (1929, p. 20).[8]

The 1911 Census is generally regarded as being accurate as far as demographic information is concerned but, as we have said above, some doubts may exist on its tenure breakdown of the agricultural labour force. It must be emphasized, however, that any possible problem in this respect affects, only the Southern provinces, because of the particularly complex tenurial arrangements in use in the South. There appears to be no practical way of adjusting for the overestimation of wage labourers without making heroic assumptions of doubtful validity. Given that we are thus forced to use the tenure breakdown as it exists, are we likely to bias our analysis in doing so and, if we are, what direction will the bias take?

The answer is that the bias is not likely to matter to our results, for two reasons. In the first place, as Galassi and Cohen have argued (1994), the over-estimation of wage labourers probably cut into the number of share croppers more than into other rural workers; in fact, the 1907 Census is emphatic in reporting the presence of share contracts all over the South, and yet very few of them actually appear in the Census taken only a few years later. For our purposes, the bias introduced by having too many wage labourers and too few sharecroppers is likely to be minor. In fact, from the perspective of the landowner, the same agency problem is present with a sharecropper or a wage labourer when it comes to handling animals. In either case the person actually working with the livestock does not have a direct stake in the animals themselves, and thus the same sort of incentives would exist for the owner of the work animal to provide his workers with a beast that could withstand a certain amount of neglect or abuse.

[8] According to Serpieri, setting the annual labour of an adult male as 1.0, males from 10 to 17 years of age and over 68 are equivalent to 0.5; women in the same age brackets are 0.3, and adult women are 0.6.

Secondly, the fact remains that the labourers reported as wage workers in the Census did in fact work for wages part of the year. In other words, the Census data are not incorrect in the sense of classifying as wage labourers individuals who were actually full-time share tenants or small operators. Rather, the Ministry's interviewers simplified the South's complex reality by reporting as a wage worker someone who, in the course of the agrarian year, was also a sharecropper or occasionally rented a plot for a fixed sum. In other words, the Census returns do not distort the data relating to the agency problem we are seeking to analyze. Rather, they simplify reality in a way that, while not entirely accurate, does not significantly affect the underlying issues we are interested in.

We return now to the 1908 livestock Census. These data were collected in a way similar to the demographic census of a few years later, by means of interviews by Ministry personnel. The main difficulty for us is that the returns are reported geographically and not sectorally, so that while we know, for instance, how many horses were in the province of Milan in 1908, we do not know how many were farm animals and how many worked in urban centres or in the manufacturing or transport sectors. We have thus had to adjust the 1908 returns, which we did as follows. For horses, we have tried to exclude all non-farm animals. We thus subtracted from each provincial total, the number of horses reported in towns of a certain size[9] as well as horses in towns with significant harbours or military bases. We have not tried to estimate how many horses were kept for meat production since, unlike the French, Italians seldom eat horsemeat. Further, mules were extensively used by the army, in particular for its mountain troops, stationed largely in northern Italy - yet another example of the principal agent problem discussed by Kauffman (1996 b). All military mules have also been subtracted from our data.

For cattle, the census does not distinguish between draft and meat cattle, though it does break down the number of heads by gender and age for each province. We can approximate the number of work oxen by taking the number of oxen over one year of age. This is because Italian food habits tend to favour veal over beef, so that cattle over one year of age were not likely to be kept for meat. We also excluded all cows, on the grounds that they were kept for milk and calving. For obvious reasons, all bulls were excluded.

All the data we are using were published after the reorganization of the statistical service in 1905-6, which significantly improved the methods of data collection and the representativeness of sampling. Overall, data quality is

[9] This posed a problem because of varying patterns of urbanization in different parts of Italy. In the South, even sizeable towns can still be predominantly agricultural (agrotowns), while in the North even small towns can have significant industrial activities. In deciding which animals to exclude, therefore, we relied more on previous information about an area's main economic activity and organization than on an arbitrary threshold size for the entire country.

generally thought to be good (Valenti 1911, Federico 1982), though perhaps somewhat better for the northern provinces than in the South. Whenever possible, data have been cross-checked in several different publications to insure against misprints or inconsistencies, not an uncommon occurrence at the time. No such errors have been found.

## 5. Econometric Results

We are now in a position to test whether the allocation of draft animals we observe in Italy in the early years of the twentieth century was in some sense "efficient". Did factors such as alleviating principal-agent problems matter after taking into account varying local conditions? Our hypothesis, deriving from our discussion in section III, is that agency problems were particularly strong in the sharecropped and wage-labour areas, and thus we expect to find oxen and mules associated with these tenure systems. We do not have prior views concerning whether share tenancy or labour contracts should be associated with oxen or mules, though in practice we found that landlords with sharecroppers preferred oxen and landlords with wage labourers chose mules. Horses, in contrast, we expect to be associated with owner occupiers or fixed-rent tenants supplying their own draft power. The testing of our hypothesis involved estimating three series of Ordinary Least Squares (OLS) regressions using first horses as a percentage of all draft animals in a given province, then the percentage of mules, and finally the percentage of oxen, as the dependent variable. As explanatory variables we use the percentage of total agricultural labour in each province for each of the four types of tenure arrangements (fixed rent, share rent, wage labour, owner occupation), a land type proxy (the percentage of wheat land in the hills, plains and mountains) to control for differences in quality of farm land, and a feed proxy (the percentage of meadows that were irrigated, seasonal and dry) to control for the availability of high-quality feed on the farms. Our priors relate exclusively to the tenure variables, with which we try to capture the agency problems. We discuss each group of regressions in turn.[10]

First, we focus on horses. As noted earlier horses are the least abuse-resistant of the animals used for draft purposes. Thus we expect them to be more important in provinces where owner-occupiers farms were more plentiful. Table 3 gives a summary of regressions estimated using the number of horses as a percentage of all draft animals in a province as the dependent variable.[11] In only one of the regressions estimated were any of the tenancy variables statistically significant. In the one instance where the form of tenancy seemed to matter, the statistically significant variable was

[10] We are able to use OLS regressions rather than Tobit regressions as none of the dependent variables are centred around 0% or 100%. The category of donkeys is the omitted set of regressions.

the percentage of owner-operators with a positive and large coefficient. This is compatible with our prior that owners used horses for work more often than the more abuse-resistant animals. However, since only one of the tenancy variables turned out to be significant we consider it more likely that the data relating to horses be somewhat unreliable.[12] The number of horses in a province in our data set also includes riding horses, and although we have tried to separate out 'urban' horses not used in farm work we lack adequate information to assert that we have, in fact, excluded all of them. This probably introduces a large amount of background noise so that none of the tenancy variables correlate with horse use.

For horses, what does seem to matter, both statistically and economically, is the percentage of land in a province allocated to irrigated or seasonal meadows. In both cases the coefficients are positive and in nearly every case statistically significant at one percent. However, the variable for irrigation seems to be the most important economically. Irrigating ground is costly, yet

**TABLE 3 - Results of OLS regression models with horses as a percent of total draft animals as the dependent variable**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Owner | -0,060 | 0,150* | | | | |
| Sharecropper | | | | -0,017 | | |
| Fixed-rent tenant | | | 0,172 | | | |
| Wage worker | | | | | | |
| Mountains | -0,054 | -0,052 | | | | |
| Hills | | | | | | |
| Plains | 0,075* | 0,180** | | | 0,108*** | 0,130*** |
| Irrigation | 0,337*** | | 0,384*** | 0,401*** | 0,315*** | |
| Arid | | | | | | |
| Seasonal | 0,268*** | | 0,202** | 0,195*** | 0,213*** | 0,235*** |
| Constant | 0,208*** | 0,185*** | 0,197*** | 0,214*** | 0,177*** | 0,178*** |
| Adj-$R^2$ | 0,27 | 0,14 | 0,18 | 0,17 | 0,27 | 0,21 |

***= significant at 1%
**= significant at 5%
*= significant at 10%

[11] In the estimation of the OLS regression models heteroskedasticity was detected using "likehood ratio tests", as might be expected with such a cross-sectional data set. The estimates given are properly weighted to account for the heteroskedasticity.

[12] Also when the variable "irrigation" (percentage of irrigated hectares) is added in, the variable "owner" (the percentage of owner-operators) becomes insignificant. Thus these variables are collinear which would mean that none of the tenancy variables explain horse use in Italy.

the fodder produced in such areas is of a higher quality. Because horses require high-quality feed to remain healthy, whereas mules or oxen can adapt to a lower quality diet, the horse may have been used more often in those areas where high-quality fodder grew more easily. We unfortunately lack livestock prices for Italy in this period, but going on the assumption that horses were cheaper to buy than other animals (as was the case elsewhere[13]), we see the connection between the high-quality feed and horses as follows. If the ground must be irrigated for farming, agents might choose a type of work animal that is less expensive to buy initially, because they already have high start-up costs with the irrigation systems, and can feed a horse with relative ease. The high-quality feed produced with irrigation fits the horses' needs, while feeding oxen, that can sustain themselves just as efficiently on much poorer quality feeds, with irrigated feed would be "wasting" this comparatively more expensive fodder.

Further, the variable relating to the percentage of farmland in plains is consistently positive and in most cases highly statistically significant, suggesting that plains farming and horses were closely related. This may reflect the greater ease of pulling ploughs on the flat light soils suitable for wheat, the crop most commonly grown on Italy's plains. Horses pull at a faster rate than do oxen, but oxen produce greater torque (of use in heavy

**TABLE 4 - Results of OLS regression models with mules as a percent of total draft animals as the dependent variable**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Owner | | | | | | |
| Sharecropper | | -0,241*** | | | -0,244*** | -0,148* |
| Fixed-rent tenant | | | | | | |
| Wage worker | 0,284*** | | | 0,268*** | | 0,205** |
| Mountains | | | | | | 0,032 |
| Hills | | | | | | |
| Plains | | | | -0,100** | -0,108** | -0,139*** |
| Irrigation | | | | | | |
| Arid | | | -0,619*** | -0,270* | -0,273* | |
| Seasonal | | | -0,199** | | | |
| Constant | -0,020 | 0,158*** | 0,181*** | 0,038 | 0,219*** | 0,076 |
| Adj-$R^2$ | 0,16 | 0,14 | 0,26 | 0,34 | 0,34 | 0,34 |

***= significant at 1%
**= significant at 5%
*= significant at 10%

[13] Unfortunately no known price data exist for draft animals in Italy in this period.

soils or breaking sod). Horses were thus preferable on flat lands, where added torque was not necessary.

To sum up this first group of regressions, we found tenure variables to be generally weak explanations of horse usage in Italian farming. Environmental factors such as feed quality and land type appear more important than agency issues in horse selection. While these results do not support our hypothesis, they at least do not contradict it, especially in view of the severe coverage problems associated with horse data.

The picture is clearer when we approach the choice of the two more abuse-resistant types of draft animals, mules and oxen. Interestingly, each animal's geographic distribution was consistently linked to a particular tenancy arrangement: wage workers for mules, sharecroppers for oxen.

To begin with mules, their use in Italy appears to have been associated positively with wage workers and negatively with sharecroppers. Table 4 presents results of OLS regressions in which the dependent variable is the number of mules as a percentage of all draft animals.[14] Wagehands were supplied with mules because these animals were more abuse-resistant than the otherwise close substitute, the horse. As wagehands did not own the animals they were working in the fields, it made sound economic sense to provide mules to these workers. Mules, as we said, monitor themselves and refuse to work themselves into as state of overexhaustion. As noted earlier, there was a high degree of turnover with respect to wage labour, in the sense that owners of land would bring in an outside labour force during certain months of the year and then after the specific tasks were done the workers would move on to their next job. The following year the process would be repeated, not necessarily with the same workers. Thus, with a labour force that was constantly changing the cost of monitoring these individuals was large; using mules limited the capital loss careless or abusive wagehands could inflict on landlords, and probably reduced overall monitoring. When both wagehands and sharecroppers are used in regressions on the percentage of mules as the dependent variable, the signs turn out negative for sharecroppers and positive for wagehands.[15] The link between wagehands and mules probably reflects the importance of wage contracts in southern Italy. Of the two abuse-resistant animals, mules were preferred in the South because there the distances between villages and the distances between farms and villages were much greater than in the North. As the mule travels faster than the ox, mules may have been more widely used because of their comparative advantage in travel. Thus given that landlords had to provide their workers with an abuse-resistant animal, if it also had to be used to travel

[14] Again heteroskedasticity was detected with the use of likelihood ratio tests, thus the estimates reported are properly weighted to account for the heteroskedasticity.

[15] An F-test was conducted on regression 6 in Table 4 to see whether all variables taken together were significant. The F-statistic of 9.64 was significant at the 5% level.

great distances the mule had a decided advantage over the slower ox.

One other interesting finding in these regressions is the inverse relationship between mules and dry areas of Italy, as proxied by the dry meadows variable. It is generally assumed that mule use was associated with hot and dry climates, yet in Italy their use in those areas was inversely proportional to the percentage of arid hectares in the province. This clearly shows that the notion that the choice of mules over horses is determined by such factors as ability to endure hot, dry climates is rooted more in myth than fact. The easy 'environmental' answer to draft animal choice neglects the importance of the economics of agency.[16]

The adoption of oxen also appears to have been driven in large measure by principal-agent problems. Table 5 contains regression results with the number of oxen as a percentage of all draft animals as the dependent variable.[17] Three variables consistently stand out as economically and statistically significant. The percentage of oxen varies positively with the percentage of sharecroppers in a given region.[18] This variable is always

**TABLE 5 - Results of OLS regression models with oxen as a percent of total draft animals as the dependent variable**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Owner | | | | | | |
| Sharecropper | 0,427*** | | | 0,357*** | 0,269*** | 0,115 |
| Fixed-rent tenant | | | | | | |
| Wage worker | | -0,587*** | -0,484*** | | | -0,399** |
| Mountains | | | | | | |
| Hills | | | | | | |
| Plains | | | 0,161** | 0,154* | | 0,173** |
| Irrigation | | | | | | |
| Arid | | | 0,932*** | 1,016*** | 1,332*** | 0,897*** |
| Seasonal | | | | | | |
| Constant | 0,304*** | 0,674*** | 0,484*** | 0,173*** | 0,210*** | 0,420*** |
| Adj-$R^2$ | 0,12 | 0,19 | 0,49 | 0,45 | 0,43 | 0,49 |

***= significant at 1%
**= significant at 5%
*= significant at 10%

[16] A similar argument had been put forth regarding the extensive use of mules in American southern agriculture; however, one of the hottest states, Florida used nearly twice as many horses on its farms as mules. In Florida there were also very few sharecroppers, which seems to be a more encompassing explanation for their choice of draft animals (Kauffman 1993a, pp. 338-9).

significant at 1% and the coefficient is always large, which suggests its importance in the decisions to use oxen. In like fashion, the variable relating to the number of wage workers in a region is also statistically significant and large. However, in contrast with with sharecroppers, the wage worker variable is negatively related to the percentage of oxen in a given region.[19] One possible explanation is that sharecroppers are associated with the central regions of Italy. This area has heavy clay soils, mostly on hilly ground, on which the greater torque power of oxen gives these animals a net advantage over faster but less powerful mules or horses (Klinkenborg 1993, p. 89). The ox's slower, constant pace also proved less of a drawback in the more densely populated central regions, where distances to the market were much shorter, than was the case in the South.

Equally interesting, the other variable affecting the choice of oxen was the percent of dry meadows in a region: its coefficient is positive, large and highly statistically significant. Given that oxen's digestive system can convert plant fibre into a usable source of feed, unlike the digestive systems of horses and mules, their greater use in hot dry regions where vegetation is sparse reflects this animal's adaptability to difficult conditions.

## 6. Conclusions

In this paper we argue the spatial pattern of draft animals in early twentieth-century Italy can be explained by the various types of tenure systems and labour contracts found in different provinces. The view held by many historians of Italian agriculture that the system was somehow inefficient is incompatible with our findings. We found evidence that the distribution of draft animals during this period was, in large measure, based on the existence of principal-agent problems in the labour hiring practices found in Italian agriculture. The two most abuse-resistant types of draft animals (mules and oxen) were associated with the types of agricultural labour for which physical capital had to be provided by the landowner (wage workers and sharecroppers). Landlords thus had to decide between mules and oxen. Local factors played a large role in determining the choice of mules for wage workers and oxen for sharecroppers. More delicate animals were, according to our results, weakly but positively related with owner occupation and more strongly with feed availability, even though severe data problems lead us to view these results with a great deal of caution.

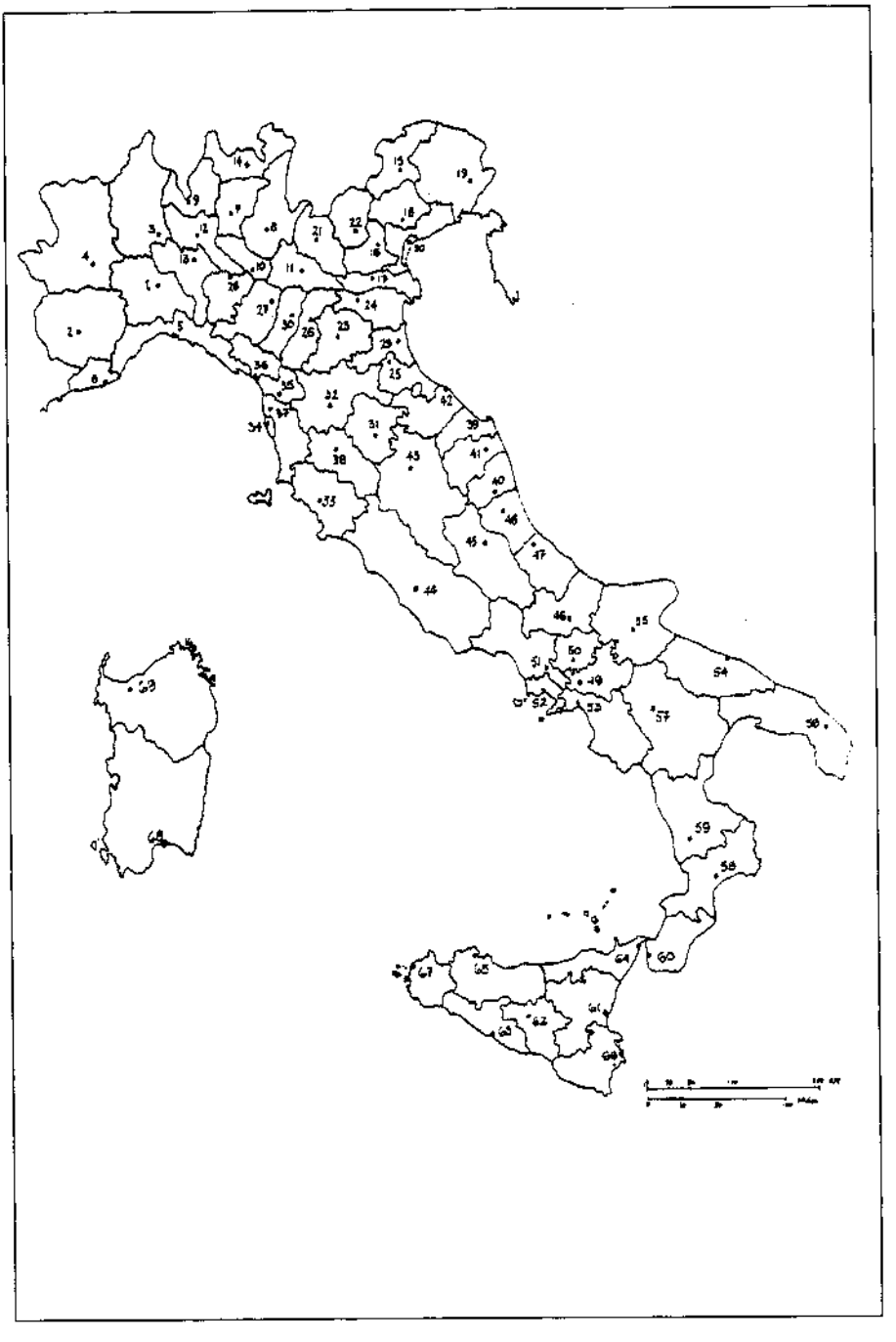
[17]As in the previous cases, heteroskedasticity was detected and corrected, thus the estimates reported are properly weighted.

[18]This finding is consistent with earlier work done by Liebowitz (1992) in which he found oxen to be located in areas of France where there were large numbers of sharecroppers.

[19]An F-test was conducted on regression 6 in Table 5 to see if all variables taken together are significant. The F-statistic of 17.13 was significant at the 1 percent level.

Our conclusions are interesting for two reasons. First, they provide further support for the argument that 'traditional' agricultural societies allocated resources consistently with what modern economic theory suggests. In that respect, our work is a contribution to the growing body of evidence that what has been called the New Institutional Economics can indeed be used to approach such radically different social structures as the U.S. Army and Italian farming society. Secondly, however, and of greater significance to the actual problem under discussion, our findings highlight yet again how wide of the mark some scholarly research can be when dealing with complex issues without the intellectual support of sound theorizing. The charges of inefficiency levelled at Italian farming practices are really the result of an imperfect understanding of the actual problems faced and, we argued, efficiently solved by supposedly illiterate and ignorant peasants.

**FIGURE 1: Provincial Boundaries, 1911.**



*NORTH:*

| Piedmont: | Lombardy: | Venetia: | Emilia Romagna: |
|---|---|---|---|
| 1. Alessandria | 7. Bergamo | 15. Belluno | 23. Bologna |
| 2. Cuneo | 8. Brescia | 16. Padova | 24. Ferrara |
| 3. Novara | 9. Como | 17. Rovigo | 24. Forlì |
| 4. Torino | 10. Cremona | 18. Treviso | 26. Modena |
| | 11. Mantova | 19. Udine | 27. Parma |
| | 12. Milano | 20. Venezia | 28. Piacenza |
| | 13. Pavia | 21. Verona | 29. Ravenna |
| | 14. Sondrio | 22. Vicenza | 30. Reggio Emilia |

Liguria:

5. Genova
6. Porto Maurizio

*CENTRE:*

| Tuscany: | Marche: | Latium: |
|---|---|---|
| 31. Arezzo | 39. Ancona | 44. Roma |
| 32. Firenze | 40. Ascoli Piceno | |
| 33. Grosseto | 41. Macerata | |
| 34. Livorno | 42. Pesaro Urbino | |
| 35. Lucca | | |
| 36. Massa Carrara | Umbria: | |
| 37. Pisa | | |
| 38. Siena | 43. Perugia | |

*SOUTH:*

| Abbruzzi: | Puglie: | Calabria: | Sardinia: |
|---|---|---|---|
| 45. L'Aquila | 54. Bari | 58. Catanzaro | 68. Cagliari |
| 46. Campobasso | 55. Foggia | 59. Cosenza | 69. Sassari |
| 47. Chieti | 56. Lecce | 60. Reggio Calabria | |
| 48. Teramo | | | |
| Campania: | Basilicata: | Sicily: | |
| 49. Avellino | 57. Potenza | 61. Caltanissetta | |
| 50. Benevento | | 62. Catania | |
| 51. Caserta | | 63. Girgenti | |
| 52. Napoli | | 64. Messina | |
| 53. Salerno | | 65. Palermo | |
| | | 66. Siracusa | |
| | | 67. Trapani | |

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