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A new reading of the economic system of the Grand Duchy of Tuscany through the georeferencing of shops and factories at the time of the setting up of the Lorraine Land Registry (1835)

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Abstract

This paper focuses on the reconstruction of the social and economic conditions of the Grand Duchy of Tuscany in the mid eighteen thirties on the basis of recent geohistorical information. To perform this reconstruction, we georeferenced information relating to the nineteenth-century factories and shops recorded in the Land Registry. To date, this aspect has received little attention when considering the historiographic traditions of this area, firmly rooted in a sharecropping system based on the three main Mediterranean agricultural products.

The use of geostatistical tools allowed us to determine the height and slope of each of the geometries in the two geodatabases. We were also able to create positive spatial data autocorrelations, determine specific production and trading areas and thus determine the anthropisation levels of these territories in the outlying areas of the State.

The online publication of these geographical databases on the cartographic portal of the Tuscany Region through a dedicated WebGIS was the last phase of our study. Considering both the number and density of geometries surveyed, our work is an extraordinary example of how geohistorical research may be combined with new technologies for the purpose of studying geohistorical content and disseminating it to the general public.

Keywords: Tuscan Lorraine Lande Registry, Historical GIS, WebGIS, Shops and factories, Economic system.

Il presente contributo è dedicato alla ricostruzione delle condizioni socioeconomiche del Granducato di Toscana alla metà degli anni '30 del XIX secolo alla luce di recenti acquisizioni informative di carattere geostorico. Per poter effettuare questa operazione e rileggere i caratteri di questo caso

studio si è proceduto alla georeferenziazione delle informazioni relative agli opifici e alle botteghe ottocentesche censiti nel catasto lorenese, elementi considerati marginalmente nella costruzione del paradigma storiografico di questo territorio saldamente ancorato sul sistema mezzadrile e la trilogia agraria mediterranea.

Il ricorso a strumenti di geostatistica ha consentito, oltre a determinare l'altimetria e la pendenza di ognuna delle geometrie dei due geodatabase, di creare una serie di autocorrelazioni spaziali positive dei dati, di determinare le aree di specializzazione produttiva, di quelle di vendita dei beni al dettaglio e conseguentemente di definire il grado di antropizzazione di questi territori nelle aree periferiche dello Stato.

La pubblicazione di queste banche dati geografiche online sul portale cartografico della Regione Toscana attraverso un WebGIS dedicato è stata l'ultima fase di una ricerca che, tanto per il numero quanto per la densità di geometrie censite, risulta essere uno straordinario esempio di sintesi tra ricerca geostorica e utilizzo di nuove tecnologie.

Parole chiave: Catasto Lorenese Toscano, Historical GIS, WebGIS, Botteghe e opifici, Assetti economici.

Introduction

In recent times, the historical cadastral map of the Grand Duchy of Tuscany and the relating property registers have become available in digital form. The map has scales ranging between 1:325 and 1:5000 and, overall, the documents include a total of 12,000 map sheets and 320,000 register pages. This impressive number of sources allowed us to reconstruct the distribution of the factories and shops in this area in 1835 and to examine the social and financial aspects of the territory (Fig. 1).

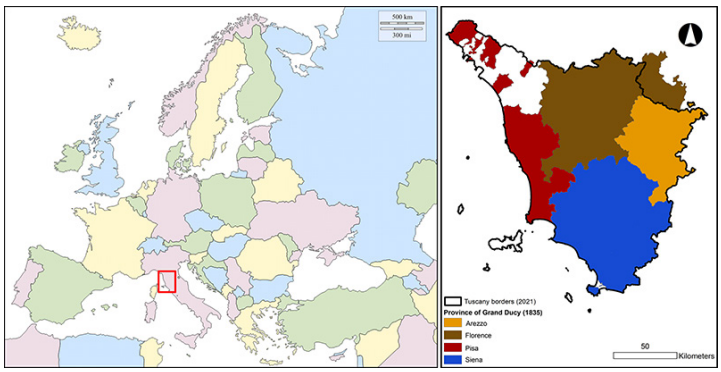

Fig. 1. The red rectangle on the left shows the area under study. The figure on the right shows the territorial division of the four administrative provinces of the Grand Duchy in 1835. Maps by authors.

The land registry maps on which point georeferencing was based were acquired in high-resolution

digital form as part of the Tuscany Region project called CA.STO.RE.[1] They were georeferenced and joined together in a cartographic continuum covering the Grand Duchy as well as a good part of the lands of the Bourbon and Este States (merged into present-day Tuscany). These latter states also had land registries more or less similar to the Grand Duchy registry.[2] The SITA publishes this data online under a CC-BY licence, through a WEBGIS and a dedicated WMS service. These platforms allow millions of users every day to view Tuscany's historical cartography and to use this extraordinary cartographic database with their own Desktop GIS software.[3]

The scans of the land registry records are instead being implemented on a dedicated server. They are linked to the respective map sheets containing the land registry parcels. This step is nearing completion and will allow users to view the historical cartography and the land registry data of each plot of land (when the Land Registry was created in 1835, the Grand Duchy was composed of 2,266,685 land registry parcels).[4]

The large amount of material available, together with the creation of information layers and concentration models – an incredibly easy operation today thanks to GIS instrumentation – has enabled two results to be achieved [1]. Firstly, the creation of Historical GISs regarding the distribution of the businesses that contributed to the regional economy. Secondly, the opportunity to add this new geohistorical information to our overall knowledge of Tuscany, centred on sharecropping. As examined further on, these information layers are useful for replacing the traditional three-product model of the region (wheat, olives and vine) with a four-product model (wheat, olives, vine and chestnuts). This leads to reducing the dichotomy between flat-hilly economies (rich) and more typical mountainous ones (featuring subsistence economies).

According to the descriptions of the officials of the State of Lorraine in their Final Report following completion of the Land Registry, the Grand Duchy was regarded as having a prevailing rural-based economy. Instead, our examination of the Tuscan shops brings to light the very lively and dynamic situation of the State capital (this is where the *Tavole di Stima* (Estimate Tables) are held which detail the type of business activities conducted) but also of the capitals of the *Compartimenti Comunitativi* (Community Compartments), and of many outlying villages. As in the case of trading posts, the information layer of factories reveals a polarisation of production, which was certainly due to the distribution of energy resources. This justifies the spreading of the population throughout the nineteenth century and explains the subsequent abandonment of the State's peripheral areas following the introduction of fossil energy systems. It was indeed no longer necessary to use energy sources outside the towns and villages which were far from the trading posts and available only

1 CA.STO.RE. Project http://www502.regione.toscana.it/castoreapp/ (last visited, March 13, 2023).

2 Since 2012, this huge digitised cartographic and documentary heritage of Tuscany has been made available to the public by the regional SITA (Territorial and Environmental Information System), following an agreement between MiBACT (Ministry for Cultural Heritage and Activities and Tourism) and the Region of Tuscany. https://www.regione.toscana.it/documents/10180/12431710/AccordoCastore_1_3_MIBAC_RT_20040722.pdf (last visited, March 13, 2023).

3 Statistics of use of the WMS services of the Tuscany Region http://www502.regione.toscana.it/tabulae/flow.html?_flowId=viewReportFlow&standAlone=true&ParentFolderUri=undefined&reportUnit=/logs_accessi_servizio_top&output=pdf (last visited, March 13, 2023).

4 Archive of the State of Florence (hereinafter ASFi), Segreteria di Gabinetto Appendice, 244, G. Inghirami and L. de' Ricci, *Relazione finale al granduca della deputazione sopra il catasto (30 set. 1834)*.

during certain seasons of the year.

The spatialisation of the nineteenth-century factories and shops via georeferencing provides key knowledge for understanding the economic dynamics of the region and for overcoming the traditional models studied up until now on Tuscan sharecropping and on the three product-based agricultural system.

The last step of this study regards the publication of the layers created through public WebGIS and WMS services overlapped with SITA cartographic information. In addition to consulting the data and downloading it in the form of vectors under a CC-BY licence for the geographical databases (in shapefile format), we are also able to gain insight into how the region has developed and evolved over time.

Georeferencing of nineteenth-century Tuscan geohistorical data

As mentioned above, the archival data used for the creation of the geographical databases of nineteenth-century factories and shops was taken from the Grand Duchy land registries (prior to the unification of Italy), previously acquired in digital form during a research project co-funded by the Region of Tuscany and ISTC (Inter University Centre for Territorial Science).[5] The decision to use this source was based on a number of reasons:

- The fact that this geometric and parcel-based land registry covers almost all of Tuscany. The maps and registers in it give a clear picture on the date of activation of the land registry in 1835[6] of a region that would shortly afterwards suffer the irreversible effects, firstly, of the introduction of steam and then, over the following decades, of electricity;
- The exceptional quality used in creating the registry as well as the excellent state of conservation of the maps and records;
- The fact that the Tuscany Region decided to acquire and disseminate the digitised images on freely accessible platforms available to all, ensuring the preservation of the archival material;
- The fact that the data, both in terms of maps and property related documents (estimate of assets), was originally collected by public officials public and was not, as in previous periods, based on the owners' declarations;
- Finally, the coexistence of demographic sources and secondary sources regarding those exact years.

An exceptional amount of documentation was handled to examine the sources. The search in the *Tavole Indicative* (Indicative Tables) alone required the selection of data in no less than 3,000 volumes – roughly 5,145 linear metres. To this, we must add the search for shops and factories in the Samples, Estimate Tables and Preparatory Tables [2]:13-29.

At the time of drafting of the Land Registry, the Grand Duchy of Tuscany was divided into 242

5 https://www.regione.toscana.it/documents/10180/12431710/All_A-Accordo+MIB-AC-CIST-RT.pdf/9f39a3a8-fa6e-4951-9090-4ed0c417a3d1 (last visited, March 13, 2023).

6 ASFi, Segreteria di Gabinetto Appendice, 244.

communities, each split into a variable number of sections. Tax income was expressed in *lire* (accounting currency) and in florins (actual currency). The scale used for the map sheets varied between 1:350 for inhabited areas and 1:5000 for rural areas [3]; [4]. A map called *Quadro d'unione* (Index map) was drawn up for each community on a single sheet with scale varying between 1:20000 and 1:30000. The main man-made and natural elements as well as the borders of the *sezioni comunitative* (community sections)[7] were drawn on the map. Unfortunately, this map has not always been preserved over time for each community.

The construction of the geographical databases of Tuscan factories and shops using the cadastral archive sources prior to the unity of Italy was based on three sequential steps: the acquisition of data in the archive sources; the construction of a table of attributes with all the information acquired; and, finally, vectorisation of the data collected in two specific point geodatabases.[8] A digital camera equipped with a stand was used to acquire the documentary sources. Roughly 320,000 images were produced relating to the land registry records of the four provinces that formed the Grand Duchy (Florence, Pisa, Siena and Arezzo) and currently included in the ten Tuscan provincial State Archives. A huge number of images were recorded systematically and provided with a metadata describing, for each single archival unit, the state of preservation and the method of digitisation of the volume. They were then linked to the respective map sheets of the CA.STO.RE. project. This wealth of information will be able to be used not only for studies and research on nineteenth-century Tuscan landscape, but also for town and country planning, which according to Tuscan regional law must take into account pre-existing historical features [5]:71-81; [6]:603-610.

With the georeferenced raster maps of the Land Registry (CA.STO.RE. project) and the scans of the registries, we then started to create the databases (using Microsoft Access software) using the information contained in the above registries without any data normalisation.

The third step for the construction of the geodatabases consisted of vectorising the shops and factories through point geometries with the previously collected information and linking the table of attributes in the geodatabase with the respective data in the Access database. With a simple intersect operation in GIS environment, we also added data from the DTM (Digital Terrain Model) to these point layers. The data regarded the heights but also the exposure and inclination on which these geometries were located.

At the time of the Grand Duchy of Tuscany, products were also sold at farmers' markets, once or twice a week. In addition to the information layers regarding shops and factories, therefore, we also created a further layer using the data provided by Repetti on the presence or absence of weekly markets in each community in 1833 (Fig. 2) [7]. Together with the layer regarding shops, this layer was very useful for completing the picture of the economic activities in the Grand Duchy and especially of the places where trading activities were conducted.

Based on the information provided in the *Historical, Physical and Geographical Dictionary of*

7 To use the same proportion throughout the entire area, the sections needed to be divided into a variable number of map sheets.

8 The generated layers – in shapefile format – have the same number of fields of the cadastral registers. Indeed, each of them contains serial textual or alphanumeric information and has the same characteristics of the original document. The collection of the data has been done in a source-oriented manner and therefore any errors in the sources have been reported in the file attribute table.

Tuscany, written by the Tuscan geographer, historian and naturalist Emanuele Repetti, we were able to further the information we had by creating a layer with 1833 demographic data, that is, just two years before the Land Registry was set up. Then, we linked this data to the rest of the geographical databases to complete the information about the Grand Duchy.

Fig. 2. Presence (red) and absence (yellow) of markets in the Grand Duchy communities. Map by authors.

Analysis of geographical databases of factories and shops

If we examine the information extracted from the land registries, we see that in the area of present-day Tuscany there were slightly more than 18,600 factories, annexes and artisan shops (12,512 factories and annexes and 6,100 artisan shops). This calculation does not include data from the Grand Duchy areas which merged with Emilia-Romagna and with Liguria and Umbria on the date the land registry was set up (1835).

Of the total number of georeferenced factories, chestnut dryers reaching a total of 5,794 units were the most widespread type of factory. The number of water-powered factories – 3,771 including wheat, flax and chestnut mills, as well as olive presses, wool mills and paper mills –, kilns, quarries (e.g., lime) and mines (iron, borax salt, etc.) was also very high (Fig. 3).

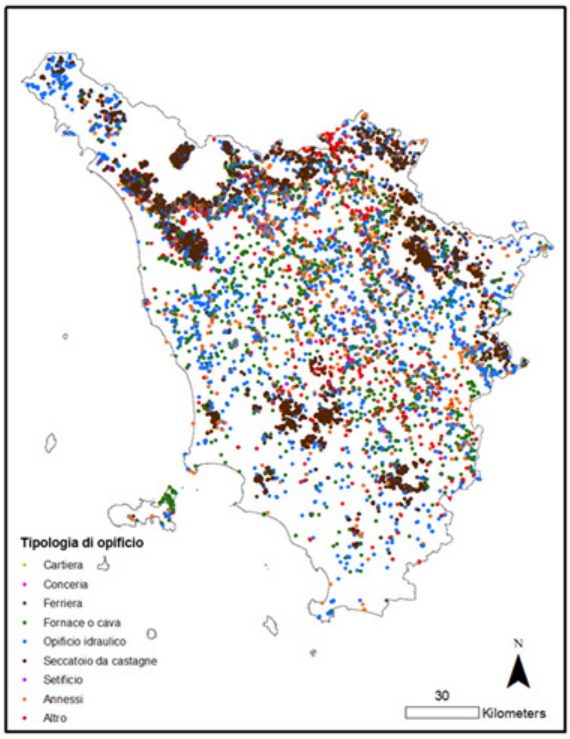

Fig. 3. Layer of vectorialised factories using land registry sources. Map by authors.

Since our work involved thoroughly examining all the registries, in addition to georeferencing the businesses specifically dedicated to the processing of agricultural products, we also decided to collect data relating to buildings called "annexes" in the land registries. Annexes are buildings which were of service to the factories and included: millraces, water collection basins, pomace collection areas, but also yards used for drying bricks before firing them in the kilns, retting pools for hemp or rags, and so on [8]:5-19. In other words, infrastructure that was not necessarily connected to the factory's mechanical processes but was essential for the factory to operate.

If we observe the geographical distribution of the georeferenced factories, what immediately catches the eye is that the buildings rose in very specific areas and, if we view chestnut dryers for example, often with truly extraordinary product concentration levels. The fact that the data refers to a time when electricity had not yet been invented implies that these businesses needed to be located in areas provided with energy sources. In fact, if we select water-powered factories and their annexes in the geodatabase and overlap them with the Tuscan hydrography layer, we clearly see that they nearly all rose close to water courses of a prevalently torrential nature (reservoirs were in fact often built to store the water that would then drive the water wheel).

Again, thanks to the opportunities offered by GIS systems, we not only imported into the layer of factories data regarding the current administrative areas in which our points fall but also the data extracted from the DTM (Digital Terrain Model) raster regarding height, exposure with respect to the azimuth and slope (terrain steepness). The latter amount of information was truly

immense, making it almost impossible to load it all manually into the database. But, above all, the information was particularly useful. It enabled us to notice that the *metati* (chestnut drying houses) were almost entirely (73% of the total) located at a height of between 180 and 600 metres. A much smaller number of buildings (around 18%) were recorded as being positioned above this range, while the percentage dropped to 9% in the range between 0 and 179 metres. Once again, after cross-checking with the administrative data, we observed that in the communities of central-western Tuscany (Monti Pisani and Amiata), these factories were located at lower heights than in the northern Apennine area where they were generally found at greater heights despite the colder climates.

Mills and olive presses were mainly built at much lower heights than chestnut dryers. Less than 4% rose at a height ranging between 180 and 600 metres, 18% between 600 and 1000 metres, 9% above 1001 metres, and the remaining 69% between 0 and 179 metres above sea level.

Turning to the terrain slope where chestnut dryers were located, we see that in the central and southern parts of the region they rose on slopes ranging between 11 and 18 degrees, while in the northernmost areas between 18.1 and 23.5 degrees. Mills and oil presses were built in areas with steeper slopes. In central and southern municipalities, mills were located on terrain slopes ranging between 23.6 and 27.7 degrees, while oil presses on land with slopes between 17.7 and 23.5 degrees.

This information is also extremely helpful for identifying man-made contexts. While chestnut dryers, which also play a key role in defining chestnut wood areas [9]:386-414, were built at higher altitudes and had a predominantly seasonal attendance, water-powered factories, which generally operated all year round, had a continuous presence of people (who lived in the area) engaged in milling activities. Inevitably, the communication systems and infrastructure that were strictly connected to these production processes required maintenance services. Maintenance was essential for the operation of the factories and for ensuring that the agricultural products were received from the valley as quickly and easily as possible.

In order to understand factory energy requirements, measuring the heights and slopes was essential; this was confirmed when comparing data from the northern and central-southern areas. If we consider mills and oil presses, for example, the former were generally located at lower altitudes and on areas with greater slopes. Indeed, assuming that the energy required to produce the same amount of product using similar machines is the same, the different position of the factories and the steepness of the land on which they were built are an indication of the different morphological and climate conditions of the sub-areas on which these factories were situated.

On the other hand, if we compare the distribution of factories by province between the date on which the land registries were set up and present day, we notice that, after the significant changes in the administrative areas and the creation of the provinces of Grosseto, Massa Carrara, Prato, Pistoia and Livorno, there are clearly some areas that lost a high percentage of factories. One of the most significant cases is certainly the Province of Pisa: in 1835, it counted 3,422 facilities, which if still existing in today's province would have dropped to 1,339. Siena would also have suffered a similar fate: its 3,289 activities would have dropped to 1,878 factories today. Lastly, the province of Florence, which following the creation of the provinces of Prato and Pistoia, but also the transfer of territories to the current province of Pisa, would have recorded a 50% reduction in its factories (falling from 4,118 to 2,086).

Trading posts: artisan shops and markets

A total number of 6,100 shops were identified and georeferenced in the textual documentary sources, the *Tavole Indicative* or in the *Campioni dei Proprietari* (Owners' Samples), using the methods described above for the layer of the shops. Of these, the highest number (3,117) were located in the city of Florence, while the remainder in smaller towns and villages.

No shops were found outside the urban areas, apart from about a hundred (3.3% of the total) and were generally situated along the main roads. Overall, out of the 242 Tuscan communities, only 158 had at least one shop (65.3%), 17 had at least 50 shops, and only 7 communities had more than 100 shops (Fig. 4). Alongside Florence, the provincial capitals (Pisa, Siena and Arezzo) were the towns with the highest number of shops. These towns also hosted the main weekly markets where foodstuffs were brought from the countryside and sold. The presence or less of selling activities was strictly linked to two factors:

- The concentration of population (who did not have land where they could grow food for themselves and their families and so had no other option than to purchase food);
- The presence of economic capital and, therefore, of a secondary and tertiary sector.

Figure 4 was obtained by placing the map of the population next to the map of nineteenth-century shops. If we look at the figure, it is clear that as the distance from the inhabited towns and villages increases, showing a prevalence of scattered houses compared to the inhabited areas, the population in rural areas grow food for themselves and their families (except for uncommon goods) for their basic needs. This explains the absence of shops selling foodstuffs.

The large nineteenth-century urban centres in Tuscany comprised three types of shops: A) shops selling basic necessities for the livelihood of people; B) shops selling products with a high economic value; C) craft activities specialising in the production of goods requiring very expensive production tools.

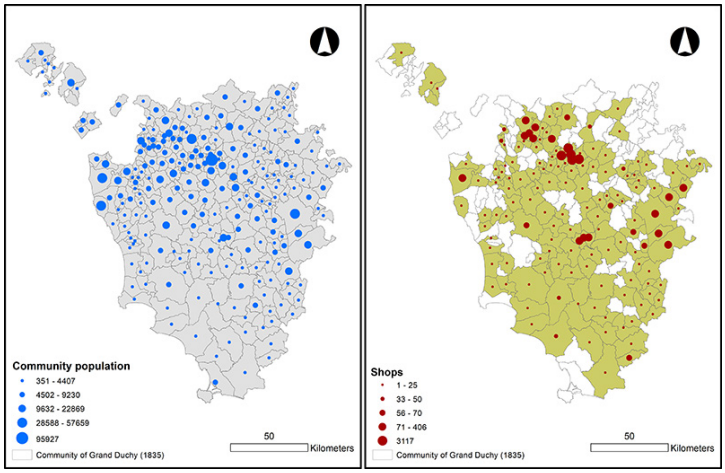

Fig. 4. Population distribution on the left. Concentration of shops throughout the communities on the right. Maps by authors.

As reported by the land registry technicians in the records of the Estimate Tables, specific details about every single type of shop have unfortunately gone lost for almost all the Grand Duchy, due to a regrettable perusal of the documentation by the officials of the State Archives of Florence in the nineteen sixties and seventies [10]. Almost all the records of the city of Florence and of the community of San Miniato (now in the province of Pisa) were saved from this rather random removal. In the case of Florence, which counts the largest number of businesses, we were therefore able to analyse the wide range of trade activities. Since we had georeferenced all the urban buildings using historical land registry cartography, we also analysed their geographical distribution (Fig. 5).

Of the 3,117 Florentine businesses, 711 were generically referred to as '*botteghe*' (shops). Businesses including grocers, haberdashers, barbers and cobblers amounted to over 100, followed (between 70 and 50) by tailors, woodcutters, ironmongers, greengrocers, taverns and wine sellers. On the whole, there were more than 480 different types of shops in Florence, 27.4% of which sold basic necessities, 63% sold what we would call today personal goods (bookshops, umbrella shops, engravers, goldsmiths, perfumeries, tobacco shops, armoury shops, hatters, etc.), while the remaining 7.6% consisted of proto-industrial workshops (leather manufacturers, wool merchants, silk merchants, mills, etc.).

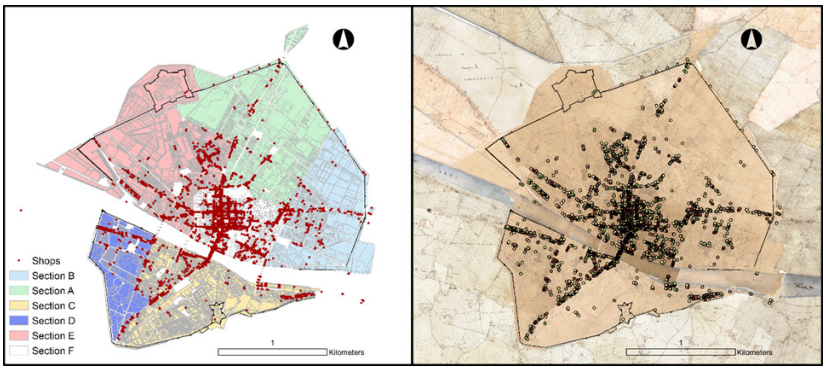

Fig. 5. On the left, overlapping between the parcel layers of the different sections of the community of Florence and the layer of shops. On the right, overlapping between the historical map (CA.STO.RE.) and point layer of the shops by type of activity. Maps by authors.

Considering once again the centre of Florence, the highest number of shops were concentrated in section F. This section was smaller than the others but had the greatest number of vertically developed buildings. Section F was then followed by section E (both in the northern part of the city with respect to the river Arno) and by section C, situated in the southern part of Florence (Fig. 5 left). With regard to how the different shops were distributed in Florence (Fig. 5 right), it is interesting to notice that there are areas where specific products were sold. The most interesting example is the manufacturing and trade of hides, all gathered in the Santa Croce district. Another example is the case of trinket manufacturers in the area around the Duomo or of goldsmiths in the Ponte Vecchio area (who are still there today, after two hundred years). Another interesting aspect to point out is that the owners of several businesses (up to a maximum of ten) often

opened their shops close to each other in the same street or district, if middle-class owners, or in several districts, if religious or noble owners.

If we divide the number of inhabitants by the number of business activities in the main towns, we find that there was one shop for every 30 inhabitants in Florence, one for every 95 in Siena, one for every 87 in Arezzo and one for every 227 in Pisa.[9]

Farmers' markets were held in 55% of the Grand Ducal communities (133 out of a total of 242). This figure was taken from the Reports drawn up by geographer Targioni Tozzetti in 1833, so very close to the land registry date. The data was georeferenced by linking it to the centroid created for each administrative area. If we consider the presence of street markets throughout the Grand Duchy and compare it with the presence of shops, we see that markets were held in all the main villages and towns. Practically no trace of shops can be seen instead in the outlying, mainly rural areas.

In a similar and very interesting manner, the georeferenced data shows that there were almost no shops at all in the Apennine and Romagna areas of Tuscany. The lack of shops was compensated by weekly markets, where traders evidently brought their goods (Fig. 4). Indeed, if we exclude the urban towns and the area to the north-west of Florence and we subtract the raster density models produced using the shapefile of the shops from the shapefile of the markets, we see that there are very few markets and a prevalence of shops in rural areas (Pisan and Grosseto Maremma) and more generally where there are few roads and a high number of scattered houses (Fig. 6).

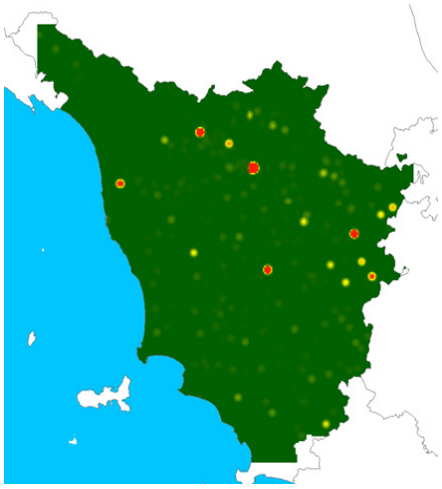

Fig. 6. Concentration map obtained through a Map Algebra operation by subtracting the density map of shops (green) from that of markets (red). Map by authors.

9 The data on the shops taken from the *Tavole dei Proprietari* for the district of Pisa underestimates the number of businesses in Livorno as well. This tells us that the land registry technicians used a different data collection system, a fact that makes us even more aware of the great damage caused by the elimination of the *Tavole di Stima*.

Re-examining traditional studies on the Tuscan sharecropping system

Observing the Tuscan sharecropping system is rather like looking at an object through a kaleidoscope. The image that we see when rotating the instrument generates a multitude of symmetrical figures that shift and change shape although we are looking at (and showing) the same object.

The contract used for the sharecropping system was similar to the *métayare* in France or the *masoveria* in Catalonia, if we wish to geographically remain in the parallels between 40 and 45 degrees north of the western Mediterranean. The contract changed according to place and time: sharecropping in central Italy lasted from the late Middle Ages to the first decades of the twentieth century [11]:243-260.[10] Its term initially lasted several years and then gradually became annual, yet it was always made between two parties:

- The owner, or possessor (usufructuary, emphyteuta or intermediary tenant) of the land (and therefore of the working capital);
- The farmer (with his family) who worked on the farm and gave half of the yield to the owner.

Sharecropping system contacts were made up of many clauses, often deliberately unclear, which were repeated and perpetuated for centuries. According to scholars [12]:139-154; [13]:3-63; [14]:201-259; [15], the origin of this type of contract in central Italy is attributed to the end of noble regimes in towns/cities and to the subsequent creation of manufacturing and trading urban centres with increasingly less mercantile and more land-based interests.

The debate on sharecropping contracts in different areas of Europe dates back to as early as the second half of the eighteenth century according to a physiocratic view, initially in the legal and then in the political and economic spheres [16]:53-101; [17]:110-141. During the twentieth century, physiocracy was regarded negatively among historians of economic thought and economists (both neoclassical and Marxist). The reason was that it contrasted with the model of the large-scale lease of land, considered more suitable for the growth of free enterprise and for the increase in productivity. This thought was fundamental for the germination of first the agricultural and then the industrial revolution [18]:61-82.

Alongside legal and administrative considerations regarding land ownership and management systems, traditional studies dealing with the rural structure of the Grand Duchy have always called attention to the fact that the agricultural backbone of the countries bordering this part of the Mediterranean was always based on three agricultural products: wheat, oil and wine. In all of these studies, from the earliest to the most recent, sharecropping has been associated, particularly in Tuscany, with mixed farming production. It is regarded as the main, if not only, economic resource of the population due to the less significant role played by the Italian and then Mediterranean mercantile sector.

The three-product structure mentioned above has always underestimated or in some ways failed, at least in Tuscany, to give full importance to the value and economic weight of another single-crop rural product of key importance for the survival of entire segments of the population: chestnuts. In the Grand Duchy (1835), chestnut groves covered 5.8% of the entire area of the Lorraine territory, with percentages in the coastal and inland (Apennine) mountains varying

10 Sharecropping was abolished in Italy by Law no. 756 of 15 September 1964. Foremost [11].

between 15.7% and 29.8%.

An adult chestnut tree can produce between 25 and 50 kg of fruit and a hectare of traditional chestnut grove has an average one hundred trees. A simple calculation shows that a traditional forest of one hectare could produce 25 to 30 quintals of chestnuts in return for a very low investment compared to cereal growing. Let us consider wheat production in Tuscany: it had a yield of 3.2 tonnes/hectare yet required fertilisers and animals for ploughing the fields; furthermore, a part of the seed produced (150-200 kg/hectare) had to be kept for the following year. So, considering that the number of calories for fresh chestnuts is 165 kcal/100 g (370 for dry chestnuts), compared to 300/330 kcal per 100 g of durum wheat, we begin to get a good glimpse at how important this fruit – which was also turned into flour for breadmaking – was in Tuscany.

When considering the three-product agricultural model of the Grand Duchy of Tuscany and perhaps of other geographical areas too, this model should clearly be updated with the addition of chestnuts. We should speak therefore of an agricultural system based on four products. This statement shows just how important the georeferencing of nineteenth century factories has been and is confirmed by the number of chestnut dryers analysed (5,794 out of a total of 11,029 factories) and by their geographical distribution throughout Tuscany in mountainous areas lacking suitable climate or soil for growing cereals. Although depopulated today, these areas were once an economic fulcrum thanks to their energy resources (Fig. 7).

A further aspect we focused on when reading the heuristic approach proposed by classical historiography according to which the Grand Duchy of Lorraine had an almost exclusively rural status, regards the true economic characteristics of the Grand Duchy. The idea of an almost agricultural State was borrowed to a large extent from the officials of the Lorraine State. As recalled in the Instructions and Regulations of the Land Registry (1819) and in the Final Report (1834) signed by Giovanni Inghirami and Lapo de Ricci of the Land Registry Deputation, the officials describe the Tuscan economy as depending solely on the 'Agricultural Industry' [19]. Based on the data we have acquired, this inspiring archetype, which is without doubt perfectly fitting for the Medici Grand Duchy, is highly inadequate if we consider the real economic nature of the proto-industrial manufacturing and trading sectors that flourished throughout Tuscany during the second half of the nineteenth century.

The layers of factories and trade activities examined via georeferencing reveal a number of sub-areas (micro-regions) with both productive and trade specialisation patterns. While in the case of shops and markets, these activities were concentrated in areas where people lived, factories instead rose where the energy resources needed to drive the machines were situated. At the same time, they had to be at a reasonable distance (or proximity) from the places where raw materials were produced. The breaking of this balance, due to the introduction of energy from fossil material, led to the demographic impoverishment of what are presently peripheral areas and to the subsequent abandonment/control of the territory.

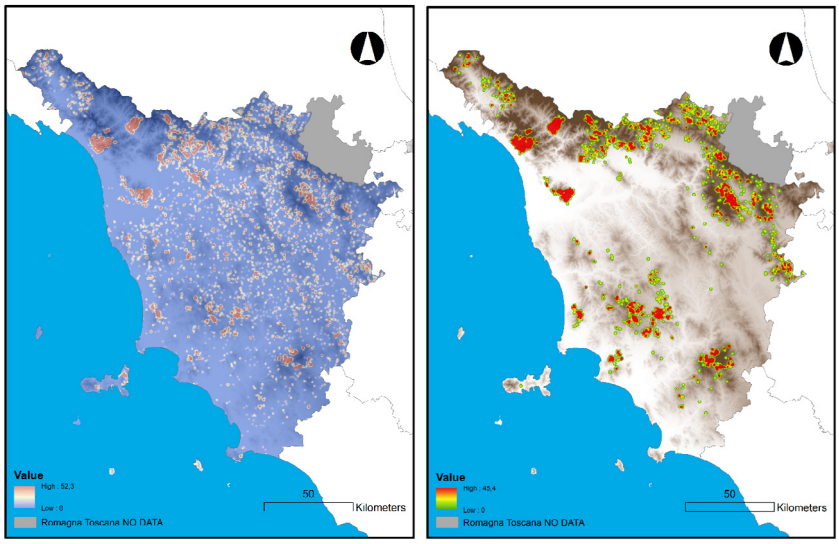

Fig. 7. Concentration maps (with 1 km radius) of factories and annexes (left) and dryers (right) superimposed on the DTM at 20 metres. Maps by authors.

Conclusion

The Grand Duchy of Tuscany is undoubtedly a fortunate case in which an extraordinary number of tax-related cartographic sources, which are quite exceptional for both their quality of compilation and state of preservation, were combined with an equally exceptional readiness by the regional public service to acquire and distribute the digitised data on platforms freely accessible and available to all [27]. This key condition made it possible to create geographical databases that are outstanding in terms of size and data accuracy. Yet they also allowed us to highlight Tuscany's economic activities and the relationship, before the advent of electricity, between delocalised natural resources (almost always water) that drove factory machinery and the raw material supply needs of these same factories (a balance determined by the distance between the road network and the production sites).

The vectorised manufacturing and commercial data of the nineteenth-century Grand Duchy revealed a number of long lasting proto-industrial sub zones located in areas outlying the places where people lived and products were sold. The former, once production hubs of key importance, are currently marginal and often abandoned areas. In fact, we cross-referenced the data on historical factories (12,512 points) with the data on industrial manufactured products in the topographical database of the Region of Tuscany (36,634 polygons). The results revealed that only five of the factories georeferenced in the nineteenth century are still situated in the same geographical position, all with currently different functions. The spatialisation of the information collected with the GIS and through the creation of density maps, clearly shows that the economic axis (Lucca-Pisa-Livorno) was an extremely active polyfunctional area, practically

more important than the much more populated central-northern area (Pistoia-Prato-Firenze) (Fig. 8). The strong connection with energy sources continued until the definite establishment of centralised industry, when factories acquired a more industrial nature and gradually migrated closer to raw materials and communication routes [20]:149-157.

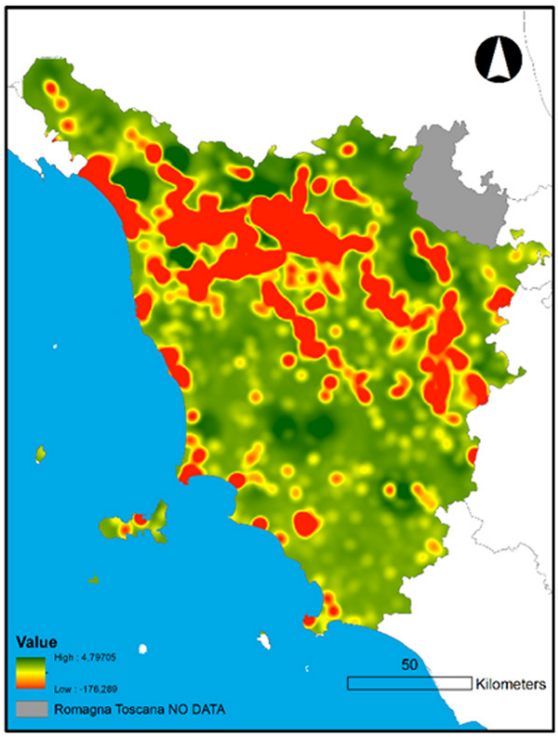

Fig. 8. Concentration map obtained through a Map Algebra operation by subtracting the density map of 1835 factories (green) from that of current Tuscan industries (red). Map by authors.

Examination of the attributes of the geodatabase of Tuscan factories shows how settlement dynamics, which had suffered following the introduction of the first steam engines and centralised industrial systems, received a definite, fatal blow with the onset of the second industrial revolution. The changes in the production systems led to an equally profound and irreversible transformation of the landscape: almost complete abandonment of factory buildings, where one or more households usually lived, and resulting deterioration of the sites (for example, property, roads, vegetation and water systems). The fact that the mountainous areas had lost their economic importance was therefore the main reason for human impoverishment, especially in these areas [21]:14-44. Places that had been inhabited and put to use for over two thousand years ended up being deterritorialised within just a few decades – with different speeds depending on the type of manufacturing and proto-industrial sub area [22]:79-88.

As confirmed by cross-referencing the database of factories with that of industrial manufactured products and buildings in the Tuscany Region DBT, the abandonment of production sites in mountainous areas, that is, those demographically most affected by abandonment, was therefore

one of the factors that had a most significant bearing on a rapidly deteriorating territory.

On the other hand, if we look at the distribution of shops from a geohistorical perspective between 1835 and present day, it is clear that there has been no migration. Quite the opposite, in the face of an extraordinary and diversified growth in the number of urban activities, there has been a general spread of businesses beyond town boundaries.

Vectorisation of the data in the historical cadastral sources made it possible to assess the distributional weight of the productive and economic activities in the different areas of the region and to review the historiographic model of the Grand Duchy of Lorraine which tended to define the State as being exclusively rural. In fact, if we multiply the number of factories and shops by an average number of eight members per family and divide it by the total number of residents in the Grand Duchy (1,375,232), we notice that 11.6% of the population were employed in an economic activity other than sharecropping.[11] Georeferencing of the productive activities also confirmed that the three-product based agricultural model should be replaced by a four-product based model which also includes chestnut cultivation.

The chestnut tree, also called bread tree in these areas, was undoubtedly an essential and significant part of the economy of the (currently marginal) mountainous areas. Yet it clearly extended beyond geographical boundaries if we consider the large number of facilities used for drying chestnuts and turning them into flour.

A final aspect to be highlighted regards the publication of the geodata [23]:4-18. Once systematised, the layer of the factories (and shortly of the shops) was published in open data form with a CC BY 4.0 licence on the cartographic platform of the SITA of the Region of Tuscany (GeoScopio). Here, it can be viewed and searched using, for example, the nineteenth-century cartographic base of CA.STO.RE. as a background or by downloading it directly onto one's own personal computer and using it freely (Fig. 9).

The instrumental use of these geographical databases has ultimately made it possible to broaden knowledge about the Grand Duchy of Tuscany and to produce new meta-sources [24]:40-70; [25]:3-17. Acquiring and combining information about how the places of production, processing and sale of products were geographically distributed expands our understanding of the financial conditions throughout the Grand Duchy at a crucial time that culminated in its accession to the new Kingdom of Italy in 1859 [26]:68-79.

11 Non-productive categories such as the clergy, merchants and nobles should be added to this percentage.

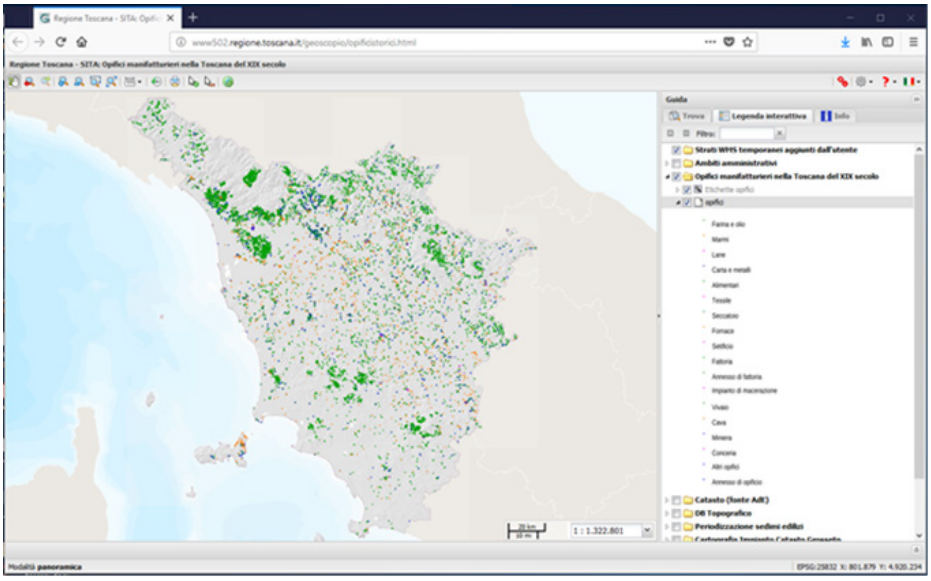

Fig. 9. Screenshot of the WebGIS of the Tuscany Region SITA with uploading of the geographical database of the factories, http://www502.regione.toscana.it/geoscopio/opificistorici.html (last visited, March 13, 2023).

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