The path to survival: the response to the production crisis of the late 18th century in the Spanish region of Guadalajara

DOCTORAL THESIS IN ECONOMIC HISTORY

Carlos Santiago Caballero
Department of Economic History
London School of Economics and Political Science

To my parents and my four brothers

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Abstract

The thesis studies the economy and society of the province of Guadalajara during the eighteenth century, with an especial focus in the production crisis of the 1760s and the way in which the population in the province was able to avoid its negative effects. The contributions of the thesis are several. First it provides an original dataset with more than 200,000 observations that includes time series of grain production, baptisms, burials and prices for the eighteenth century. The dataset also includes a considerable cross section database for more than 1,000 municipalities in New Castile with economic and social variables extracted from the Catastro de la Ensenada. The thesis adds new quantitative information to recent academic debates like the analysis of income inequality in pre-modern times, and the study of economic integration.

The results indicate that the province of Guadalajara did not suffer the effects of a Malthusian crisis for several reasons. Firstly, the region was ready to face a production crisis, thanks to a low population density and a high production of grain per capita. Secondly, income inequality decreased, especially improving the situation of the smallest grain producers. This improvement was particularly intense during the last decades of the eighteenth century coinciding with the production crisis. Finally, the levels of economic integration also allowed producers in Guadalajara to increase their incomes by supplying grain to the surrounding urban areas like the city of Madrid. We will therefore conclude that Guadalajara was able to avoid a Malthusian crisis thanks to the structure of its population, a better distribution of income and due to the high level of economic integration with the rest of New Castile.

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1. Introduction – Sources

1.1 Introduction

Since the publication of "*An Essay on the Principle of Population*" in 1798, the ideas of Thomas Malthus have been highly influential in the literature on economic development. Even today the Malthusian model is presented as the most reliable explaining the relationships between demographic growth and the availability of resources in pre-modern economies. According to the model, in a pre-modern society, population will grow at exponential rates while resources will only grow arithmetically. Therefore the amount of resources per capita will diminish until they reach a point when population levels are not sustainable. At that moment automatic checks such as famines or wars will take place to return population to pre-crisis levels. Therefore, it is the relationship between resources and population that will allow first a sustained demographic growth and later the appearance of a population decline.

This thesis is a study that analyses the evolution of population and grain production in Spain during the eighteenth century. The case study will include the province of Guadalajara, in the interior of Spain and part of the Crown of Castile. Spain did not enjoy the benefits of the industrial revolution that took place in England during the late eighteenth century, and therefore can be classified as a pre-modern society limited to the constraints characteristic of a Malthusian economy. The thesis will introduce the grain production series that have been collected for the province of Guadalajara and that show a sharp decline in the 1760s. The most probable origin of this serious production crisis was a climate change that took place during the second half of the eighteenth century that affected Spain. The short supply of food combined with a growing population led to an increase in the price of grain that reduced the value of real wages. According to a traditional Malthusian model, the limitation of resources as a consequence of the crisis should have had a serious effect on a population that had been growing since the beginning of the century. However, the demographic series that has been collected for Guadalajara does not show any crisis, but rather suggests that the second half of the eighteenth century was a period of strong and sustained demographic growth. The thesis tries to understand how this abnormal situation took place in a pre-modern society and the forces that can explain it beyond the restrictions imposed by a traditional Malthusian model. Economic integration and income inequality are the two missing links that we will analyse, and that will help to better understand how the inhabitants of Guadalajara were able to face a climate change and the subsequent production crisis that took place in the 1760s.

The thesis contributes to different debates that have been highly controversial in the literature of economic history. The most important one is the discussion about the validity of the Malthusian model in the case of pre-modern economies. The thesis will show that even a backward and agrarian society can be able to escape from the Malthusian trap. Another contribution is made to the case of the economic history of eighteenth century Spain. Traditionally considered a century of increasing inequality, the thesis shows that at least in the case of Guadalajara, income inequality decreased particularly during the late eighteenth century. The study of economic integration is another debate that the research will consider, supporting the most recent studies that suggest that economic integration levels in eighteenth century Spain were higher than suggested in traditional literature.

The study will first present a general framework in chapter two, analysing the economic and social environment that surrounded and therefore influenced the province of Guadalajara. The chapter will provide the necessary knowledge to understand the socio-economic environment of the time as well as the institutional framework. Chapter three will consist of a study of climate and geography in both Spain and Guadalajara, to show that the province of Guadalajara is one of the most climatically marginal provinces of Spain, and therefore the ideal place to study the effects of a climate change like the one that took place in the 1760s.

The fourth chapter will introduce the climate change of the late eighteenth century, as well as an analysis of the literature on past climate changes and their origins. The chapter will show that the climate change of the late eighteenth century, also known as the Malda anomaly, was considered one of the most important climatic shifts of the last five hundred years, which consisted of an increase in both inter-annual and intra-annual climatic volatility.

The effects of the Malda anomaly were clear in the production of grain in Guadalajara. Chapter five presents the estimations of grain production, wheat, barley, rye and oats in the province of

Guadalajara during the eighteenth century. The series were created from primary sources and show a sharp decline in the production of grain in the 1760s coinciding with the the Malda anomaly. The chapter will also present an analysis of Guadalajara divided into six different regions that will introduce important differences between the different areas. This study will help to understand the different demographic paths that each area of the province followed during the eighteenth century which will be analyzed in chapter six.

According to a traditional Malthusian model, the decrease in grain production should have had produced a crisis with regards to population levels. Chapter six presents a regional social and demographic study of Guadalajara. In the second part of the chapter we estimate the population of Guadalajara during the eighteenth century using baptismal and burial records. The series show that during the production crisis the demographic series does not show any decline, and that in fact the second half of the eighteenth century is a period of strong and sustained demographic growth, even more intense than during the first half of the century.

The next two chapters of the thesis introduce two new variables that help to understand why Malthusian theory fails to explain the behavior of a pre-modern economy such as Guadalajara. Chapter seven introduces the concept of income inequality and its role in the demographic outcome of a production crisis. Amartya Sen used income inequality to show how famines could appear in cases where the production of food did not diminish. we used the same argument but in the opposite direction, trying to explain how the population grew while facing a decrease in the quantity of food available. Sen's explanation is based on his entitlements theory, and explains that what matters is not just how production changed but also how well that production was distributed between the members of society. Therefore in a society where production decreases but equality improves, the population can increase if indeed that production is better distributed between its members. Measuring inequality in the production of grain, we found that inequality decreased during the second half of the century, and that this pattern was more intense between the smallest producers. Therefore, by applying Sens entitlements ideas as a theoretical framework, it helps explain how population increased in Guadalajara in conjunction when production, in per capita terms, was diminishing.

Chapter eight studies the levels of economic integration in Castile during the eighteenth century. Pre-modern societies are normally associated to close economies with low levels of economic integration. This chapter will show however that the levels of economic integration in eighteenth century Castile were higher than expected by the traditional literature, and that the links between the provinces in the interior of Castile improved during the second half of the century. If economic integration increases, then the effects of a production crisis can be avoided by importing the necessary resources from surrounding areas or even from international markets. Therefore the high levels of economic integration in the second half of the century helped to avoid some of the worst effects of the production decline that took place in Guadalajara.

The last chapter of the thesis combines the information from all the previous chapters and tries to answer the main question of the thesis. How did a pre-modern society avoid the effects of a production crisis? The chapter explains in depth a traditional Malthusian model, and the links between the main demographic, economic and climatic variables that it includes. After presenting the different links and supporting them both theoretically and empirically, we introduce the concepts of economic integration and income inequality in order to complete it, and to explain why Malthusian theory failed to explain the demographic behaviour of eighteenth century Guadalajara.

1.2 Sources

The information presented in this thesis includes estimations from primary sources of several economic and social variables. The main series estimate grain production, fertility, mortality and grain prices for eighteenth century Guadalajara and Madrid. The *tazmias* (tithes), baptisms, burials and accounting books from ecclesiastical authorities are the base for the time series analysis of the thesis. They provide the yearly data for the whole eighteenth century. In this case the samples have been selected based on the availability of primary sources in the different archives, and this availability, or lack of it, has been the main factor in the selection of the different municipalities. The *Catastro de la Ensenada* on the other hand provides the information to carry out the cross section analyses in the mid eighteenth century that are the complement to the time series analysis, and allows us intra and inter-regional comparisons.[1]

The final dataset includes more than 200,000 observations from individual producers, households and ecclesiastical authorities directly extracted from the manuscripts kept in the Historical Diocesan Archive of Sigüenza-Guadalajara, the Historical Diocesan Archive of Getafe, the National Historical Archive and the Municipal Historical Archive of Getafe. Although a total estimation of the amount of documentation is always difficult, an initial calculation suggests that the reading of between 40,000 to 50,000 pages of manuscripts were necessary in order to construct the dataset.

[1] The Catastro was a general survey that took place in the early 1750s in all the villages and towns of the Crown of Castile and that contains information about the economy and society of each municipality.

1.2.1 Grain production

From Old English *teotha* (tenth), the tithe represented a yearly tax that had to be paid by every producer to the ecclesiastical authorities. The first citations to the tithe can be found in the Old Testament, where according to the Genesis Abram paid the tithe to Melchizedek, the King of Salem (Jerusalem) who also occupied the charge or priest of El Elyon ("the Most High God") (Genesis 14:18). It was a common feature in the economic framework of the middle ages and of modern European countries. In Spain the tithe survived until the *Desamortizacion of Mendizabal*, a process of confiscation of ecclesiastical properties led by the liberal Spanish government in 1837.

The tithe series presented in this thesis have been extracted from the tazmias books of every village and town included in the sample.[2] The books were written in every parish and in the twentieth century were transferred and centralized in the Historical Diocesan Archive of Sigüenza. The tazmias books are a very rich source of information for economic historians, and include detailed records about the amount that was taxed by the church to every peasant in every town and village. This level of detail is not a common feature, as most of the records in countries like England only kept the total amount of product taxed and not the distribution per producer. The use of tithe records to analyse the evolution of agrarian production has been a common feature in the economic history of Spain.[3]

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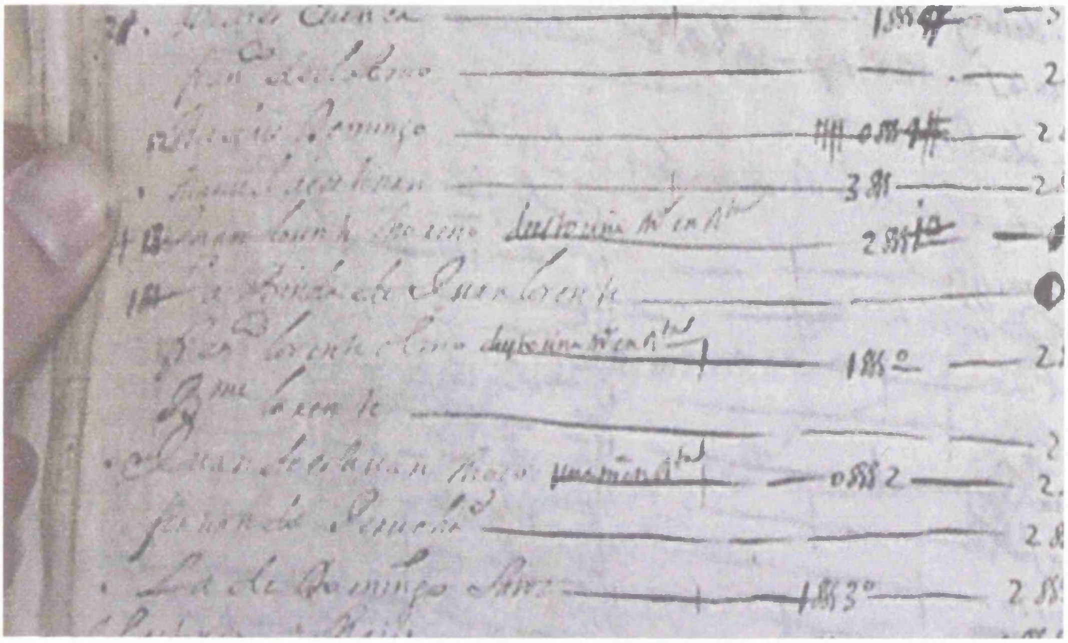
[2] The series corresponds to the following municipalities and parishes: Alboreca/San Andres, Alcuneza/ San Pedro, Alpedroches/Asuncion de Nuestra Señora, Angon/Santa Catalina, Anquela del Pedregal/Asuncion de Nuestra Señora, Aragosa/Nuestra Señora de la Paz, Bañuelos/Asuncion de Nuestra Señora, Canales de Molina/San Cristóbal, Cantalojas/San Julian, Castejon de Henares/San Miguel, Ciruelos del Pinar/Santa Magdalena, La Fuensaviñan/Asuncion de Nuestra Señora, Galve de Sorbe/Asuncion de Nuestra Señora, Herreria/Asuncion de Nuestra Señora, Hijes/Natividad, Ledanca/Asuncion de Nuestra Señora, Miedes de Atienza/Natividad, Mohares/San Cristóbal, Riba de Saelices/Santa Maria Magdalena, Rillo de Gallo/Santo Domingo de Guzman, Santiuste/Transfiguración, Sienes/Santa Eulalia, Torrubia/Asuncion de Nuestra Señora, Trillo/Asuncion de Nuestra Señora, Valdelcubo/Santiago, Villares de Jadraque/Natividad and Villaseca de Henares/San Blas.

[3] Ladurie, E. and Goy, J., *Tithe and agrarian history from the fourteenth to the nineteenth centuries: an essay in comparative history* (Cambridge, Cambridge University Press, 1982)

Figure 1.1: Example of an eighteenth century tithe book



Tithes reflect the evolution of real production trends when two basic conditions are met. Firstly the amount that the tithe represents and therefore the amount that the peasant is taxed has to be constant during the whole period, and if it changes then we should know this happened to calibrate the estimations. If that is not the case, then the estimations of real production would lead to erroneous conclusions and miscalculations. Secondly the effects of cheating have to be small. If an important share of the harvest is hidden from the eyes of the ecclesiastical authorities that collected the tithe, the estimation of total production would again be seriously undermined. In response to the first condition, the tithe series presented in this work always represented ten per cent of the total harvest. There was a wide range of information about ecclesiastical taxes in the tazmias books that not only contained tithe records. For instance apart from the ten per cent of the tithe, the books also included the payment of primicias, a tax that did not represent a direct percentage of the harvest but a fixed tax that was paid once the production of the peasant surpassed a certain threshold under which the producer was exempt from pa ying it. However, this information has been excluded from the estimations and therefore do not influence the results in any way. The second important point is that the tithe remained at a flat ten per cent during the whole eighteenth century, and therefore miscalculations based on the movements of the tax should not represent a problem. About the second matter, the occultation of part of the harvest by the peasant, cheating was not a significant force until the political and social turmoil created by the Napoleonic wars in the early nineteenth century.[4] One of the ways of detecting the amount of cheating was the existence of trials for hiding part of the harvest. These sort of trials existed and they normally were recorded. The lack of information about them in the books reflect the fact that cheating was still not as generalized as it would be in the following century. The option of cheating was not just risky, but also normally condemned to failure in Guadalajara where villages were very small and therefore the control of the local priest very high. The description of the tithes and the way the tax was defined was perfectly explained in the answers to the Catastro de la Ensenada.

To the fifteenth [question] they said that in this village of Alboreca there are several taxes, tithe rights and primicia that in the case of wheat, barley and oats for every ten fanegas one is paid. In the case of wool one out of ten [units], one lamb out of every ten and also one cheese out of every ten, and that in the primicia one half fanega is paid for every eleven, for all these species and also for rye and peas if they are cultivated. If that amount is not reached everything that exceeds ten will be collected until the previously mentioned eleven. And although the harvest exceeded those eleven nothing else will be paid. And if the production does not reach ten half fanegas then nothing will be paid at all from this right of primicias, understanding that this right is not performed in the case of oats, and that it is a right that is property of the priest of the parish of the mentioned village of Alboreca and as such he receives it.[5]

The series collected start in 1678 and finish in 1811, although the amount of information available differs significantly depending on the municipality. There are complete series for the whole eighteenth century for fourteen municipalities. On the other hand the village of Trillo only has information of tithes from 1760. A total of 25 tithe series were collected, and have been smoothed with the application of a 9 years moving average centred in the fifth year. The existence of small information gaps was solved by using simple interpolation, in the case of longer periods of time like four or five years, the results were based on an estimation extracted from the other tithe series in all the cases with correlation coefficients higher than 70 per cent.

1.2.2 Demographic variables

Fertility has been estimated by using baptismal records, also kept by the local parishes. The dataset has been entirely extracted from the historical archive of Siguenza-Guadalajara and includes 25

[4] Garcia Sanz, A."La produccion de cereales y leguminosas en Castilla la Vieja. Los diezmos del Obispado de Segovia de 1570 a 1800" in Ladurie, E.L.R., and Goy, J., Tithe *and agrarian history from the fourteenth to the nineteenth centuries: an essay in comparative history* (Cambridge, Cambridge University Press, 1982)

[5] Catastro de la Ensenada. Book of Alboreca, pp. 241-242.

municipalities from the province of Guadalajara. [6] Baptismal records have been widely used in the literature as the most important proxy of demographic changes in early modern times. Some authors such as Nadal have indeed accepted baptismal series even as a good proxy of population trends.[7] Alvar has also used baptismal records, assuming an average of 40 births per 1,000 inhabitants he multiplied the number of baptisms by 40 in order to get an estimation of total population. [8] The main problem in this case is the difference between the number of births and the number of baptisms. It is clear that not all the births ended up in a baptism and that a percentage of the babies that were born died before they could be baptised. However in the case of Spain, this problem was not as significant as in other parts of Europe. The time that passed between the birth and the baptisms was very short, and in many cases it took less than a week since the baby was born until he was baptised.[9] Therefore although there is obviously some room for miscalculations, we believe that the percentage of births that was not recorded was relatively low.

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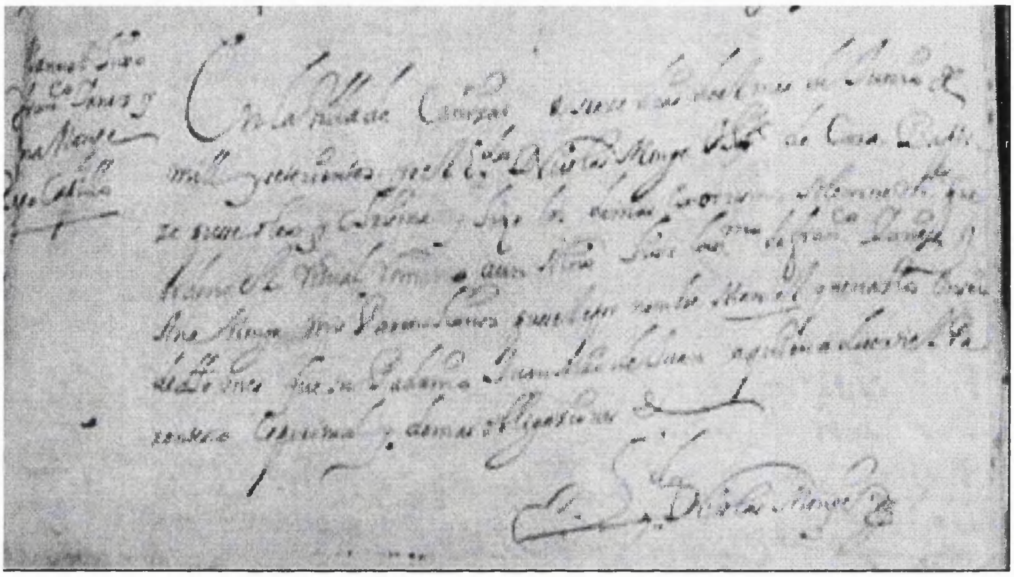
[6] The series includes the following municipalities and parishes: Albares/San Esteban, Anchuela del Pedregal/San Andres, Anquela del Ducado/San Martin, Arroyo/Inmaculada, Bañuelos/Asunción de Nuestra Señora, La Bodera/Santiago, Cantalojas/San Julian, Cañizares, Castilmimbre/Asunción de Nuestra Señora, Ciruelos del Pinar/Santa Magdalena, La Cobeta/ Asunción de Nuestra Señora, Concha/San Juan Bautista, Congostrina/Asunción de Nuestra Señora, Galve de Sorbe/Asunción de Nuestra Señora, Garbajosa/San Miguel, Hijes/Natividad, Milmarcos/San Juan Bautista, Olmeda de Jadraque/San Mateo, Peralejos de las Truchas/San Mateo, Renales/San Sebastián, Riba de Saelices/Santa Maria Magdalena, Setiles/Asunción de Nuestra Señora, Sienes/Santa Eulalia, Somolinos/Inmaculada and Torrubia/Asunción de Nuestra Señora.

[7]Perez Moreda, V and Reher, D., *Demografía histórica en España*, (Madrid: Ediciones El Arquero, 1988) for a most recent study see Llopis E., "El crecimiento de la población española, 1700-1849: índices regionales y nacional de bautismos." *Revista de ciencias sociales* (24) 9-24. (2004)

[8]Alvar Ezquerra, A., "Demografia rural y Fuentes no parroquiales. El centro y el oriente madrileños" *Cuadernos de Historia Moderna*, Nº-10. (1989-1990) p.12

[9] Reher, D.S., *Familia, población y sociedad en la provincia de Cuenca*, 1700-1970 (Madrid: Centro de Investigaciones Sociologicas, 1988)

Figure 1.2: Example of an eighteenth century baptisms book



In the case of mortality, we have used burial records also kept by the local parishes in the province of Guadalajara. In this case the sample was not as big as in the case of baptisms, and the geographical coverage was not as generous either.[10] However the reliability of burial series as proxy of mortality is very high, as all the deaths were properly recorded by the church. Therefore some of the problems that appear in the case of fertility do not affect the consistency ad robustness of the estimations of mortality.

1.2.3 Prices

The thesis uses many different price series, and although most of them come from secondary sources, some of them have been produced from primary sources. This is the case for wheat and barley prices for Madrid that were extracted from accounting books of the parish of Santa Maria Magdalena in Getafe. There were several reasons behind the creation of these series. Firstly, the material in the historical diocesan archive of Siguenza-Guadalajara does not provide enough evidence to create grain price series for the province of Guadalajara. Secondly, the closest available series from secondary sources came from Hamilton and the town of Toledo. Therefore we decided to create a new series for Madrid, geographically closer to Guadalajara and with enough material from primary sources to carry out the research. There was another important reason to choose Madrid. As the political and economic centre of Castile, Madrid was the most important market for the surrounding provinces, including Guadalajara. Therefore the study of prices in Madrid is a key element in assessing the effects of prices on incomes of the producers of Guadalajara. The series

[10] Cantalojas, Hijes, Galve de Sorbe, Bañuelos, Somolinos, Milmarcos, Valdelcubo, Torrubia, Adobes and Azañon.

were extracted from the accounts of the parish of Santa Maria Magdalena that every year sold the surplus of grains to the market, a movement that was always carefully registered in the accounting books of the parish. The sale took place always at the same time of the year, avoiding the consistency problems consequence of the intra-annual cyclical changes of grain prices.

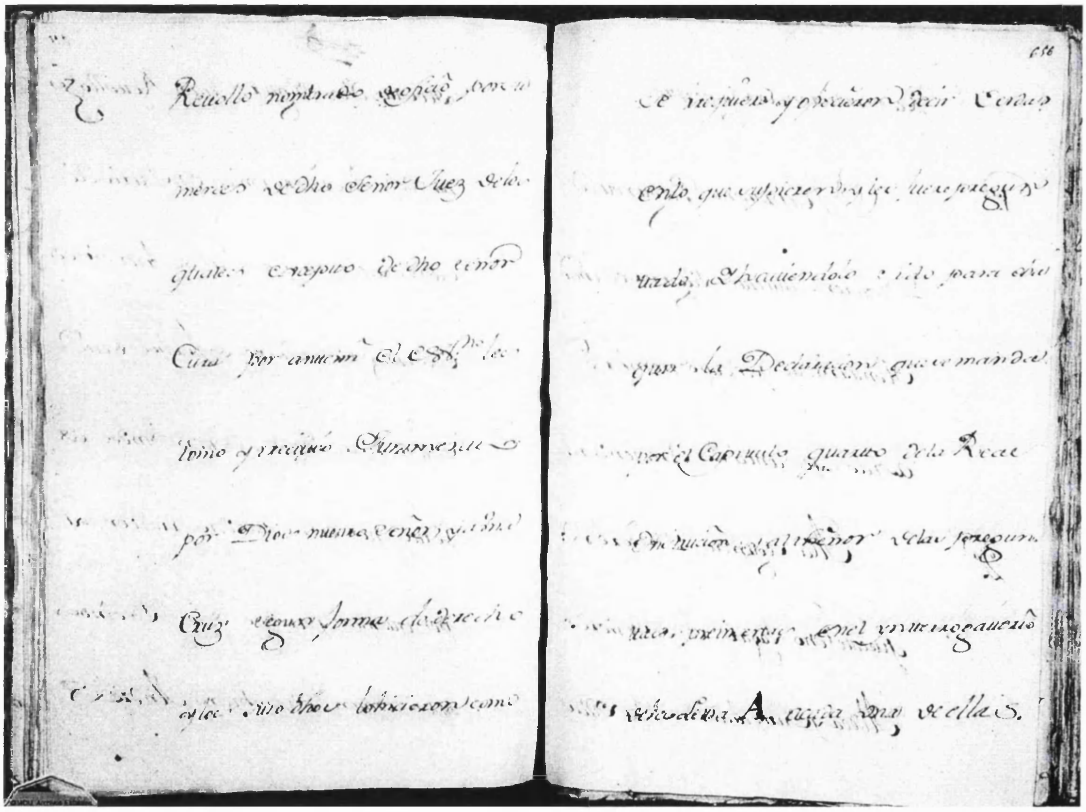
1.2.4 Catastro de la Ensenada

The Catastro de la Ensenada is a census ordered in 1749 and that covers more than 15,000 towns and villages in the Crown of Castile. The origins of the Catastro can be found on the intentions of the government to impose a tax to substitute the old tax system, and therefore includes information about goods, prices, production, wages, etc. However the reality is that the Catastro is a monumental work that includes information about the Castilian society and economy in almost every single aspect. Every municipality had to give information about its name, limits, houses, wealth, production, livestock, trade, manufactures as well as a long list of socio-economic variables. It consisted of 40 general questions that were submitted to every village in the kingdom. The following map presents the provinces where the survey took place.

Figure 1.3: Guadalajara within the Crown of Castile

The process to answer the questions was perfectly outlined in the order published the 10th of October 1749. First the major of the village received a letter from the provincial authorities noting the date when the royal order would arrive as well as to make public the information that was attached to it. The second step was the election of a committee in the village that would be responsible to answer the 40 questions. They were chosen by the local council and included two or more experts on the criteria demanded by the order, like the different lands, products, population, etc. The third stage included the arrival of the external authority that had to carry out the questionnaire, with the help of a lawyer, a scrivener, and the experts that were necessary in every case. Then the local authorities with the committee chosen were called to an audience. The last step was the proper answer that the committee had to give to the questions that were annotated by the scrivener. All the members declaring took an oath with the local priest as witness.

Figure 1.4: Example of the Catastro de la Ensenada



The process although systematic was long and not always satisfactory. Nevertheless even taking these problems into account, the Catastro is without a doubt the most important descriptive work of Castile of modern times. The survey started by asking the name of the village or town, its political status and its size, municipality and neighbouring settlements. From the forty questions included in the survey, we can obtain information about economic and social variables for every village in Castile. For instance, question number fourteen asked about the amount of food produced both in quantity and value. The exact content of the question was:

"What is the normal value that every year the fruits have *produced by the lands of the municipality, and what was their quality."*

The answers to the questions were literal, for example, the authorities from the village of Benquerencia de la Serena answered the previous question by skating:

"every fanega of wheat that is harvested in the village considering some years with others is sold in sixteen reales, the one of rye in eleven and the one of barley in eight ..."[11]

The prices and all of the quantitative information included in the Catastro was not just specific for the year when the answers were given, but an average of several years that were normally the five previous to the interview. If that was not the case and the value given was the one for a single year, then the information could be affected by short term events and therefore would present methodological problems. Another important aspect to highlight is that the Catastro was carried out over several years, and that if the values given in the answers were the ones of a specific year, then the cross section comparisons could be misleading. Therefore the nature of the answer allows us to avoid these problems and therefore improves the reliability of the source.

The geographical coverage of the dataset includes the six provinces of Castile with more than a thousand towns and villages.[12] In this case, the dataset includes the price of wheat, population, number of poor people and the hours necessary to walk one league. In the case of the province of Guadalajara, the dataset is more generous in terms of variables, including more than three hundred municipalities from the province. Some of the variables that have been extracted from the Catastro in this case include the size of the municipality, the number of peasants, shepherds, workers, aristocrats, wages, taxes paid, production of grain and wool, etc.

During the eighteenth century, when the Catastro de la Ensenada was created, the geographical boundaries of the province of Guadalajara did not match the ones in the present. In the early 1750s current Guadalajara was divided into six different provinces: Madrid, Cuenca, Soria, Segovia, Toledo and Guadalajara itself.

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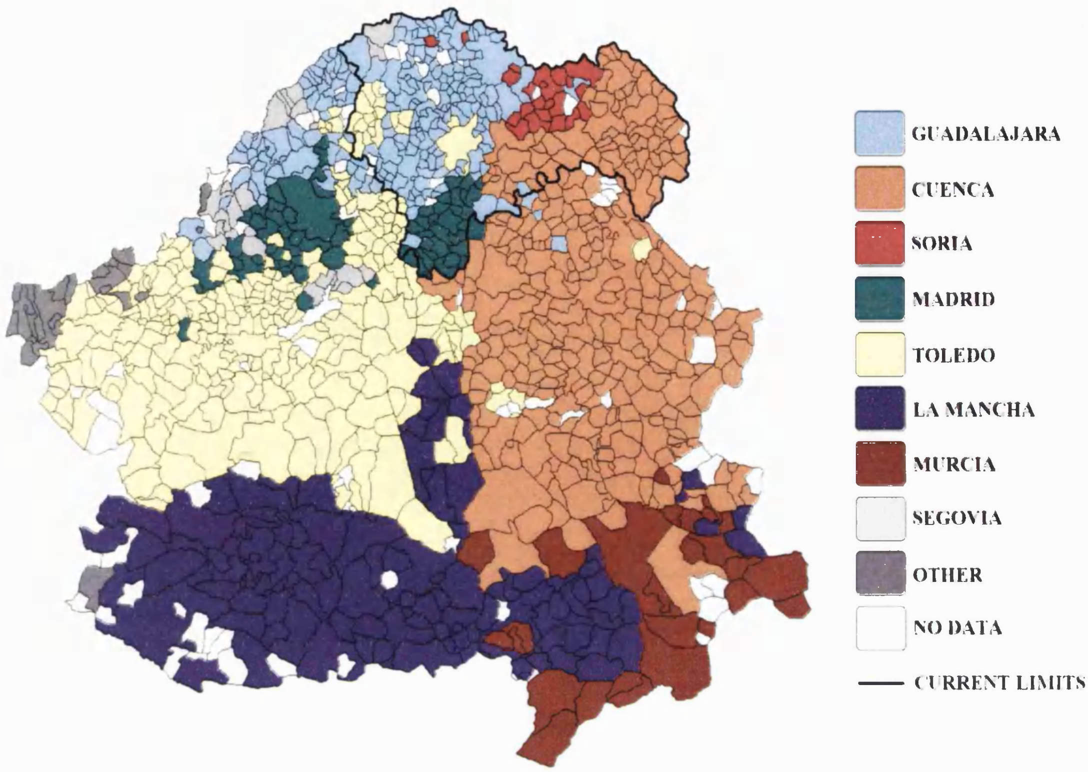
[11] Catastro de la Ensenada, book of Benquerencia de la Serena
[12] The provinces are by their modern name, Madrid, Guadalajara, Toledo, Cuenca, Ciudad Real and Albacete.

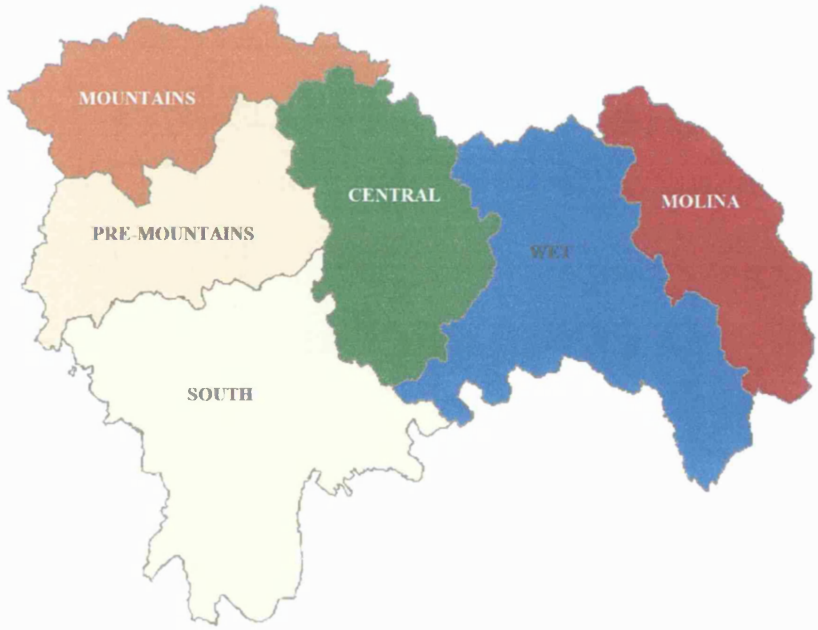
Figure 1.5: Old and current limits of Guadalajara



However the geographical scope of this thesis includes not the old boundaries presented in the map in light blue, but the current ones defined by the black line. Therefore the main problem relies on the elaboration of macroeconomic figures for the whole province from the aggregated information in the Catastro, that as previously explained, includes the information for the old boundaries. Therefore, in order to maintain consistency, we did not use that macroeconomic information provided by the Catastro. When the average or macroeconomic results are presented for Guadalajara, the information has been elaborated by including all the municipalities that are present within the modern limits and averaging or aggregating them accordingly to obtain the macro figures. The same procedure was followed in the choice of the samples for the production or demographic variables that in order to represent current Guadalajara, include municipalities that in the eighteenth century were located in other provinces. It is therefore important to note that the geographical boundaries of the thesis are based on the current province of Guadalajara, and that the information and datasets collected match with them.

We decided to divide the province of Guadalajara into six main regions based on environmental and demographic factors. The division takes into account the geography of the regions, the climatic conditions in the different parts of Guadalajara, and also the spatial distribution of the population. The region of the mountains includes those villages that are literally situated in the hilly areas in the north of Guadalajara. The region of Molina comprises the eastern border of Guadalajara. The South includes the more urbanized areas located in the south west of the province. The Pre-Mountains region occupies the area between the South and the region of the Mountains. The Wet region includes the areas in the middle of Guadalajara that were benefited by higher levels of rainfall. Finally the Centre includes the villages and towns between the Wet region and the South.

Figure 1.6: Regional division of Guadalajara



2. Guadalajara within the Spanish framework

2.1 Social structure

The social structure of Spain was relatively stable from the middle ages to the early modern and modern times. Society was stratified into classes with the aristocracy and the church on the top, followed by a majority of workers and peasants that were not just the labour base of the country, but also its financial foundations. This section will introduce the relationship between the main social classes and the control of land.

2.1.1 The four pillars of the social system

The ***church*** was one of the main social and institutional pillars of the old regime in Spain, and was also one of the main owners of land in the country. The rights that had been acquired for centuries had been supported and defended by the crown since medieval times. The amount of land in the hands of the church increased during the modern age, and the eighteenth century was not an exception to this trend. The Catastro de la Ensenada points out that in the mid-eighteenth century the clergy controlled up to 12.3 per cent of the lands and between 20 to 24 per cent of the agrarian production in the Crown of Castile. [13] The difference between both numbers indicates that the land that were controlled by the church were in general more productive. This situation produced a significant number of complaints, and Campomanes who controlled the finances of the Spanish government in 1760 criticized the privileges of the church on his Treaty of the Regalia of the Amortization.

[13] Marcos Martin, A., *España en los siglos XVI, XVII y XVIII* (Critica, Barcelona, 2000) p.184.

Table 2.1: Distribution of land and agrarian production (value) in the Crown of Castile in the mid 18th century.[14]

	Property of land				Agrarian production			
	Civil		Ecclesiastical		Civil		Ecclesiastical	
	Reales	%	Reales	%	Reales	%	Reales	%
Avila	1,015,306	80.2	251,361	19.8	13,619,518	73.1	500,910	26.9
Burgos	4,473,697	83.3	898,524	16.7	44,926,178	79.2	11,770,064	20.8
Cordoba	1,172,025	80.1	290,407	19.9	30,930,950	70.6	12,856,013	29.4
Cuenca	7,225,568	90.0	805,279	10.0	32,264,682	77.6	9,327,595	22.4
Extremadura	4,194,558	78.5	1,148,843	21.5	57,268,892	71.7	22,582,254	28.3
Galicia	1,301,019	94.2	794,041	5.8	92,503,141	92.0	7,997,926	8.0
Granada	2,708,711	82.8	562,543	17.2	55,245,279	77.4	16,114,678	22.6
Guadalajara	1,325,028	86.4	208,272	13.6	19,597,018	76.3	6,092,198	23.7
Jaen	2,029,081	85.3	348,385	14.7	22,976,342	67.4	11,107,354	32.6
Leon	10,205,198	87.5	1,462,753	12.5	48,959,864	78.2	13,674,843	21.8
Madrid	473,375	82.4	101,258	17.6	18,293,512	77.4	5,335,397	22.6
Mancha	3,256,618	72.8	1,217,853	27.2	29,847,139	72.7	11,203,436	27.3
Murcia	1,195,168	87.6	169,354	12.4	72,489,753	85.2	12,573,204	14.8
Palencia	3,577,392	83.2	723,168	16.8	16,965,476	74.1	5,934,819	25.9
Salamanca	1,453,343	73.3	528,267	26.7	15,691,716	62.1	9,582,736	37.9
Segovia	1,623,866	86.9	244,922	13.1	21,795,271	76.3	6,761,521	23.6
Sevilla	3,079,128	80.0	770,818	20.0	97,093,594	71.0	39,601,230	29.0
Soria	3,591,994	90.6	373,741	9.4	22,023,078	75.9	6,979,336	24.0
Toledo	2,887,484	79.5	742,403	20.5	53,914,771	70.3	22,818,677	29.7
Toro	998,843	81.2	230,960	18.8	15,426,848	71.5	6,157,572	28.5
Valladolid	1,499,476	80.9	354,160	19.1	26,175,873	69.6	11,444,730	30.4
Zamora	202,032	72.6	76,183	27.4	8,657,902	64.7	4,729,654	35.3
Total	71,188,910	85.3	12,303,495	14.7	816,666,797	75.9	259,654,410	24.1

Aristocracy was one of the other pillars of the old regime, and like the church, a member of the nobility counted on a very favourable institutional and legal framework to maintain its privileges and control significant amounts of land. The *majorat* was probably the most important institution in terms of land property. The *majorat* did not just allow the aristocrats to retain the control of the land that they possessed, but also included other measures that made the transmission of its property impossible. According to the law, the property of all the land had to be inherited entirely by the oldest son or by a close relative if there was none. It became legal in Spain in 1505 and was not

[14] Marcos Martin, A., *Economia, sociedad, pobreza en Castilla, 1500-1814* (Excma. Diputación Provincial de Palencia, 1985) p.103.

abolished until the early nineteenth century after the social and political turmoil created by the Napoleonic invasion. The agglomeration of land in the hands of a few land owners acted as a disincentive to increase the productivity of land, as unlike in many parts of England, in Spain the concentration of land did not led to the existence of economies of scale and was more a question of social prestige rather than of economic profitability.

The ***bourgeoisie*** was also interested in the agrarian economy, and the urban elites increased their properties in the countryside. The reasons behind this situation were diverse, although more than economic, as in the case of the aristocracy, they responded to the desire of improving their social status. The control of land was seen in modern Spain as a sign of social prosperity and in many cases as a necessary step to become an aristocrat.

Peasantry composed the lowest social class, a group that during the eighteenth century lost not just access to common land, but also to part of the land that they owned. Given the legal framework that has been presented above, it is easy to understand how the church and aristocracy were able to maintain the control of their properties. In the same way it is easy to explain how many unprotected peasants lost the control of their land and saw how the power and influence of the privileged classes in the agrarian economy increased. According to the census of Godoy in 1791, during the late eighteenth century agrarian workers represented 52.8 per cent of the total population in the countryside, peasants that rented land represented 30.3 per cent and peasants that owned their own land a mere 16.5 per cent.[15] During the eighteenth century, the amount of peasants with land decreased to levels that had only been reached at the end of the sixteenth century. In Old Castile they represented 22.9 per cent of the total rural population, in Extremadura on the other hand just 13 per cent. The number of agrarian workers in New Castile was around 66 per cent, similar to many provinces in Andalusia that were characterised by the existence of *latifundios* or huge properties in the hands of a single owner.[16]

Therefore, the economic inequality between classes that was common in the early modern age worsened in Spain during the seventeenth and the eighteenth centuries. The forces behind this process were above all the static governments that never challenged the interests of the church and the aristocracy, and therefore the lack of reforms that were put in place were immediately counterbalanced by the actions of the privileged classes.

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[15]Marcos Martin, *Economia, sociedad,* p.192.
[16]Marcos Martin, *Economia, sociedad* p.621.

2.1.2 The reforms of the Bourbons

Too little and too late is the definition that most academics present to explain the reforms that were tried by some of the Bourbon governments in Spain during the eighteenth century. Bourbon monarchs were especially concerned about the supply of food in the country, and to achieve complete self sufficiency in the production and consumption of food products. The food trade deficit in Spain had reached maximum levels at the end of the eighteenth century when under strong demographic pressures, up to one million fanegas of wheat had to be imported to guarantee the supply of food.[17]

The ideals of the Bourbon governments were based on an idyllic society composed by small and medium agrarian producers, with enough economic independence to guarantee their own supply. The incentives of holding private property would also encourage them to invest in improving their land and therefore also to increase their productivity. However, these good intentions and liberalizing policies were always careful not to alter the social order that was in place in Spain, with the privileges of the church and aristocracy kept intact. The contemporary politician Campomanes suggested that the problem was not who owned the land, but making sure that small peasants could be able to rent them at appropriate prices. Therefore the policies pointed out to the contractual framework and not to the property rights in the land market.[18]

One of the ways of increasing the production of food without changing the property rights of the land was the repopulation of areas with low population density, where the productive potential had not been yet reached and the availability of land was higher than in other parts of Spain. A good example of this sort of "colonization" is the case of La Carolina, a village founded in 1767 under the reign of Carlos III and the capital of the new settlements that were created in the region of Sierra Morena in the south of Spain. However the extent of the repopulations was very modest and therefore did not have a significant impact in the agrarian economy of the country. A second option of making more land available for the small producers without touching the lands of the privileged classes was the privatization of the common lands in the hands of the local governments. However, as mentioned above, the amount of these lands had been reduced considerably during the eighteenth century, and also counted on the opposition of pressure groups that were contrary to the expansion of arable land. Facing some opposition the distribution of common lands increased at the end of the

[17] Marcos Martin, *Economia, sociedad,* p.626.
[18] Marcos Martin, *Economia, sociedad,* p.223.

1760s and were legally recognised and regulated in the Royal Provision of the 26th of May, 1770.[19] Although the allocation of lands was not ideal and some of them did not reach the smaller producers, it helped to improve the situation of some peasants and increased the amount of arable land at their disposal.

The different Bourbon governments also tried to apply other policies in order to reduce the risk of the peasants who rented lands, through intervention in the nature of the contracts. These interventions consisted of different legal changes such as the Real Decreto of the 26th of March 1764, or the Real Provision of 1763. The first one gave support to the colonizers against land owners and the second one tried to avoid expropriations of land from small peasants in Galicia, a support that was extended to the rest of the territories of Spain with the Real Provision of the 20th of December 1768.[20] However, not all the legislative changes were equally positive for small peasants, for example the Real Provision of the 26th of May 1770 that liberalised evictions.[21] The reforms also tried to reduce the power of some economic pressure groups like the Mesta, a powerful organization of livestock owners that had maintained important privileges since medieval times. The rights of the Mesta were seen by the governments as an important break for the agrarian development of the country, and the pressure over the organization increased especially during the 1770s when small and medium livestock owners saw how their right to access pastures was reduced.[22]

However, the most important economic reform was probably the liberalization of grain trade through the law implemented on 11th of July 1765. The new law tried to improve the stability of grain prices that had increased considerably and to raise the production of grain. It also tried to improve the internal movement of grain in order to face the alimentary deficit that Spain was suffering. The main change was the suppression of the maximum price of grain that was controlled by the government, and the end of the prohibition of reselling grains in the market. However the reform was too ambitious and it was not backed by the resources required to guarantee its application. Political and social pressures from groups like city authorities and big land owners immediately appeared, and were able to reduce the scope of the reform and in many cases even to avoid its complete application.

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[19]Llopis, E., "Expansion, reformismo y obstáculos al crecimiento (1715-1840)" in Comin, F., Hernandez, M. and Llopis, E., *Historia economica de España.* (Barcelona: Critica, 2002) p.28.
[20] Marcos Martin, *Economia, sociedad,* p.217 and Llopis, E., "Expansion, reformismo", p.27.
[21] Marcos Martin, *Economia, sociedad,* p.225.
[22] Llopis "Expansion, reformismo", p.29.

The consequences of the liberalization of grain trade were not the expected ones. The elimination of the maximum price allowed an increase in the stocks of grain. One of the positive results of the reform was the reinforcement of the internal grain market that started to be developed during the first decades of the eighteenth century. [23] The decades after the liberalization experienced an increase in the levels of economic integration between the main Spanish urban centres, although some authors such as Llopis argue that the integration of prices was not a consequence of a direct movement of grains, but rather of the reduction of information costs.[24] The volatility of grain prices was also reduced during the decades that followed the reform. [25] However the main problem that the reformers faced was the uneven distribution of land, and this was the main reason behind the failure of the changes. The elimination of a maximum price meant that speculators and big producers could retain production when the prices were generally low and release it when they increased, especially under strong demographic pressures.[26] Therefore a reform that was aimed to help small producers and guarantee the supply of food benefited big land owners and worsened the situation of the consumer. Production therefore was not increased, and years after its promulgation, the law of 1765 was heavily criticized. Future reforms like the Expedient of Agrarian Law were not materialized, and the failure of the changes created an economy that was not able to face the demographic growth of the eighteenth century.

The Bourbons also tried to reform the financial system that was considered one of the major breaks for the development of the Spanish economy. The Bank of San Carlos was created in 1782 in the law of the 2nd of June. The main purpose of the bank was to support the financial necessities of the state that was involved in numerous military conflicts during the late eighteenth century. Foreign policy was based on the recovery of the trade with America and the territories that had been lost by the Treaty of Utrecht. The aggressive policy included wars with France, England and Portugal that increased military expenditures up to 60 per cent of the royal budget. [27] Until the second half of the 1790s the cost of wars had remained relatively constant, but since then it increased significantly and the emission of government bonds for the value of three billion reales was required. [28] One of the main tasks of the Bank of San Carlos was to guarantee that the money was available offering funds

[23]Llopis, E., "La integración del mercado español del trigo en los siglos XVIII y XIX: un procesi precoz, prolongado y agitado." VIII Congreso de la Asociación Española de Historia Economica. Santiago de Compostela. (2005) p. 249.
[24] Llopis, "La integración del mercado", p.250.
[25] Llopis, "La integración del mercado", p.246.
[26] Marcos Martin, *Economia, sociedad,* p.625.
[27] Llopis "Expansion, reformismo", p.49.
[28] Marcos Martin, *Economia, sociedad,* p.176.

to the crown in advance, and also supporting the validity and stability of the government bonds that became the new financial instrument of the crown. In order to provide guarantees, the Bank of San Carlos obtained the monopoly on the extraction of silver and the emission of bills to increase the liquidity of the system.

There were also developments in the financial system of the rural areas, basically with the *censos* or *censales* that were maintained during the eighteenth century as the most important financial instrument. Interest rates were reduced both in the Crowns of Castile and Aragon, to around 3 per cent in the second half of the eighteenth century. [29]

2.2 Agrarian production

The eighteenth century is a period of demographic growth, a growth that on the other hand was not supported by an equivalent increase in agrarian production. In the cases where agricultural output increased, the rise was not a consequence of improved productivity, but rather of an extensive growth due to the use of more land. [30] During the first half of the eighteenth century, available tithe series show a growth of production that in some cases increased by more than 40 per cent in comparison to the levels reached at the end of the seventeenth century. The second half of the eighteenth century was less impressive, with stagnation in many cases and even recessions in some of the regions. Therefore, facing diminishing production per capita, the demographic growth in Spain was reduced during the second half of the century. [31]

The first half of the eighteenth century was in general a period of economic growth and agrarian expansion in all Spain. Some areas of the interior however had a slower recuperation from the seventeenth century crisis and did not recover the production levels of the end of the sixteenth century until the mid and in some cases even late eighteenth century. [32] In the interior the increase in agrarian production was based on an extension of arable land. The North of Spain and the Mediterranean coast however were able to improve productivity by introducing new products like maize.

[29] Llopis "Expansion, reformismo", p.54.
[30] Anes Alvarez, G., *Las crisis agrarias en la España moderna* (Taurus, Madrid, 1970) p.196.
[31] Marcos Martin, *Economia, sociedad,* p.585.
[32] Marcos Martin, *Economia, sociedad*

Figure 2.1: Main Regions of Spain

2.2.1 The northern coast

In the north of Spain the rise in agrarian production started during the late seventeenth century and continued during the eighteenth century. In **Galicia** production reached the maximum levels in 1760 and later suffered a period of stagnation during the last third of the century. This was the general trend in Western Galicia with a production model based on maize that after a period of expansion started to experience diminishing returns and showed clear signs of exhaustion. The Eastern side of Galicia on the other hand introduced a more diversified production with potatoes that allowed the growth of output during the second half of the eighteenth century, only showing signs of stagnation during the last years of the century. In the interior of Galicia, the production in the rural areas increased until the 1760s, although the second half of the eighteenth century experienced stagnation and the levels of the 1760s would not be reached until the nineteenth century.[33]

In the **Basque Country,** maize was a key product that improved the situation of many peasants during the seventeenth century and whose effects were still important until the last decades of the eighteenth century. In fact by 1700 the production of maize equalled the production of wheat that had been traditionally the most important grain in the area. The downturn in the Basque Country took place during the last decades of the eighteenth century and production reached its minimum

[33] Marcos Martin, *Economia, sociedad*, p.587.

levels in 1800.[34] The Rioja Alavesa which specialised in the production of wine, also suffered stagnation, partly as a consequence of the increase in the amount of land that had to be used to produce wheat to feed the increasing population.[35] The trends were slightly different in the province of Alava where the crisis of the seventeenth century continued during the first decades of the eighteenth century, followed by a period of recovery based on the production of grains that by the end of the century had increased by around 50 per cent.[36]

Cantabria and **Asturias** followed a similar model with the quick adoption of maize. However, the model was quickly exhausted and a recession in agrarian production started during the last decades of the seventeenth century until well into the eighteenth century. One of the possible explanations of the quick decline of an economy that had been growing consistently can be found in the intense demographic growth. The increase in population produced a division of land and increased the number of small farms that faced quick diminishing returns.[37] The second half of the eighteenth century was however a more positive period and the agricultural output increased by around 33 per cent.[38] In this case, the growth was probably extensive, a consequence of the privatization of common lands that increased the amount of arable land and therefore the total production of the region.

2.2.2 The Mediterranean Coast

The eighteenth century is a period of growth in the Mediterranean Coast of Spain. In areas like Catalonia, Valencia and Murcia peasants improved their productivity by introducing a more diversified and intensive production. There are no tithe series for **Catalonia**, although the analysis of prices of food and rents of land seem to indicate that there was a significant increase in the production of food. During the whole eighteenth century the price of food products tripled while the rent of land doubled during the same period.[39] Catalonia increased the production of wine at the expense of land that had been traditionally used to produce grain. The deficit was covered through imports of grain, and presents a dynamic and highly specialized economy. **Valencia** was also a highly specialized, with a diversified economy that was orientated to the production of cash crops like rice, maize and legumes. The growth in Valencia was probably higher than the one in Catalonia. The available series show that the whole eighteenth century was a period of almost

[34] Marcos Martin, *Economia, sociedad*, p.589.
[35] Marcos Martin, *Economia, sociedad*, p.589.
[36] Marcos Martin, *Economia, sociedad*, p.590.
[37] Marcos Martin, *Economia, sociedad*, p.591.
[38] Marcos Martin, *Economia, sociedad*, p.592.
[39] Marcos Martin, *Economia, sociedad*, p.595.

constant growth with the only exception of the 1760s and the stagnation that appeared after the expansion of the 1770s. [40] The intense development and the specialization of the Valencian economy were able to sustain a strong demographic increase with yearly growth rates of 1 per cent.[41] Strong and sustained demographic growth was also one of the main characteristics of the economy in **Murcia**, a region that tripled its population during the eighteenth century.[42] The demographic miracle of Murcia cannot be explained without a sustained and equally remarkable growth of agrarian output. In the coastland areas near to the most important population centres, the growth took place until the mid eighteenth century, followed by a short period of stagnation and later recovery during the 1770s and 1780s. In the interior of the province in Albacete the rise started later in the mid eighteenth century although it was more intense than in the coast, almost doubling the production of grain in a trend that was also followed by other agrarian products like olive oil and wine.[43] In **Mallorca** the growth of the late seventeenth century decreased during the first half of the following century, and was followed by stagnation and later decline in agrarian production. [44]

2.2.3 Aragon

Aragon, as with most of the country, based its growth on the extension of arable land instead of increasing productivity, with a rise in the amount of grains but also of olive oil and wine. Aragon had a small population density, and therefore the amount of land at the disposal of small peasants was superior to other regions of Spain. The abundance of land therefore allowed not just the cultivation of staple food products, but also of cash crops such as hemp and silk. [45]

2.2.4 Andalusia

Stagnation is the best description of the economic evolution of the region of **Andalusia** during the eighteenth century. In the archbishopric of Seville the rise of production that took place during the late seventeenth century fell in 1705, and that peak of production would not be reached again during the rest of the century. [46] The production of olive oil and wine were especially affected, with the stagnation generalized both in the eastern and western halves of Andalusia.[47] On the other hand the

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[40] Marcos Martin, *Economia, sociedad,* p.599.
[41] Marcos Martin, *Economia, sociedad,* p.600.
[42] Marcos Martin, *Economia, sociedad,* p.603.
[43] Marcos Martin, *Economia, sociedad,* p.603.
[44] Marcos Martin, *Economia, sociedad,* p.605.
[45] Marcos Martin, *Economia, sociedad,* p.607.
[46] Marcos Martin, *Economia, sociedad,* p.609.
[47] Marcos Martin, *Economia, sociedad,* p.610.

series from Ponsot show that in Seville, Huelva and Cadiz the production of cereals was constant from 1720 until the early nineteenth century.[48]

2.2.5 The interior of the peninsula

Extremadura in the interior was probably the most affected region during the eighteenth century. The main reason behind the problems in Extremadura relies on the abundance of pastures and their economic importance. After the crisis of the seventeenth century, Extremadura enjoyed a short period of growth that was able to recover part of the population that had been lost during the previous decades. However, a long term analysis shows that the production levels at the end of the sixteenth century were never reached again, partly as consequence of the pressure from some important land owners that were reluctant to stop using their lands as pastures. As Extremadura, **New Castile** was not able to surpass the production levels that had been reached during the late sixteenth century. The general trends during the eighteenth century show a very stable production that increased in the middle of the century to be followed by a crisis in the 1760s and a brief recovery to finish the century with another production crisis. [49] In **Old Castile** the increase of arable land made a rise of agrarian production possible. However, although tithe series show a better performance than New Castile and Extremadura, the production was always below the levels that had been reached in the late sixteenth century. [50] In the Duero Basin however, the situation was more positive. There was an increase of production in Tierra de Campos, Segovia and Zamora that although also suffering the crisis of the 1760s, the regions recovered very quickly and were able to support an intense demographic growth. [51]

Summarizing the eighteenth century was a period of intense growth in some regions of the periphery and stagnation in most of the interior and the north of Spain. The slow growth that took place in the interior was in general consequence of a rise in the amount of arable land that was used to produce crops and feed the increasing population. However this extensive growth model quickly suffered from diminishing returns and severe production crises still took place in almost all the country. The lack of incentives to increase efficiency and the high inequality in land distribution were probably the main factors driving the low productivity levels that were present in rural Spain.

[48] Marcos Martin, *Economia, sociedad,* p.609.
[49] Marcos Martin, *Economia, sociedad,* p.615.
[50] Marcos Martin, *Economia, sociedad,* p.617.
[51] Marcos Martin, *Economia, sociedad,* p.616.

2.3 Population

The study of population trends in modern times faces a considerable handicap, the lack of reliable information and therefore the difficulty to properly estimate demographic trends. There are not censuses with the required continuity and therefore historical demographers had to rely on estimations based on proxies like baptismal records. The work recently published by Llopis includes the most complete dataset of baptismal series for Spain during the eighteenth century. The main results are presented in the following table. [52]

Table 2.2: Decadal average baptisms in Spain by region 1700-1800 (1700=100)

	Galicia	Asturias	Cantabria	Basque Country	Navarra	La Rioja	Aragon	Old Castile	Madrid
1700	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1710	96.4	98.4	94.,2	95.5	100.3	90.7	103.0	97.6	95.3
1720	104.0	102.9	103.9	102.9	102.0	101.4	116.2	112.4	109.1
1730	104.6	108.3	101.1	109.9	104.6	98.4	115.9	110.3	105.9
1740	104.7	112.7	97.9	114.0	107.7	99.1	122.6	111.1	112.5
1750	113.6	125.9	108.9	116.3	106.8	105.1	133.9	121.7	122.2
1760	118.6	135.8	115.4	119.0	112.2	105.0	157.6	126.8	124.0
1770	116.7	141.1	110.0	122.1	120.7	101.0	152.9	122.8	117.8
1780	1271	146.6	118.5	124.3	123.8	106.5	148.6	128.5	120.1
1790	131.3	148.1	123.6	129.0	130.7	115.0	170.9	136.1	137.5
1800	131.7	144.1	118.8		136.2	111.4	165.1	121.1	124.0

	New Castile	Extremadura	Andalusia	Catalonia	Valencia	Murcia	Baleares	Canarias	Spain
1700	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1710	97.1	97.9	94.1	103.1	97.7	113.3	106.8	106.6	98.5
1720	113.0	112.9	104.4	119.5	119.3	127.5	96.5	108.2	110.7
1730	106.9	108.9	101.7	131.8	135.4	139.4	104.3	121.3	112.9
1740	108.3	117.3	99.4	132.3	139.1	144.7	110.7	119.2	114.9
1750	118.3	128.1	110.5	150.0	160.8	157.0	106.5	124.6	126.0
1760	127.8	128.8	113.9	162.0	181.3	171.5	117.6	131.1	134.7
1770	128.4	134.1	105.0	174.3	191.8	167.3	119.1	136.9	135.1
1780	131.3	139.6	105.3	183.5	190.9	177.0	114.9	139.9	139.4
1790	145.1	148.9	125.1	208.4	209.9	177.7	116.5	148.5	151.6
1800	123.1	145.2	112.7	204.4	211.4	170.8	122.5	165.2	145.3

Source: Llopis, personal communication

The eighteenth century is a period of intense demographic growth, reflected in an increase of 45 per cent in the number of registered baptisms. However the trends were not homogenous in all the country. The Mediterranean coast experienced the largest increase doubling the number of

[52]Llopis, "El crecimiento"

baptisms, followed by Aragon with a 65 per cent increase and the Canary Islands where the series rose by 60 per cent. The results in the interior were less impressive than in the periphery, although the general balance was still positive in all the regions with increases that ranged from 11 per cent in La Rioja to 45 per cent in Extremadura. Chronologically the most favourable decades were the 1710s, 1750s, 1760s and 1790s, although there were also periods of demographic crisis like the first decade of the century or the stagnation of the 1770s.

2.4 Prices and wages

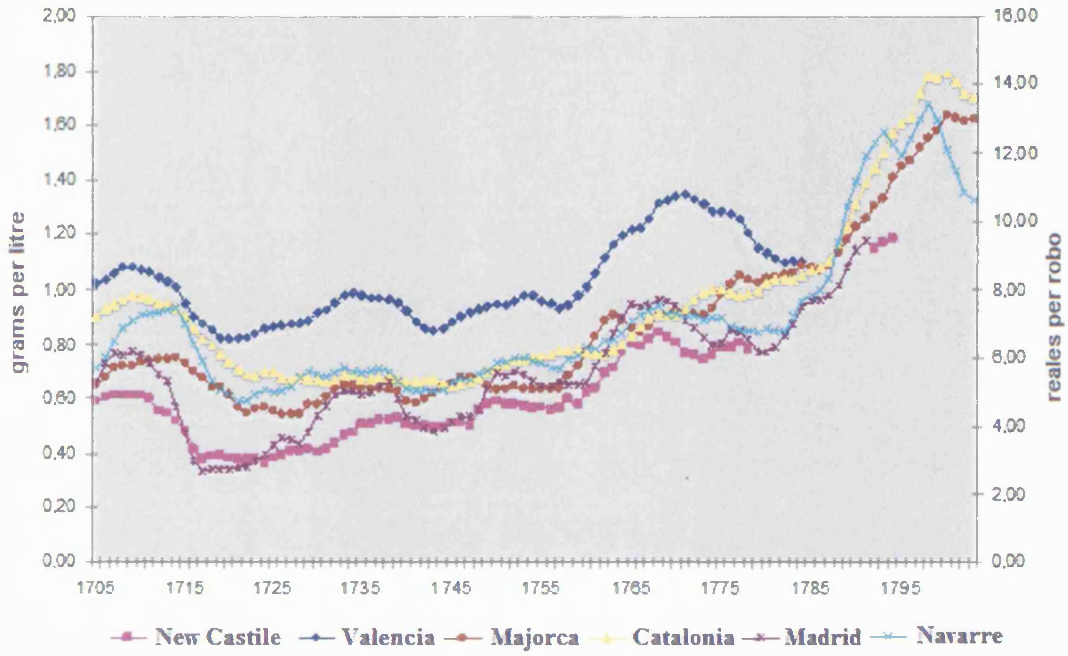
There are abundant historical sources available in Spain to reconstruct the evolution of past price and wage series. Some important studies have collected large price and wages datasets like the ones published by Hamilton during the first half of the twentieth century.

2.4.1 Prices

Given the abundance of data and the nature of the thesis we decided to study the evolution of wheat prices, the staple grain and most important agricultural product. In order to allow the realization of comparisons between different series, all of them except the one for the region of Navarre were standardized from local currencies to grams of silver per litre.

The following graph presents the evolution of wheat prices during the eighteenth century in six Spanish regions. The balance in the long term is clear, an intense growth that in cases like Majorca tripled the prices of wheat during the eighteenth century. The first two decades of the century is a period of price contraction that is a continuation of the deflation that started during the last decades of the seventeenth century. The following three decades experienced a relative stability that was broken in the second half of the century when prices increased exponentially in all the series.

Figure 2.2: Price of Wheat in six Spanish provinces 1700-1800
(Grams of silver per litre of wheat)

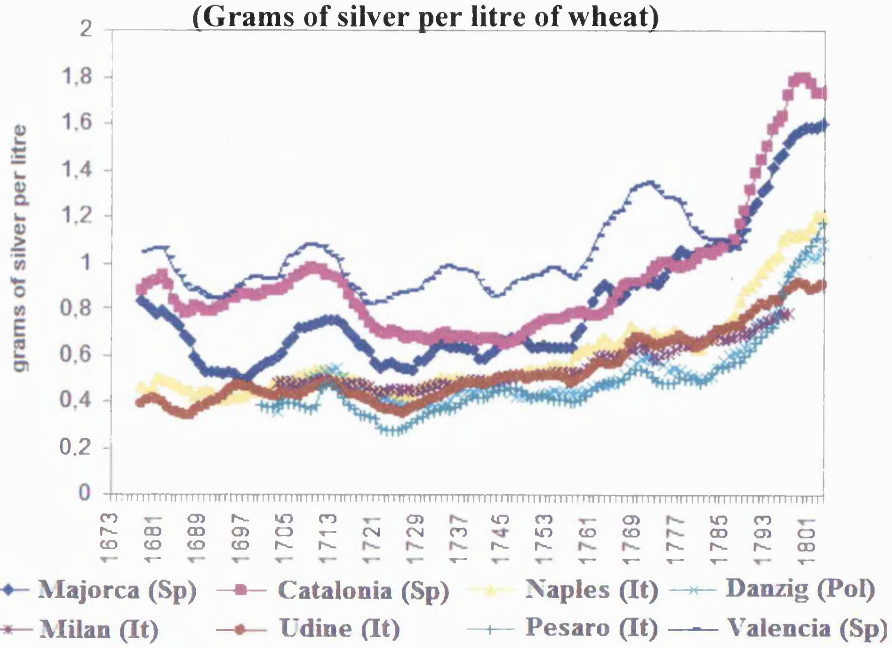


Source: Own calculations from Hamilton (1947), Ardit (Personal Communication), Feliu (1991) and Arizcun Cela (1989)

The movements of international series of wheat prices were in general very similar to the Spanish case, with a period of relative stability that ended in the second half of the century when prices consistently increased in all the series. The standardized prices in grams of silver show that price levels were considerably higher in Spain, that in some cases tripled the prices of other European series. The gap between the Spanish and international series increased during the eighteenth century, as the inflationary process at the end of the century was more intense in Spain than in the rest of Europe. Therefore the flows of grain trade should have increased between Spain and the southern Italian provinces, a traditional supplier of wheat for the coastland Spanish towns. Recent studies tend to suggest that this increase in commercial exchanges did take place in the northeast of Spain at the end of the eighteenth century. [53]

[53] Llopis, E. and Socota, S., "Antes, bastante antes: la primera fase de la integración del mercado español de trigo, 1725-1808", *Revista de Agricultura e Historia Rural*, (2005) p.250.

Figure 2.3: Price of Wheat in eight international regions 1700-1800
(Grams of silver per litre of wheat)

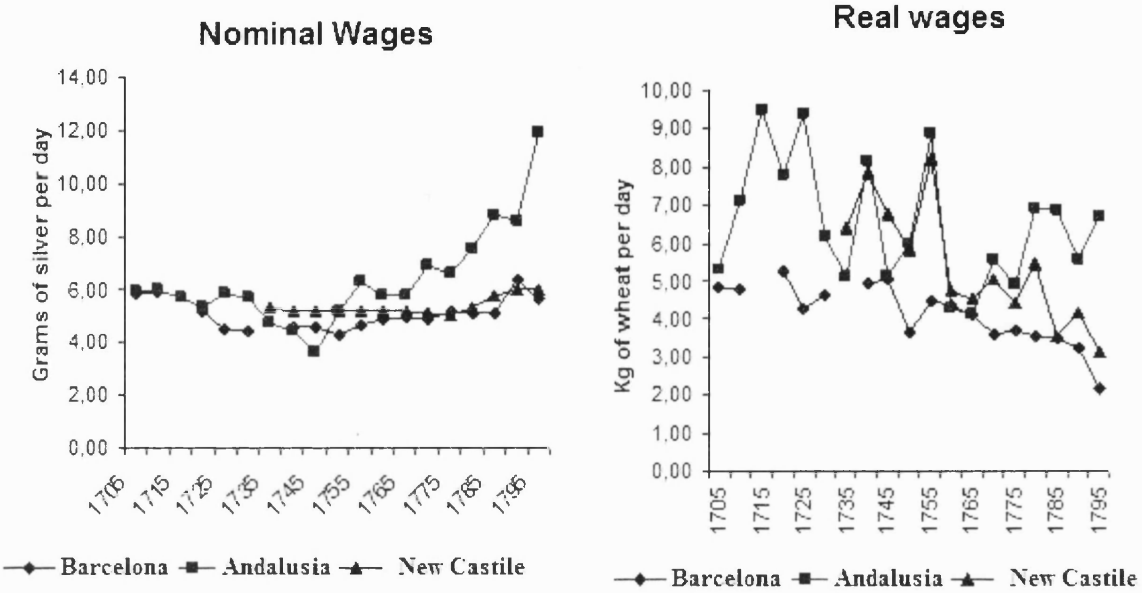


Source: Own calculations from Ardit (Personal communication), Feliu (1991) and Allen and Unger Database(http://www2.history.ubc.ca/unger/ECPdb/index.html)

2.4.2 Wages

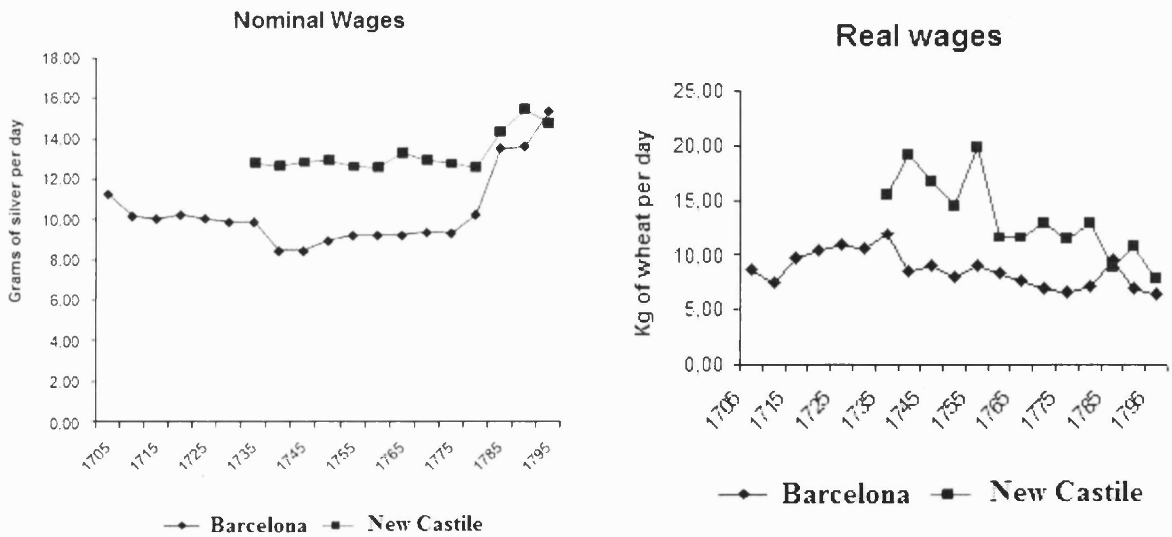
Nominal wages in Spain were stable during most of the eighteenth century, a stability that finished in the last quarter of the century when nominal wages increased in all the samples. The rise of nominal wages was more intense in the case of Andalusia, while the increase in the series of Catalonia and New Castile were more modest. However, when wages are transformed from nominal to real using wheat prices as deflator the situation is very different. Real wages were reduced by 50 per cent on average in Andalusia, Catalonia and New Castile. Therefore the eighteenth century was a negative period for workers, facing increasing prices that were never matched by the increase in nominal wages.

Figure 2.4: Wages of unskilled workers in Spain, 1700-1800



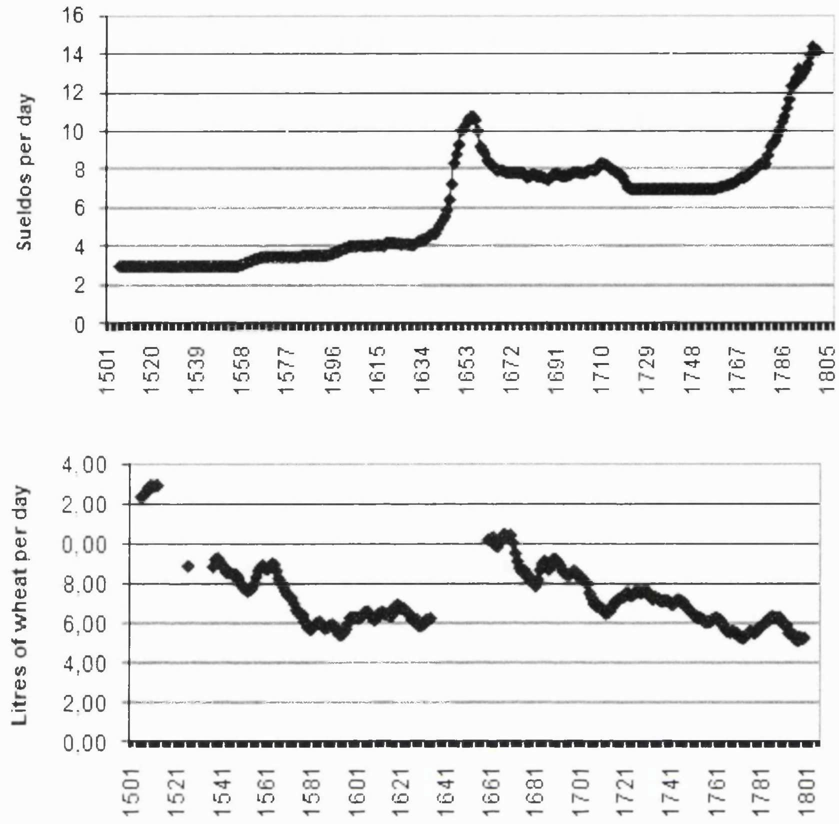
Source: Calculations from Hamilton (1947)

Figure 2.5: Wages of master carpenter in Spain, 1700-1800



Source: Calculations from Hamilton (1947)

Figure 2.6: Wages of Unskilled Construction Worker in Barcelona, 1500-1800



Source: Calculations from Feliu (1991)

Conclusion

The Spanish social structure of the eighteenth century was highly unequal, controlled by the aristocracy and the clergy that also were the main owners of land. The Spanish governments were concerned about the low productivity of the Spanish agriculture and tried to introduce new legislation in order to improve the state of the small peasants and the incentives to invest in their properties. However, the reforms started by the Bourbon governments failed because they did not undertake any significant change in the property rights, the most important obstacle to guarantee access of small peasants to land. Therefore, although the objectives of the reforms were the right ones, the strong influence of pressure groups and the traditional establishment made their success impossible. The influence of the reformists was only visible in the long run when their ideals were the base of the liberalist movement that followed the end of the war of independence during the Napoleonic invasion.

In terms of agrarian production, some areas like the Mediterranean coast were able to succeed in transforming their production system into diversified economies. On the other hand in the interior of Spain and the north, the increases in grain production that took place in the first half of the century were based on an extension of arable land that soon faced diminishing returns. In demographic terms, the eighteenth century was a period of expansion that was more intense in the Mediterranean regions and the islands than in the interior of and the north of Spain where growth rates were modest. The demographic pressure and the stagnating economy had serious consequences, like the inflationary process that took place in the second half of the century and that eroded the incomes of workers in the Spanish economy. The consequence was that real wages fell during the whole century eighteenth, a process that was especially intense during its second half.

3. Geography and climate in Spain and Guadalajara

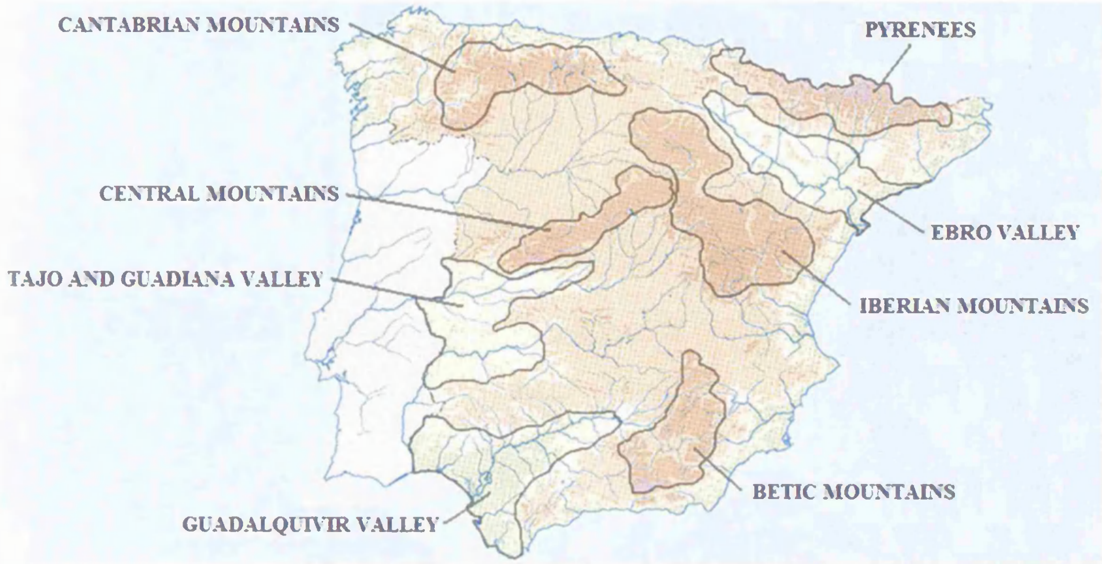
In order to understand the changes that took place in Guadalajara during the eighteenth century, we have to put the study in a broader context. Therefore this chapter will present a general overview of the country in geographic and climatic terms. Hence,the physical environment that surrounds Guadalajara and the climatic and geographical conditions that dominate in the province will be analysed. The main purposes of the chapter are therefore twofold. Firstly, to provide a general framework where the case study of Guadalajara will be studied, and secondly, to show that the province was probably the most marginal province of Spain in climatic terms and therefore the ideal place to study the effects of a climate change.

3.1 Geography

3.1.1 The geography of Spain

Located in the south western corner of the European continent, Spain occupies 85 per cent of the Iberian Peninsula. The country has an average altitude of 660 meters, being the second highest in Europe surpassed only by Switzerland. The Spanish geography can be divided into the huge central plateau, coastland areas and the alluvial valleys surrounding the most important peninsular rivers. The plateau is divided into two by the Central System, one of the four main mountains that exist in Spain, separating the Northern and Southern sub-plateaus.

Figure 3.1: Geography of Spain

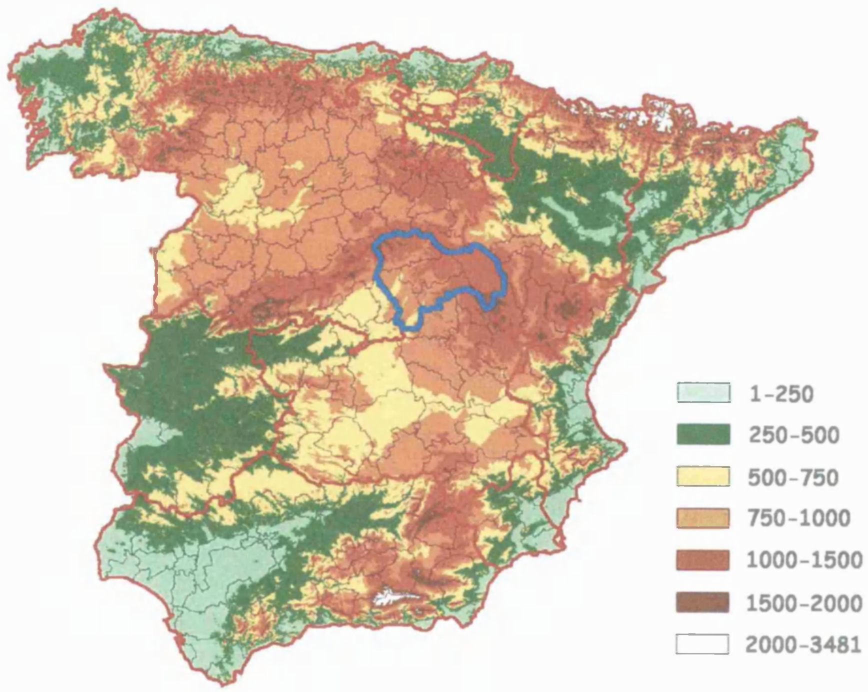


Spanish geography is therefore dominated by the central plateau, an area that occupies 240,000 squared kilometres, almost half of the Spanish territory with an average altitude of 650 meters. The Northern Sub-Plateau has an altitude that varies between 650 and 750 meters, and comprises the Autonomous Community of Castile and Leon (Old Castile and Leon in the early modern period) and also the Douro basin that crosses the sub-plateau from East to West. Guadalajara is located in the Southern sub-plateau that has a lower average altitude than the Northern sub-plateau.

Figure 3.2: Inner Plateaus in Spain

Land fertility depends on numerous factors, including geographical ones such as altitude or slopes. The next map presents an altitude map of the Spanish territory. The main geographical elements that compose Spain are clearly visible in the map. The two main fluvial valleys, the Ebro in the northeast and the Guadalquivir in the south east and also the other minor valleys created by the effects of the Tagus and Guadiana rivers in the east. An interesting point to highlight is the considerable altitude of the northern sub plateau with an average altitude of 750 meters, and part of the southern, mainly in its eastern limits were altitude increases considerably reaching an average of 600 meters in almost all the area.

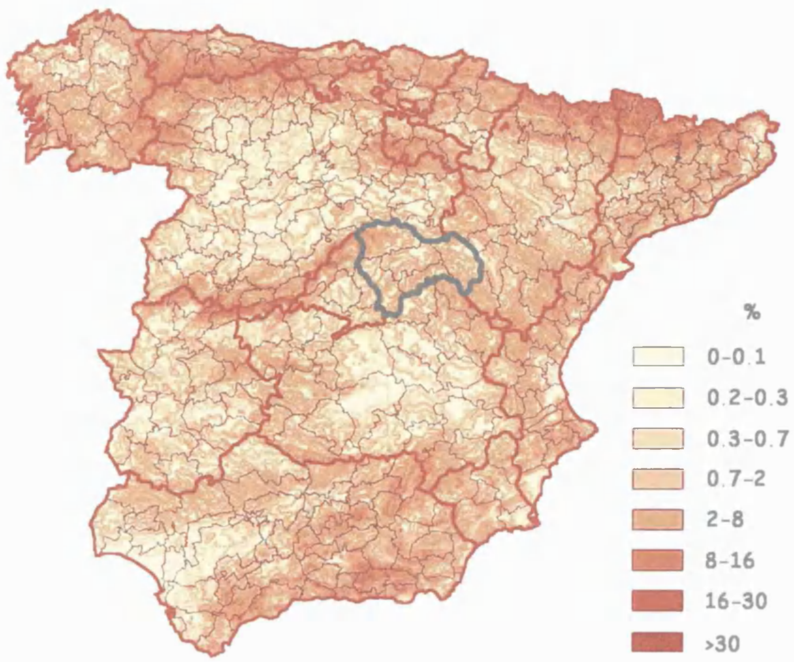
Figure 3.3: Altitude in Spain (metres)



In terms of altitude, the worst lands are those around the main mountain chains that surround the central plateau and that occupy a considerable proportion of the peninsula. There is also a clear decrease of altitude in the southern sun-plateau from east to west as we approach the Guadiana and Tagus valleys that tend to be more fertile regions. The areas with lower altitudes are located in the coast, in the area surrounding the Ebro valley in the north-east, and especially in the fertile lands of the south west in the Guadalquivir valley. In the same way, the territories in the Tagus and Guadiana valleys also have low altitudes. In all the cases, altitude is lower than 500 meters and in cases like the Guadalquivir valley they never even reach 250 meters. The province of Guadalajara presents a very disadvantageous position in terms of altitude. The main reason is its close proximity to the Iberian System that increases its average altitude, especially in its northern half and the eastern border.

Apart from altitude, another important geographical factor that affects the quality of land is gradients. Gradients are important because they offer us information about how accessible the terrain is and also the difficulties that an agrarian producer could face exploiting it. A very abrupt gradient increases transport and cultivation costs and in some cases it can even make the adoption of technical improvements impossible. On the other hand, a very flat terrain makes access and cultivation easier, hence reducing the costs mentioned before. The following map shows the situation of Guadalajara within the Spanish context. As in the case of altitude, the relative position of Guadalajara is very negative with average gradients higher than the rest of the interior of Spain. Unlike most of the other provinces of the interior, Guadalajara did not enjoy the benefits of the plateaus. It was a frontier province dividing the two internal plateaus and was heavily influenced by the existence of mountain chains that separate them. The provincial analysis shows that in Guadalajara gradients are generally high and regular, although they are greater in the northeast of the region.

Figure 3.4: Gradients in Spain

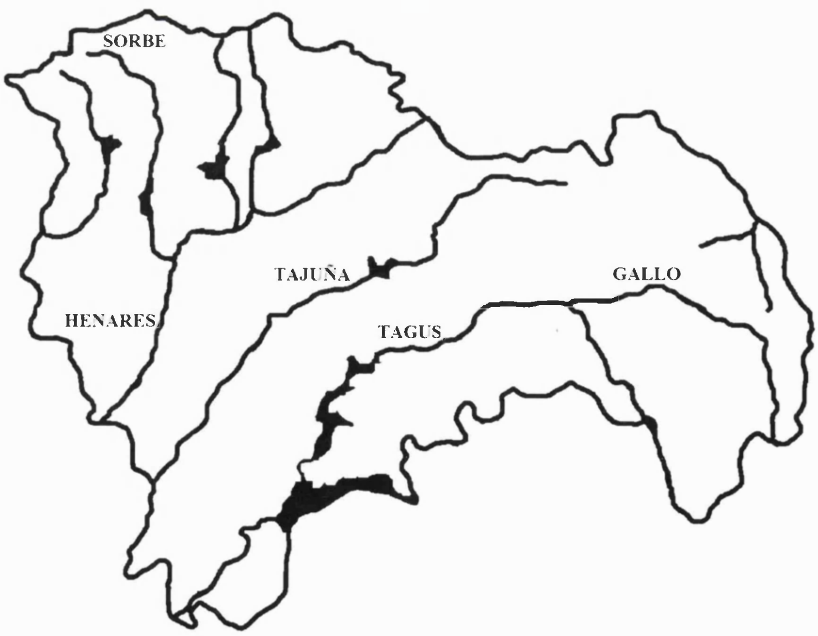


The huge plateaus in the interior, both in the north and in the south, are mainly responsible for the lesser gradients that exist in the interior of Spain. The figure also shows the very small gradients that as mentioned above are common in the Guadalquivir Valley, while the Ebro Valley is more abrupt. The rest of the peninsula suffers from high levels of gradients, mainly as a consequence of the enormous and numerous mountain chains in the interior and the periphery. This situation is especially intense in the Cantabrian coast of the north, and although altitude is relatively low in that area, gradients in many cases reach and surpass 15 per cent. Therefore in terms of gradients, the central plateau and the Guadalquivir valley appear the most favourable areas, while the north of the peninsula and the rest of the periphery are more disadvantaged.

3.1.2 The geography of Guadalajara

The hydrologic analysis of Guadalajara is very positive with a substantial number of small rivers crossing the province. The main ones are first the Henares and its tributary the Sorbe that cross the province north-south starting in the mountains of the north ending in the southwest. The centre of Guadalajara is also crossed by the Tajuña river, while the Tagus and its tributary the Gallo cross Guadalajara from East to West leaving Guadalajara through its southern border.

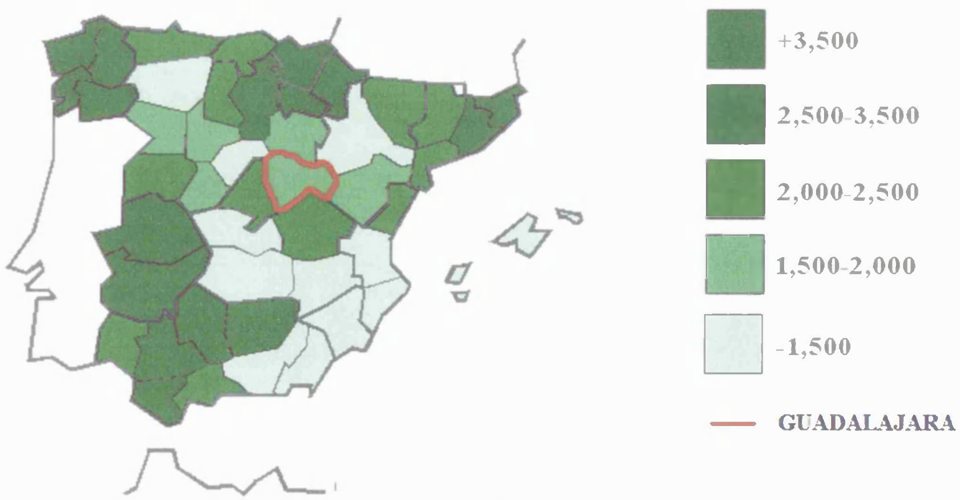
Figure 3.5: Hydrology in Guadalajara



In summary, the existence of numerous mountain chains in the Iberian Peninsula play an important role explaining its low fertility, increasing both the altitude and the gradients in the country and therefore the marginality of land. However, the situation is not equally negative across Spain. In geographical terms the Guadalquivir valley enjoys the best position in Spain, with low levels of both altitude and slopes and a fertile soil irrigated by the Guadalquivir River. The Ebro valley is also in a good position with low altitude although suffering a more abrupt landscape than the Guadalquivir valley. Across the rest of the coast, the benefits obtained from low altitude are counterbalanced by steep gradients, while the situation in the central plateau is the opposite, with high altitude but with a very flat landscape. In terms of altitude and gradients, taken within the Spanish context, the province of Guadalajara presents one of the worst natural endowments in the country. The average altitude is as high as those levels presented in the rest of the interior, but it lacks the flat terrain that is so common on the plateau. Therefore we can expect very low levels of agricultural productivity in Guadalajara, in comparison to the rest of the provinces in Spain.

We can try to corroborate these theoretical predictions with some empirical observations studying real agrarian productivity figures. The most attractive option for historical reasons and the nature of this thesis is the study of productivities of winter wheat production. The next map shows productivities of wheat in kilograms per hectare in the different Spanish provinces in 2003, information obtained from the databases of the nationals institute of statistics.

Figure 3.6: Production of wheat per Ha



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

The best values are obtained in the north, along the Cantabrian coast and especially in the Basque Country with 4,800 kilograms per hectare. The east coast of Catalonia in the north east corner, and Galicia in the north western corner, also present good productivity levels. There are also high productivities in the area occupied by the Guadalquivir, Tajo and Guadiana valleys. On the other hand, the Mediterranean coast and practically all the interior of the peninsula present the lowest productivity levels, considerably smaller than those reached in the rest of the country. Guadalajara is positioned in the middle of the sample, although its average production, 1,920 kilograms per hectare, is closer to the less productive provinces rather than to the more efficient. These results are not surprising given the disadvantageous geographical position of Guadalajara that has been described above, which very probably had a significant impact in the productivity levels presented by the province.

If we compare these results with the geographical factors that have been presented before, we can see that there is a correlation, although incorporating some important differences. The best productivities are reached in those areas with lower altitude, while the interior of the country and the areas with mountains present the lowest productivities. On the other hand, the fact that the highest productivities can be found in the Cantabrian coast, even with high levels of gradients, indicate that apart of geographical factors there are other variables that have a strong influence on the performance of grain production, the different climatic regimes in the Iberian Peninsula.

3.2 Climate in Spain

3.2.1 Guadalajara within the Spanish context

Spain is a country with a wide range of climatic diversity. The major part of the Spanish territory is under the influence of a Mediterranean-continental climate, characterized by a very extreme variability. [54] Mediterranean climate affects the Mediterranean and southern coasts, while oceanic climate covers the north coast of the peninsula.

The Mediterranean-Continental climate in dominant in the interior of the peninsula, and in some parts of the interior of Spain with very high altitude it becomes Mountain climate. This regime is based on extreme temperatures with very cold winters and very hot summers. Although the average thermal amplitude is moderate, the extreme thermal amplitude is very high. [55] Rainfall in the Mediterranean-Continental climate is not abundant with an average of 600 mm per year, with a distribution that is not homogeneous, and that sometimes produces torrential rains.

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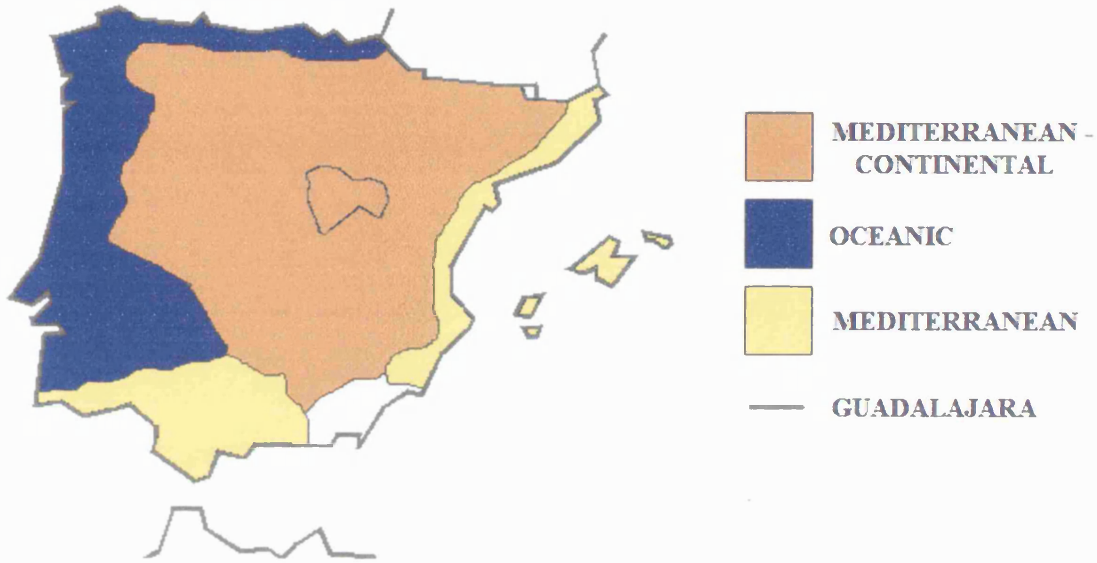
[54] Tortella, G., *El Desarrollo de la España Contemporánea: Historia Económica de los Siglos XIX y XX*, (Madrid: Alianza Universidad Textos, 1995) p.8.

[55] Average thermal amplitude measures the difference between the average maximum and the average minimum of the year. Extreme thermal amplitude measures the same difference but between the maximum and minimum values of the year reached in a certain day, or in other words between the hottest and the coldest days of the year.

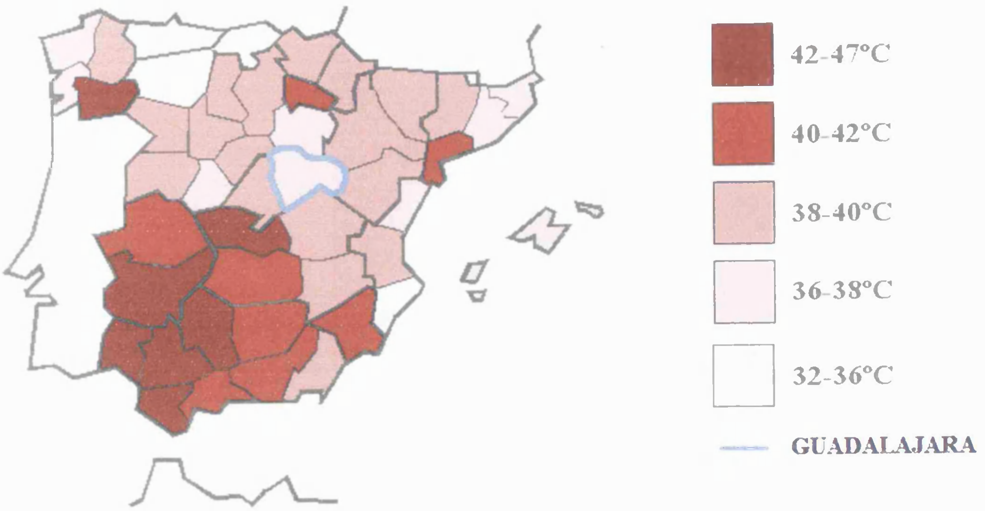
Figure 3.7: Climatic Regimes in the Iberian Peninsula and the Islands



As figure 3.7 shows Guadalajara is under the influence of a Mediterranean-Continental climatic regime. Therefore the province has very hot summers, very cold winters, and a climate characterized by very high variability.

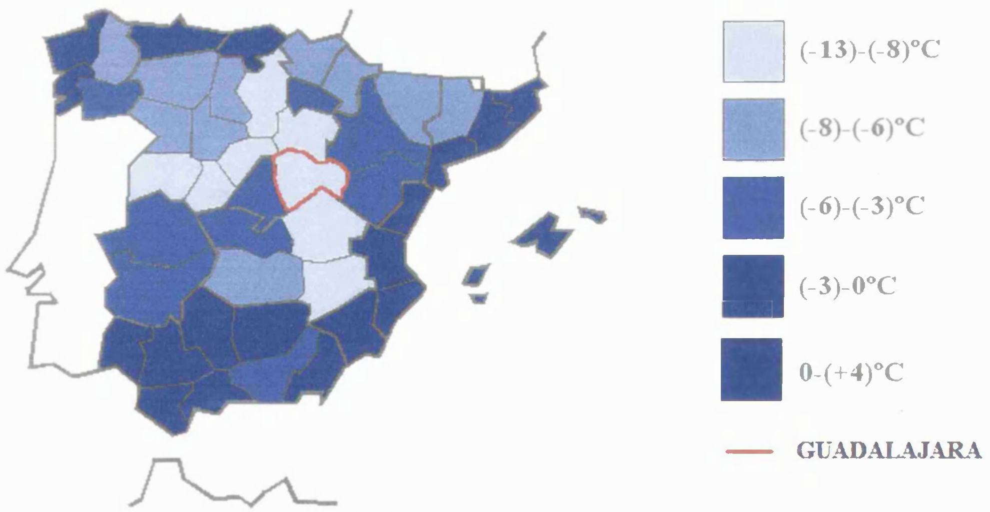
The next figures presents the absolute maximum and minimum temperatures reached in the all the Spanish provinces, or in other words, the maximum temperature during the hottest day of the year and the minimum during the coldest. Finally the difference between both known as absolute thermal amplitude that is used to measure how extreme the climatic regime is in an area.

Figure3.8: Maximum absolute temperature



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

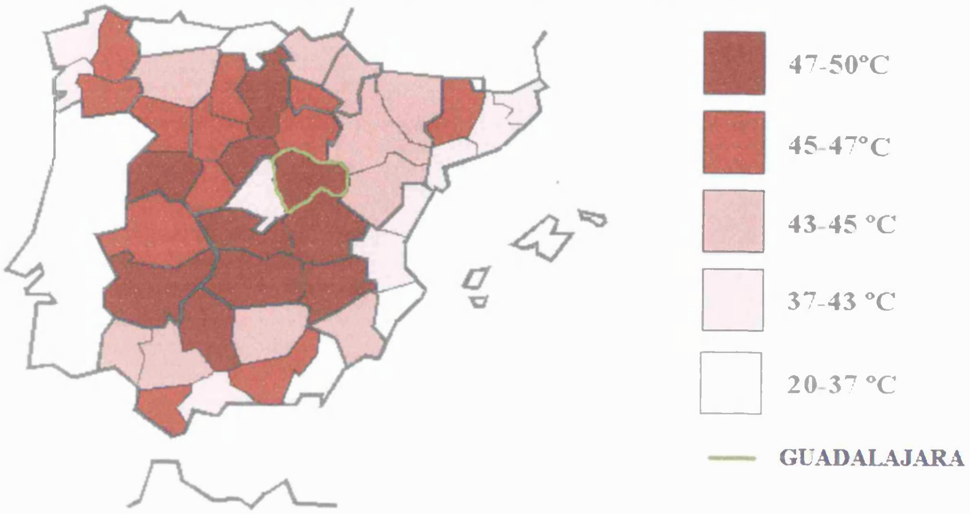
Figure 3.9: Minimum absolute temperature



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

Figure 3.10 shows that the thermal amplitude is higher in the provinces of the interior, in all New Castile, Extremadura and Old Castile, and also in some provinces of the south in Andalusia. In the more extreme cases, thermal amplitude reaches 50°C. These results prove that as explained above the Continental-Mediterranean climate of the interior is more extreme than the regimes in the rest of the country. On the other hand, coastland areas present the lowest levels of thermal amplitude that do not surpass 30°C, 40 per cent lower than in the interior of the peninsula. This wide range of temperatures in the interior of Spain has important consequences in the agriculture of the area, like an extension of the period of frosts during the coldest months of the year. On the other hand, during the rest of the year temperatures are often above 30°C, a situation that is in many cases associated to long periods of droughts.

Figure 3.10: Absolute thermal amplitude

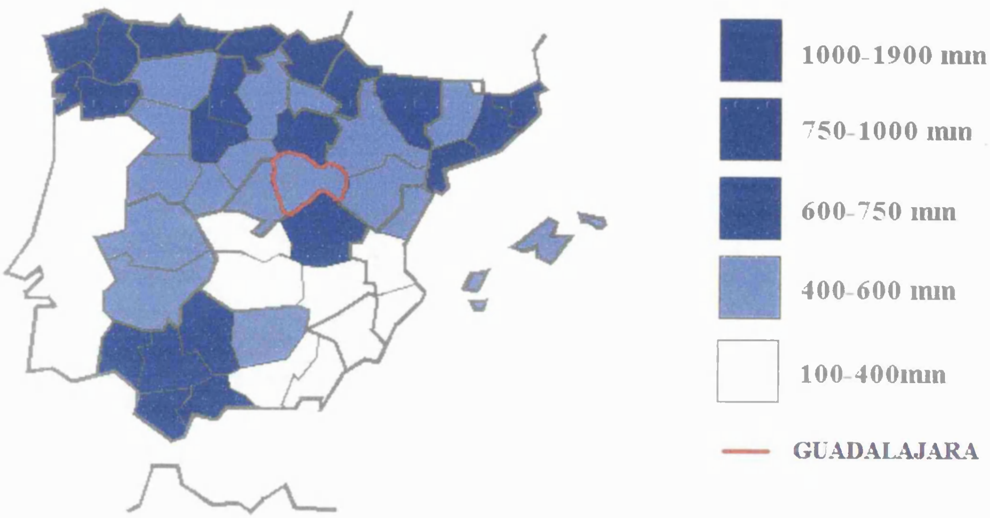


Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

Rainfall is therefore another fundamental aspect to analyse in the different climatic regimes of Spain. The next map presents the level of rainfall in the different Spanish provinces. As it has been mentioned before, the interior of the peninsula has lower levels of rainfall than the coast with the only exception being the south east provinces that are affected by the dry subtropical climate. The map shows that rainfalls are mainly located in the Cantabrian coast and in the Guadalquivir valley. In terms of rainfall Guadalajara is in a middle point between the wet Spain of the north and the dry and arid southeast, with an average rainfall of 477 mm during the period 2000-2004. [56]

[56] Base de datos INEbase, INE

Figure 3.11: Rainfall levels

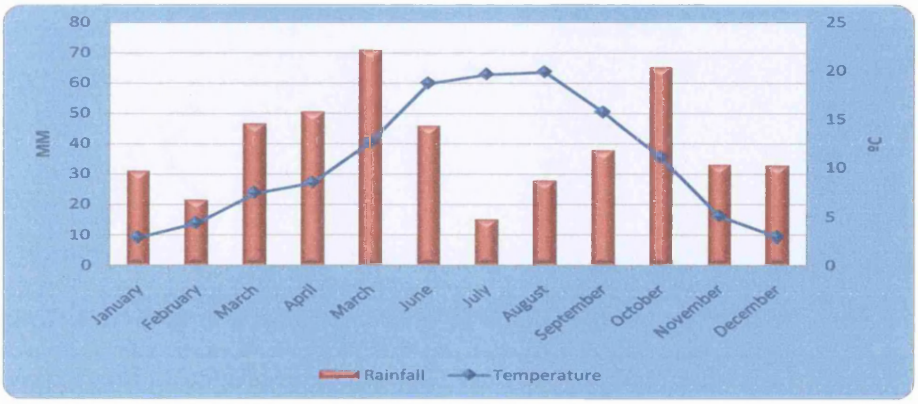


Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

3.2.2 Climate in Guadalajara

Temperatures in Guadalajara follow an intra-annual trend characteristic of temperate climates, with an average minimum temperature of 3°C in January and a maximum average temperature of 20°C in August. The hydrological cycle in the province presents a very strong seasonality, with most of the rainfall being concentrated in spring and autumn with summers and winters being relatively dry. In inter-annual terms rainfall in Guadalajara tends to be very unstable with some dry years followed by wet periods. The following graph shows the monthly average temperatures and rainfall in Guadalajara. As it was explained above, temperatures present a traditional bell distribution with maximums in summer and minimum in winter, being more common in the period May-June and in October.

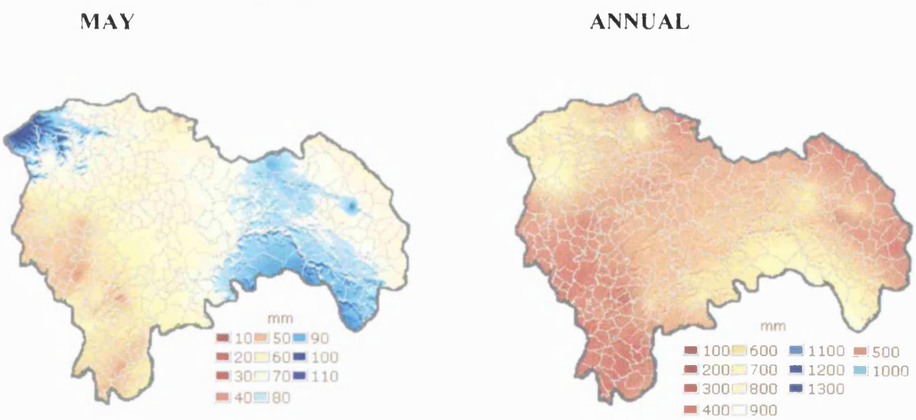
Figure 3.12: Intra-annual distribution of rainfall and temperature in Guadalajara



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

The spatial analysis of rainfall presents some interesting results. As it is showed in figure 3.13, most of the rains are concentrated in the west of the Mountains region and in the Wet region. On the other hand, part of the Pre-Mountains and the South regions are the driest areas of Guadalajara with a considerably lower average rainfall.

Figure 3.13: Geographical distribution of rainfall in Guadalajara

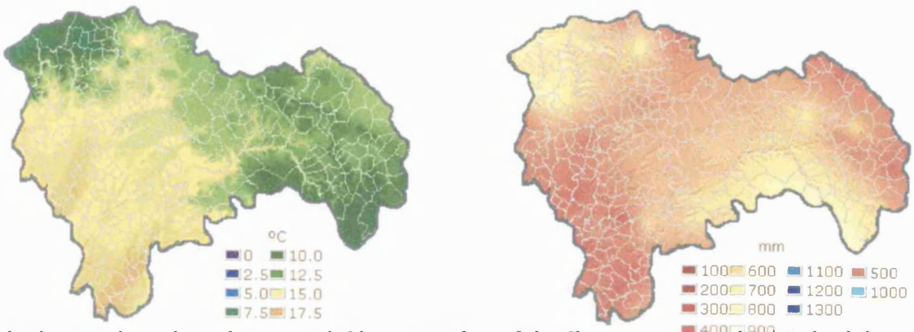


Source: Own Calculations based on the Digital Climatic Atlas of the Iberian Peninsula. Methodology and applications in bioclimatology and geobotanic ISBN 932860-8-7. Universidad Autónoma de Barcelona, Bellaterra

The same spatial analysis of temperatures shows a very similar pattern. The coldest area is located in the Mountains, with an average annual temperature below 10ºC. The Pre-Mountains and South regions are on the other hand the warmest parts of Guadalajara with an average annual temperature that very often surpasses 17ºC. Molina is in a middle position between the cold temperatures of the north and the warmer values of the southwest.

Figure 3.14: Geographical distribution of temperature and rainfall in Guadalajara

AVERAGE ANNUAL TEMPERATURE AVERAGE ANNUAL RAINFALL

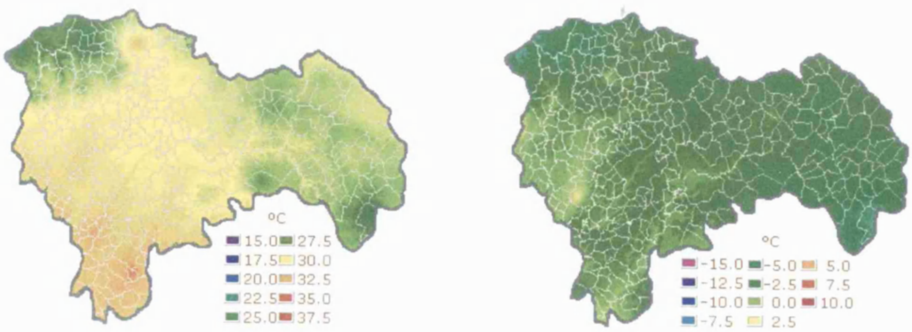


Source: Own Calculations based on the Digital Climatic Atlas of the Iberian Peninsula. Methodology and applications in bioclimatology and geobotanic ISBN 932860-8-7. Universidad Autónoma de Barcelona, Bellaterra

We can also measure the spatial distribution of the absolute maximum and minimum annual temperature. Figure 3.15 shows the continental influence of the climatic regime in Guadalajara. Absolute maximum temperatures reach very often 30°C and in cases like the South in summer they can reach 37°C. Winter however presents very cold temperatures, below zero in almost all the province, and in the case of the Mountains and Molina even below -10°C. Therefore the absolute thermal amplitude above 50°C represents the intense variability and extreme character of the climate in Guadalajara.

Figure 3.15: Geographical distribution of seasonal temperature

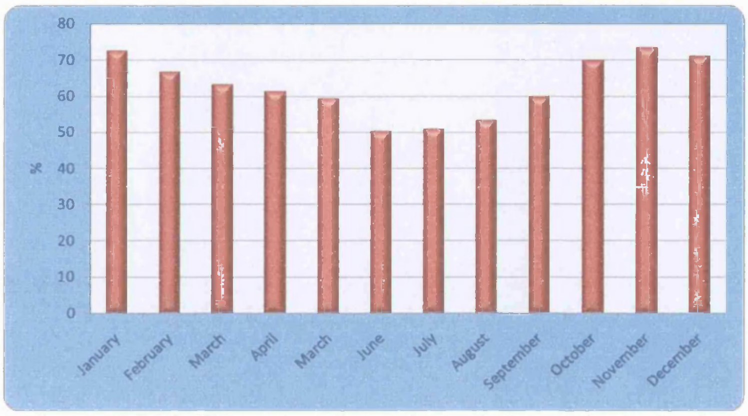
MAXIMUM TEMPERATURE IN AUGUST MINIMUM TEMPERATURE IN JANUARY



Source: Own Calculations based on the Digital Climatic Atlas of the Iberian Peninsula. Methodology and applications in bioclimatology and geobotanic ISBN 932860-8-7. Universidad Autónoma de Barcelona, Bellaterra

Relative humidity levels are very low in Guadalajara with an average annual humidity of 60 per cent. The highest values are reached in winter with an average humidity of 70 per cent, and the minimum in summer when relative humidity levels do not usually surpass 50 per cent.

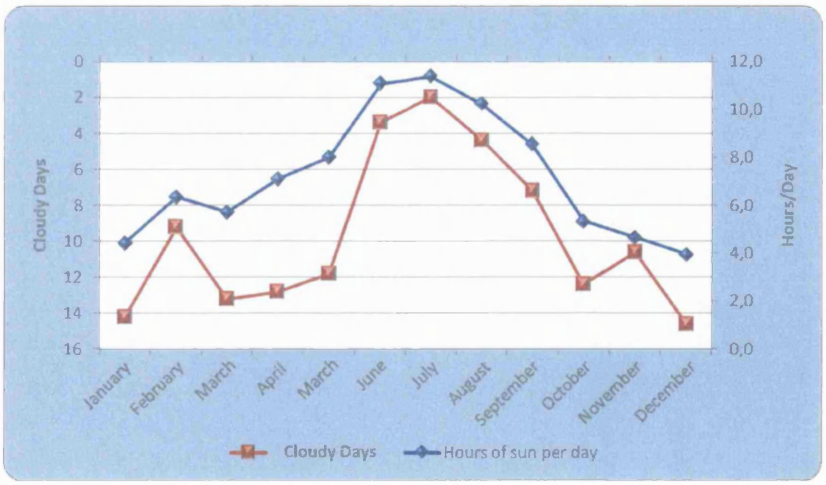
Figure 3.16: Humidity levels in Guadalajara



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

Apart from temperatures, another key climatic variable is the amount of solar energy received by the region. This variable is especially important in the case of agrarian production because it affects the production of biomass and therefore the harvest. Figure 3.17 shows the amount of solar energy received by the province of Guadalajara in number of hours of sun per day. The maximum levels are, as expected, reached during the summer. This is consequence of two different factors; firstly the length of the day that is extended during summer, and secondly the amount of cloudy days also reaches its minimum during the same period.

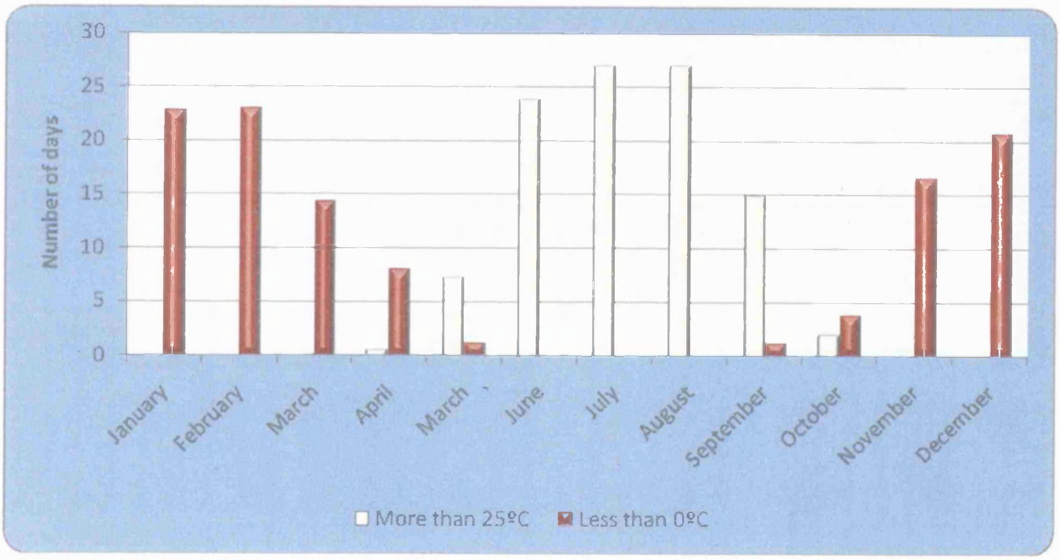
Figure 3.17: Intra-annual distribution of cloudy days and hours of sun per day



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

Another way of measuring climatic variability apart from the thermal amplitude is the amount of days that reach and surpass certain thresholds of temperatures. In the case of Spain, those thresholds have been defined by the Spanish Institute of Statistics as 0°C and 25°C. Figure 3.18 shows the number of days per month that surpass those thresholds in Guadalajara. The results show that the amount of days that surpass 25°C are located in the three months of summer, while the coldest days reaching temperatures below 0°C are concentrated in winter. The most interesting result of this study is the very strong seasonality of the variables. There are almost no extremely hot months outside summer and almost no extremely cold months outside winter. However, in both seasons more than two thirds of the days can be considered climatically extreme in terms of temperatures, highlighting once more the strong continental influence of the climatic regime in Guadalajara.

Figure 3.18: Intra-annual distribution of extreme temperatures



Source: INE (INEBase: http://www.ine.es/inebmenu/indice.htm)

Conclusion

We can therefore conclude this chapter confirming that the geography in the Iberian Peninsula is highly influenced by the existence of numerous chains of mountains in the interior and the periphery, and also by the central plateau that occupies a significant proportion of the country. The best lands in terms of altitude are located along the coasts and especially in the two main fluvial valleys, the Guadalquivir valley in the south west and the Ebro valley in the north east. The geography of Spain is also very abrupt, with high gradients in all the territory except in the central plateau and the Guadalquivir valley. The province of Guadalajara suffers one of the worst geographical endowments within the Spanish framework, defined by very high altitude levels combined with high average gradients that increase transport costs and the difficulties of working the land. There are also important differences within Guadalajara, like those between the mountainous north and south.

Although there are many different climatic regimes in Spain, the continental-mediterranean dominates the interior of the peninsula, and is characterised by extreme temperatures and a very irregular hydrologic cycle. The climate along the coast is more humid and stable than in the interior, temperatures are higher in the south while rainfall is more intense in the north. The north of the country and the fluvial valleys contain the most fertile lands, in the northern case because of the generous rains, and in the fluvial valleys as a consequence of the water provided by the rivers and the sediments that work as natural fertiliser. The situation of Guadalajara is again very negative, being part of the Mediterranean-Continental climatic regime that dominates most of the interior of the Iberian Peninsula. The climate is therefore extreme with very marked seasonal changes in temperature and rainfall, presenting the highest thermal amplitude in Spain. The spatial analysis of climate in the province again shows differences between the different regions, with smoother seasonal changes in the centre and a more radical and extreme variability in the Mountains and Molina. Therefore Spain and more particularly Guadalajara, seems to be the ideal candidate to analyze the effects of climate changes like the ones that will be described in the next chapter.

4. Past climate changes

Climates change. This statement is a clear fact that has been confirmed in the very long run. Curiosity of human beings about past climate changes has grown substantially during the last decades, mainly as a consequence of the global warming that the planet is experiencing. This interest has encouraged the revival of paleoclimatology, the science that studies and analyses past climate changes with the hope that by understanding such occurrences, we will be able to predict and face the changes that may occur in the future. Spain was not an exception and in the eighteenth century it suffered the effects of a climate change with the increased variability of weather.

The first section of the chapter introduces the birth and development of paleoclimatology, a field that studies the evolution of past climate changes. This section will also look at the development of the subject in Spain, the growth that took place during the second half of the twentieth century and the way in which the accumulation of knowledge reached a critical point in the late 1990s with the creation of the first climatic series for the Iberian Peninsula. The next part of the chapter will present a brief overview of the main theories explaining past climate changes, with a particular focus on the effects of solar and volcanic activities as the major players in pre modern climate alterations. The next section introduces the evolution of the two main climatic variables studied in this thesis, temperature and rainfall in Spain during early modern times and especially during the Malda Anomaly that took place during the second half of the eighteenth century. Finally, the last section of the chapter will look at the effects that these changes in climate may have had in a pre-industrial economy, with the direct and indirect effects in agrarian production.

4.1. Paleoclimatology: birth and development of a new discipline

Instrumental measurement of climatic variables started in the nineteenth century. There are therefore less than two hundred years of instrumental measurements, a very small proportion not just in geological but also in human scale. This is not based on a lack of instruments (Galileo created the first thermometer during the first half of the seventeenth century) but rather due to the impossibility to realize systematic measurements and to an enormous diversity of scales that were too heterogeneous in nature. Newton, for example, had a thermometer with two fixed points, 0ºC that is the temperature when water solidifies, and 12ºC, which was established to be the average temperature of the human body.

In addition to the technical problems, the study of past climate changes was not a popular issue within the scientific community. It was not until the 1960s that paleoclimatologic studies increased in importance and attractiveness. For H.H. Lamb, the main reason was that until the 1960s the evolution of climate had been relatively benign, and therefore nobody was worried about the study of its future or the analysis of its past. [57] On 15th April 1974, the international community of politicians joined the interests of the international community of scientists in a speech by Henry Kissinger, then secretary of state of the United States in the general assembly of the United Nations. In his speech, Kissinger declared that the threat of climate changes was real, pressing for the creation of organisms to study the future evolution of climate. [58] This new interest in future climate also provided funds and a market for the study of past climates. During the 1970s, Professor Gordon Manley published a series of temperatures for central England since 1659. [59] The first studies about past rainfall series appeared in 1976, when George James Symons published the first rigorous study including monthly rainfall in England. [60]

On the other hand, in spite of small although important advances, there were essential problems that researchers had to resolve. First of all, the reconstruction of climatic variables required a huge investment in time. The second problem was based on the difficulties of obtaining funds to finance the investigations. Finally, there were important restrictions not just temporal and economic but also technical. The role played by the development of the space industry would provide an essential help

[57] Lamb, H.H., *Climate, history and the modern world* (London: Routledge, 1982) p.12.
[58] Lamb, *Climate*, p.12.
[59] Manley, G., *"Central England temperatures: monthly means 1659–1973" Quarterly. Journal of the Royal Meteorological Society* (1974)
[60] Craddock, J., "Annual rainfall in England since 1725." *Quarterly. Journal of the Royal Meteorological Society* (1976)

to resolve the latter ones, thanks to the aid that they provided to understand the nature of wind streams.

Since the 1970s, new techniques like chemical analyses of isotopes or dendrology encouraged the creation of new millenarian series of climatic variables. Crowley, Mann, Briffa and Jones are just some examples of these new estimations that take full advantage of the scientific advances applied to paleoclimatology. New different methodologies were established in order to create climatic series of the past.[61] The analysis of tree rings and their width is one of the most popular, a technique known as dendrology.[62] However, this system presents some problems that are especially important in the case of Spain because the growth of tree rings can depend on changes in temperature, rainfall or both, and therefore are strongly influenced by the climatic regime in the area where the tree grew. From this point of view, the extreme diversity of climatic regimes in Spain can be a problem, and in the same way this technique also presents some methodological inconveniences.[63] Other investigations have used the concentrations of pollen that on the other hand present the same problems as that of the tree rings.[64] The study of chemical isotopes is a very recent technique with a promising future, like for example the analysis of the relationship between 16O and 18O in ice cores. [65] In any case the subject is a very young science, proved by the fact that most of these studies have been published in the twenty first century.[66]

Apart from the scientific methodologies to estimate past climates, there are other sources like the analysis of historical sources such as diaries or chronicles to establish climatic series, especially of

[61]Baker, D.G., "Botanical and chemical evidence of climatic change: a comment", *Journal of Interdisciplinary History* 10:4 *History and Climate: Interdisciplinary Explorations* (1980) p.814.
[62] Fritts, H.C., Lofgren, G. and Gordon, G.A., "Past climate reconstructed from tree rings", *Journal of Interdisciplinary History* 10:4 *History and Climate: Interdisciplinary Explorations* (1980)
[63] Baker, "Botanical", p.815.
[64]Webb III, T., "The reconstruction of climatic sequences from botanical data", *Journal of Interdisciplinary History* 10:4 *History and Climate: Interdisciplinary Explorations* (1980)
[65]. Wilson, A.T., "Isotope evidence for past climatic and environmental change", *Journal of Interdisciplinary History* 10:4 *History and Climate: Interdisciplinary Explorations* (1980) see also Wilson, A.T., Hendy C.H. and Reynolds, C.P. , "Short-term climate change and New Zealand temperatures during the last millennium", Nature 279 (1979) p.316.
[66] As selection see Briffa, K.R. and Osborn, T J., "Blowing Hot and Cold", *Science*, 295 (2002) also Briffa, K.R. et al, Low-frequency temperature variations from a northern tree-ring density network. *J. Geophys. Res.*, 106 (2001)" Crowley, T.J., Causes of Climate Change over the Past 1000 Years, *Science*, 289 (2000) Crowley T.J. and Lowery, T., How Warm Was the Medieval Warm Period?, *Ambio*, 29, (2000) Jones, P.D. et al, High-resolution palaeoclimatic records for the last millennium: Integration, interpretation and comparison with General Circulation Model control run temperatures, *Holocene*, 8 (1998) Jones, P.D. et al, Surface air temperature and its changes over the past 150 years, *Reviews of Geophysics*, 37 (1999) Jones, P.D., Osborn, T.J. and Briffa, K.R., The Evolution of Climate Over the Last Millennium, *Science*, *292* (2001) Mann, M.E., Bradley, R.S. and Hughes, M.K., Northern Hemisphere Temperatures During the Past Millennium: Inferences, Uncertainties, and Limitations, *Geophysical Research Letters*, *26* (1999) Mann, M.E. and Jones, P.D., Global surface temperature over the past two millennia, *Geophysical Research Letters*, 30 (15) (2003) Mann, M.E. et al, Optimal Surface Temperature Reconstructions Using Terrestrial Borehole Data, *Journal of Geophysical Research,* 108 (D7)(2003)

extreme events like floods or droughts. This historicist variation is also a very young discipline, even more than its scientific counterpart, although from its beginnings fifty years ago it has experienced an impressive advance. Its origins can be located with central European academics, the first ones that started applying this sort of techniques to study past climate changes, figures like Christian Pfister, economic historian or Emmanuele Le Roy Ladurie. With the development of the field, a new methodology to study the qualitative information provided in manuscripts was established to transform them into quantitative series, a fundamental step in the evolution of the discipline that took place during the 1960s.[67] But it was during the 1980s when the most important developments on historical paleoclimatology took place. The methodology suggested by Pfister recommends a sample of documentary sources that are suitable for the study of past climates. Those include chronicles, municipal acts, meteorological diaries, accounting books or ecclesiastical documents like rogation ceremonies, where such observations can be direct or indirect. Direct observations are more these sorts, and are sometimes daily. On the other hand, indirect observations can offer climatic information, although the nature of the document is normally economic or cultural such as manuscripts indicating low levels of harvest as a consequence of climatic events.[68] One of the problems of historicist reconstructions is that the observation may be biased by the nature of the observer. For example, a mild summer can be very hot for someone that has only lived very cold ones. On the other hand, these sorts of problems can be solved when the sources are systematically analysed and when the sample of qualitative sources reach a significant number. New academics like Glaser provided support for a subject that has been consolidated in the international academic arena, encouraging the publication of an increasing number of papers mainly from regional case studies.[69] One of the consequences of this development was the Project EUROCLIMHIST developed in the University of Bern under the direction of Christian Pfisted that

[67] Ladurie gives example about how the data can be used, Ladurie, E. L. R., *Histoire du climat dépuis l'an mil* (París: Flammarion, 1967)

[68]Pfister, C., Brázdil, R. and Barriendos, M., "Reconstructing Past Climate and Natural Disasters in Europe Using Documentary Evidence" *PAGES News*, 10 (2002)

[69] The most relevant publications are: Pfister, C., Fluctuaciones climáticas y cambio histórico: el clima en Europa Central desde el siglo XVI y su significado para el desarrollo de la población y la agricultura. *Geocrítica*, 82 (1989) Grove, J., *The Little Ice Age*. (Londres: Routledge, 1988), R. Glaser and R. Walsh (Eds.). *Historical Climatology in Different Climatic Zones*. Würzburg: Universität Würzburg, Würzburger Geographische Arbeiten, 80 (1991) Bradley, R.J. and Jones, P.D., (Eds.). *Climate Since A.D. 1500* (Londres: Routledge, 1992) Brazdil, R. and Kotyza, O., *History of Weather and Climate in the Czech Lands* I. Period 1000-1500. (Zurich: Geographisches Institut, 1995) Brazdil, R. and Kotyza, O., *History of Weather and Climate in the Czech Lands II. The earliest daily observations of the weather in the Czech Lands* (Brno: Masaryk University, 1996) Brazdil, R. and Kotyza, O.,*History of Weather and Climate in the Czech Lands III. Daily Weather Records in the Czech Lands in the Sixteenth Century II.* (Brno: Masaryk University, 1999)

has gathered an enormous amount of information and climatic series from a wide range of European countries from the early sixteenth century.[70]

In Spain, the main paleoclimatological studies have been developed within the historicist stream. One of the reasons is that the conservation of the Spanish archives and their excellent state are an invaluable source for this discipline. It is therefore not a surprise that academics consider Spain to be one of the countries with a higher potential for the creation of past climatic series. For example, in recent dates Spanish scholars have been able to create series of floods or droughts using the information from ecclesiastical institutions about rogation ceremonies.[71]

Manuel Rico Sinobas is considered the first Spanish climatic historian in the mid nineteenth century. He was a medic in Castile that collected references from manuscripts and historical sources like civil registers in towns that included information written by the political leaders with references to climatic information. He even tried to create a centralised archive with all this climatic information, to create aggregates and therefore establish a reconstruction of climate variables for the Spanish territory. However, nobody continued his work after his death until Horacio Bentabol in the early twentieth century, an engineer that published a study gathering a considerable amount of documents including information about the climate, that in any case he never tried to analyse systematically. [72]

It was not until the mid twentieth century when a key figure appeared, Fontana Tarrats, considered the father of historicist paleoclimatology in Spain. Professor Fontana was aware of the huge potential of the Spanish archives that has been highlighted before and developed an intense research locating and gathering information. Therefore, the work of Fontana is very similar to the work of Horacio Bentabol a hundred years ago, collecting and archiving information of Spain at a regional level.[73] The amount of information was so important that even today his work is still being analysed by modern climatic historians.

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[70] A preliminary versiórn of the database can be found in www.euroclimhist.com
[71] Barriendos has used this methodology extensively in his works.
[72] Bentabol, H., *Las aguas de España y Portugal.* (Madrid: Vda. e Hijos de M. Tello, 1900)
[73]Fontana Tarrats, J.M., *Entre el cardo y la rosa. Historia del clima en las Mesetas*, manuscript, (1971-1977) Fontana Tarrats, J.M., *Historia del clima en Cataluña. Noticias antiguas, medievales y en especial de los siglos XV, XVI y XVII*, manuscript (1976) Fontana Tarrats, J.M., *Quince siglos de clima andaluz*, manuscript (1976) Fontana Tarrats, J.M., *Historia del clima del Finis-Terrae gallego*, manuscript, (1977) Fontana Tarrats, J.M., *Historia del clima en el litoral mediterráneo: Reino de Valencia más Provincia de Murcia*, manuscript (1978) Fontana Tarrats, J.M. *et al. El clima de Baleares, hoy y ayer: 1450-1700*, manuscript, (1974-1975)

In the 1980s, the first publications about historicist paleoclimatology appeared in Spain within the university system trying to establish a clear methodology to select the right documentary sources.[74] In 1994 the first two PhD theses about the subject were defended, with Mariano Barriendos and his study of Catalonia and Fernando Sanchez Rodrigo and his case study of Andalusia.[75] Since then, there has been an intense revitalization of the discipline in Spain with new figures like Mariano Barriendos and the creation of working groups integrated in international networks of paleoclimatic studies. The result is a growing number of publications during the last ten years, in national but especially in international journals, that normally focus their analysis on series of rainfall and droughts at a regional level.[76]

We can therefore conclude this brief summary of the literature confirming that paleoclimatology both in its scientific as well as in its historicist face is enjoying an intense development. One of the main reasons is the impressive development of scientific methods and the establishment of a clear methodology to transform qualitative sources into quantitative series. However, we cannot forget the end of the economic barrier that Gordon Manley continuously mentioned. The speech of Kissinger in 1974 highlights the worries of the political class dealing with the devastating effects of climate change. Nowadays this concern is very clear, and one of the outcomes of this fear is the increasing funding for the study of past climate changes with the hope that by understanding the past we will be able to predict the changes of the future.

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[74] Like the work of Albentosa: Albentosa, L.M., "La importancia del conocimiento de las fluctuaciones climáticas en los estudios históricos. Aproximación al clima de Tarragona durante el siglo XVIII" *Universitas Tarraconensis*, 4 (1981-1982)

[75] Barriendos, M., *Climatología histórica de Catalunya. Aproximación a sus características generales (ss. XV-XIX)*. Barcelona: Departamento de Geografía Física y Análisis Geográfico Regional, Universidad de Barcelona, 1994, Tesis doctoral inédita. Rodrigo, F.S., *Cambio climático natural. La Pequeña Edad del Hielo en Andalucía. Reconstrucción del clima histórico a partir de fuentes documentales*. Granada: Departamento de Fisica Aplicada, Universidad de Granada, Tesis inédita, 1994.

[76] Barriendos, M., El clima histórico de Catalunya (siglos XIV-XIX). Fuentes, métodos y primeros resultados. *Revista de Geografía*, 30-31 (1996) Barriendos, M., Climatic variations in the Iberian Peninsula during the late Maunder Minimum (AD 1675-1715): an analysis of data from rogation ceremonies. *The Holocene*, 7, 1, (1997) Barriendos, M., Gomez, B. and Peña, J.C., "Series meteorológicas instrumentales antiguas de Madrid y Barcelona (1780-1860). Características documentales y de observación." in J. Martin Vide (Ed.), *Avances en climatología histórica en España*. (Barcelona: Oikos-Tau, 1997) Barriendos, M. and Martin Vide, J., "Secular Climatic Oscillations as Indicated by Catastrophic Floods in the Spanish Mediterranean Coastal Area (14th-19th Centuries)" *Climatic Change*, 38 (1998) Barriendos, M.and Llasat, M.C., "The Case of the 'Maldá' Anomaly in the Western Mediterranean Basin (AD 1760–1800): An Example of a Strong Climatic Variability" *Climatic Change*, 61 (2003) Barriendos, M. and Martin Vide, J., "The use of rogation ceremony records in climatic reconstruction: a case study from Catalonia (Spain)" *Climatic Change*, 30 (1995) Rodrigo, F.S., Esteban Parra, M.J and Castro Diez, Y., "An attempt to reconstruct the rainfall regime of Andalusia (southern Spain) from 1601 A.D. to 1650 A.D. using historical documents." *Climatic Change*, 27 (1994) Rodrigo, F.S., Esteban Parra, M.J. and Castro Diez, Y., "The onset of the Little Ice Age in Andalusia (Southern Spain): detection and characterisation from documentary sources." *Annales Geophysicae*, 3 (1995)

4.2 Origins of pre-modern climate changes

The existence of climate changes in the past is a fact established by the scientific and academic community. We therefore should not address their existence, but their origins and the forces behind those changes. In the last decades many theories about the origins of climate changes have been developed and at the same time abandoned as new technologies produced breakdowns in our knowledge of the issue. The main theories can be divided into two main streams, those that assume that the changes have an origin endogenous to earth, and those arguing that the main causes are exogenous to our planet.

Within the endogenous school of thought we can emphasize four main theories. The first one is the theory of **continental drift** that maintains that climate changes are originated by the movement of continents producing changes in their climatic regimes. One of the examples is the change of climate in Africa when it moved from the South Pole to its current position. [77] In the same way, when water passages like in the case of Panama were closed, there were also changes in the direction of oceanic streams that produced changes in climate. [78] The main problem of this theory is not methodological or realistic, but a problem of scale. The arguments are correct, but the geological timeline is too big and therefore completely useless to analyse history in a human scale. The second theory is the **theory of reflection** that is based on the ability of the surface of the planet to reflect solar rays.[79] According to this theory, increases or decreases of vegetation, ice or deserts produce changes in the amount of solar rays reflected by earth and therefore in the amount of warm that is expelled from the surface, producing changes in climate. The third main theory is the **volcanic theory**, which states a series of volcanic eruptions can and did produce changes in climate. [80] The reasoning behind this argument is that volcanic eruptions expel important amounts of dust into the air, decreasing the amount of solar rays that penetrate the atmosphere and therefore reflecting heat from the sun, reducing temperatures. [81] The volcanic theory is closely related to the last main endogenous hypothesis, the **atmospheric theory**. In this case, theorists argue that changes in the composition of the atmosphere (like increasing amounts of CO_2) can alter the climate. [82] At present, almost nobody doubts the fact that industrial emissions of CO_2 are a driving force of global warming, a belief that was not so clear just thirty years ago. In a quotation with more

[77]Bryson, R.A and Murray, T.J., *Climates of hunger: mankind and the world's changing weather* (Madison, University of Wisconsin Press, 1977) p.139.
[78]Huntington, E., *Climatic changes: their nature and causes* (New Haven, Yale University Press, 1922) p.44
[79] Bryson y T.J. Murray, "Climates", p.140.
[80] Huntington, *Climatic changes*, p.45.
[81] There is an excellent register of the main volcanic eruptions during the last 500 years in Pittock, A.B., *Climatic Change and Variability* (Cambridge, Cambridge University Press, 1978) p.261.
[82] Bryson and T.J. Murray, "Climates", p.142.

than just anecdotal value, Ellsworth Huntington pointed out that *"We are unable to accept this theory for a number or reasons".* [83]

On the side of exogenous theories, the choices are less abundant. The theory of **eccentricity of Croll** proposes that the elliptic movement of earth around the sun and the different degrees of proximity can have an influence on climate, especially through changes in winds and oceanic streams. [84] This theory is related to a more modern proposal that concludes that the effect of the translation movement around the sun have direct effects on climate changes on earth. [85] However,the main exogenous theory is probably the **solar theory**, a hypothesis whose importance has increased in the last decades thanks to the support of empirical evidence obtained from satellites and direct observations. According to this theory, solar activity is not constant and there are small changes that produce important variations on the amount of solar wind that the sun produces and that is received by earth.[86] The relationship between sun spots and solar activity has been confirmed by recent studies. Therefore their study can be useful to create estimations of solar activity from several centuries ago when astronomers started recording their existence.[87]

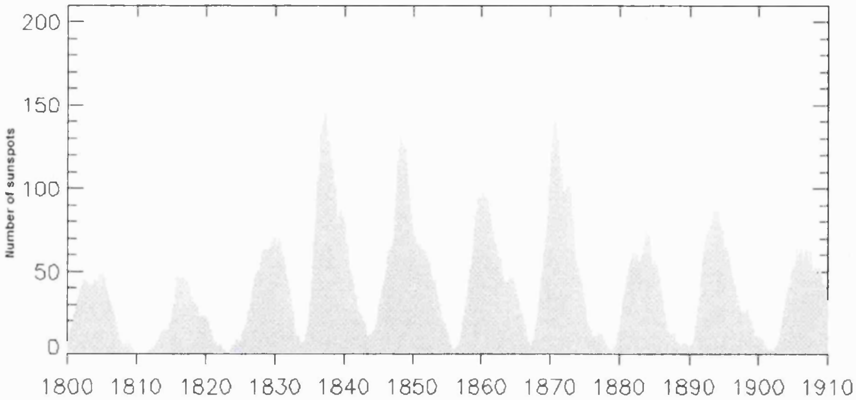
However, accepting that all the previous theories are probably correct, their effects and the temporal framework of action that is derived from each one varies considerably. For example, the theory of continental drift is completely useless in the study proposed in this thesis because geological and human scales can not be compared. Therefore, we are interested in those theories whose temporal scales can be comparable with human history. For that reason the two theories that can be applied to this study are the volcanic and the solar theories, the solar theory probably being the most relevant. Extensive studies concluded that changes in the level of solar and volcanic activity can explain between 41 and 64 per cent of changes in temperatures before 1850. [88] We have excluded the effects of the atmospheric theory because it was irrelevant for pre industrial times.

The solar theory: According to recent studies the solar theory is the main force driving climate changes in pre industrial times.[89] There are instrumental measurements of solar radiations but they are very recent, for previous ages astronomers used the records of sunspots to estimate solar

[83] Huntington, *Climatic changes*, p.45.
[84] Huntington, *Climatic changes,* p.34.
[85] Bryson and T.J. Murray, "Climates", p.141.
[86] Huntington, *Climatic changes*, p.49.
[87] It is interesting to not that even at the end of the 1970s sunspots still were not associated with solar activity, see Bryson and Murray, "Climates"
[88] Crowley, "Causes"
[89] Crowley, "Causes"

activity. Their analysis allows the observation of 11 year cycles like the ones presented in the next figure.

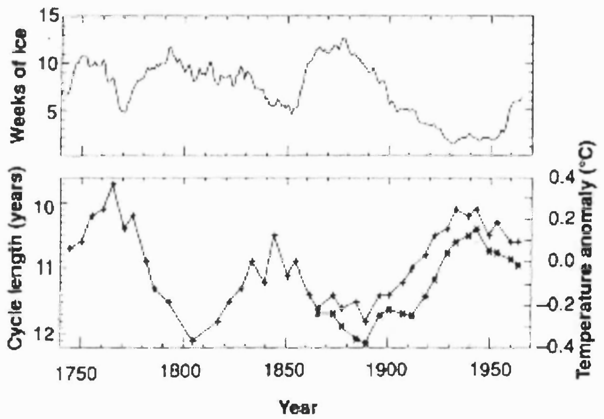
Figure 4.1: Sunspots numbers 1800-1910



Source: Graph from the SIDC (Solar Influences Data Analysis Center) [90]

The duration of the cycles and their intensity have been key variables that have been analyzed and directly related to climate changes. One of the most famous and cited publications was the study by Friis-Christensen and Lassen that compared the relationship between the length of the solar cycle and changes in temperatures. The results are presented in the next graph. [91]

Figure 4.2: Solar Cycle and Temperature, 1725-1990



Source: Graph from Friis-Christensen and Lassen (1991)

[90] The data can be found in http://sidc.oma.be/index.php3

[91] Friis-Christensen, E and Lassen, K., "Length of the solar cycle: an indicator of solar activity closely associated with climate", *Science* Vol 254, N° 5032 (1991) p.700.

Vulcanism: The foundations of this theory has been briefly explained in the lines above. The emission of huge amounts of dust to the atmosphere produced a global cooling reflecting the heat produced by the sun that did not reach the surface of the planet. This link has been empirically analysed, especially through the study of very intense eruptions that had direct consequences on climate. One example is the eruption of the Krakatoa volcano in 1883. However, this sorts of isolated eruptions only have very short term effects, and in order to produce a sustained climate change it is necessary a continued chain of powerful eruptions.

4.3 Past climate changes in Spain

During the sixteenth and seventeenth centuries, Spain lived periods of 40 years with intensification of very extreme climatic events like droughts, snowfalls or floods. Experts have identified three main climatic oscillations in Spain during the last five hundred years, the first oscillation between 1580 and 1620, the Malda anomaly between 1760 and 1800 and finally the third oscillation that corresponds to the end of the Little Ice Age between 1830 and 1870. [92] The first oscillation was a period of global cooling that affected not just to Spain but also to all the Northern Hemisphere. It was characterised by decreasing temperatures and increasing rainfall in the form of catastrophic floods.

Temperature and rainfall are therefore the two main climatic variables that have been studied to measure the effects and intensity of climate changes in the past. In this thesis, temperatures will be presented in northern hemisphere estimations created from both historical and scientific sources. Rainfall series however are local estimations from historical sources and are more precise than temperatures. The local study of rainfall is possible thanks to the extensive information that is provided in historical sources that on the other hand are not so generous in the case of temperatures. This section includes rainfall series for Catalonia in the north east, Toledo in the centre of the peninsula, and Andalusia in the south.[93] The data has been extracted from the studies by Crowley and Lowery in the case of temperatures and from Barriendos and Rodrigo in the case of rainfall. The methodologies followed by the authors have been largely established in paleoclimatology and the results published and reviewed in academic journals.

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[92] Barriendos and Martin Vide, "Secular", p.60.

[93] Rodrigo, F.S. et al., "A 500-year precipitation record in southern Spain." *Internacional Journal of Climatology*, , (1999)

The estimations of temperature presented in this chapter have been gathered from a wide range of sources. Thomas Crowley and Thomas Lowery collected information from fifteen historical and scientific sources, like tree rings in Colorado, English shipping records, Chinese manuscripts, ice cores from mountains like Tibet and mud from the Sargasso Sea in the Atlantic Ocean. [94] Therefore, unlike other estimations, the series combine the best part of the two paleoclimatological families, the scientific and the historicist. There are also documentary sources at local level about the evolution of temperatures. However, they are not very abundant and its systematic analysis to carry out annual series of temperature is not always possible. In the case of Spain there are manuscripts concerning severe changes in temperatures in different parts of the country like the annotations of the local priests of Lanciego, a small village in the Basque country. Such evidence is however very sketchy to create long term and consistent series.

The nature of the Spanish historical sources is ideal for the creation of rainfall and drought series. In the case of excess rain, the information in the documents is normally focused on the analysis of the damages produced by floods and published by municipal authorities. In many of the cases, the document also included the amount of money and the levels reached by the flood, making it possible to study the intensity of the event with excellent precision. Intense periods of heavy rainfall were also recorded by ecclesiastical authorities and rogations ceremonies *pro serenitae* (to calm down) were carried out by the church in order to "calm down the fury of the sky". On the other hand, the study of droughts is possible thanks to the study of rogation ceremonies *pro pluvial* (to encourage rain) that ecclesiastical authorities carried out after the petition of civil authorities to finish with long periods of droughts that were ruining the harvests. [95] The ceremonies were different depending on the level of the threat. The Spanish church had very specific rituals to follow depending on the gravity of droughts. In the case of low severity the authorities considered that prayers in masses would be enough to finish with the drought. However, as the level of the crisis increased, new and more complex measures were introduced from the public exhibition of religions figures to processions and even pilgrimages to holy places.

[94] Crowley, T.J. and Lowery, T.S., "How warm was the Medieval warm period?" *Ambio* 29 (2000)

[95] The method is explained in Barriendos, and Martin Vide, "Secular", p.475.

Table 4.1: Ecclesiastical reactions to climatic crises

Level	Effects on Agriculture	Action	Character Civil/Ecclesiastical
I	None (preventive)	Special prayers in the mass	Intra ecclesiastical Intra Civil
II	Small damages	Public exhibition of religious figures inside the church	Intra Ecclesiastical Intra Civil
III	Partial lost of harvest	General procession through the town with relics or figures	Extra Ecclesiastical Intra Civil
IV	Severe lost of harvest	Immersion in water of relics or figures	Extra Ecclesiastical Intra Civil
V	Subsistence crisis	Pilgrimage to sanctuaries of especial veneration	Extra Ecclesiastical Intra Civil

Source: Barriendos (1995)

Figure 4.3: Images used in the religious ceremonies

Saint Severus: With relics in Barcelona since the fifteenth century it was the level III of *pro pluvia* ceremonies that included a public procession through the streets of the city.

Blessed Sacrament: Used since 1619 when the Vatican forbade the immersion of relics in water. It was the level IV *pro pluvia*.

Our Lady of Montserrat: It was the maximum *pro pluvia* level in Catalonia with pilgrimages to her sanctuary from all over the region.

There were also references to other extreme climatic events such as snowfalls and hail, although the amount of information is not as generous as in the case of droughts and floods. In the case of snow, the references were normally taken in places where the episode was a rare one or when it directly affected economic activity like transport or the production of water mills. The case of hail and electric storms was similar, although the effects on harvests and buildings more direct and sometimes disastrous. The Spanish church also had especial rituals to follow in these cases that included *contra nebulam* and *ad repellentdam tempestates*.[96]

The documentary sources presented have been systematically analysed by climatic historians, following a consistent methodology established in the literature.[97] The results included in these studies include a wide range of datasets that track down the evolution of past climate in Spain at local levels from the sixteenth century.

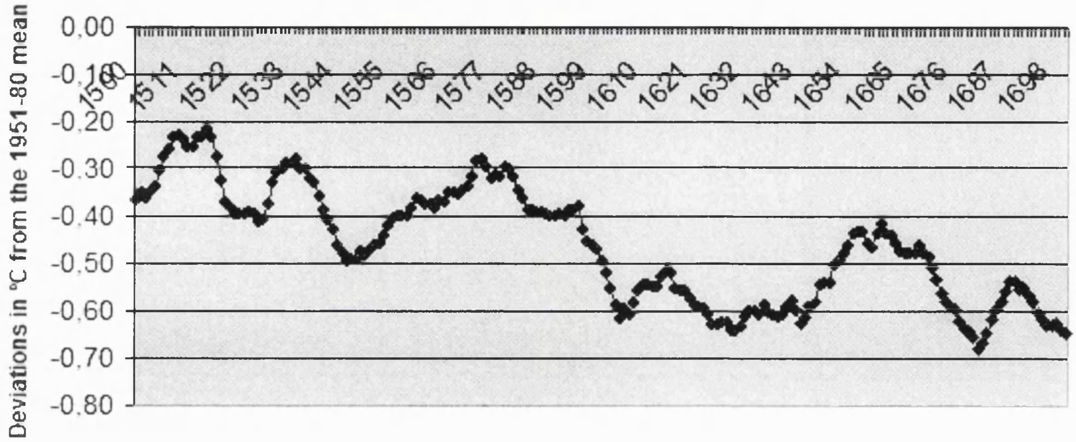
4.3.1 Climate before the Malda Anomaly

Given the nature of the thesis and the chronological framework, very long run cycles are pointless, and therefore we have to focus our analysis on smaller ones. There are positive (increasing temperatures) and negative (general cooling) periods. For example during the medieval warm period temperatures were similar to the ones that the earth has experienced in the last decades, although according to the authors not as warm as the current global warming. However, ou r analysis starts not in the medieval age but in the sixteenth century. Especially in its last decades Spain witnessed some of the worst years of the Little Ice Age, a global cooling that started in the fourteenth century (although some authors delay its beginning to the late sixteenth century) and ended in the late nineteenth century.

The sixteenth century is a period of relative climatic stability, although the last quarter of the century will suffer the beginning of a global cooling that will affect the Iberian Peninsula until the end of the seventeenth century. The next graph presents the evolution of temperature between 1500 and 1700. The series shows the values in deviations in °C from the 1951-80 mean.

[96] Barriendos, and Llasat, "The Case", p.554.
[97] Barriendos, and Llasat, "The Case"

Figure 4.4: Temperature in the Northern Hemisphere 1500-1700 (deviations in °C from the 1951-80 mean)



Source: Crowley and Lowery (2000)

The graph shows that from the first half of the sixteenth century to the early seventeenth century, northern hemisphere temperatures fell an average of 0.5°C. This fall may appear to be a small change, but it has been proved that a fall of 0.3°C can double the probability of harvest failure in marginal areas.[98] In addition, this predicted fall is just an annual average, and as recent studies have proposed, seasonal changes may have been harder, with winter temperatures falling by more that 1.75°C.[99] We also have to take into account that, as we have seen in the previous sections of this chapter, the different climatic regimes in Spain can produce different outcomes. For example, the continental-Mediterranean climate of the interior of the Iberian peninsula like the one in Guadalajara suffered a higher thermal amplitude than the areas in the periphery, so the fall of temperatures was probably more severe in these interior areas of Spain than on the coast.

In the case of rainfall, the datasets are more complete including not just yearly observations, but also monthly series. This allows not just the study of inter-annual variability but also intra-annual and seasonal changes between 1500 and 1800.[100] The average annual series of rainfall in the south of Spain (Andalusia) for the sixteenth and seventeenth centuries is presented in the next graph.

[98] Crowley, "Causes"
[99] Shindell, D.T. et at., "Solar forcing of regional climate change during the Maunder minimum", Science 294 (2001)
[100] Rodrigo, et al., "A 500-year"

Figure 4.5: Rainfall in Andalusia, 1500-1700[101]

Source: Rodrigo (1999)

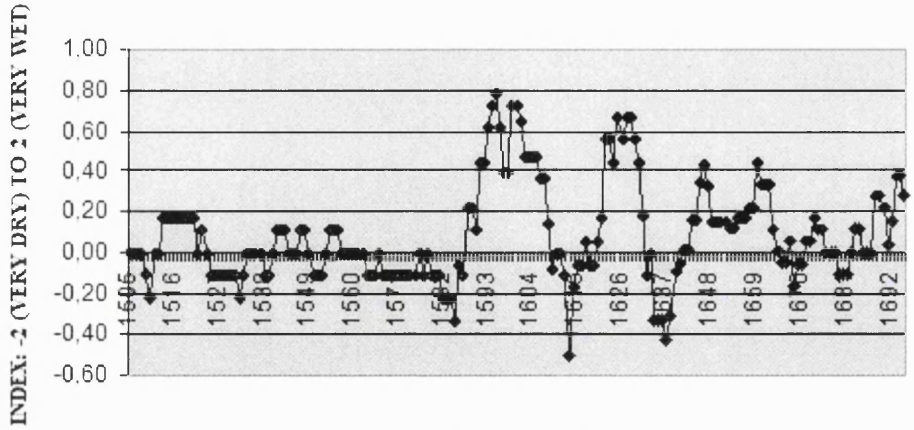
The results indicate a relative stability during the sixteenth century until the 1540s and especially the 1580s when there was a considerable increase of rainfall that was maintained until the mid seventeenth century. Some of the years are especially intense, like 1626 when very heavy rainfall was recorded in the interior of the peninsula and the Guadalquivir valley from January to February.[102] There were also long periods of droughts, for example during the periods 1565-1568 and 1628-1634.

The seasonal analysis reveals some differences. The springs of the sixteenth century were generally dry and the increase in yearly rainfall during the end of the century was mainly a consequence of an increase in Spring precipitations which, as can be observed in figure 4.6 grew in significance during the 1580s until the beginning of the seventeenth century.

[101] The index takes values from 2 (very wet) to -2 (very dry) for every season. The results presented in the graph compose the annual index calculated as suggested by the authors as the sum of the four seasonal indexes.

[102] Barriendos, personal communication.

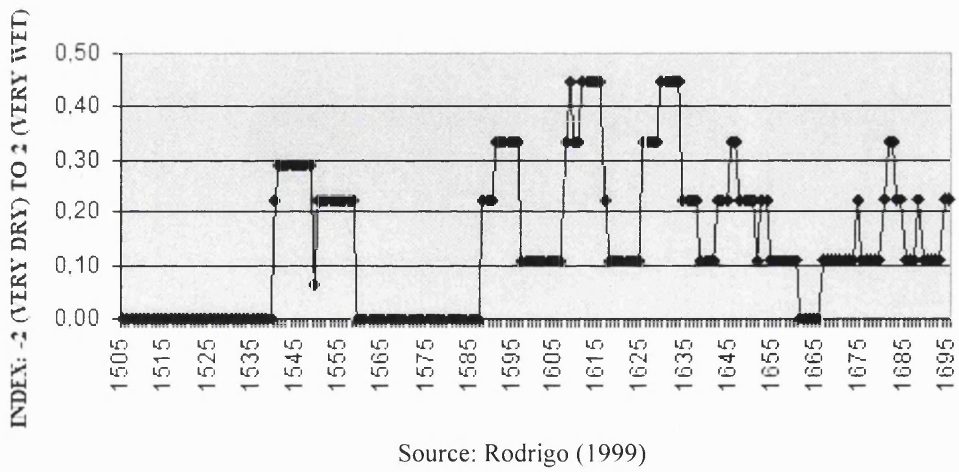
Figure 4.6: Spring rainfall in Andalusia, 1500-1700[103]



Source: Rodrigo (1999)

Summer precipitations were in general quite low during the sixteenth century, although like in the case of spring rainfall they did suffer changes in the late sixteenth century, especially after 1585 when there was with a considerable increase.

Figure 4.7: Summer rainfall in Andalusia, 1500-1700[104]

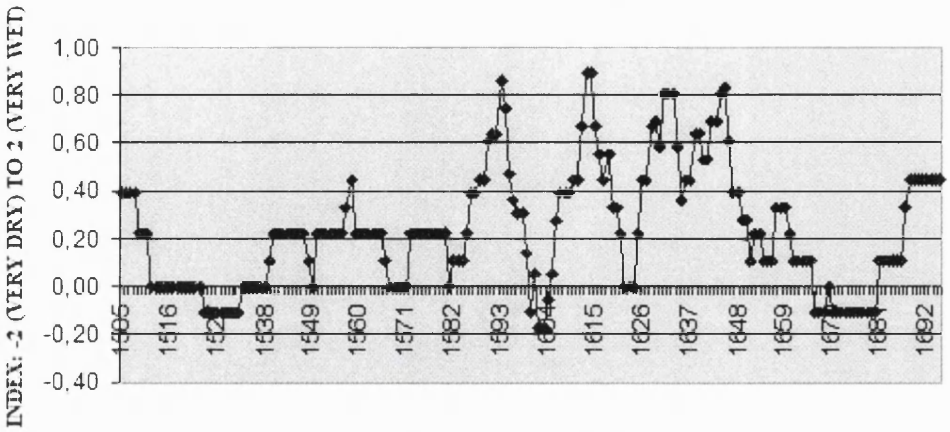


Source: Rodrigo (1999)

The same pattern is observed in autumn rains, with a first half of the sixteenth century relatively dry with some episodes of droughts during the decades 1520s, 1530s and 1550s. However these deficits were reduced in the second half of the century, although from 1570 onwards the increase was dramatic with catastrophic floods that did affect not just the south of Spain but also Catalonia and the central plateau.

[103] The index takes values from 2 (very wet) to -2 (very dry)
[104] The index takes values from 2 (very wet) to -2 (very dry)

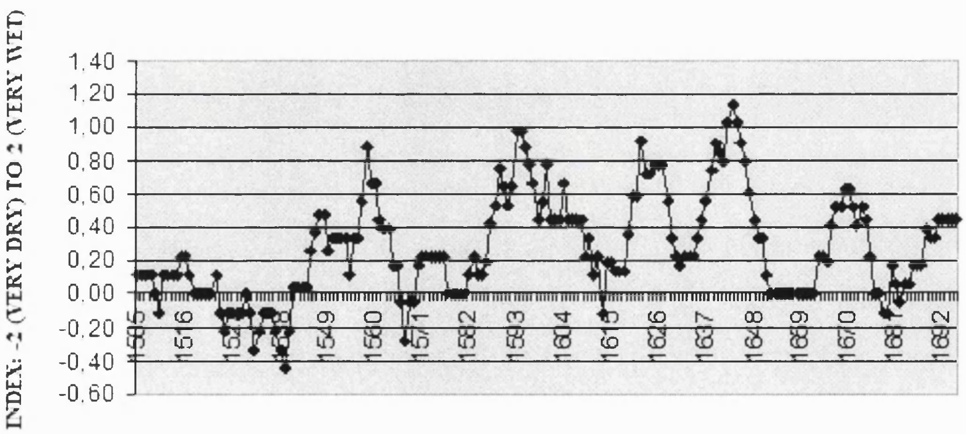
Figure 4.8: Autumn rainfall in Andalusia, 1500-1700[105]



Source: Rodrigo (1999)

Winters of the first half of the sixteenth century were dry, even with periods of droughts between 1530 and 1550. As in the case of autumn rains the water deficit was reduced during the second half of the century when floods that had been isolated events during the first half, intensified their numbers during the last third of the century, especially from 1585. The seventeenth century was defined by a continuity of heavy precipitations combined with shorter periods of droughts.

Figure 4.9: Winter rainfall in Andalusia,1500-1700[106]



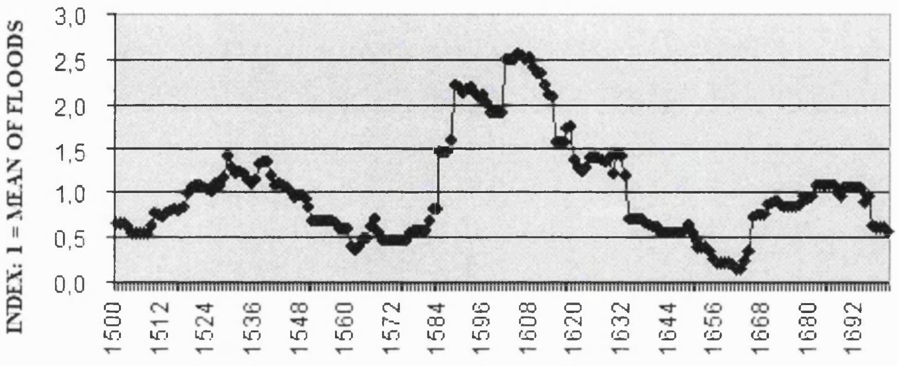
Source: Rodrigo (1999)

The next figure moves the geographical framework to Catalonia in the north east corner of the peninsula. It presents the index of floods for the Catalan coast from 1500 to 1700. The oscillations identified in the series coincide with the series created by Rodriguez for Andalusia and that have been analysed previously, as can be observed in the following graph. For that reason the summary

[105] The index takes values from 2 (very wet) to -2 (very dry)
[106] The index takes values from 2 (very wet) to -2 (very dry)

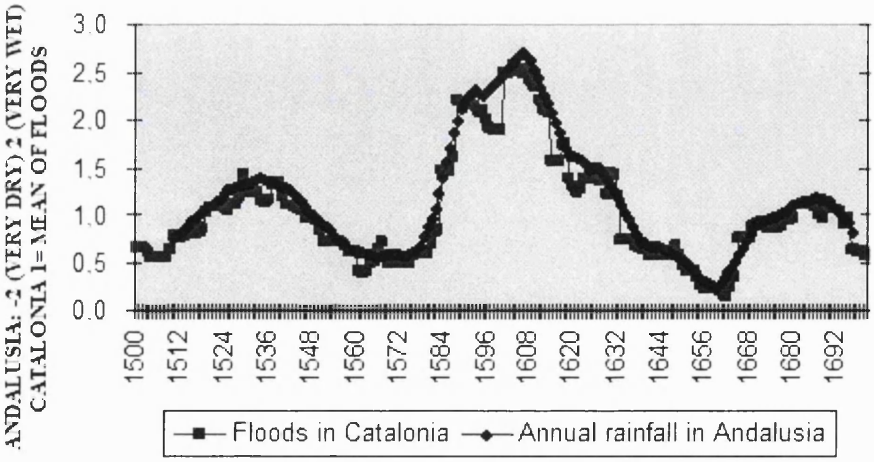
is the same with a dry sixteenth century and a dramatic increase of precipitations in the late part of the century. There are also specific years that were especially remembered by the contemporaries, like 1617 known as the year of the deluge, when a tempest damaged the east coast of Spain from Valencia to the Pyrenees.[107]

Figure 4.10: Frequency of catastrophic floods in Catalonia, 1500-1700[108]



Source: Barriendos (2003)

Figure 4.11: Frequency of catastrophic floods in Catalonia and annual rainfall in Andalusia, 1500-1700



Source: Barriendos (2003) and Rodrigo (1999)

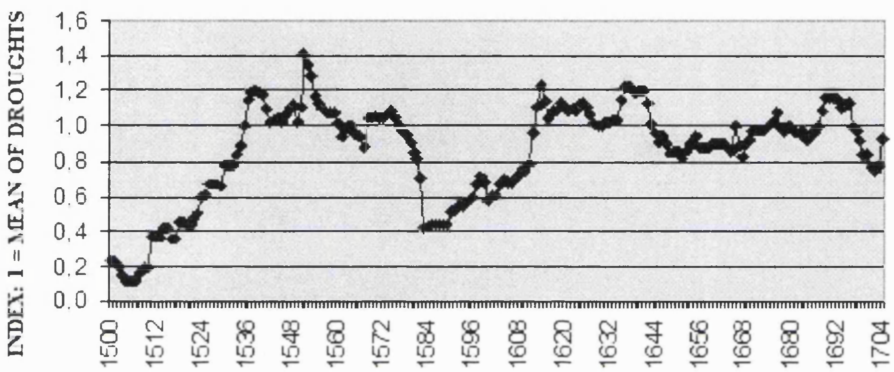
The next graph shows the index of droughts for the Catalan coast. The sixteenth century presents an increase in the number of droughts that peak in the middle of the century with a long drought in the

[107] Barriendos, and Llasat, "The Case"

[108] The index shows the frequency of floods every year, when the value is 1 the amount of floods equals the mean of the sample. Therefore a value of 2 means that in that year the number of floods doubled the expected. On the other hand a value of 0.5 means that the number of floods that took place were half of the expected.

period 1565-1568. Afterwards there was a deep decline of droughts coinciding with the initial oscillation identified by Barriendos and that kept the index to very low levels between 1580 and 1620. Droughts appeared again in the 1620s to be reduced again during the second half of the seventeenth century.

Figure 4.12: Frequency of droughts in Catalonia, 1500-1700[109]

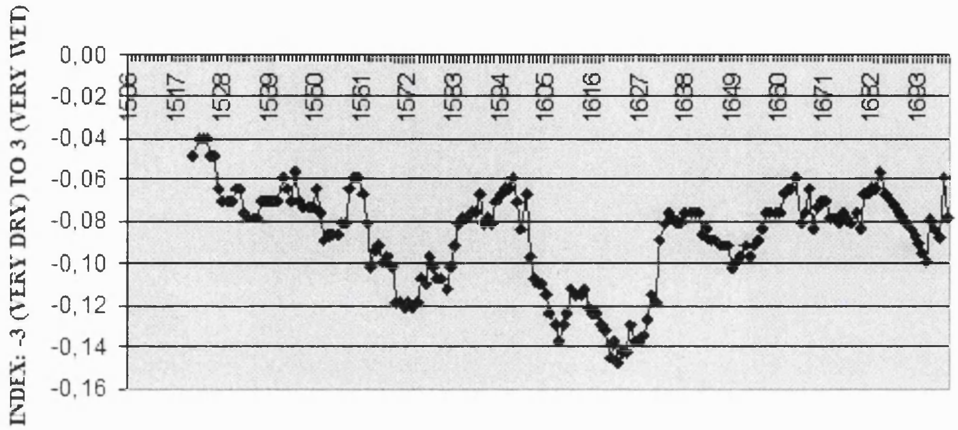


Source: Barriendos (2003)

The series for the interior of the Iberian Peninsula also identify the effects of the initial oscillation. The next graph presents the series of rainfall for the province of Toledo, in central Spain. The dataset is more reduced and therefore the data are presented using a 30 years moving average. The effects of the initial oscillation are clearly identified in the graph and start in the 1580s. However unlike along the coasts, after the first years of the seventeenth century, a period of droughts started and was maintained for more than twenty years. Afterwards rains increased and the water cycle became more stable reducing the periodicity of droughts and floods, extreme events that still appeared although with less frequency than in previous decades.

[109] The explanation is the same as in footnote 116.

Figure 4.13: Rainfall in Toledo, 1500-1700[110]



Source: Barriendos (Personal communication)

Therefore the main difference between the series of Toledo and those in the periphery is the timing of the initial oscillation which was shorter in the interior of the peninsula than in the coastland areas like Catalonia and Andalusia. Therefore the phase of low precipitations that has been identified after the oscillation also appears before in the interior than in the periphery. One of the possibilities is the different climatic regime that exists in the interior, Mediterranean-continental, and the Mediterranean in the coast where as we have seen before the water cycle is more intense than in the Mediterranean-continental.

In summary, the sixteenth century was a dry period with stable temperatures that even increased. Droughts were more common in the mid sixteenth century, especially during the period 1565-1567. The last third of the century suffered a considerable increase of rainfall that during the last two decades produced catastrophic floods that were accompanied by a decrease in temperatures. This initial oscillation is, according to Barriendos, the most intense in the last 500 years in Spain, and although the number and intensity of droughts was reduced the new climate increased the number of frosts and strong snowfalls. The oscillation ended in the 1620s in the periphery and a decade before in the interior with the beginning of a new period of droughts that lasted until 1640. The second half of the seventeenth century was characterised by a new wave of cold temperatures that according to the series presented by Crowley and Lowery reached a minimum in the 1680s. However, during the second half of the seventeenth century there were also some positive events, like the reduction in the number of droughts and floods with a more stable water cycle. On the other

[110] As in the case of Andalusia, the annual index presented in the graph is a sum, in this case of the monthly indexes.

hand, the reduction of temperatures also included an increment of some extreme climatic events like snowfalls.

4.3.2 The Malda Anomaly

Of the three climatic oscillations identified by climatic historians, this thesis studies the effects of the Maldá Anomaly that took place during the second half of the eighteenth century. The anomaly was identified by the climatic historian Manuel Barriendos and consisted of an increase in the variability of climate in the Iberian Peninsula. It was named in honour of the Baron of Malda, who in his diary left his testimony of the anomalous weather of the period. The eighteenth century is considered the end of the Little Ice Age and is characterized by the appearance of the second climatic anomaly of the last 500 years, the Malda Anomaly.[111] According to Barriendos, the Malda Anomaly started around 1760 and finished in the beginning of the nineteenth century, reaching its peak around 1780. The main characteristic of the anomaly was the incredibly high climatic variability, with periods of droughts that were followed by catastrophic floods in relatively short periods of time. Between 1782 and 1785, in the middle of the worst years of the Malda Anomaly, a doctor from Cordoba described the climatic variability and its relationship with the appearance of diseases with endemic character.

" ... *from this irregular weather, extraordinary for Cordoba, came an epidemic of tertiary fever...* "[112]

In 1786 the Baron of Malda wrote in Barcelona.

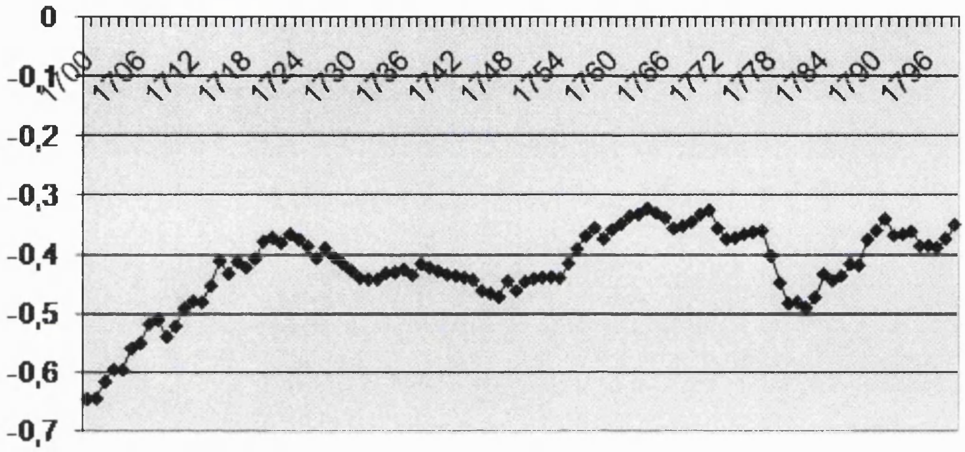
The case of the lightings was mostly unexpected as it is an extraordinary event, because storms normally take place in the middle of April and continue until October. This proves that climate has carried out a mutation and that weather has therefore changed in relation to its [normal] seasonal sequence from many years ago.[113]

The evolution of temperatures during the eighteenth century was a continuation of the cold weather that appeared during the seventeenth century, that however tended to disappear. The general

[111] The anomaly was named by Barriendos.
[112] Barriendos, and Llasat, "The Case", p.202.
[113] Barriendos, and Llasat, "The Case", p.202.

temperature trend is therefore a positive one with increasing temperatures from the lowest points reached at the beginning of the century, and by the end of the 1790s temperatures rose by 0.3°C.

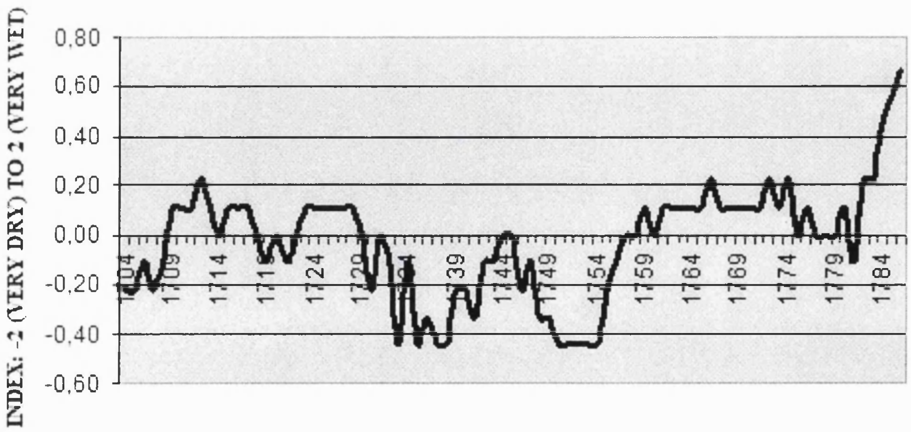
Figure 4.14: Temperature in the Northern Hemisphere, 1700-1800 (deviations in °C from the 1951-80 mean)



Source: Crowley and Lowery (2000)

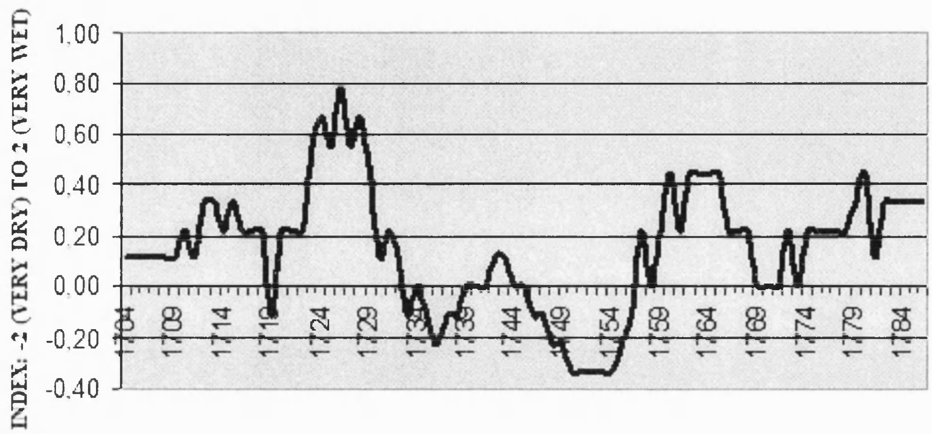
Rainfall series for the eighteenth century presented in this section are estimations for the south of Spain. The volatility of climate is so high that even within the same year periods of droughts and catastrophic floods can be identified.

Figure 4.15: Spring rainfall in Andalusia, 1700-1800



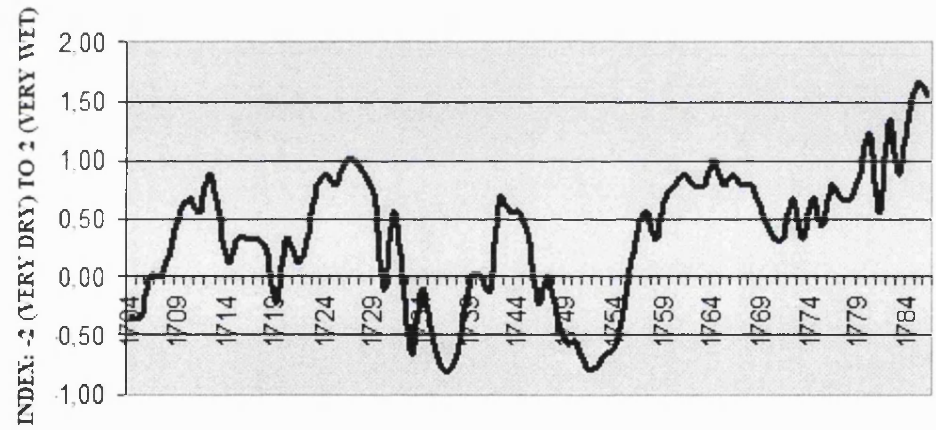
Source: Rodrigo (1999)

Figure 4.16: Autumn rainfall in Andalusia 1700-1800



Source: Rodrigo (1999)

Figure 4.17: Annual rainfall in Andalusia, 1700-1800



Source: Rodrigo (1999)

However, although the series presented above can give us information about long run trends, the characteristics of the Malda Anomaly makes the use of annual and even seasonal indexes difficult to identify due to its intense short term variability. In fact the annual figures, as Barriendos shows in his studies, probably do not differ that much from average values reached in previous decades. One of the ways that we have to measure the intensity of the anomaly is comparing the period with the series of the sixteenth and seventeenth centuries presented before and with the values of the nineteenth century also available. The following table shows the number of years and seasons with high internal variability from 1521 until 1900. The results prove that most of the unstable periods took place during the Malda anomaly between 1750 and 1810.

Tables 4.2 and 4.3: Climate variability during the Malda anomaly

Unstable years (one season with drought and another with floods)			*Number of cases*		*Number of cases during the Malda Anomaly*	
Location	*Period*	*Years (I)*	*N°*	*Frequency 1 in x years*	*N°*	*% of total*
Barcelona	*1521-1896*	*376*	*28*	*11.5*	*10*	*36%*
Gerona	*1438-1881*	*444*	*34*	*13.1*	*8*	*24%*
Tarragona	*1493-1874*	*382*	*8*	*34.3*	*3*	*38%*
Tortosa	*1565-1858*	*294*	*20*	*14.7*	*10*	*50%*
Seu dÚrgell	*1539-1843*	*305*	*4*	*76.3*	*1*	*25%*
Vic	*1568-1900*	*333*	*11*	*30.3*	*0*	*0%*
Cervera	*1484-1850*	*367*	*4*	*91.8*	*2*	*50%*

Unstable Seasons (one month with drought and another one with floods)			*Number of cases*		*Number of cases during the Malda Anomaly*	
Location	*Period*	*Years (I)*	*N°*	*Frequency 1 in x years*	*N°*	*% of total*
Barcelona	*1521-1896*	*376*	*5*	*75.2*	*3*	*60%*
Gerona	*1438-1881*	*444*	*6*	*74.0*	*4*	*67%*
Tarragona	*1493-1874*	*382*	*1*	*<382*	*1*	*100%*
Tortosa	*1565-1858*	*294*	*7*	*42.0*	*3*	*43%*
Seu dÚrgell	*1539-1843*	*305*	*3*	*101.7*	*2*	*67%*
Vic	*1568-1900*	*333*	*4*	*83.3*	*2*	*50%*
Cervera	*1484-1850*	*367*	*0*	*>367.0*	*0*	-

Source: Barriendos (2003)

The numbers presented in tables 2 and 3 show that the probability of having an unstable year during the period of the Malda Anomaly was 2.7 times higher than during any other time of the period 1500-1900. The probability of suffering an unstable season during the Malda Anomaly was also 4.3 times higher than during any other time of the period 1500-1900.

Conclusion

The study of past climate changes was in part a consequence of the growing interest in the subject after the start of the current global warming. The encouragement of the discipline from the political class was a response to the increasing damages produced by global warming and provided the funding necessary for the development of past climatic series. The scholars are divided into two clear streams, the scientific one creating climatic estimations through chemical and biological techniques and the historicist that uses a systematic analysis of documentary sources. In both cases the rise of the discipline started in the 1970s in part, and as has been mentioned before thanks to the interest and popularity of the subject in the international arena.

After studying the methodology and arguments of the main climate change theories, we can confirm that the change of the late sixteenth century was probably a consequence of changes in solar radiation, a situation that coincides in time with the Maunder Minimum of sun spots that have been used for pre-modern times to estimate solar activity.

The first two-thirds of the sixteenth century in Spain were dry with an increasing number of droughts during the middle of the century, and stable in terms of temperature. The second half of the sixteenth century saw a reduction of droughts with increasing precipitations that in the last quarter of the century reached the levels of catastrophic floods, at the same time that a shift in temperatures produced the initial oscillation. This oscillation finished in the 1620s in the periphery and ten years before in the interior and was followed by a period of droughts until the mid seventeenth century with a stabilization of the water cycle but also a new reduction in temperatures.

The Malda anomaly appeared in the second half of the eighteenth century and was characterised by an increase in the inter-annual and intra-annual climate variability. The information available shows that the instability of climate was considerable and that the anomaly was common to all Spain. With the Malda anomaly, Spain suffered one of the worst and most radical climate changes of the last 500 years. It supposed a strong and sustained external shock whose economic consequences would be equally visible. The still backward and extensive agrarian economy of the country suffered the effects of the anomaly, especially the production of grain that was in particular sensitive to changes in the climatic conditions.

5. Grain production and the agrarian economy in eighteenth century Guadalajara

This chapter introduces the series of grain production that we have estimated using the information provided by tithe records. It also studies the structure of the economy in Guadalajara including the geographical distribution of grain production and other alternative economic activities such as the production of wool.

The first section will describe the institutional framework that peasants had to face in the eighteenth century including the structure of property rights, as well as the possibility of having access to common lands and of investing in improving productivity. The second section will introduce the estimations of grain production in the province of Guadalajara based on tithe records kept in the Historical Diocesan Archive of Sigüenza-Guadalajara. The reliability of the series will then be tested and analysed including the evolution of the production of the four staple cereals. The next part of the section will have a look at the distribution of the different grains and their share in the total production of cereals, as well as their volatility during the eighteenth century. After that the relationship between wheat production and prices will be analysed including the price series of Hamilton for Toledo and the new series created for Madrid. Finally the section will present a comparative analysis between the series estimated for Guadalajara and other grain production series available for different regions of the interior and the periphery of Spain.

The third part of the chapter will present a general view of the agrarian economy of Guadalajara. The economic structure of every region of the province will be analysed including the production of both grain and wool. The results show that those regions with a lack of natural resources like the Mountains were able to compensate this situation by diversifying their production of food.

5.1 Land ownership

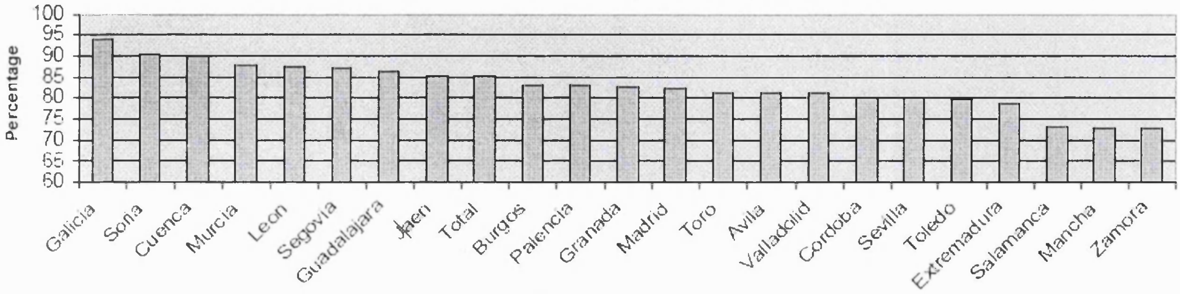
The establishment of property rights as well as the control of land is a factor that not only affects the production of grain, but also plays a role in the incentives that the peasants and owners faced to improve their farms and therefore to increase productivity. This section will discuss the ownership of land in eighteenth century Castile and Guadalajara, using information contained in the Catastro de la Ensenada. A new method to calculate the proportion of very small peasants will be presented using the payment of primicias, a fixed tax that depended on the total amount of grain produced and that very small producers did not have to pay. It will also introduce the mayorazgo (*majorat*), the most important institution that was used to preserve the control of properties in the long run between the privileged social classes. Finally, the section will present the incentives that the producers had to invest in their lands to increase productivity and the possibility of having access to public lands in order to expand the production of grain.

5.1.1 Ecclesiastical v secular ownership

In the case of eighteenth century Spain, the most important and scarce factor was land, with the church being the biggest individual land owner of the time. The Catastro de la Ensenada offers information about the percentage of land that was owned by the church and by secular producers in each province of Castile. According to the census, the percentage of lands in the hands of secular producers varied significantly in the different provinces of the crown, from a maximum of more than 90 per cent in the case of Galicia to around 70 per cent in the case of the province of Zamora. The percentages of land in each province owned by secular producers according to the Catastro are presented in the next graph.[114]

[114] Marcos Martin, *Economia, sociedad*, p.103.

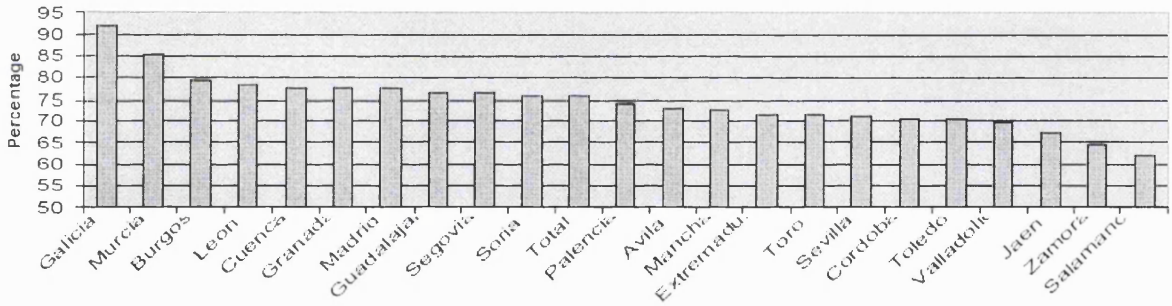
Figure 5.1: Percentage of land owned by secular producers, mid 18th century



Sources Marcos Martin (1985)

However the Catastro is also generous in terms of data about production, and gives detailed information by province about the percentage of the agrarian output that was produced by secular lands. In this case the percentage varied from more than 90 per cent in the case of Galicia to slightly more than 60 per cent in the province of Salamanca. The results are presented in the next graph.

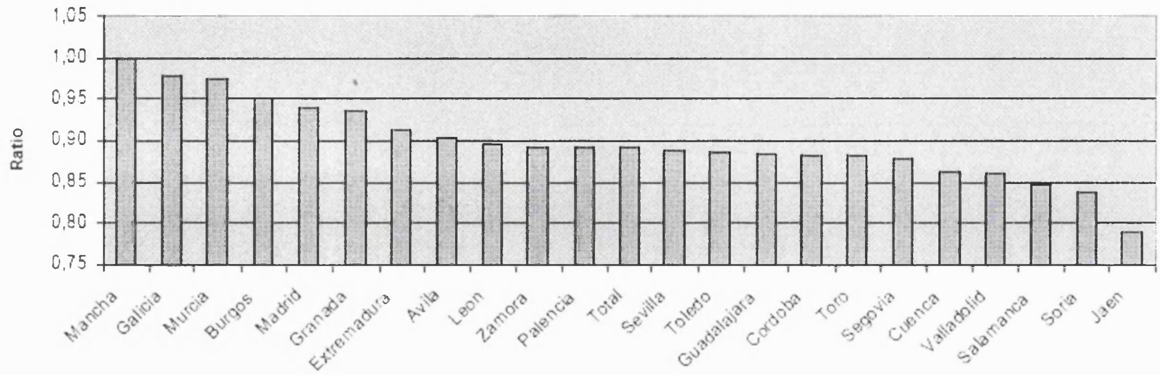
Figure 5.2: Percentage of output by secular producers, mid 18th century



Sources Marcos Martin (1985)

In all the cases the percentage of output in the hands of the church was higher than the percentage of lands that the ecclesiastical authorities owned. This is a clear sign showing that the lands that the church owned were more productive than those in the hands of secular producers, explaining the differences that the data present. We can extract more information from the data provided by the Catastro. If we divide the two variables presented above, we can obtain a good estimator of the power of the church in terms of land productivity by province. Therefore, if the ratio percentage output/percentage land is equal to 1, the proportion of land and production owned by the church will be the same. If it is greater than 1, then the percentage of land owned by the church will be higher than the proportion of output. As explained before, this was a situation that was not apparent in any of the provinces of Castile. On the other hand, if the ration is less than 1, then the proportion of output in the hands of the church will be superior to the percentage of land owned. Therefore, the smaller the ratio the higher the difference Land/Output and therefore the higher the difference in productivity between the lands of the church and the lands owned by secular producers. The results are presented in the next graph.

Figure 5.3: Ratio Percentage Output / Percentage Land, mid 18th century



Sources: Own calculations from Marcos Martin (1985)

Therefore, in terms of land distribution, the data implies that the situation of Guadalajara was not very good for secular producers, and that the province is part of the back of the list where the productivity of the lands possessed by the church was relatively better.

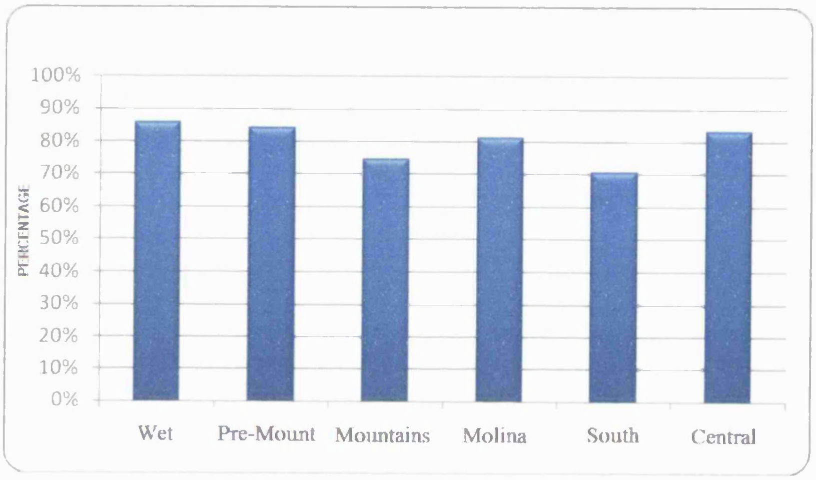
5.1.2 The proportion of very small peasants

If we study the distribution of the producers in Guadalajara, the situation does not look so negative. The tazmias (tithe) books included not just information about the tithe that can be used to estimate total production, but also about other taxes that were also collected by the church. One of these taxes was the primicias, which is a very interesting tax from the point of view of the economic historian. It was not a direct percentage of the harvest, but a flat tax that was paid only by those that surpassed a certain production level.

"the primicia is paid for every eleven half fanegas, one for all these species and also for rye and peas if they are harvested. If that amount is not reached everything that exceeds ten will be collected until the previously mentioned eleven. And although the harvest exceeded those eleven nothing else will be paid. And if ten half fanegas are not reached then nothing will be paid at all from this right of primicias"

Therefore, if the peasant produced more than 5.5 fanegas he had to pay only one half fanega, no matter how much he exceeded that level by. If he produced between 5 and 5.5 fanegas he had to pay anything that exceeded the 5, and if he did not reach 5 fanegas he was exempted. Therefore, the analysis of the amount of grain collected through the primicias tax compared to the number of producers can give us a rough estimate of how many peasants produced more than 5.5 fanegas. By using the amount of grain that was collected through the primicias, we can roughly estimate the percentage of peasants in every village that produced more than 5.5 fanegas of wheat. The results are presented in the following graph.

Figure 5.4: Percentage of peasants that produce more than 5.5 fanegas of wheat, mid 18th century

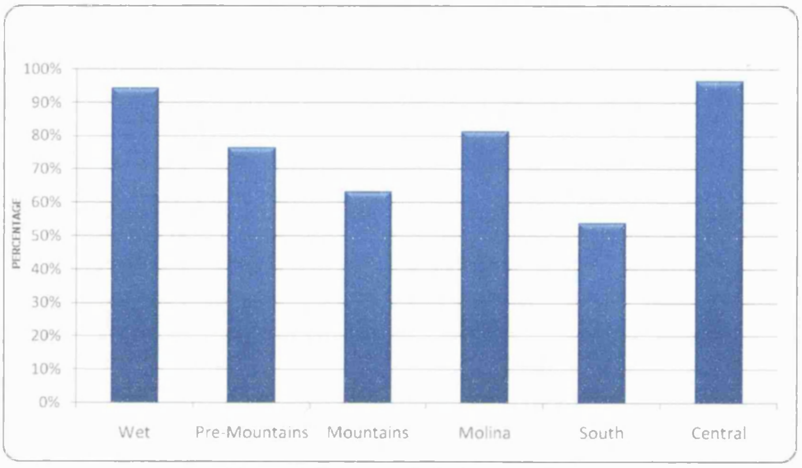


Source: Catastro de la Ensenada

The results show that the Mountains and the South were the two regions where the percentage of producers that did not reach the level of 5.5 fanegas was higher. On the other hand, in the other four regions, the Wet Region, Molina, the Pre-Mountains and the Central areas more than 80 per cent of the peasants did produce more than 5.5 fanegas of wheat. Therefore, we can conclude that the amount of small producers of wheat was higher in the South and Mountains than in the rest of the province.

However, the reasoning for such a situation are very differen. In the case of the South the urban character of the region is probably what is responsible, while in the case of the Mountains, the case is the opposite, being an area with a higher production of wool and also where the production of wheat was difficult for geographical reasons. As figure 5.5 shows, the percentage of peasants was also smaller in the case of the Mountains and the South, showing again the differences with the more fertile regions that produced more per capita and had a higher percentage of peasants in relationship to the total number of workers.

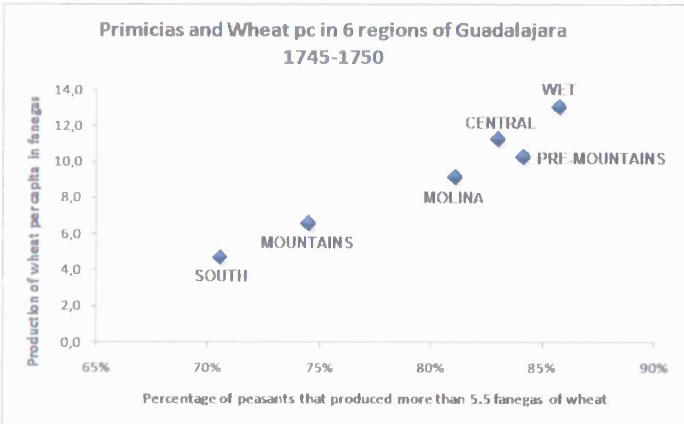
Figure 5.5: Percentage of peasants over total workers, mid 18th century



Source: Catastro de la Ensenada

There was also a strong correlation between the percentage of producers that paid the primicias and the production per capita. Figure 5.6 shows how in the different regions of Guadalajara a high level of production per capita was related to a high percentage of peasants that produced more than 5.5 fanegas of wheat. Therefore, the regions that were more productive were also the ones where the percentage of very small peasants was lower.

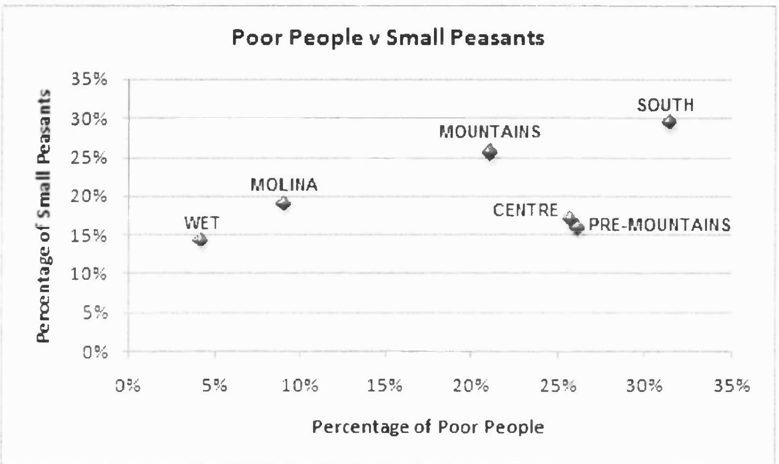
Figure 5.6: Proportion of Very Small Peasants v Production of Wheat pc 1745-1750



Source: Own calculations from the Catastro de la Ensenada

According to our calculations, the average productivity of one hectare of land in Guadalajara was around 6 fanegas of wheat. Therefore, the peasants that did not pay the primicias probably did not cultivate more than 1 hectare of terrain of wheat, an amount that was just enough to maintain the wheat consumption of a small household at almost subsistence levels. Hence, the peasants that did not pay the primicias were not just small but very small producers that produced just enough grain to guarantee their own consumption and that once taxes and rents were discounted, had to rely on other sources of income in order to survive. The following figure which compares the percentage of very small peasants that did not produce more than 5.5 fanegas of wheat with the number of poor people per 1,000 inhabitants in the six regions of Guadalajara, as expected, indicates that both variables seem to be connected. The number of poor people was extracted from the Catastro that included a question asking about their numbers in each municipality. The people in this group included the extremely poor and therefore represent the lowest social class in terms of wealth.

Figure 5.7: Proportion of Very Small Peasants v Proportion of Poor People 1745-1750



Source: Own caltulations from the Catastro de la Ensenada

5.1.3 The mayorazgo

The mayorazgo (majorat) was one of the most famous institutions related to property rights in early modern Spain, with its main role trying to prevent the division of properties. It was used mainly by the members of the aristocracy in order to preserve their economic and social status in the long run. The mayorazgo was created by the laws of Toro in 1505, and implied that all the properties would be inherited by the oldest male heir. The system was widely criticized by Gaspar Melchor de Jovellanos in his book *Informe en el Expediente de la Ley Agraria* and by some of the advisors of the Bourbon kings that ruled Spain during the late eighteenth century. Although legally abolished in 1820, the mayorazgo was still in place and survived almost intact until 1833.[115]

[115] Carmona Pidal, J., "Las estrategias economicas de la vieja aristocracia española y el cambio agrario en el siglo XIX", Revista de Historia Economica, N° 01 Invierno, 1995) p.65.

Though in principle the mayorazgos were available to everyone, in practice, they were mainly used by the aristocracy. In order to create a mayorazgo, the petitioner had to ask for royal permission that might then be granted. Spanish kings were aware of the economic effects of the mayorazgos, especially of those that were relatively small. According to eighteenth century authors, small mayorazgos were bad for the economy because the privilege of enjoying them created people who lived in idleness and with their inactivity ruined the economy of the country. According to figures like the Count of Floridablanca, they were also highly inefficient. One of the arguments was the lack of investment in the properties that were included in the mayorazgo. If a father had several sons, he would not invest to improve the properties of the mayorazgo because the oldest son would receive not just the mayorazgo itself but also the wealth that the father invested on it leaving nothing for his younger children. Supporting this claim, Floridablanca wrote in a report to King Carlos III that only big mayorazgos that could afford investments to increase their productivity should be allowed to survive. In 1789, a new law was passed that made the creation of new mayorazgos valued at less than three thousand ducats of rent illegal, making the institution only available for the highest social classes.[116]

5.1.4 Investments and access to common lands

The lack of investment to improve the productivity of land was, according to the literature, one of the biggest problems of the Castilan agriculture in the eighteenth century. Llopis argued that the small average size of the farms was the key to explain the poor levels of investment. When they rented their properties, big landowners such as the church and the aristocracy preferred small tenants because the rent per unit of land was higher than in the case of big ones. However, it was difficult to obtain economies of scale in small farms, meaning that most of the producers did not have enough money, savings and therefore ability to invest in their land. According to estimations of Garcia Sanz, in 1800 peasants used 37 per cent of their production to pay tithes, rents and other taxes that had to be paid in specie. Therefore, the possibility of obtaining savings that could have been invested to improve the productivity of their lands was relatively small. In addition, the owners of the land did not collaborate with the peasants that rented their land in order to improve its efficiency. Although some owners did invest directly in their properties, this was something that happened in some areas of the Mediterranean but was not common in Castile.[117]

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[116] Royal Decree, 28th April 1789.

[117] Llopis, E., "España, la "revolución de los modernistas" y el legado del Antiguo Régimen" in Llopis, E., El legado economico del antiguo regimen en España (Madrid: Critica, 2004) p.39.

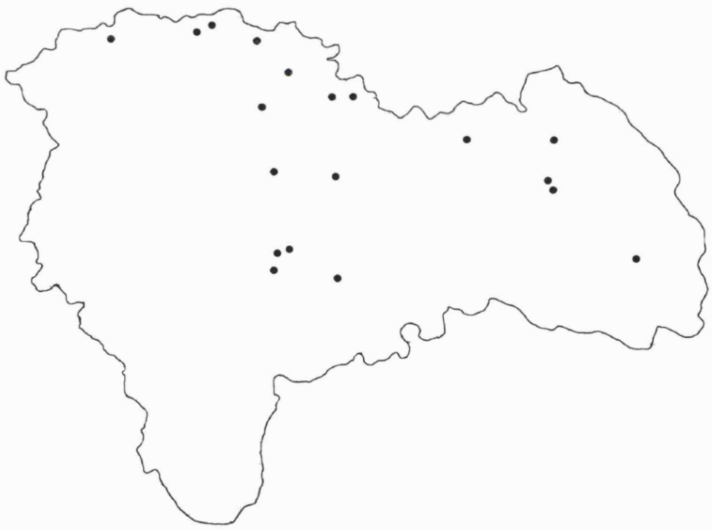
In Guadalajara, as in the rest of Castile, a considerable amount of land was in the hands of the municipalities and according to Garcia Sanz in 1750, between 20 per cent and 30 per cent of the land in Spain was owned by civil authorities.[118] However, the access to this enormous surplus of land was normally controlled by the local oligarchies and aristocrats. The access to public land increased during the second half of the eighteenth century, although the influence of pressure groups such as big landowners and stockmen limited it.

5.2 The production of grain in eighteenth century Guadalajara

5.2.1 Grain production series

The following map shows the province of Guadalajara and the municipalities of the villages included in the study. The sample includes all the series that were available in the archive of Sigüenza-Guadalajara.

Figure 5.8: Geographical distribution of the tithes sample in Guadalajara

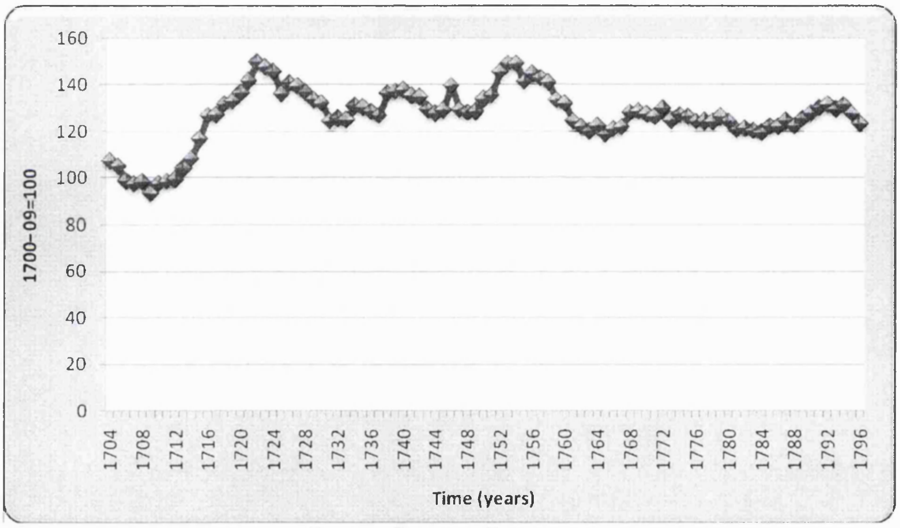


The production of all the grains was aggregated by volume. The results show that grain production suffered a production crisis during the first years of the eighteenth century and that was a continuation of a longer depression that started during the last decades of the seventeenth century. The series show an absolute minimum in the last years of the 1710s and a later and strong recovery when the production of grain increased by almost 50 per cent until the middle of the 1720s. Thereafter, the data shows a period of stagnation that lasted 25 years until the last period of

[118] García Sanz, A., "Bienes y derechos comunales y el proceso de su privatización en Castilla durante los siglos XVI y XVII: el caso de tierras de Segovia", *Hispania*, nº. 144. (1980)

production growth that took place in the first half the 1750s when the production of grain increased by almost 30 per cent. The last decades of the eighteenth century were a period of crisis and stagnation that coincides with the political crisis of the old regime that affected all of Europe and that started with the economic crisis of the late 1750s. In the case of Guadalajara, the production of grain fell by more than 20 per cent between 1754 and 1763 and the levels of production achieved in the early 1750s would not be reached again during the rest of the century. The following figure presents the evolution of total aggregated grain production, wheat, barley, rye and oats in volume in the sample for Guadalajara.[119]

Figure 5.9: Grain production in Guadalajara 1700-1800 (9 years moving average)

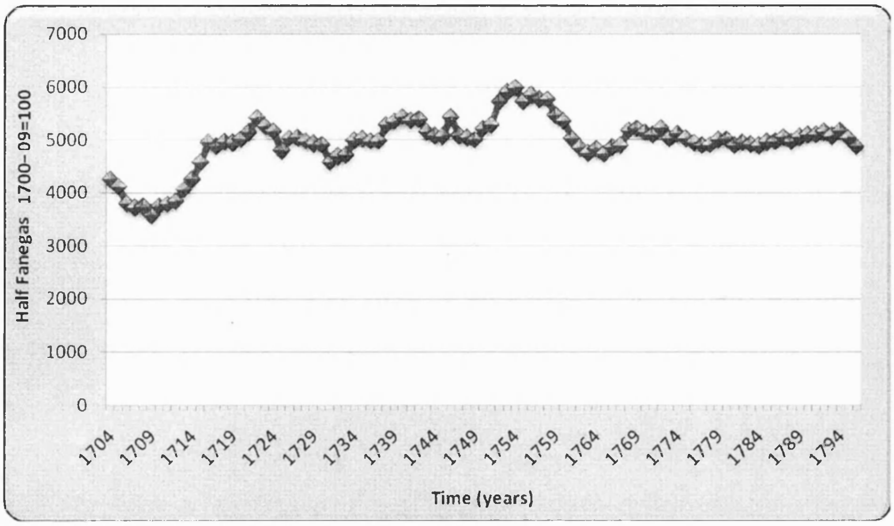


Source: Same as footnote 2

Dividing the series by grain, we can observe some differences. In the case of wheat the behaviour of the series is exactly the same that has been described above. The reason is simple in that wheat represented more than two thirds of the total production of grains and therefore it was the most influent grain of the sample.

[119] The municipalities are Madrigal, Miedes, Santiuste, Hijes, Navalpotro, Imon, Ciruelos, Anquela, Castejon, Aragosa, Villaseca, Sienes and Villares de Jadraque.

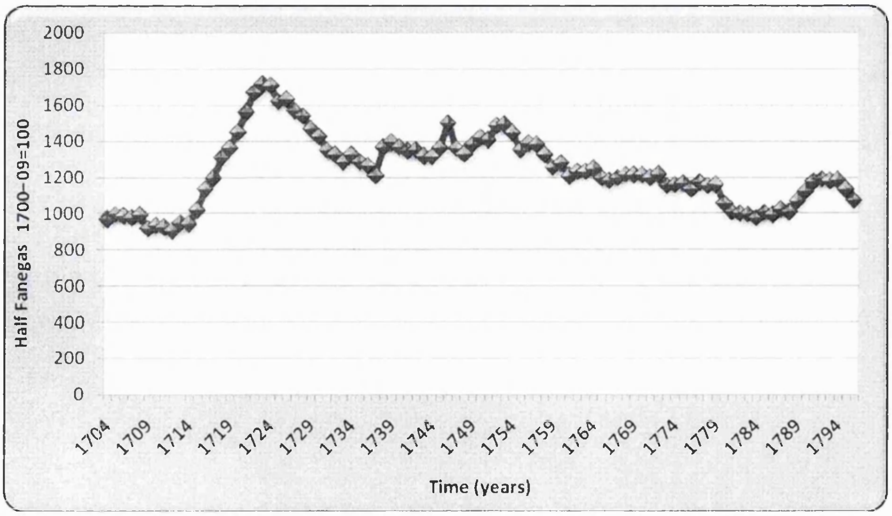
Figure 5.10: Wheat production in Guadalajara 1700-1800 (9 years moving average)



Source: Same as footnote 2

Barley was the second most important grain in terms of volume. The evolution of barley production was again similar to wheat, although in this case the changes were more intense as the series presented a higher volatility. Production at the end of the century presented very similar values to those achieved during the first decades of the eighteenth century.

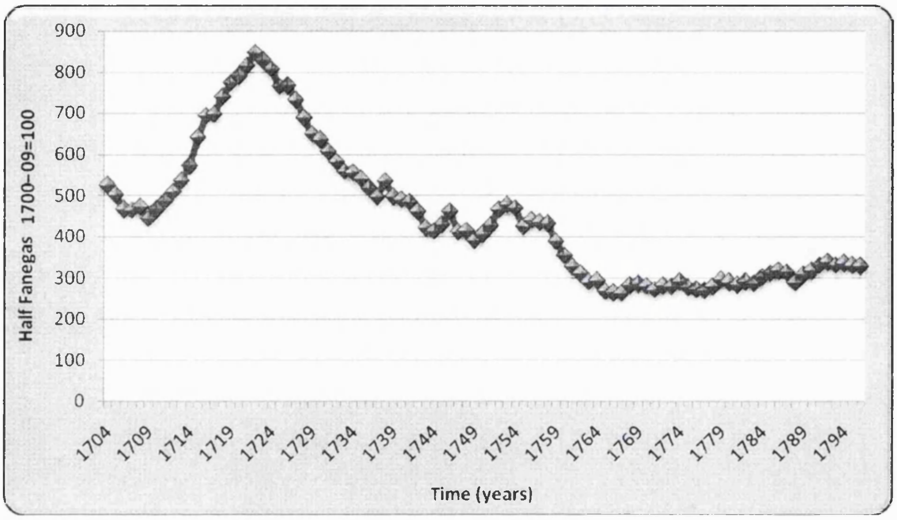
Figure 5.11: Barley production in Guadalajara 1700-1800 (9 years moving average)



Source: Same as footnote 2

Rye was one of the minor grains and also presents more volatile than wheat and barley production. The crisis of the early eighteenth century was followed by a very intense recovery that increased the production from 450 half fanegas to more than 800, almost doubling the production in less than twenty years. However, the production during the following decades would rapidly fall until the end of the 1760s when it reached its lowest point.

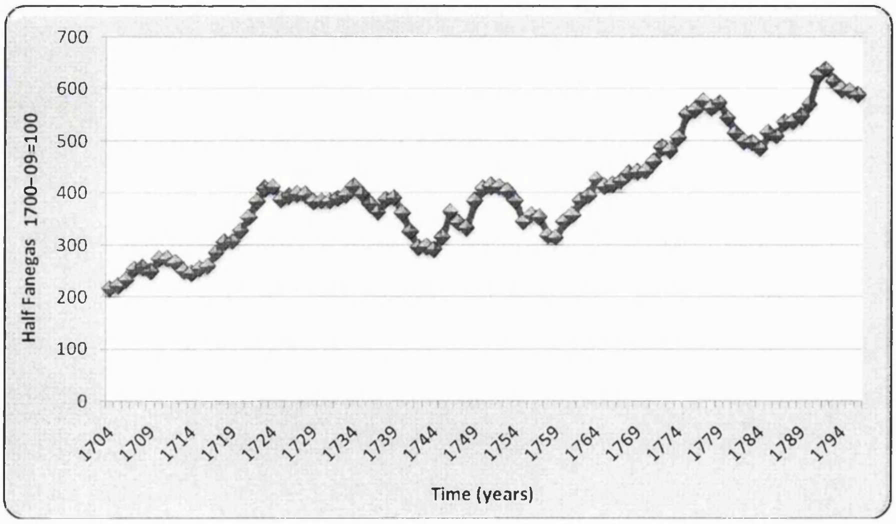
Figure 5.12: Rye production in Guadalajara 1700-1800 (9 years moving average)



Source: Same as footnote 2

On the other hand, the production of oats is the only one that can be clearly defined as a success story. The levels of the early eighteenth century of 200 half fanegas moved to more than 600 by the end of the century, with clear peaks and troughs that however showed a very clear positive trend.

Figure 5.13: Oats production in Guadalajara 1700-1800 (9 years moving average)



Source: Same as footnote 2

Therefore, we can conclude that although the movements of grain production in eighteenth century Guadalajara depended on the sort of grain, there are some general trends that followed the next phases.[120]

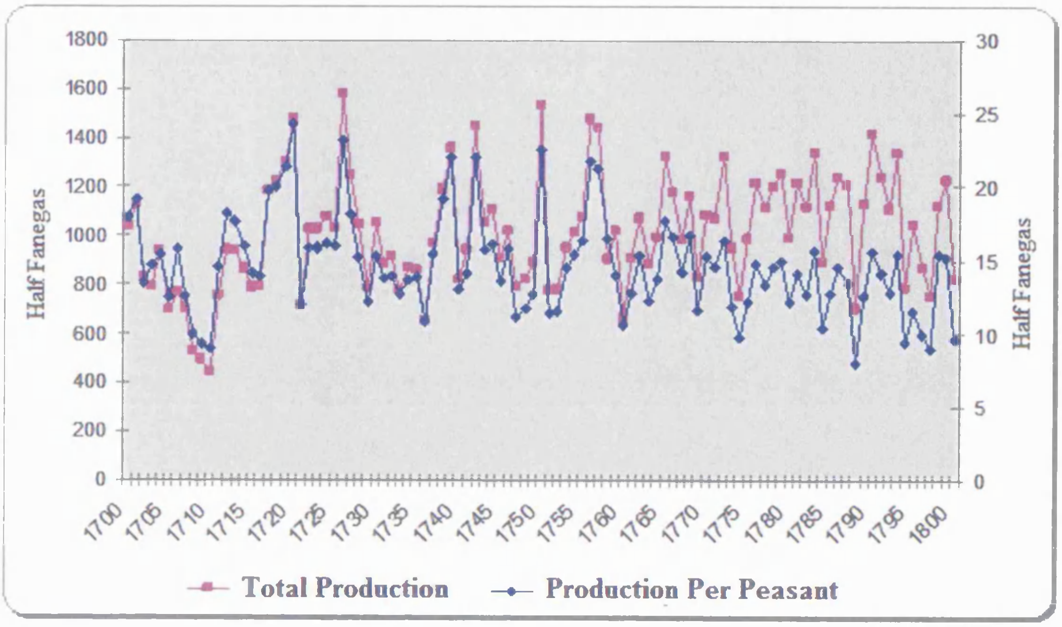
- ***1700-1709***: Deep crisis that started in the last decades of the seventeenth century.
- ***1710-1722***: Quick recovery of the levels lost in the previous crisis.
- ***1723-1731***: Crisis with an average fall in the production of more than 20 per cent.
- ***1732-1754***: Sustained recovery, more intense during the first half of the 1750s when production grew by more than 20 per cent.
- ***1755-1763***: Crisis with production decrease of 30 per cent.
- ***1764-1800***: Stagnation.

5.2.2 Reliability of the series

One of the most controversial issues in the utilisation of the tithe concerns the information that it provides. Tithes tell us how total agrarian production changed, but information about per capita output or productivity figures is more difficult to obtain. The number of producers changed over time, as did the amount of land that was put under cultivation. We can however check this relationship with the information provided in the tazmia books taking as a case study the village of Bañuelos, a municipality where we count on very detailed information for every year. For every year of the eighteenth century, the total production was divided by the amount of producers in order to get a series of output per producer. This variable was then compared to the series of total production estimated from the tithe series, the results are presented in the next graph.

[120] Agustin Gonzalez Enciso distinguishes the expansion until 1760, the crisis and a later recovery and a last crisis at the end of the century in Gonzalez Enciso, A. et. al. *Historia economica de la España moderna,*(Madrid, Actas, 1992) p.229.

Figure 5.14: Total Production v. Production per peasant (I) in Bañuelos, 1700-1800



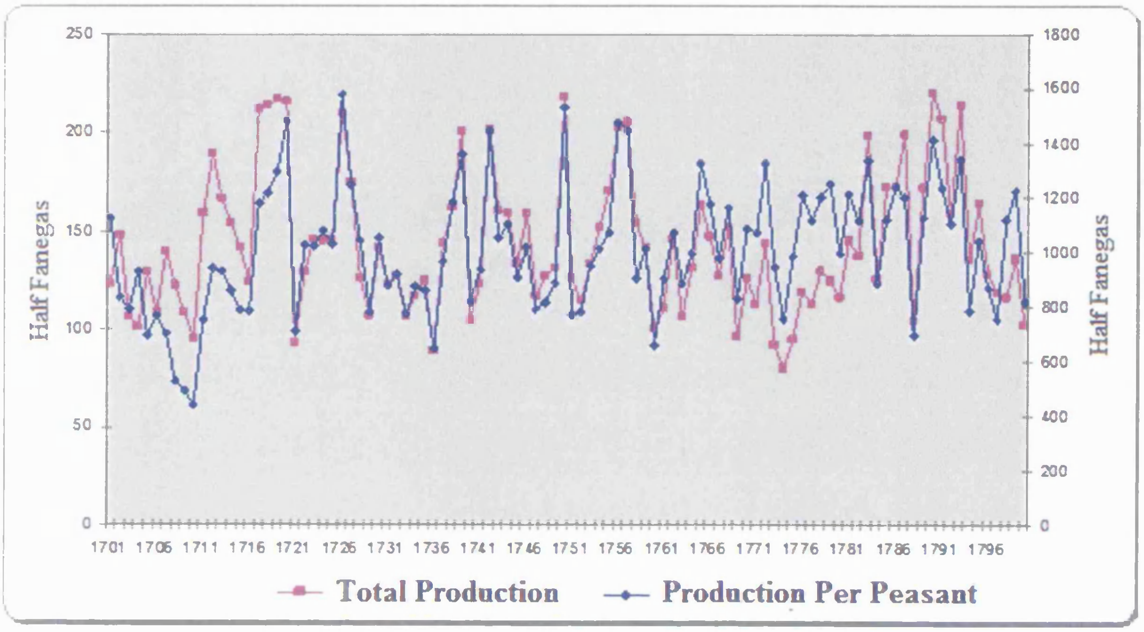
Source: Same as footnote 2

The correlation between both variables is very high and statistically significant (R=0.78), pointing out that the trends presented by the study of tithes are a good estimator of the evolution of output per producer. However, another important issue is deciding if output per producer is a good proxy of productivity. As stated before, the number of producers changed during the eighteenth century and therefore the sample of producers did too, introducing noise in the estimation. This explains partially why the correlation was weaker during the second half of the century. To solve that problem we took advantage once more from the rich information provided in the tazmia books, where each producer being taxed was identified with his Christian name and two first surnames. Therefore, it is possible to follow the output of every producer on a yearly basis. We created a sample of producers whose production was followed during the whole eighteenth century. [121] The sample was carefully chosen to be sure that it included producers of different sizes and therefore is a good representation of the area as a whole. On the other hand, producers tended to disappear after a period of approximately 20 years, probably because they passed away. When this happened, the producer was immediately replaced by another one being sure that the new one shared the same characteristics than the last one in terms of total output produced. Therefore, a consistent and diversified sample of producers was created and the evolution of their output was compared with the evolution of total production extracted from the tithes. The correlation is again very high and

[121] The sample is included in the digital dataset.

statistically significant (R=0.78) showing that the evolution of tithes are a good estimation of the trends of output per produced and therefore proving its utility as a representative proxy.

Figure 5.15: Total Production v. Production per peasant (II) in Bañuelos, 1700-1800



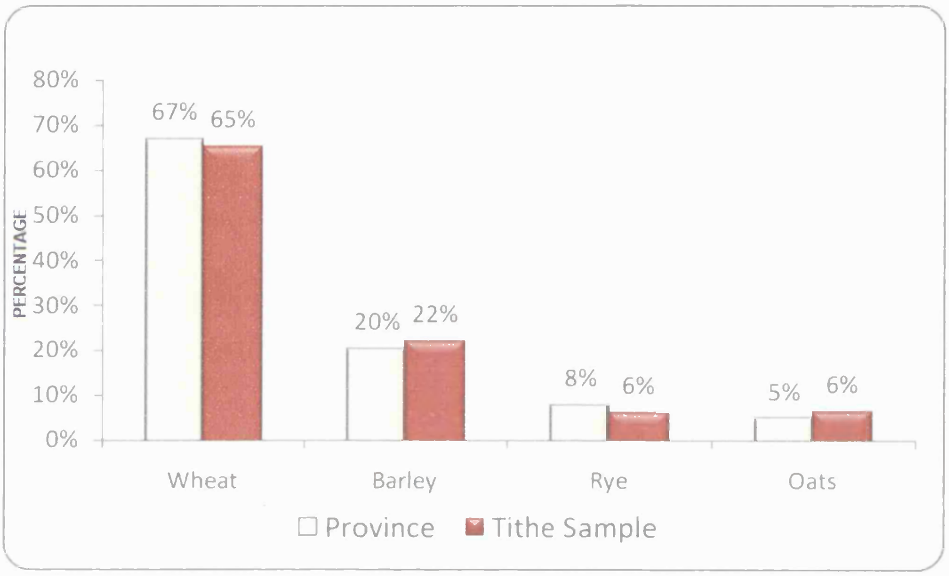
Source: Same as footnote 2

We can also check the reliability of the tithe estimations by comparing their results with the ones presented in the Catastro de la Ensenada. In the general survey, one of the questions asked about the average production per year during the last five years. The survey in Guadalajara took place in 1751 and therefore the information provided in the Catastro includes the average production between 1747 and 1751, as one of the answers shows:

"To the sixteenth [question] they said that for every year of the last five, that were counted from the year of one seventeen forty seven until the year of seventeen fifty one, both inclusive, the tithe accounts ..."

Therefore, we can compare the information of the Catastro with the information obtained from the tithe series between 1747 and 1751. The next figure presents the shares of every grain in the total production of grain for the period 1747-1751 presented in both the general survey and the tithe series. The results are very similar and therefore support the reliability of the estimations calculated from the tithes.

Figure 5.16: distribution of grain production in volume 1747-1751



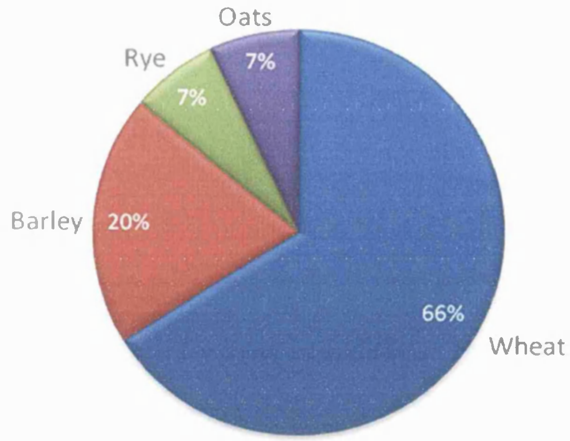
Source: Same as footnote 2 and Catastro de la Ensenada

5.2.3 Distribution of grains

In terms of distribution, as previously explained, the production of grain was strongly dominated by the presence of wheat. In the sample collected, for the whole eighteenht century wheat represented 66 per cent of the total production of grain in volume, followed by barley with a 20 per cent, and then rye and oats with a share of 7 per cent each one. However, if we transform the production from kind to cash, the difference and share of wheat increases considerably as a consequence of being by far the most expensive of the four grains.[122] Transforming the numbers from volume into grams of silver using the price series of Madrid, the share of wheat rises from 66 per cent to 81 per cent, while the values of the so called inferior grains is reduced. In the case of barley, the shares falls from 20 per cent to 12 per cent, in rye from 7 per cent to 4 per cent and the share of oats falls from 7 per cent to 3 per cent.

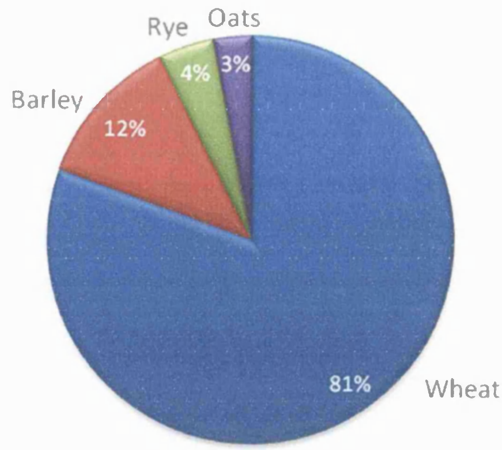
[122] The prices used were a combination of Hamilton for Toledo and the series that I created for Madrid.

Figure 5.17: Shares in Volume, mid 18th century



Source: Same as footnote 2

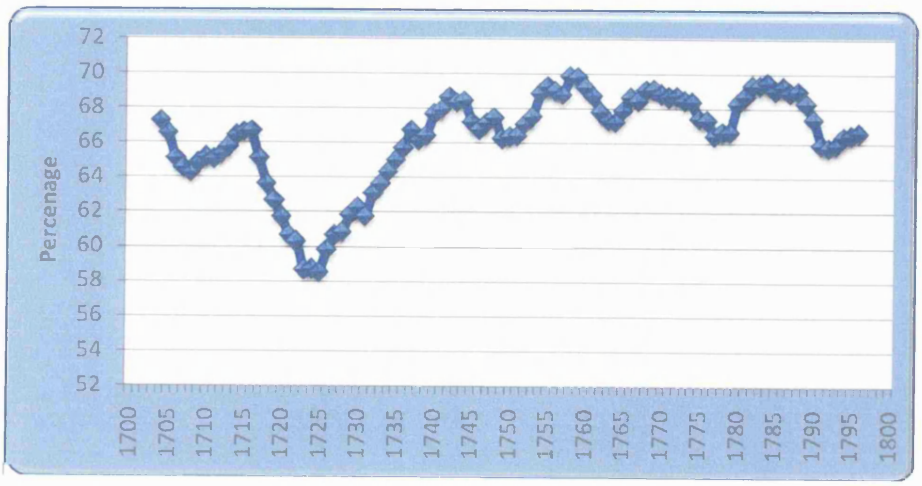
Figure 5.18: Shares in Value, mid 18th century



Source: Same as footnote 2

The share of wheat in total production is a key variable that has been closely examined by economic historians. The reason is that it reflects not just the influence of that grain in the productive structure of the economy, but also works as an indirect estimator of other variables such as urbanization rates. In early modern and modern Spain and unlike in many other parts of Europe, the sort of bread consumed was mainly white, produced using wheat instead of a mixture with other grains. Therefore, an increasing share of wheat production would mean that the population living in cities was increasing and demanding more wheat to satisfy the increase in the demand for white bread. The changes in annual percentages of wheat in total grain production in Guadalajara is presented in the following figure.

Figure 5.19: distribution % of wheat in grain production (9 years moving average) in Guadalajara (1700-1800)



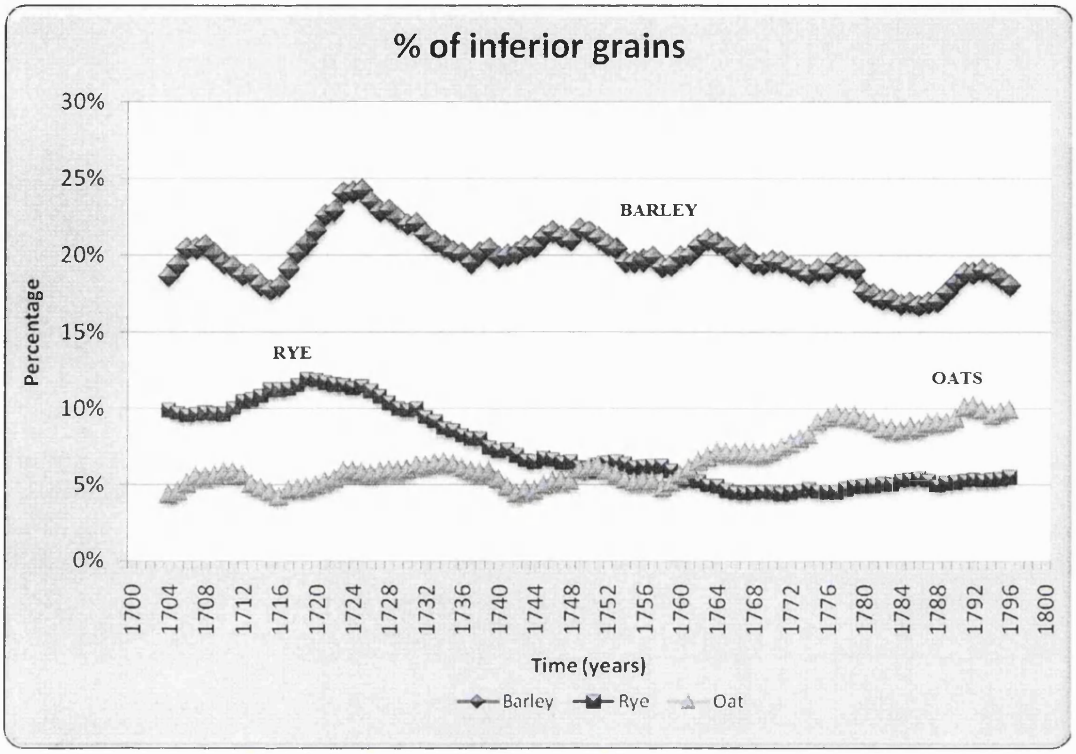
Source: Same as footnote 2

The share of wheat in Guadalajara suffered a considerable crisis during the first third of the eighteenth century falling 10 points from 68 per cent in 1705 to 58 per cent in 1725. On the other hand, the weight of rye and above all of barley increased, representing 27 per cent and 14 per cent respectively of the growth in total production that took place between 1709 and 1722. Those weights were clearly larger to the shares that they represented in the economy of Guadalajara and that have been presented above. After the 1730s, the production of wheat rose more quickly than the production of other grains, an increase that is related to the demographic growth that took place in the province of Guadalajara after the demographic crisis of the 1730s.[123] The increasing demand combined with the resistance of wheat to the production crisis of the 1720s increased the share of wheat from 58 per cent to 70 per cent. The second half of the eighteenth century did not see significant changes in the weight of wheat that remained at very high levels, again probably influenced by the increasing population that amplified the demand of white bread and therefore wheat. These trends are very similar to the ones presented in other regions in the interior of Spain, like the case of Segovia where the same decline in the share of wheat took place in the early eighteenth century, followed by a recovery during the following decades.[124]

The evolution of barley, rye and oats were again very different. As the series of production showed, the production of oats increased while the other three grains stagnated or declined. Therefore, the share of oats in grain production increased from less than 5 per cent in the early eighteenth century to 10 per cent in the 1790s. Barley and rye show very similar trends reaching maximums in the mid 1720s that were followed by an intense decline during the rest of the century. Thus, the supremacy of wheat was clear during most of the eighteenth century followed by the success of oats that doubled their presence in the production of grain. This primacy of wheat and success of oats took place at the expense of barley and rye that lost importance during most of the century.

[123] See the demographic series provided in chapter 6.
[124] Garcia Sanz, "La producción"

Figure 5.20: Percentage of inferior grains in grain production (9 years moving average) in Guadalajara 1700-1800

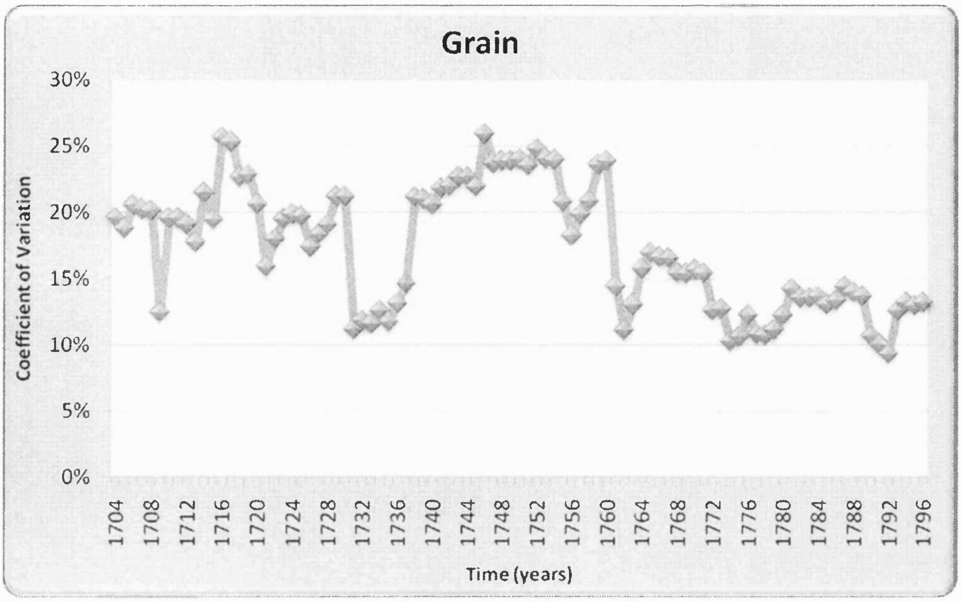


Source: Same as footnote 2

5.2.4 Volatility of the series

Another important aspect to study is the volatility of the production, as in some cases a high volatility can be more damaging for the welfare of the population than a falling production. Therefore, we created new data series using the coefficient of variation of the series with a moving average of 11 years applied to the 6th year to measure the volatility of the production around it. The results show three main phases; during the first phase between 1712 and 1724, there was an increase in the volatility of the series, followed by a second period also very volatile during the 1740s and 1750s. Finally the last quarter of the eighteenth century was characterized by a reduction in the volatility of the series that reached the absolute minimums during the last decades of the century.

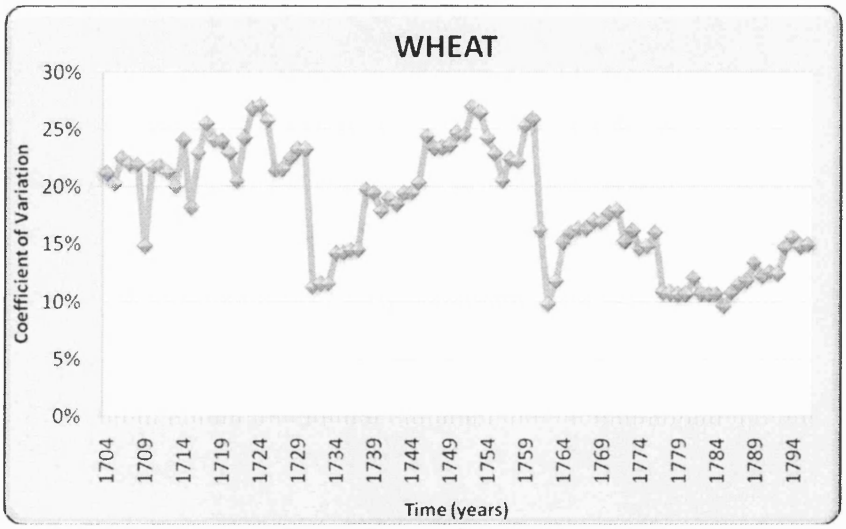
Figure 5.21: Coefficient of variation in the production of grain (9 years moving average) in Guadalajara 1700-1800



Source: Same as footnote 2

In the case of wheat production, the results are again very similar due to the strong influence of wheat in the total production of grain. The three phases are therefore clearly identified in the case of wheat and the conclusions are the same as before.

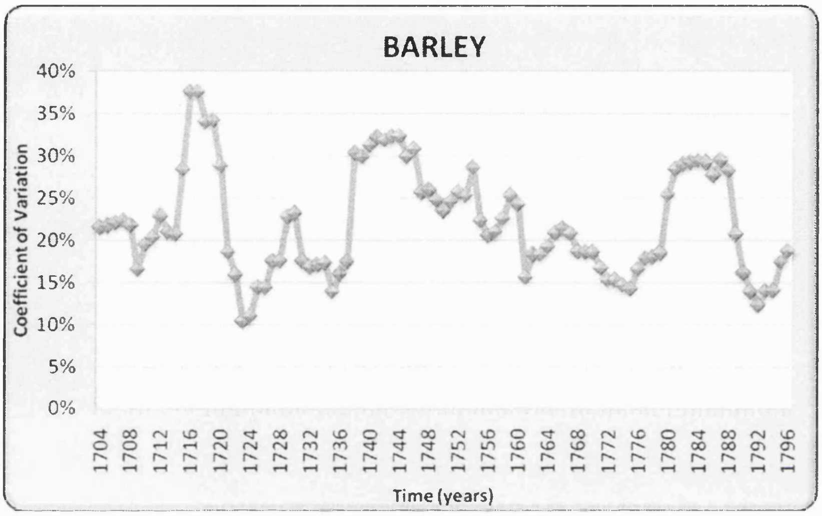
Figure 5.22: Coefficient of variation in the production of wheat (9 years moving average) in Guadalajara 1700-1800



Source: Same as footnote 2

The volatility of barley production however did present some differences. The first phase of increasing volatility is very short and is followed by a period of stability that coincides with the production crisis of the 1720s. The end of the century is not as stable as in the case of wheat, with an increase in the volatility that took place during the 1790s.

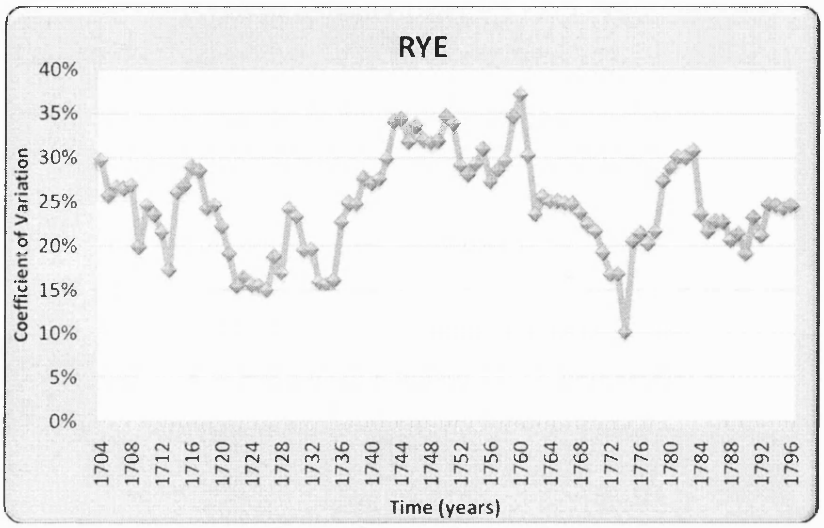
Figure 5.23: Coefficient of variation in the production of barley (9 years moving average) in Guadalajara 1700-1800



Source: Same as footnote 2

The most important difference in the case of rye is a longer second phase of inestability that started in the late 1730s and ended in the 1760s. As in the case of barley, there was an increase in the coefficient of variation at the end of the century although less intense.

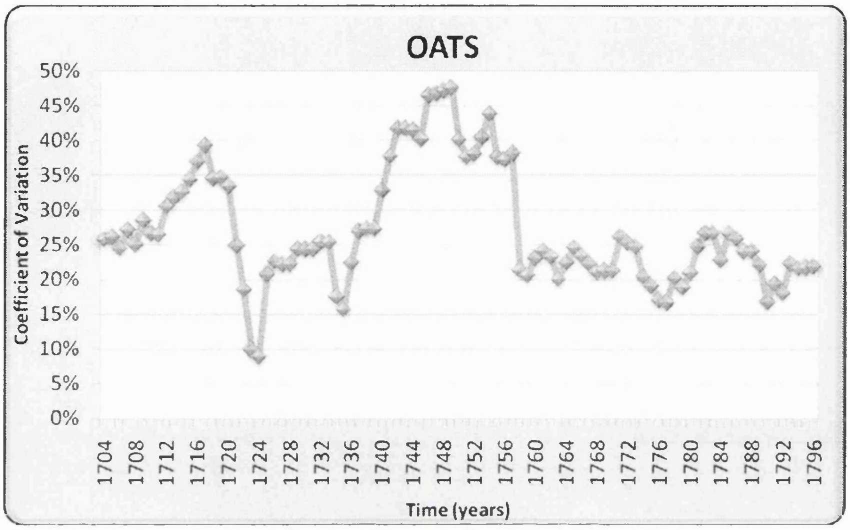
Figure 5.24: Coefficient of variation in the production of rye (9 years moving average) in Guadalajara 1700-1800



Source: Same as footnote 2

Oats present a trend similar to wheat, with a very soft first phase of inestability and a second one in the mid eighteenth century that was more intense. Finally, the second half of the century is a period of relative stability with very small variations.

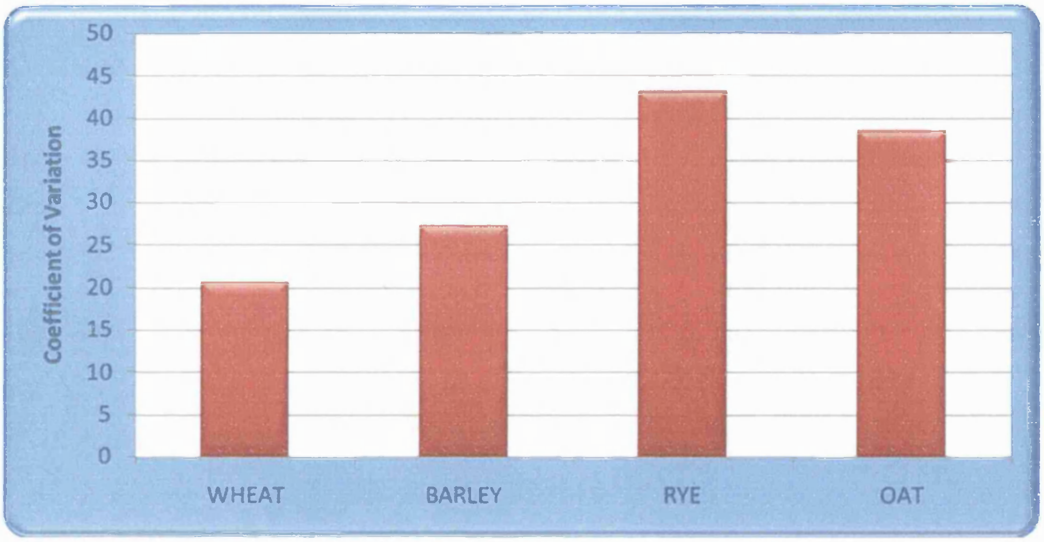
Figure 5.25: Coefficient of variation in the production of oats (9 years moving average) in Guadalajara 1700-1800



Source: Same as footnote 2

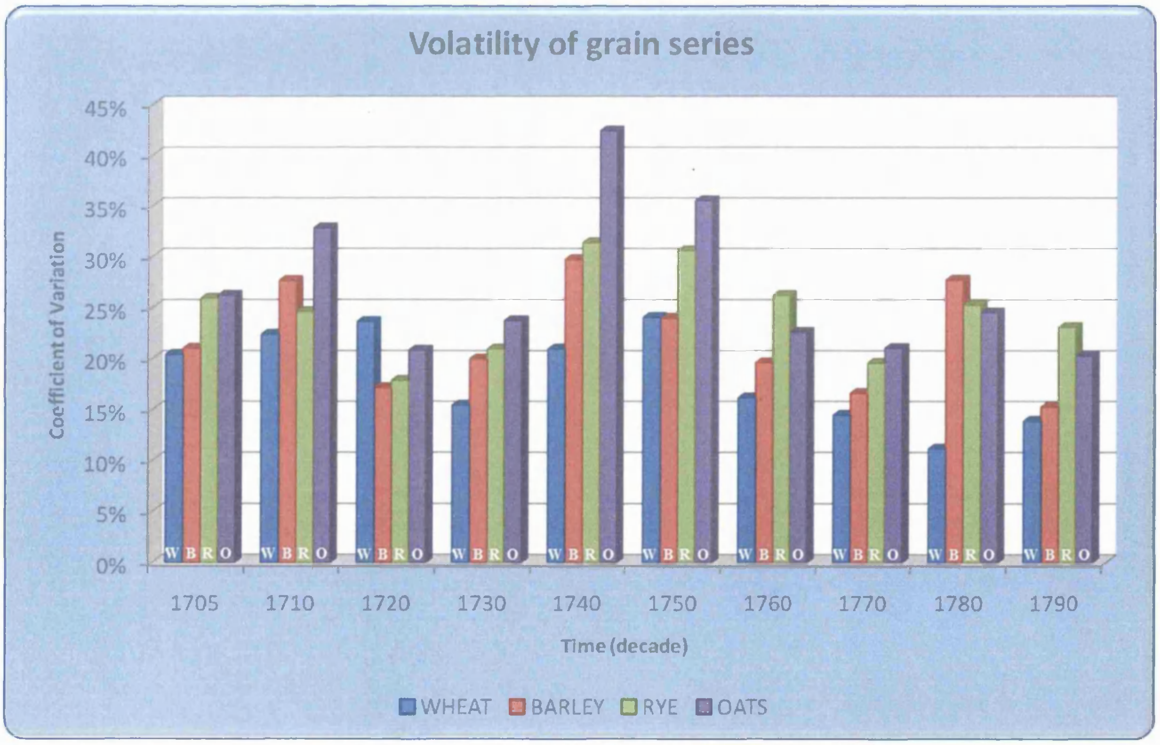
On average and during the whole century the more volatile grains were Rye and Oats with coefficients of variation of 43 and 38 per cent respectively, followed by barley with 27 per cent. Wheat was the most stable of the three grains with a coefficient of variation of 20 per cent. Therefore the two grains that kept and even increased their share in the total production of grain were the ones that maintained a strong stability during the second half of the century, while the decreasing production of barley and rye also coincides with an increase in their volatility. The explanation to these differences probably rely on the sort of land that was used to produce each grain. The best lands were usually used to produce wheat and the most marginal ones to produce inferior grains such as rye and oats. Therefore, when production had to be adjusted for climatic or simply economic reasons the first lands that were abandoned or put again into cultivation where the marginal ones, producing significant changes in the production of the cereals produced on them.

Figure 5.26: Coefficient of variation in the production of grains in Guadalajara during the 18^{th} century



Source: Same as footnote 2
Source: Same as footnote 2

Figure 5.27: Coefficient of variation in the production of grains per decade in Guadalajara, 1700-1800



Source: Same as footnote 2

5.2.5 Wheat production and prices

The next step is to analyse the relationship between the grain production series in Guadalajara and an appropriate price series. In this case we will use the price series published by Hamilton in 1947 for the city of Toledo, and the series of wheat prices that we created for Madrid from the archives of the parish of Santa Maria Magdalena in Getafe.[125] The series from Hamilton present some problems that have been discussed in the literature by the economic historians of early modern and modern Spain. The series are not consistent as many times the original data are sketchy and disconnected from the rest. The series also have to be consistent in time, as there were clear changes in prices during the year depending on how close in terms of time the source of information was to the harvest. The series for Madrid on the other hand presents a higher degree of reliability, as they belong to the same location and source is consistent based on the amount of grain that the parish sold every year to the market.

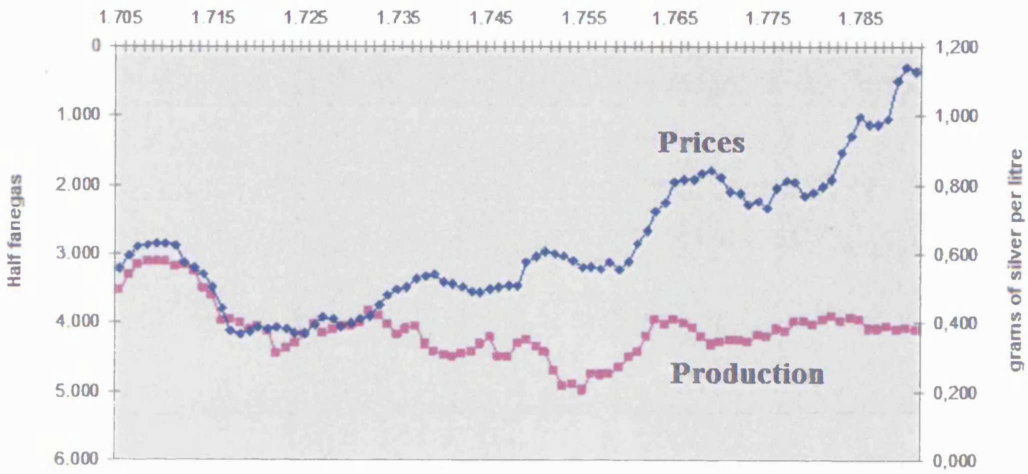
Figure 5.28: Towns of Madrid and Toledo

The analysis will also reveal the economic integration of grain markets in the interior of Spain. According to David Reher, the eighteenth century was a period of considerable economic integration in New and Old Castile.[126] In a similar study Llopis and Jerez concluded that although we cannot talk about a real market economy, integration levels were higher than previously suggested in the literature.[127] The following graphs show the evolution of total wheat production in half fanegas in Guadalajara during the eighteenth century and the evolution of prices in maravedies

[125] Hamilton, H.H., *War and prices in Spain, 1651-1800* (Cambridge, Harvard University Press,1947)
[126] Reher, D.S., "Producción, precios e integración de los mercados regionales de grano en la España preindustrial", *Revista de historia economica*, Año XIX, num 3 (2001)
[127] Llopis, E. and Jerez, M., "El mercado de trigo en Castilla y León, 1691-1788: arbitraje espacial e intervención", *Historia Agraria*, nº. 25 (2001)

per fanega in both Toledo and Madrid. The price series has been inverted in order to observe the relationship between both variables. Both series use a nine year moving average applied to the fifth year.

Figure 5.29: Price of wheat in Toledo and production of wheat in Guadalajara 1700-1800 (9 years moving average)



Source: Same as footnote 2 and Hamilton (1947)

Figure 5.30: Price of wheat in Madrid and production of wheat in Guadalajara 1700-1800 (9 years moving average)

Source: Same as footnote 2 and Accounting Book of Santa Maria Magdalena (Getafe)

The production crises coincide with periods of rising prices as it was expected and in the same way periods of relative abundance of wheat correspond with stagnation and even a decline in the level of prices. The following tables show a more detailed analysis of this relationship between the price of wheat in Toledo and the production of wheat in Guadalajara. The model is a regression analysis where the price of wheat in year t is explained by the production during the previous four years including a variable called years to capture the effects of the trend.

Table 5.1: Multiple Regression Price Toledo v Production

Parameter	*Estimate*	*Standard Error*	*T Statistic*	*P-Value*
CONSTANT	-4.0	0.86	-5.31	0.00
Anio	0.00	0.00	12.73	0.00
Prod_T	-0.28	0.13	-2.08	0.04
Prod_T1	-0.57	0.13	-4.28	0.00
Prod_T2	-0.64	0.14	-4.64	0.00
Prod_T3	-0.27	0.13	-2.03	0.04
Prod_T4	0.10	0.13	0.74	0.45

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.94	6	0.32	30.11	0.00
Residual	0.88	82	0.01		
Total (Corr.)	2.82	88			

R-squared = 68.8 percent
R-squared (adjusted for d.f.) = 66.5 percent

The results show that the independent variables are statistically significant and that a 68 per cent of the variations in the price of wheat in Toledo can be explained by the model. As expected, the variable years is positively correlated and shows the inflation that took place in grain prices during the eighteenth century. The production of grain is negatively correlated to grain prices, indicating that an increase of grain production in Guadalajara would produce a decrease in the price levels in Toledo. The most influential harvests are those that take with a lag of 1 and 2 years, while the production of wheat with a lag of 4 years does not have any influence in the level of prices.

Taking the prices of Madrid instead of Toledo does not change the results of the analysis. The only significant difference is that in the case of Madrid, only the harvests with lags of 0, 1 and 2 years have any influence in the level of prices while the harvest with a lag of 3 years unlike the case of

Toledo does not. The R2 is also high explaining the model a 60 per cent of the variations of wheat prices.

Table 5.2: Multiple Regression Price Madrid v Production

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-4.11	1.05	-3.88	0.00
Year	0.00	0.00	10.18	0.00
Prod_T	-0.56	0.16	-3.39	0.00
Prod_T1	-0.78	0.16	-4.77	0.00
Prod_T2	-0.47	0.17	-2.76	0.00
Prod_T3	-0.04	0.16	-0.27	0.78
Prod_T4	0.24	0.16	1.48	0.14

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.16	6	0.36	21.54	0.00
Residual	1.44	86	0.01		
Total (Corr.)	3.60	92			

R-squared = 60.0 percent
R-squared (adjusted for d.f.) = 57.2 percent
Volatility of the Series

5.2.6 Comparison with other series of Spain

In this section we will compare the production of grain in Guadalajara with other provinces of Spain, in order to put the case of Guadalajara into a broader Spanish context. The provinces analysed include Galicia, Leon, Valladolid, La Rioja, Avila and Segovia in the Crown of Castile and Valencia in the Crown of Aragon, for which we count on production series. The following map shows the location of the different areas included in the study.

Figure 5.31: Geographical distribution of the series

In the case of Segovia, Palencia, Valladolid, Avila, Leon and La Rioja the information provided is also based on tithe series that therefore estimate real production by using the volume taxed. On the other hand, the series of the periphery in Galicia and Valencia use the deflated evolution of the tithe that was being paid in cash and not in kind. The decadal series of Guadalajara and the other regions are presented in the following table.

Table 5.3: Tithe Series in Segovia, Palencia and Valladolid and Avila, 1690-1800

Tithe Series (base 100: 1690-1699)						
	Segovia		Palencia and Valladolid		Ávila	
Decade	Wheat	Wheat, Barley and Rye	Wheat	Wheat, Barley and Rye	Wheat	Wheat, Barley and Rye
1690-1699	100	100	100	100	100	100
1700-1709	89	92	100	107	104	115
1710-1719	106	109	94	105	132	141
1720-1729	104	110	109	122	131	148
1730-1739	107	103	118	125	116	126
1740-1749	105	102	118	122	91	108
1750-1759	132	125	132	137	135	154
1760-1769	92	89	91	101	90	109
1770-1779	108	101	113	120	112	125
1780-1789	125	116	-	-	109	120
1790-1799	132	128	-	-	96	113

Table 5.4: Tithe Series in Guadalajara, Leon and La Rioja, 1690-1800

	Guadalajara		León		La Rioja		
Decade	***Wheat***	***Wheat, Barley and Rye***	Wheat	Wheat, Barley and Rye	Wheat	Wheat, Barley, Rye and Oats	Wine
1690-1699			100	100	100	100	100
1700-1709	***100***	***100***	103	104	108	110	91
1710-1719	***102***	***104***	105	103	86	108	83
1720-1729	***118***	***133***	120	119	114	121	99
1730-1739	***117***	***122***	123	124	92	94	107
1740-1749	***119***	***118***	148	131	105	101	114
1750-1759	***141***	***137***	156	141	118	117	111
1760-1769	***112***	***111***	130	117	89	103	88
1770-1779	***119***	***117***	124	108	116	117	113
1780-1789	***111***	***109***	139	118	122	123	108
1790-1799	***117***	***118***	-	-	116	126	113

Table 5.5: Tithe Series in Galicia and Valencia,1690-1800

Deflated tithes paid in cash (base 100: 1690-1699)		
Decade	Galicia	Valencia
1690-1699	100	100
1700-1709	108	107
1710-1719	109	110
1720-1729	120	106
1730-1739	108	106
1740-1749	126	137
1750-1759	130	159
1760-1769	128	148
1770-1779	112	190
1780-1789	129	184
1790-1799	127	192

Although similar results are obtained, the comparison between Guadalajara and the five cities in the interior do also present some differences. The following table shows the production of grain in index numbers of the inner provinces of Segovia, Palencia and Valladolid, Avila, Leon, La Rioja and Guadalajara. The absolute maximums and minimums of each series are highlighted in yellow and blue respectively, production crises in beige and periods of growth in green.

Table 5.6: Comparative analysis of the tithe series

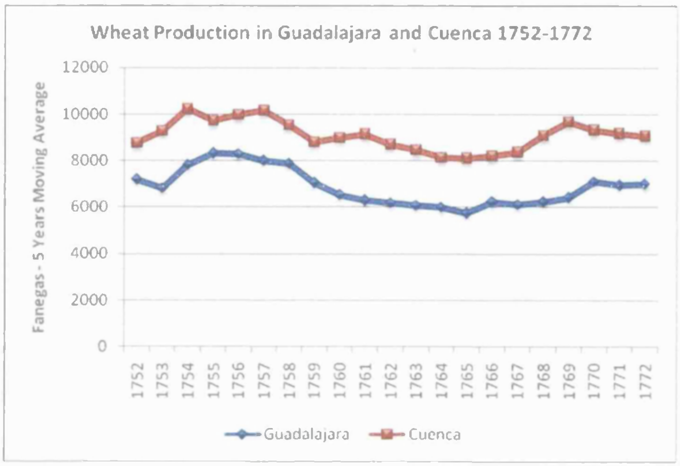
	Segovia	Palencia and Valladolid	Avila	Guadalajara	Leon	La Rioja
1690-1699	100	100	100		100	100
1700-1709	92 (Cris)	107 (Gro)	115 (Gro)	100 (min)	104 (Gro)	110 (Gro)
1710-1719	109 (Gro)	105 (Cris)	141 (Gro)	104 (min)	103 (min)	108 (Cris)
1720-1729	110 (Gro)	122 (Gro)	148 (Gro)	133 (Gro)	119 (Gro)	121 (Gro)
1730-1739	103(Cris)	125 (Gro)	126(Cris)	122 (Cris)	124 (Gro)	94 (min)
1740-1749	102(Cris)	122(Cris)	108 (Cris)	118 (Cris)	131 (Gro)	101 (Gro)
1750-1759	125 (Gro)	137 (max)	154 (max)	137 (max)	141 (max)	117 (Gro)
1760-1769	89 (min)	101(min)	109 (min)	111 (Cris)	117 (Cris)	103 (Cris)
1770-1779	101 (Gro)	120 (G)	125 (G)	117 (Gro)	108 (Cris)	117 (Gro)
1780-1789	116 (Gro)		120 (Cris)	109 (Cris)	118 (Gro)	123 (Gro)
1790-1799	128 (max)		113 (Cris)	118 (Gro)		126 (max)

The table shows that in three of the cases the absolute minimums were reached during the crisis of the 1760s. The other extreme was the 1750s when most of the series reached absolute maximums. Only Segovia and La Rioja delayed their maximum production to the 1790s, although they also registered significant improvements during the 1750s that were the second best decade of the century for Segovia (very close to the 1790s), and the third best in La Rioja after the 1790s and the 1720s. Finally, the other common feature in all the series is the important drop that took place in the 1760s. On average production decreased by 22 per cent, with Avila leading the fall with a 29 per cent followed by Segovia with a 28.8 per cent, Palencia and Valladolid with 26 per cent, Guadalajara with 19 per cent, Leon with 17 per cent and finally La Rioja with a drop of 12 per cent.

Yearly series for the province of Cuenca located in the south of Guadalajara have also been published. Figure 5.32 presents the yearly series of wheat production estimated for Guadalajara and Cuenca between 1752 and 1772 using a five years moving average. The trends presented in both regions are very similar, including the crisis of the late 1750s and a later recovery in the late 1760s.[128]

[128] Negrin de la Peña, “"El reconocimiento de la realidad agraria a través de dos fuentes fiscales: Rentas provinciales "vs" Única Contribución. El caso de Cuenca (1749-1774)"

Figure 5.32: Wheat production in Guadalajara and Cuenca, 1752-1772

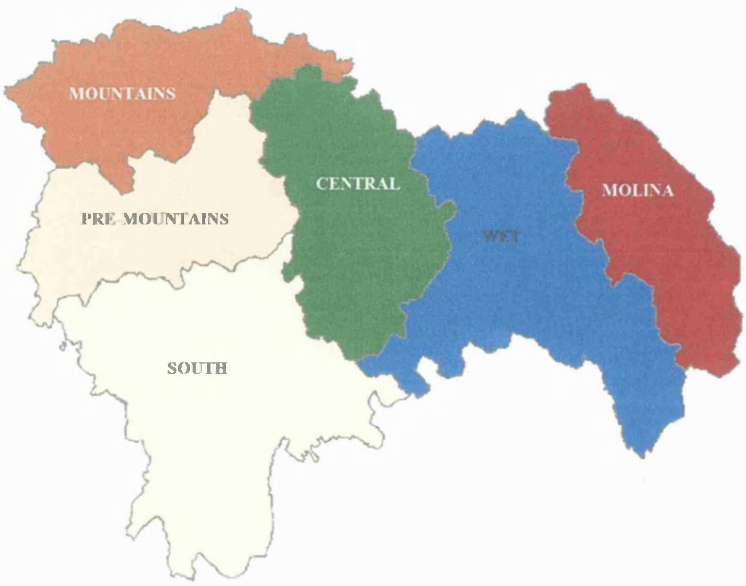


Source: Same as footnote 2 and Negrin de la Pañe (2005)

5.3 The economy of Guadalajara in the mid eighteenth century

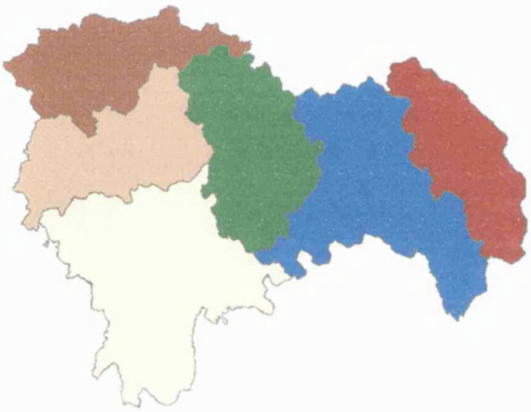
The following map shows the proposed regional division of the province of Guadalajara that was advanced in the introduction of the thesis, and that will be the geographical base of the analysis of the internal economic dynamics of Guadalajara. The results will show that the different regions had different economic structures, and that this will be one of the reasons for the different behaviour of the demographic variables that will be analysed in the next chapter.

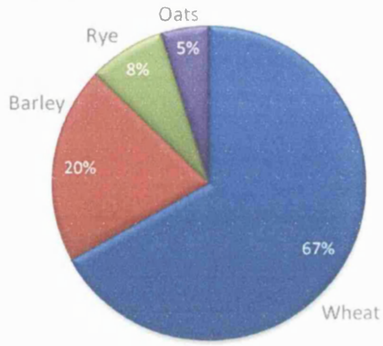
Figure 5.33: Proposed division



For every village in every region, information about the productive structure of the economy such as production, taxation, labour force, etc. was extracted from manuscripts contained in the Catastro de la Ensenada. The sample contains a total of 271 villages and towns. The aggregated results show that in the mid eighteenth century the production of wheat represented two thirds of the production of grains in volume, barley twenty per cent, rye eight per cent and finally oats five per cent.

Figure 5.34: Proposed division and distribution of grain production



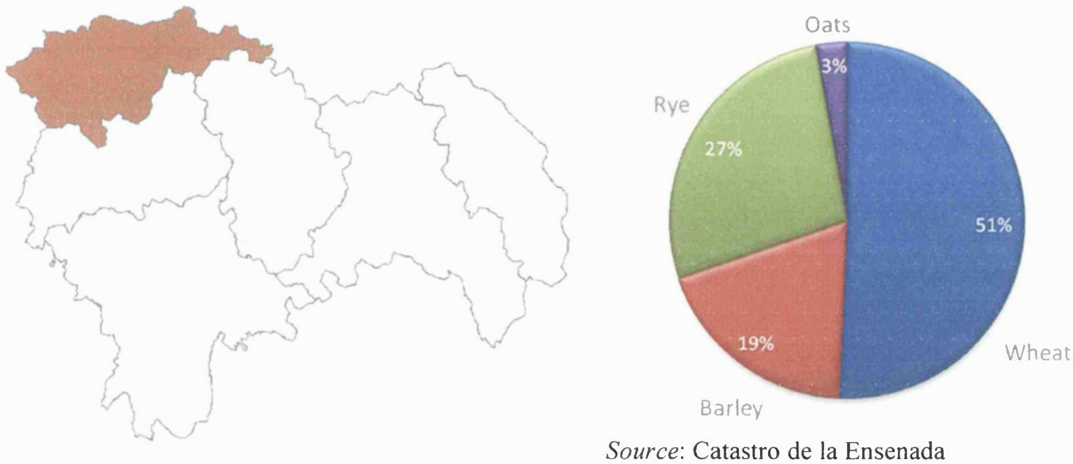


Source: Catastro de la Ensenada

The region of the Mountains contains 33 municipalities and occupies the North West border of Guadalajara.[129] A study of the production system of the region shows that in the mid-eighteenth century the Mountains were a place where the production of wheat was important, but not as much as in the rest of Guadalajara. The percentage that wheat represented in the total production of grain was 51 per cent in the case of the Mountains, 16 points below the average levels for Guadalajara. On the other hand, the most striking feature of the productive structure of the Mountains is the importance of rye that represented 27 per cent of the production of grains, in comparison to the 8 per cent in Guadalajara as a whole. The weights of barley and oats on the other hand were very similar to the rest of the province with 19 per cent and 3 per cent respectively. The relevant position that rye had in the mountains is easy to understand by looking at the diversification of production in the region. Livestock was in the Mountains more important than in the rest of Guadalajara, and the food that it received was basically based on rye.

[129] The municipalities included in the regiòn are Albendiego, Alcolea de las Peñas, Alpedroches, Arroyo de las Fraguas, Atienza, Bañuelos, Campillo, Campisabalos, Cantalojas, Cincovillas, Condemios de Arriba, Condemios de Abajo, El Ordial, Galve de Sorbe, Gascueña, Hijes, La Miñosa, La Nava de Jadraque, La Yunta, Madrigal, Majaelrayo, Miedes de Atienza, Paredes de Sigüenza, Pradena de Atienza, Romanillos, Semillas, Sienes, Somolinos, Tamajon, Ujados, Valdelcubo, Villacadima and Zarzuela de Jadraque.

Figure 5.35: Region of the Mountains and distribution of grain production, mid 18th century

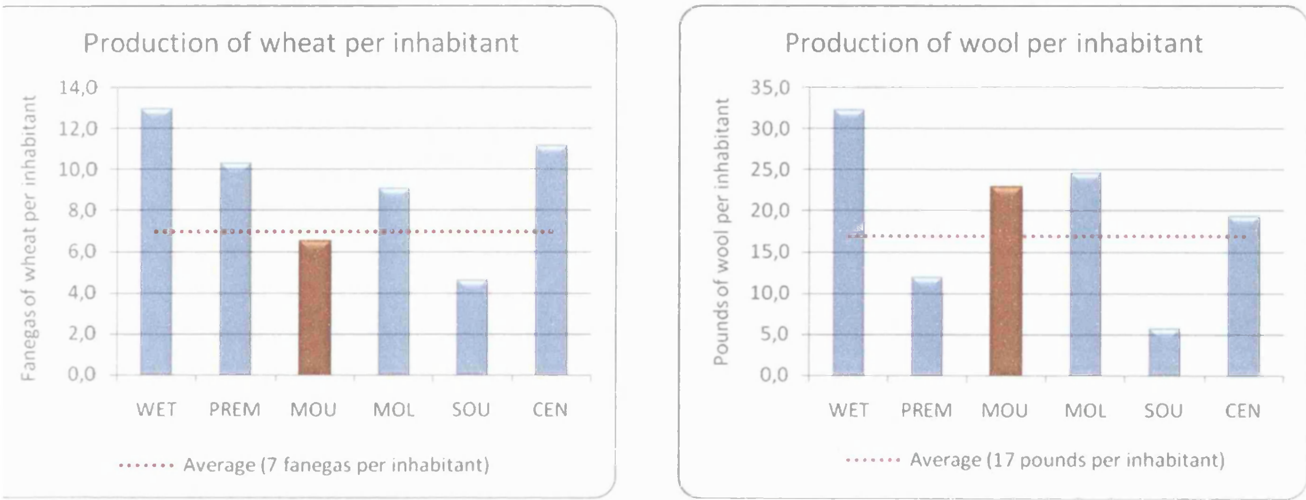


Source: Catastro de la Ensenada

As the Figure 5.36 shows, the Mountains were one of the most important producers of wool in the province of Guadalajara with 23 pounds of wool produced per inhabitant.[130] The other important reason is the lack of fertile soils in the hilly lands of the Mountains. Rye is a more resistant crop to unfavourable conditions and therefore is more productive and efficient than wheat or barley in poor quality soils and extreme climatic conditions. The high share of rye in total production is therefore easy to understand given the presence of livestock in the area combined with the lack of fertile lands. On the other hand, the production of wheat per capita did not reach the provincial average of 7 fanegas per capita. Again one of the most plausible answers is that the economy of the mountains did not rely on wheat as it was hard to grow and was based on a combination of dairy products from livestock and inferior grains as rye. The lack of wheat therefore does not reflect a backward and poor region, but one where diversification was the logical response to face serious environmental adversities.

[130] The calculations are based on tithe records contained in the Catastro de la Ensenada, that represented a 10 per cent of the production. The number of inhabitants was estimated from the same source using a coefficient of 3.92 to multiply the number of households to get total population.

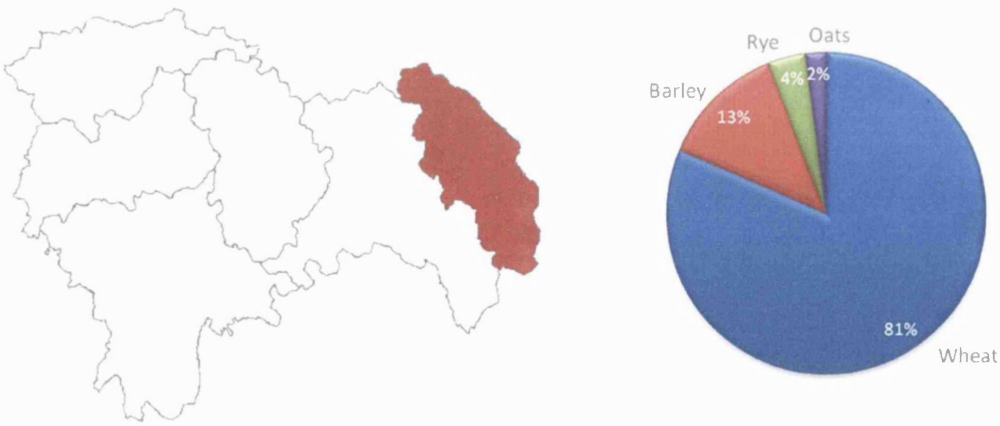
Figure 5.36: Production of wheat and wool per capita in the region of the Mountains, mid 18th century



Source: Catastro de la Ensenada

Molina occupied the eastern border of Guadalajara and included a total of 25 municipalities.[131] The distribution of grain production in Molina is exactly the opposite of the Mountains. The weight of wheat with 81 per cent is 14 per cent above the average for the region, a growth that takes place at the expenses of barley with a 13 per cent and to a lesser extent of rye with a 4 per cent and oats with a 2 per cent.

Figure 5.37: Region of Molina and distribution of grain production, mid 18th century



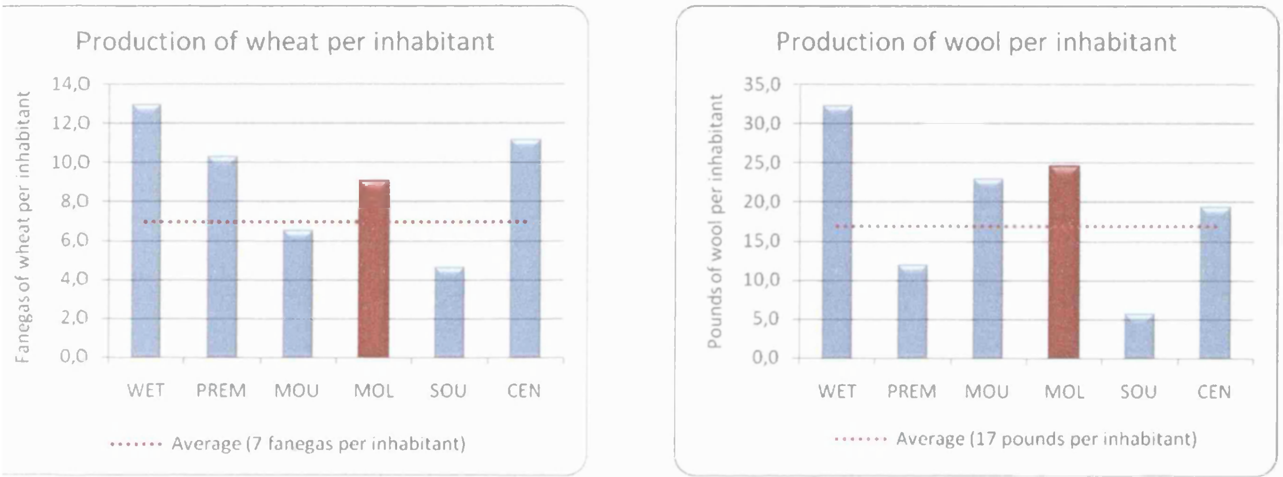
Source: Catastro de la Ensenada

The strong presence of wheat in the production of grain is also reflected in per capita levels, where Molina clearly surpasses the provincial average with a production of 9.1 fanegas per inhabitant.

[131] Molina included Adobes, Alustante, Anquela del Pedregal, Castellar, Castilnuevo, Concha, Cubillejo del Sitio, El Pedregal, El Pobo de Dueñas, Embid, Herreria, Hombrados, La Yunta, Milmarcos, Mochales, Molina de Aragon, Morenilla, Pardos, Piqueras, Rillo de Gallo, Rueda de la Sierra, Tartanedo, Tordellego, Tordesilos and Villel.

However, unlike in the case of the Mountains, the specialization in wheat production did not produce any reduction in the production of livestock. The soils in the region were more fertile than those in the Mountains and therefore allowed the existence of both sectors and did not have to rely on the production of inferior crops to subsist. The consequence is the second highest level of wool production per capita with 23 pounds per person, 5 above the average values in Guadalajara.

Figure 5.38: Production of wheat and wool per capita in the region of Molina, mid 18th century

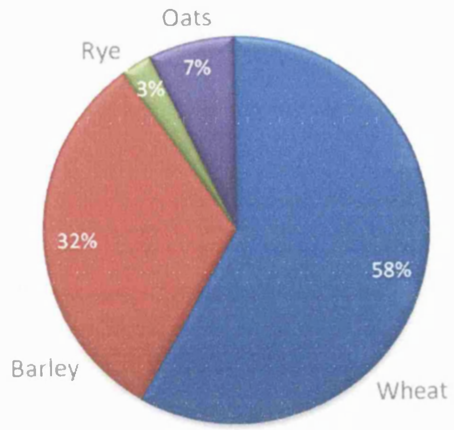


Source: Catastro de la Ensenada

The South is the biggest region in terms of total number of municipalities, with 82 villages and towns that occupy the South West of Guadalajara.[132] The production of the region is again dominated by wheat although its weight is just 58 per cent, 8 points under the average of the province. On the other hand, the weight of barley is significantly higher than the average with a 32 per cent, while oats represent a 7 per cent and rye a mere 3 per cent.

[132] The region includes Albalate de Zorita, Albares, Alcocer, Alhondiga, Almoguera, Almonacid de Zorita, Alocen, Alovera, Aranzueque, Armuña, Atazon, Auñon, Azañon, Azuqueca de Henares, Berninches, Brihuega, Budia, Cabanillas, Casasana, Caspueñas, Centenera, Chillaron, Chiloeches, Ciruelas, Driebes, Duron, El Olivar, Escamilla, Escariche, Escopete, Fontanar, Fuentelencina, Fuentelviejo, Fuentenovilla, Galapagos, Guadalajara, Hontanillas, Hontoba, Horche, Hueva, Illana, Irueste, Loranca de Tajuña, Lupiana, Mantiel, Marchamalo, Mazuecos, Millana, Mondejar, Moratilla, Pareja, Pastrana, Peñalver, Pioz, Pozo, Pozo de Almoguera, Quer, Renera, Romanones, Sacedon, Salmeron, San Andres del Rey, Sayaton, Tabladillo, Tendilla, Torrejon del Rey, Tortola de Henares, Trijueque, Trillo, Valdeavellano, Valdeconcha, Caldegrudas, Valdeolivas, Valfermoso de Tajuña, Villanueva de la Torre, Vindel, Yebes, Yebra, Yelamos de Abajo, Yelamos de Arriba, Yunqueras de Henares and Zorita de los Canes.

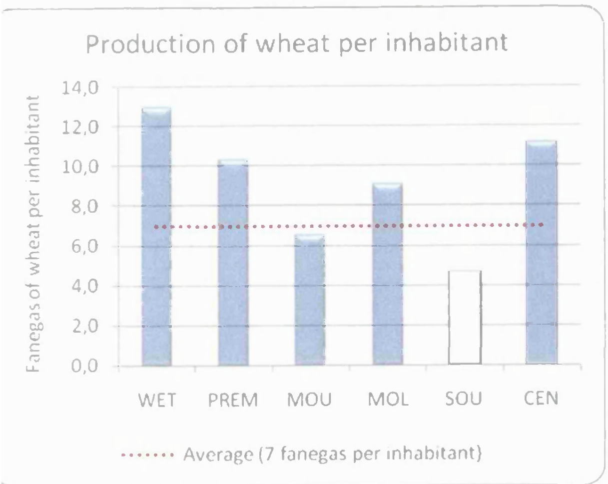
Figure 5.39: Region of the South and distribution of grain production, mid 18th century

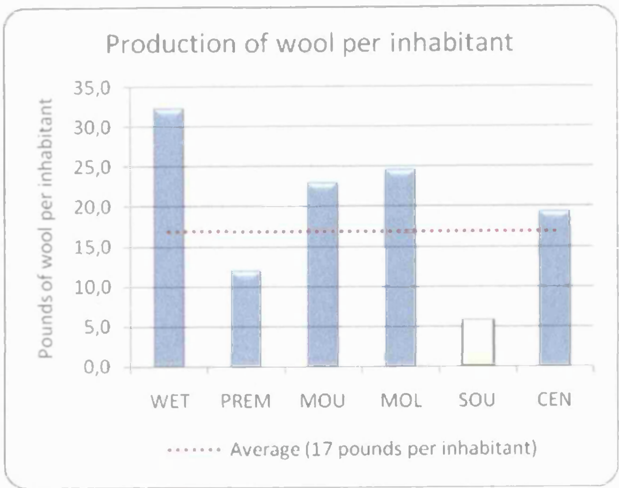


Source: Catastro de la Ensenada

The South is clearly the worst performing region in terms of production per capita. In the case of wheat the production per capita remained at 4.6 fanegas per inhabitant, by far the lowest value of the sample. In addition to the lack of grain production the scarcity of crops was not compensated by the production of livestock. The amount of wool that was produced in the South was at 5.7 pounds per person once again the lowest value of all the regions. These results match perfectly with the status of the South of Guadalajara as the most urban region of the province.

Figure 5.40: Production of wheat and wool per capita in the region of the South, mid 18th century

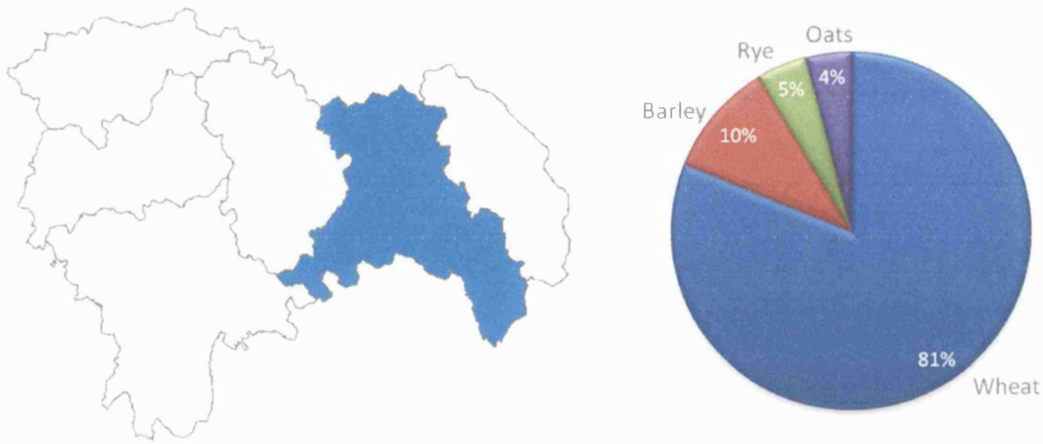




Source: Catastro de la Ensenada

The Wet region occupies the most of the eastern half of Guadalajara and includes a total of 36 municipalities.[133] The production of grains is strongly dominated by wheat that represents an 81 per cent of the total production, 14 points above the provincial average. The most affected grain by this growth is barley that only represents a 10 per cent of the total production followed by rye with a 5 per cent and oats with a 4 per cent.

Figure 5.41: Wet Region and distribution of grain production, mid 18th century

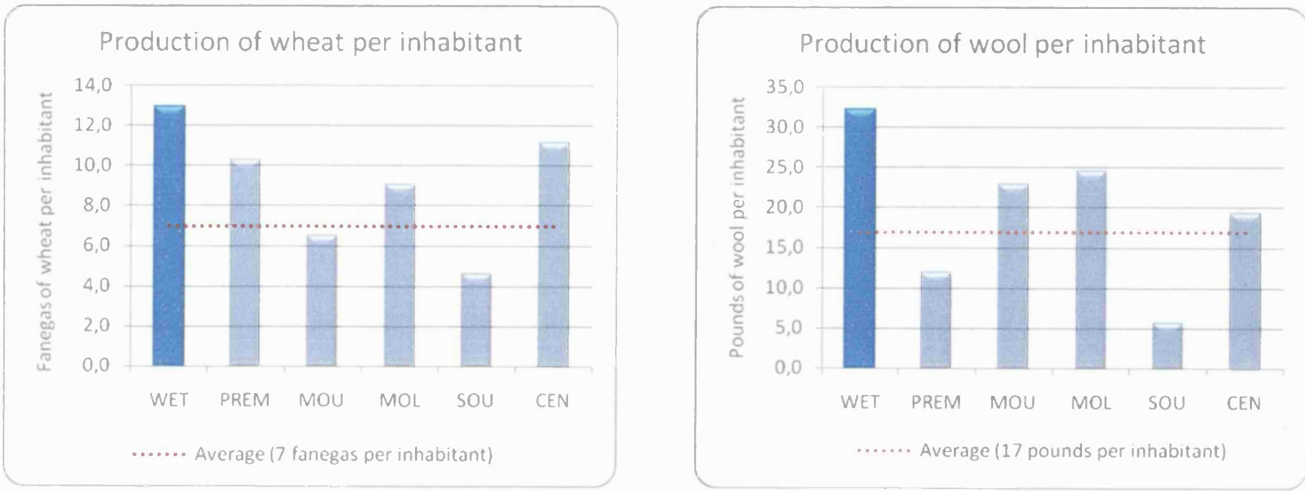


Source: Catastro de la Ensenada

In terms of production per capita, the Wet region is the richest and most fertile area of the province of Guadalajara. Its production of wheat per capita reached 13 fanegas per inhabitant, 5 fanegas more than the provincial average. On the other hand, the production of wool was also considerably higher than in the rest of Guadalajara, with 32.2 pounds per capita. The explanation of this economic success can be found on the benefits of clear environmental advantages, especially the amount of rainfall that as showed in chapter 3 was higher in the Wet region than in any other region of Guadalajara.

[133] The municipalities are Ablanque, Aguilar de Anguita, Anguita, Anquela del Ducado, Arbeteta, Armallones, Baños de Tajo, Checa, Chequilla, Ciruelos del Pinar, Cobeta, Corduente, El Recuenco, Fuenvellida, Huertahernando, Iniestola, Luzon, Maranchon, Mazarete, Megina, Olmeda de Cobeta, Orea, Peñalen, Pinilla de Molina, Poveda de la Sierra, Riba de Saelices, Selas, Taravilla, Terzaga, Tierzo, Torremocha del Pinar, Torremochuela, Traid, Valhermoso, Villanueva de Alcoron and Zaorejas.

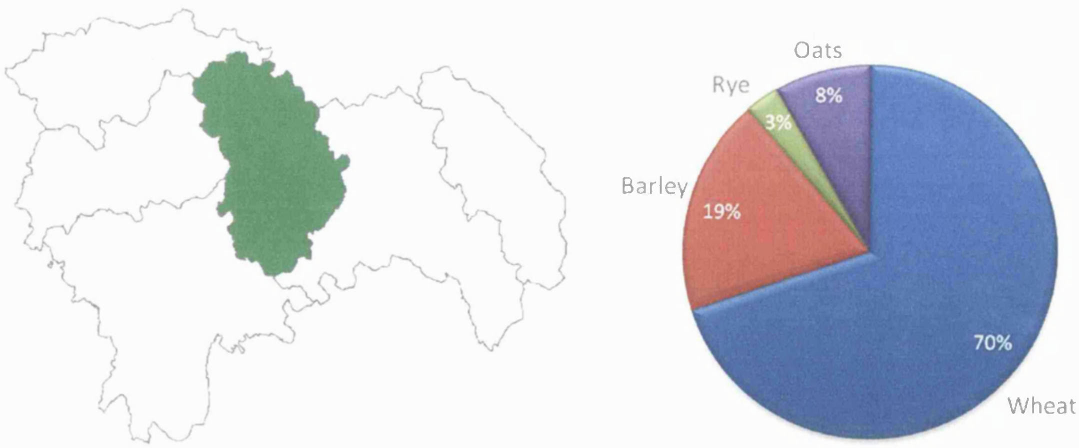
Figure 5.42: Production of wheat and wool per capita in the Wet region, mid 18th century



Source: Catastro de la Ensenada

The Central region located in the middle of the province includes 33 municipalities.[134] The production of wheat reaches 70 per cent and the weight of oats is the highest of all the regions with 8 per cent mainly from the reduction of rye. On the other hand, barley at 19 per cent presents a similar value to the rest of Guadalajara.

Figure 5.43: Central region and distribution of grain production, mid 18th century

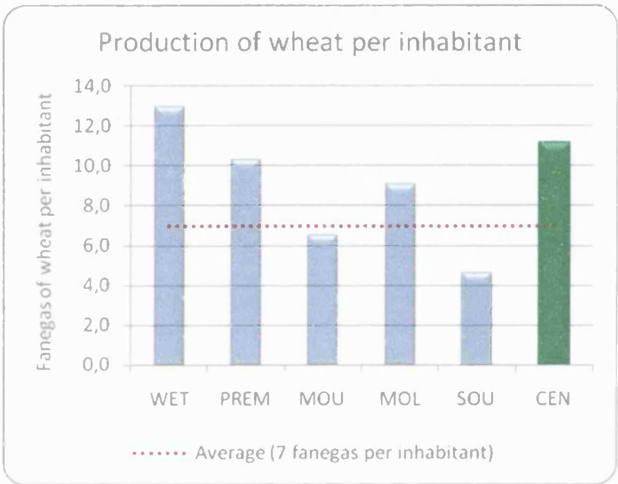


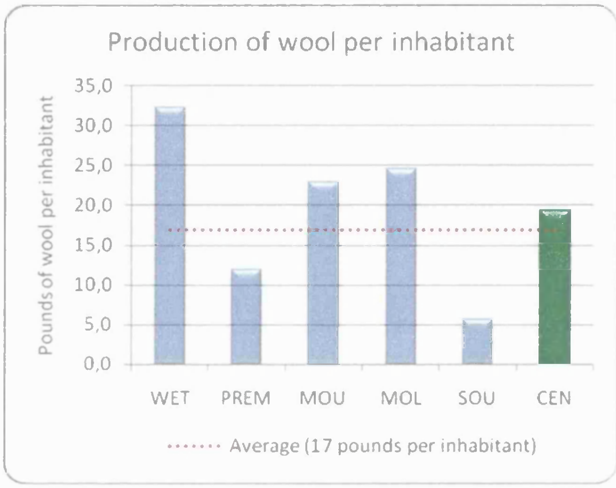
Source: Catastro de la Ensenada

[134] They are Abanades, Alaminos, Alboreca, Alcolea del Pinar, Aragosa, Baides, Barriopedro, Cifuentes, Cogollor, El Sotillo, Esplegares, Estriegana, Henche, Las Inviernas, Luzaga, Mandayona, Masegoso, Navalpotro, Ocentejo, Rebollosa de Jadraque, Rillo, Riofrio, Sacecorbo, Saelices de la Sal, Santiuste, Sauca, Solanillos, Sotodosos, Torrecuadradilla, Torremocha del Campo, Valderrebollo and Viana.

The Central region has the second highest production of wheat per capita with a value of 11.2 fanegas per inhabitant. Therefore, it is between the fertile Wet region and the Pre-Mountains and South with lower production per capita. The production of wool is 19.4 pounds per capita, slightly above the average in Guadalajara.

Figure 5.44: Production of wheat and wool per capita in the Central region, mid 18th century



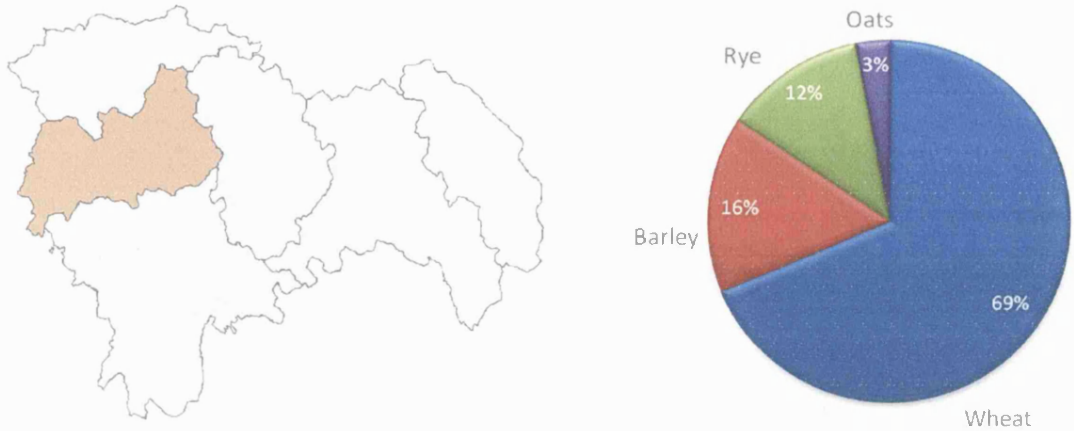


Source: Catastro de la Ensenada

The Pre-mountains area is located in the Western half of Guadalajara and includes 56 municipalities.[135] In terms of grain production it is a region that is characterized by a strong presence of rye whose 12 per cent share is almost double the provincial average, an increase mainly at the expense of barley that only has a share of 16 per cent in grain production. On the other hand, oats are by far the least important grain with just a 3 per cent of the share.

[135] Algecilla, Almadrones, Angon, Arbancon, Arroyo de las Fraguas, Bujalaro, Casa de Uceda, Casas de San Galindo, Castejon de Henares, Cendejas de Enmedio, Cendemas de la Torre, Cogolludo, Congostrina, Copernal, El Casar, El Cubillo de Uceda, Espinosa de Henares, Fuemcemillan, Fuentelahiguera, Gajanejos, Jadraque, Jirueque, La Mierla, La Toca, Ledanca, Malaga del Fresno, Malaguilla, Matarrubia, Matillas, Medranda, Membrillera, Miralrio, Mohernando, Monasterio, Montarron, Muduex, Negredo. Palmaces, Pinilla de Jadraque, Puebla de Beleña, Puebla del Valles, Robledillo de Mohernando, Robledo, Torre del Burgo, Torremocha de Jadraque, Tortuero, Uceda, Utande, Valdearenas, Valdepeñas de la Sierra, Valdepielagos, Valdesotos, Villanueva de Argecilla, Villaseca de Henares, Villaseca de Uceda and Viñuelas.

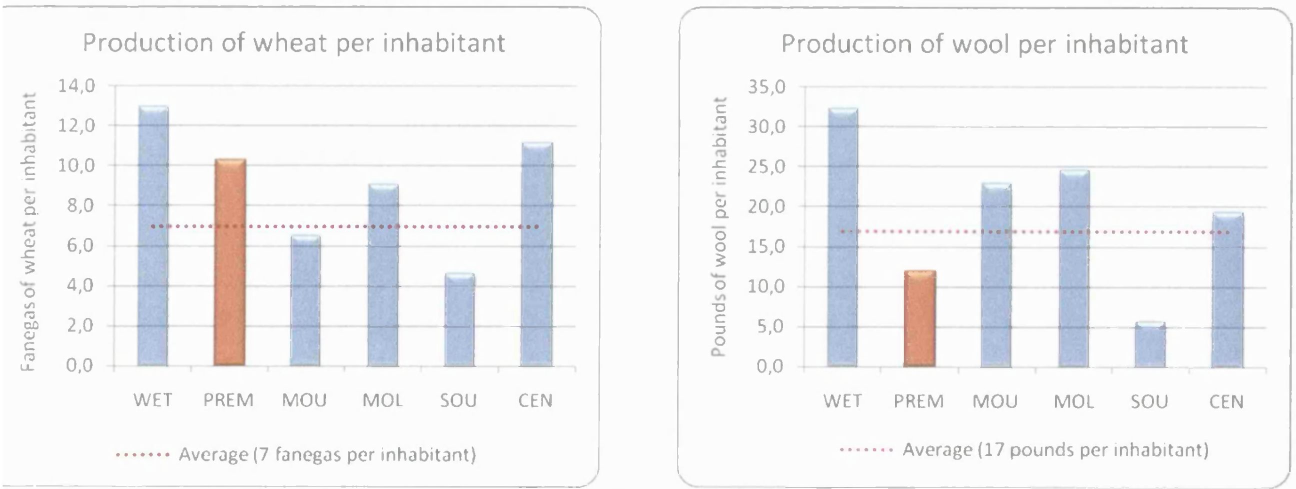
Figure 5.45: Pre-Mountains region and distribution of grain production, mid 18th century



Source: Catastro de la Ensenada

The Pre-Mountains region is a mixed economy between the diversified economies of the Mountains and the more urban economies of the South. It therefore has values that range between those of the Mountains and the South. In the case of wheat per capita the region performs well with a production of 10.3 fanegas per inhabitant well above the average of 7 fanegas per capita. However, the situation is not as good in the case of wool, where the values although higher than in the South did not reach the provincial average remaining at 11.9 pounds per person.

Figure 5.46: Production of wheat and wool per capita in the Pre-Mountains region, mid 18th century



Source: Catastro de la Ensenada

Conclusion

The distribution of land shows that in comparison to the rest of Castile, the church had a very advantageous position in Guadalajara. However, a detailed analysis of the distribution of the producers shows that the situation in Guadalajara was not so pessimistic. On the other hand, institutions like the *mayorazgo* acted like a brake on the agrarian development of Castile. The lack of investments and the small size of the producers also worked against the improvements of productivity levels. The alternative to increase the production of grain relied on access to common lands that in the eighteenth century still represented a substantial percentage of the total in Castile. The strong demographic pressure was the main driving force behind authorizations to cultivate the common lands, although the intensity of the process was significantly reduced by the actions of pressure groups and local oligarchies that were contrary to it.

The eighteenth century was a period of economic growth during its first half and of economic decline and stagnation during the second half. The production of grain increased until the 1750s when the crisis of the old regime reduced it and produced a long period of economic stagnation during the second half of the eighteenth century. The production of wheat, barley and rye suffered during the crisis while the production of oats did increase during the whole century. Grain production was clearly dominated by the presence of wheat that averaged two thirds of total production during the eighteenth century, although this share increased to almost seventy per cent during the last decades. The weight of barley and rye also decreased while the presence of oats gained importance. On average the volatility of grain production was very high during the first two thirds of the century and was significantly reduced during the last decades. The relationship between prices of wheat in Toledo and Madrid and its production in Guadalajara was strong and statistically significant. This suggests the existence of movements of grain from Guadalajara to the big urban markets of the interior of Spain. The comparative analysis with other series of grain production show some similarities that were more common during the first half of the century and also clear differences that started to appear during the second half.

The structure of the agrarian economy in Guadalajara was highly diversified. The Mountains in the north compensated for the lack of natural resources with an increase in the production of wool and livestock. On the other extreme the South region suffered a shortage of food production that had to be compensated by the surplus from the rest of the province. The weakness of the South in terms of guarantying the supply of food was one of the main reasons to explain the demographic decline that the region lived during the eighteenth century.

In conclusion, the production crisis that affected Guadalajara in the 1760s was an important shock for the economy of the region. Grain represented the most important item of the agrarian economy of the province, and its production fell by 30 per cent. The effects of such a decrease on the living standards of the population should have been so intense that they should have been reflected on population levels. However, the analysis of the most important demographic variables showed that the production crisis did not affect population negatively, and that in fact the second half of the eighteenth century was, in demographic terms, a period of prosperity and growth.

6. Demography in eighteenth century Guadalajara

This chapter will introduce the main demographic series that we have collected in the historical diocesan archive of Sigüenza-Guadalajara. This series composes the core of the population analysis of the thesis. It will also present a cross section analysis of population, social classes and labour force across the different regions of Guadalajara.

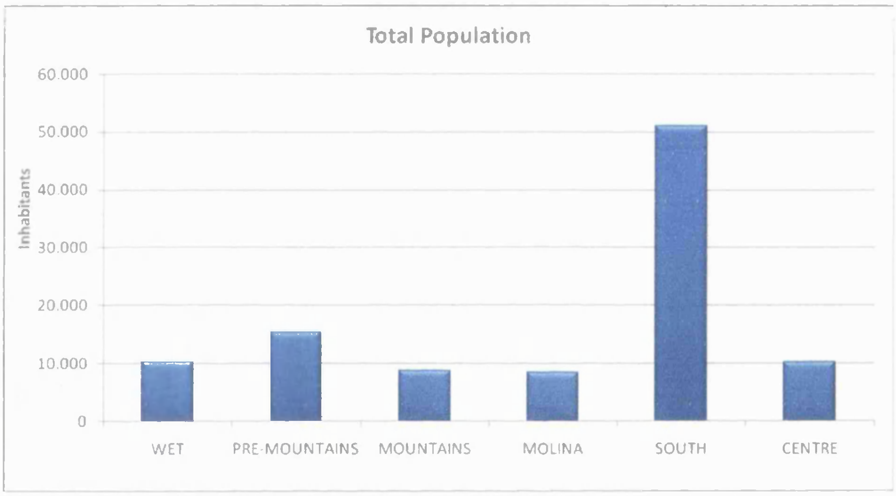
The first section of the chapter will use the information provided in the Catastro de la Ensenada to present a picture of the distribution of population, social classes and labour force in the middle of the eighteenth century in Guadalajara. The section will focus on the regional differences inside Guadalajara and the forces behind them. These differences together with the intra-provincial analysis of production shown in the previous chapter will contribute to the understanding of the regional disparities that also existed in the behaviour of the demographic variables.

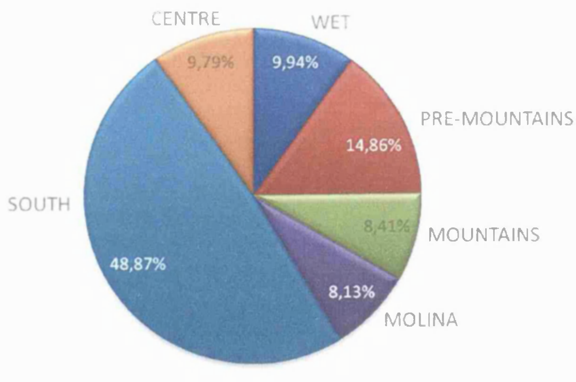
The second section of the chapter will present the series of baptisms and burials as proxies of fertility and mortality respectively. It will also show an estimation of total population during the eighteenth century based on the number of households and the natural growth of population calculated from baptisms and burials. It will also include an analysis of both baptisms and burials and its relationship with the series themselves. The chapter will conclude that the internal demographic differences in the province of Guadalajara were mostly consequence of the different economic and social structures of the six regions, and that the urban areas like the South suffered more in terms of population than the more rural areas of Guadalajara.

6.1 Geographical distribution and social stratification in the early 1750s

According to the information from the Catastro de la Ensenada, in the early 1750s the province of Guadalajara had a population of 105,000 inhabitants. With a size of 12,167 squared kilometres, the province had a population density of just 8.6 inhabitants per squared kilometre. The distribution of population by region was very unequal. For instance, the South region with more than 50,000 inhabitants contained almost half of the population of Guadalajara. The rest of the areas had a population that ranged from the 8,800 inhabitants of the Mountains to the 15,000 of the Pre-Mountains region.

Figures 6.1 and 6.2: Total population by region, mid 18th century

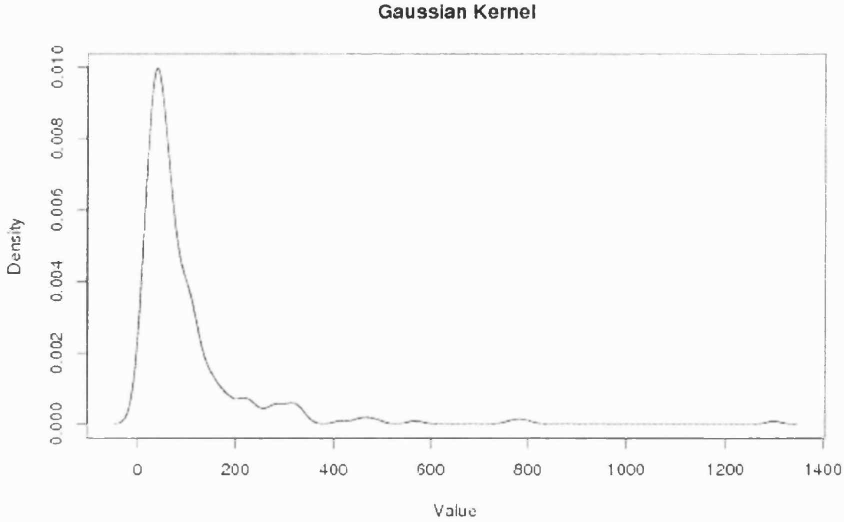




Source: Catastro de la Ensenada

Urbanization levels are one of the most important aspects of any demographic analysis. In the case of eighteenth century Guadalajara, we can use the information provided by the Catastro de la Ensenada in order to compare the sizes of the villages and towns and the regional differences that exist within the province. Question 21 in the survey requested the number of households in every village, multiplying this number by the coefficient 3.92 we can estimate the number of inhabitants of every municipality.[136] Figure 6.3 shows the Gaussian Kernel distribution of the number of inhabitants per municipality in the province of Guadalajara according to the Catrastro de la Ensenada of the early 1750s. Kernel curves measure the distribution of a statistic population and assigns a density to the different values of the observations in the sample, being higher when the value appears more frequently.

Figure 6.3: Kernel distribution of population size in Guadalajara, , mid 18th century

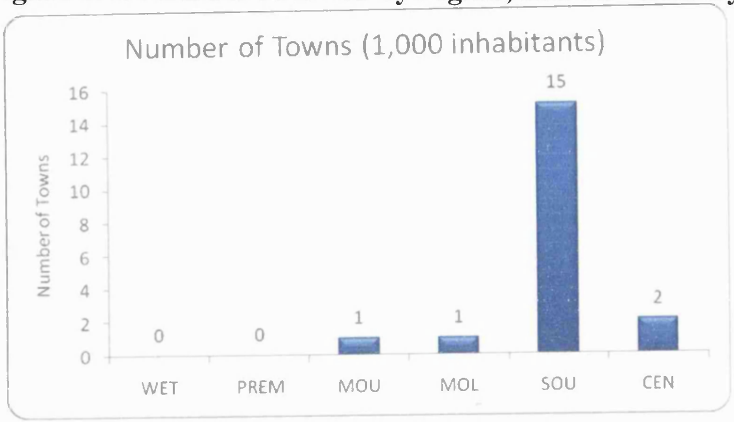


Source: Own calculations from the Catastro de la Ensenada

Most of the municipalities are therefore small villages with less than 200 inhabitants, once more highlighting the rural character of the province of Guadalajara. We identified a town as a municipality with more than 1,000 inhabitants. According to this description the Wet and Pre-mountain regions are the only ones that did not have any towns, while the Mountains and Molina had only one. The Central region had two towns and finally the most urbanized region was the South that contained 15 out of the 19 towns of Guadalajara. The urban nature of the South is again reflected in the number of inhabitants per village. Most the regions of Guadalajara range between 275 and 310 inhabitants per village, but the South is an extreme case with 631 inhabitants per municipality.

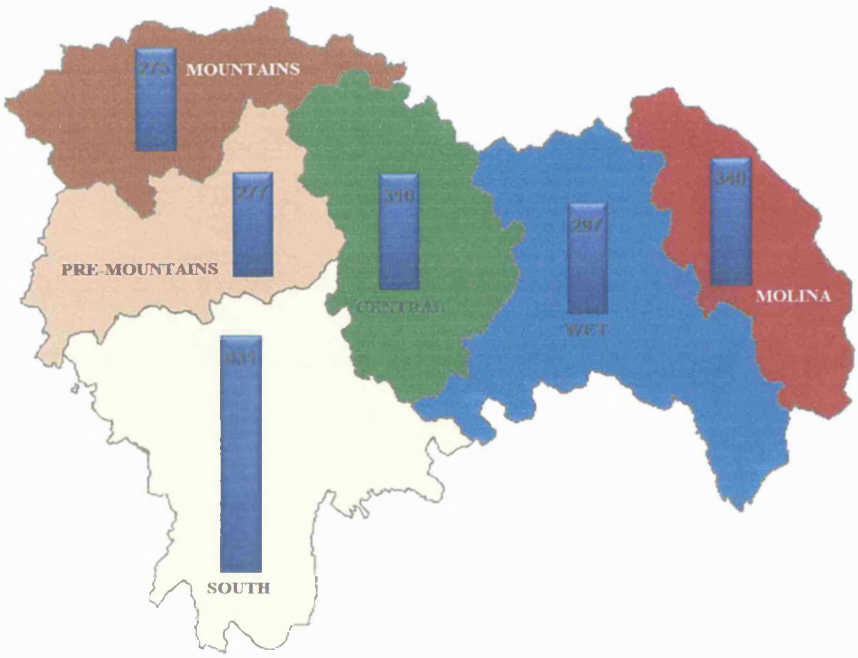
[136] The coefficient 3.92 was estimated for the province of Guadalajara.

Figure 6.4: Number of towns by region, mid 18th century



Source: Own caltulations from the Catastro de la Ensenada

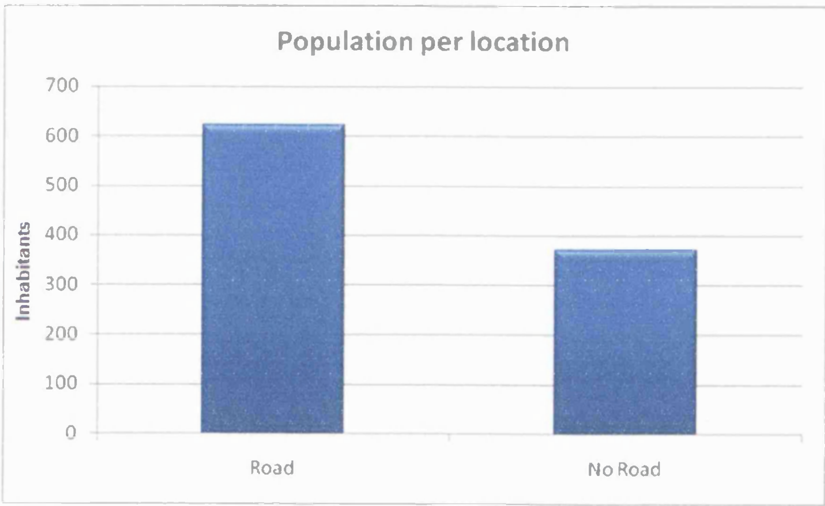
Figure 6.5: Average size of municipality by region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

One of the main factors that determine the size of a municipality is the access to the transport network, in the case of eighteenth century Castile, this meant the link to the main roads. As expected the municipalities that are directly connected to the road network are bigger in terms of population. Figure 6.6 shows that on average those municipalities that have a main road had a population of 621 inhabitants, while those that were isolated from the main network had 371. The existence of a transport network therefore has a direct impact in the size of the villages and towns, and therefore in urbanization rates.

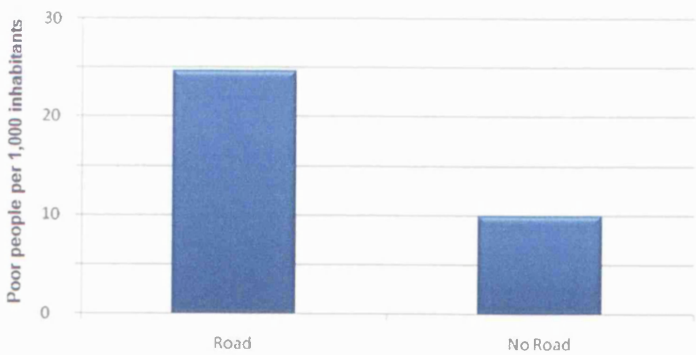
Figure 6.6: Average size of municipality by access to road in Guadalajara, mid 18th century



Source: Own caltulations from the Catastro de la Ensenada

Rural areas are in general more egalitarian than urban ones which is also reflected by the fact that in the urban areas connected by roads, the percentage of poor people is higher than in those that are not connected. Figure 6.7 shows that while in the municipalities that had a road the percentage of poor people was 25 per thousand of total population, with the villages that are not connected, the percentage did not reach 10 per thousand.

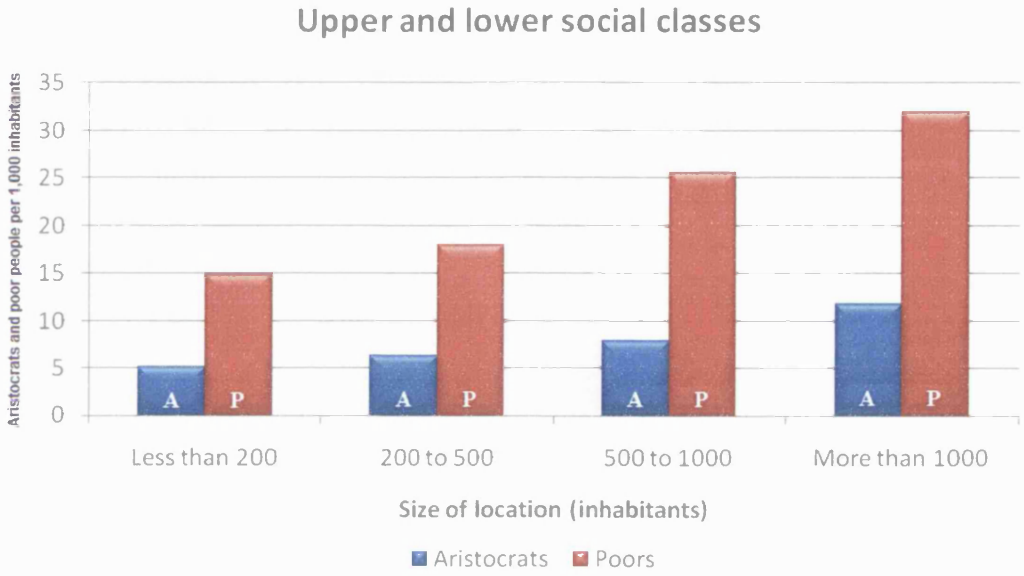
Figure 6.7: Number of poor people per 1,000 inhabitants by access to road in Guadalajara, mid 18th century



Source: Own caltulations from the Catastro de la Ensenada

If instead of looking at access to transport, we divide the municipalities by size, we can again confirm that the social disparities are higher in the more populated places. Figure 6.8 shows the number of aristocrats and poor people per 1,000 inhabitants. The results clearly show that it is within the towns with more than 1,000 inhabitants where the proportion of rich and poor people is higher, and that the percentage decreases systematically as the size of the municipalities is reduced.

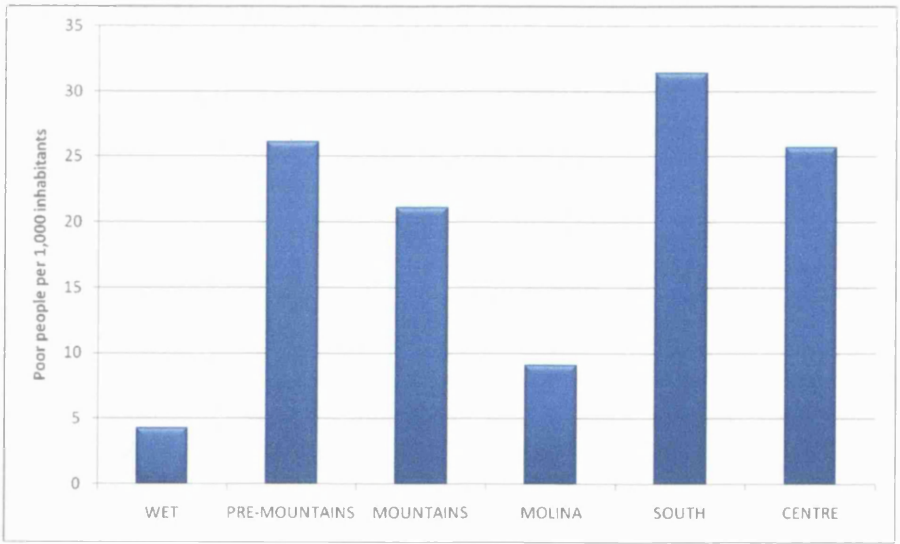
Figure 6.8: Number of aristocrats and poor people per 1,000 inhabitants by size of municipality, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

Regionally, the South which had the highest urbanization rate also had the highest proportion of poor people, followed by the Pre-Mountains region, the Central and the Mountains. On the other extreme we find the Wet region where the proportion of poor people is smaller, followed by Molina.

Figure 6.9: Number of poor people per 1,000 inhabitants by region, mid 18th century

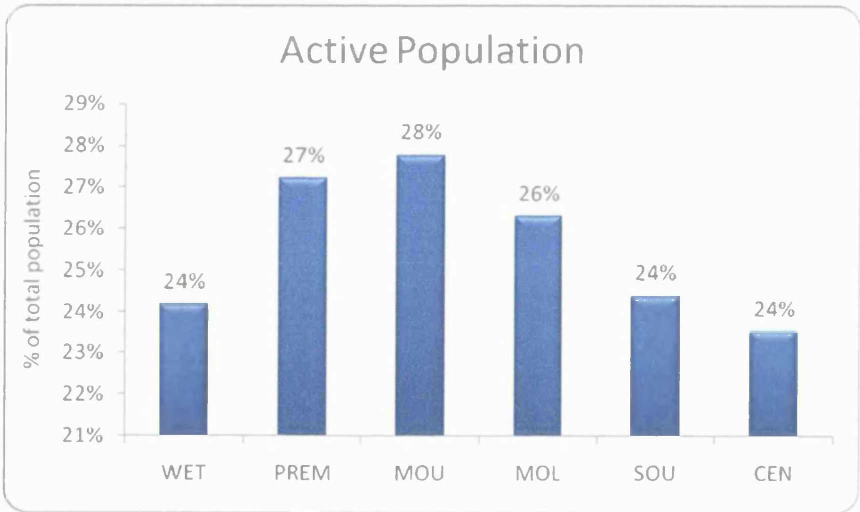


Source: Own calculations from the Catastro de la Ensenada

6.2 Labour force in the early 1750s

We defined active population as the number of workers divided by the total number of inhabitants. We identify workers by the amount of people who have a job according to the Catastro including peasants. The results presented in figure 6.10 show that the highest activity rates are located in the region of the Mountains, followed closely by the Pre-mountains and then by Molina. The size of villages in the Mountains was small and urbanization rates low. It is therefore easy to understand that the percentage of people that was needed to maintain the economy was higher in the case of the Mountains than in more urbanized areas. The South, Central and Wet regions were on the other hand the ones with lower activity rates.

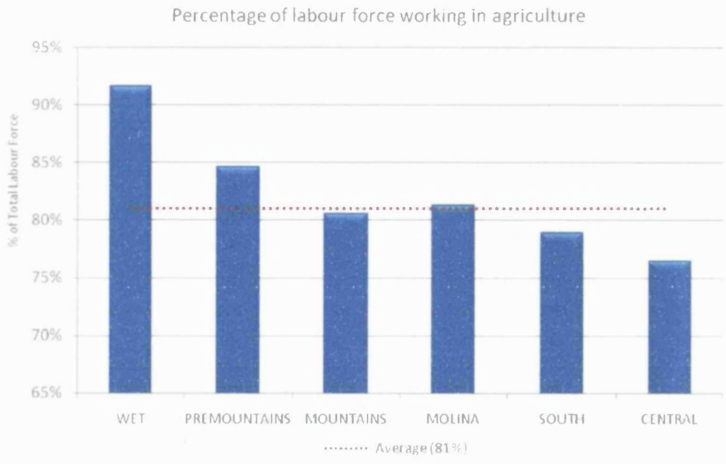
Figure 6.10: Active population by region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

In terms of distribution by sector, the labour force in Guadalajara was mainly orientated around the production of food and therefore agriculture was the most important supplier of jobs. On average 81 per cent of the labour force in Guadalajara worked in agriculture, although the trends were different depending on the region. The Wet region represented the area where there was the biggest proportion of the labour force in agriculture, with a share of 92 per cent. The Pre-Mountains area also had a percentage above the mean with 85 per cent, followed by Molina and the Mountains both with 81 per cent of the labour force. Finally, the South with 79 per cent and the Central region with 76 presented the lowest values.

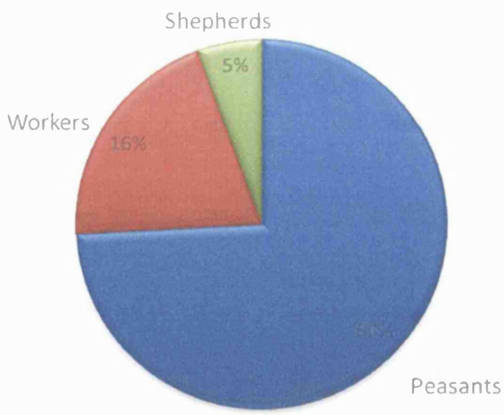
Figure 6.11: Proportion of agrarian labour force by region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The bulk of these workers were peasants that owned or rented the land that they cultivated, then workers that did not have access to land and who therefore worked for a salary, and finally shepherds. On average across the entire province, peasants were the dominant figure contributing 60 per cent of the total labour force. They were followed by agrarian workers who represented 16 per cent and finally by shepherds with 5 per cent.

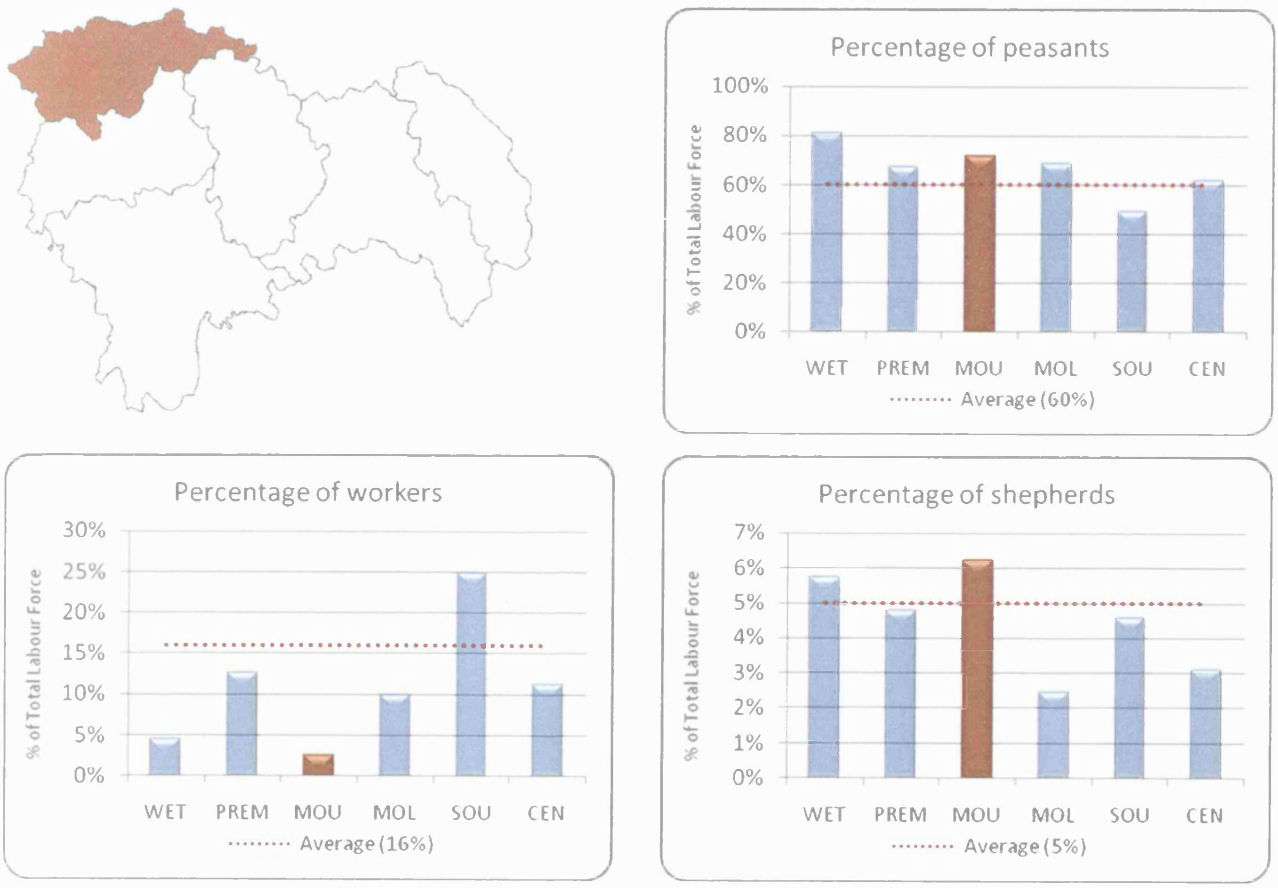
Figure 6.12: Proportion of agrarian jobs in total labour force, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

There were however important regional differences. In the region of the Mountains, the percentage of shepherds was the highest in the province and only the Wet region had a higher percentage of peasants. Almost all the producers in the region did own or rent the land that they cultivated, and the amount of workers (2 per cent of the total labour force) was the lowest value in all Guadalajara. This situation is understandable given the geographical characteristics of the area. The mountains tended to be characterised by small villages with populations that lived from the production of grain and dairy products, in a society where the percentage of inhabitants that did not work their own land or a rented one was very low.

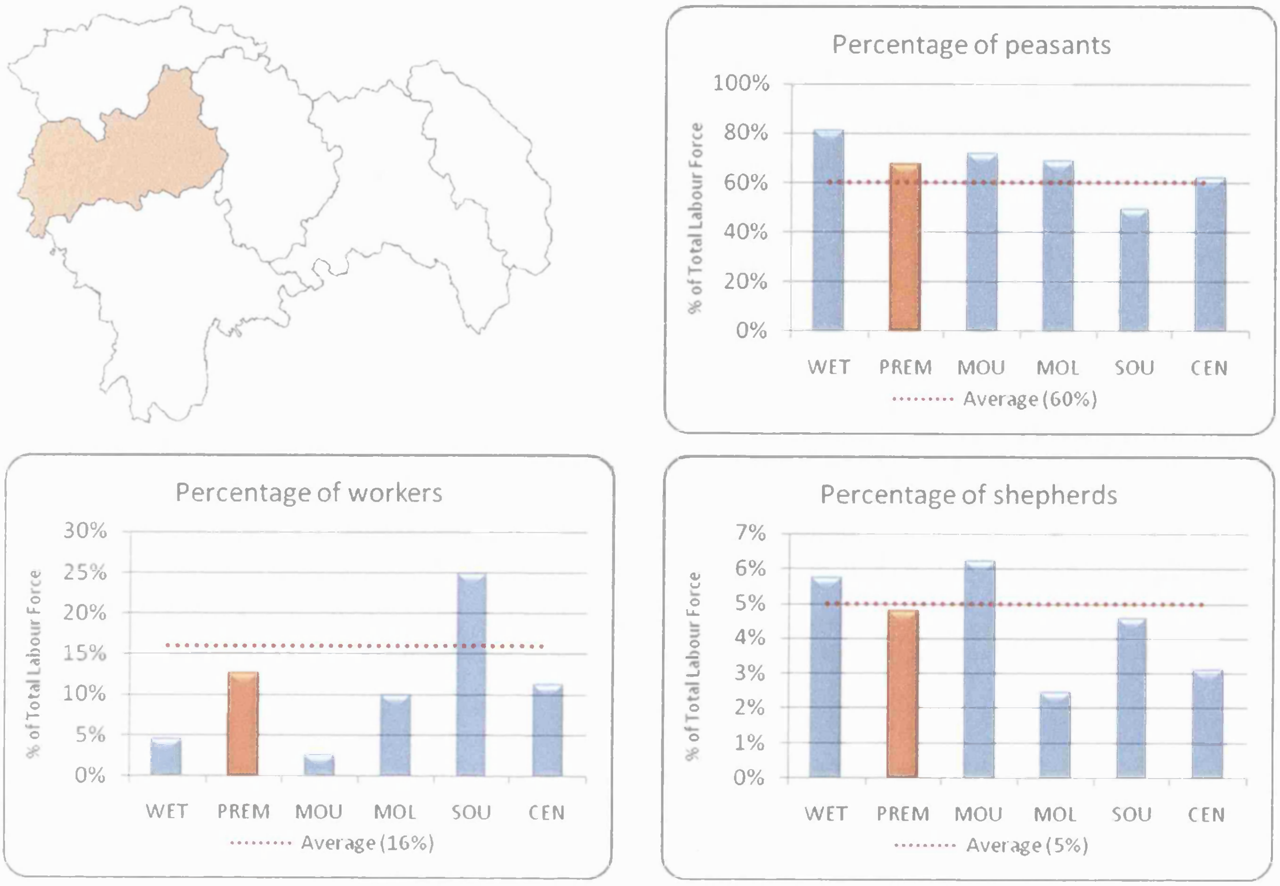
Figure 6.13: Agrarian labour force by activity in the Mountains region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The Pre-mountains region is geographically located between the mountains of the North and the urbanized South. Therefore its economy is a mix of both areas, with values in the percentages of peasants, shepherds and workers that lie in between those presented by the Mountains and the South. The region had a significant percentage of peasants and also of workers, while the percentage of shepherds is below the mean in Guadalajara.

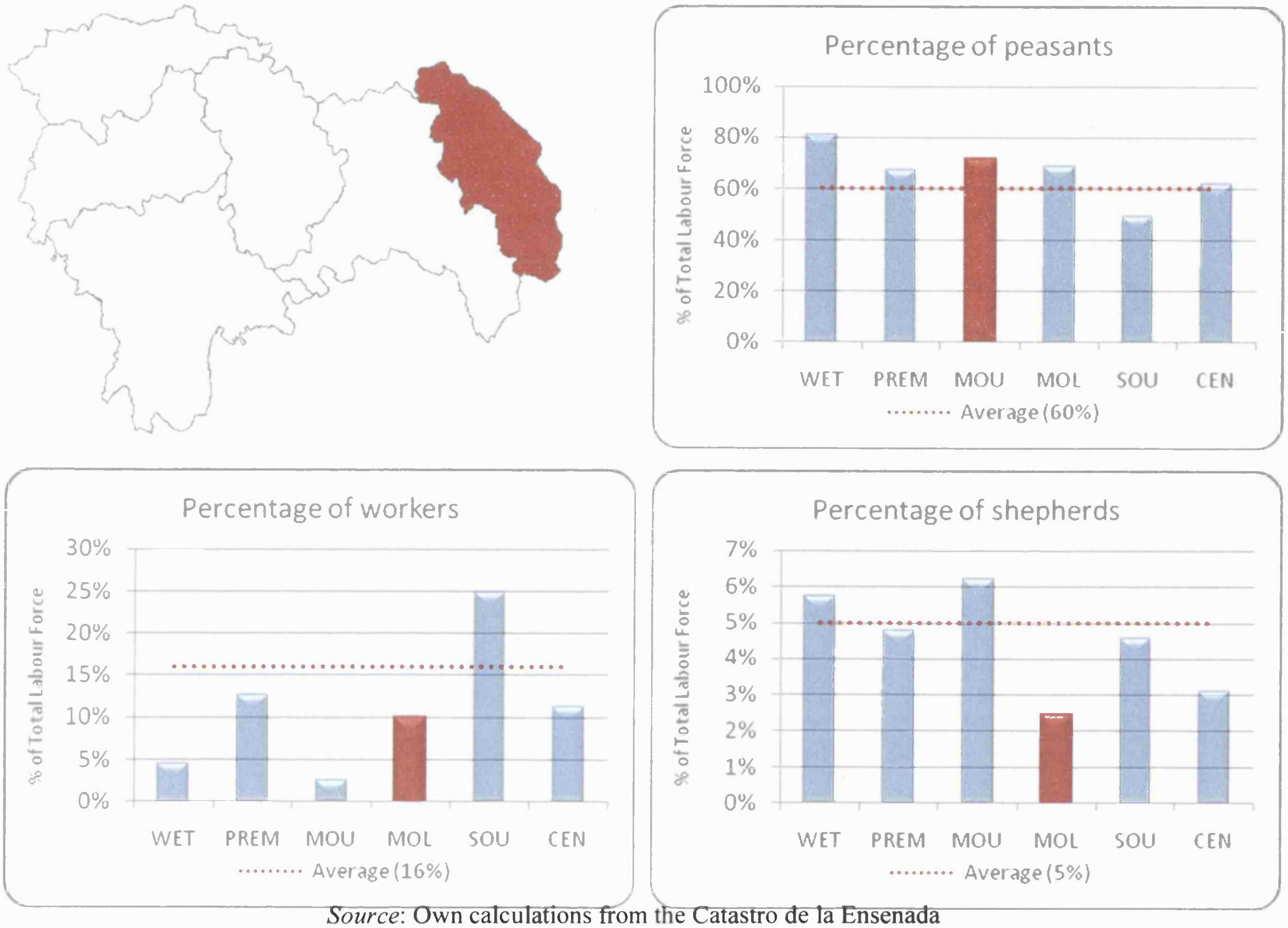
Figure 6.14: Agrarian labour force by activity in the Pre-Mountains region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

Molina is one of the main grain producers of Guadalajara and this is reflected on the percentage of peasants. The number of shepherds was surprisingly low, especially given the fact that the production of wool per capita in Molina was the second highest in the province just behind the Wet region. This implies that the number of sheep per shepherd was relatively high, a fact that can be supported by the rainfall in the area that increased the amount of available pasture. The number of workers that did not own or rent land was also significant with only 10 per cent of total workers not falling in the category. The proximity of the region to the more urbanised South was probably the reason behind this situation.

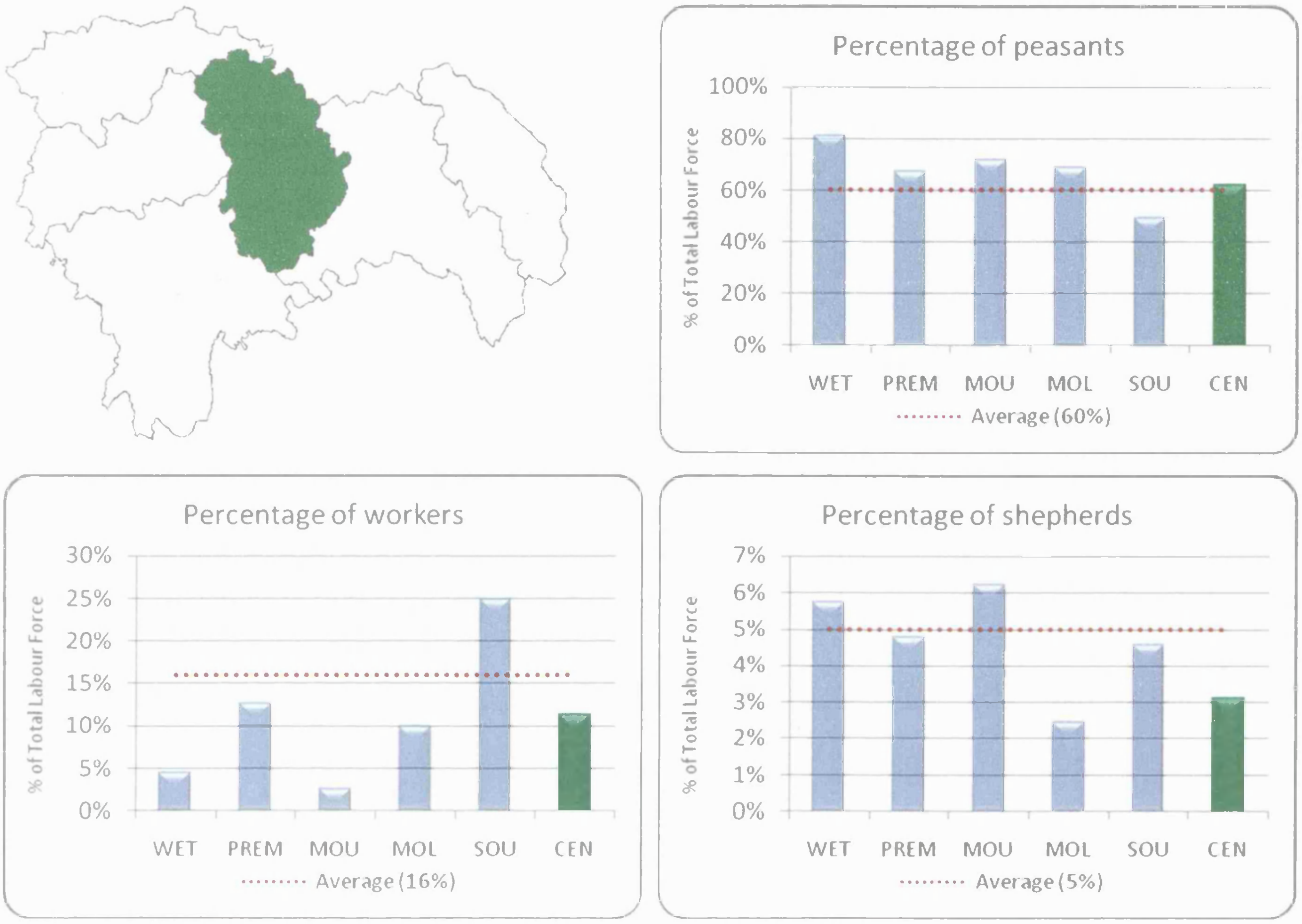
Figure 6.15: Agrarian labour force by activity in the Molina region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The lands in the Central area enjoyed better quality soil than the Mountains or the Pre-Mountains regions, although not as good as the ones in the Wet region. Located between both, the economy was a mix. The labour force is clearly dominated by peasants who represented 60 per cent of all the workers, while the percentage of workers included more than 10 per cent of the total labour force. The small number of shepherds and the high volume of wool per capita suggest that as in the case of Molina, the amount of livestock per shepherd was higher in the Central area than in the rest of Guadalajara as a whole.

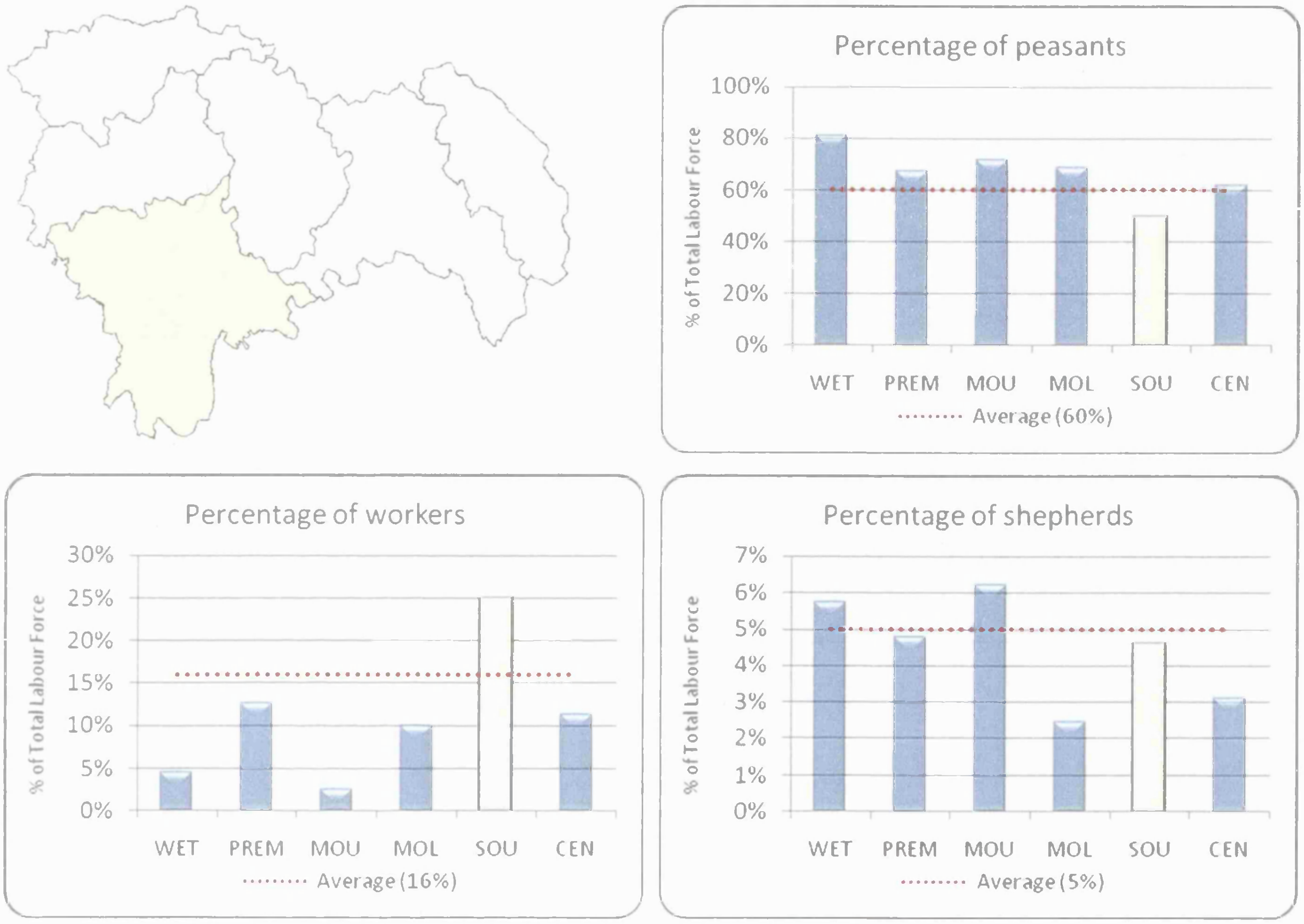
Figure 6.16: Agrarian labour force by activity in the Central region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The South of Guadalajara was the most urbanized area of the province and it also had the highest percentage of workers in the sample. The number of workers came at the expense of peasants. The South was the only area where the percentage of peasants was lower than the mean for the whole province. This situation may be related to the high proportion of aristocrats that probably controlled a higher percentage of land, leaving less available for small producers and therefore forcing many small peasants to become workers. The information available supports this possibility that the regions of Molina, Central and South are the ones with a higher proportion of aristocrats, and also the ones with a higher percentage of agricultural workers. The Mountains and Wet regions on the other hand have the lowest proportion of aristocrats and also the lowest percentages of agricultural workers and therefore the highest proportion of peasants. Although the percentage of shepherds was also below the mean, the situation of the South is not as extreme as in other areas of Guadalajara, with values that are higher than Molina or the Central regions.

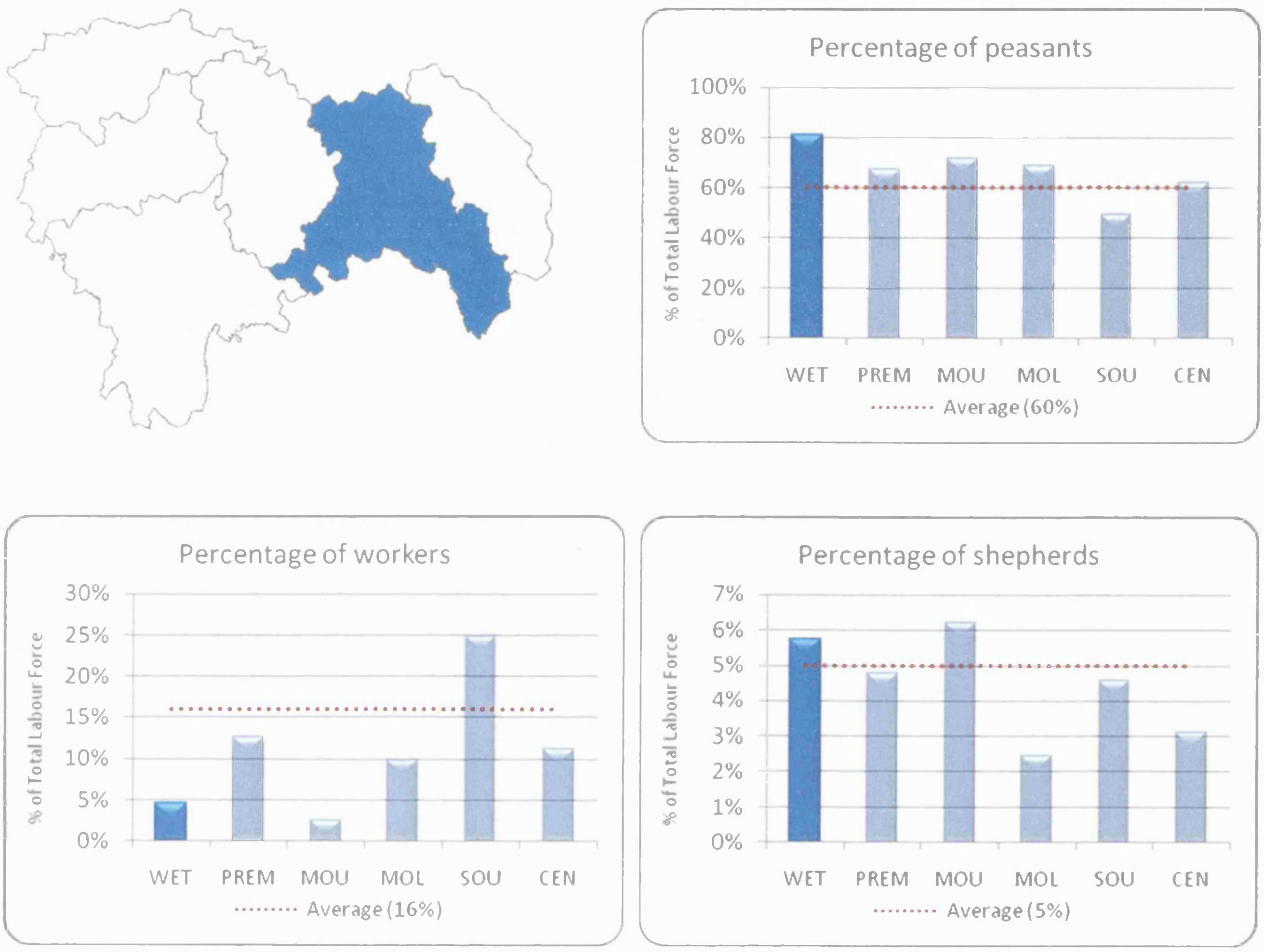
Figure 6.17: Agrarian labour force by activity in the South region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The Wet region was by far the most fertile area of Guadalajara, a fact supported by the percentage that wheat represented in the total production of grains (81 per cent) and the surplus in the production of grain. The percentage of peasants was the highest of Guadalajara, and the percentage of shepherds was the only one above the mean as well as with the Mountains. On the other hand, the amount of workers was the second lowest value of the sample with just 5 per cent.

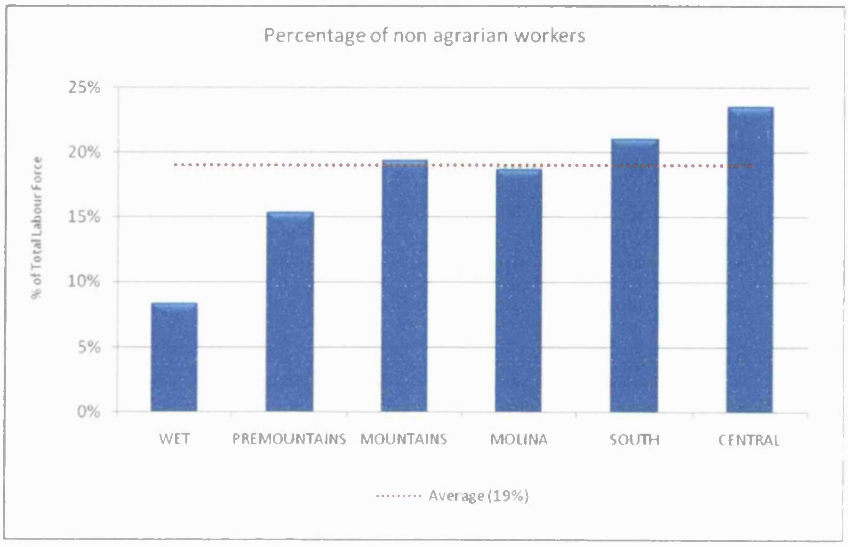
Figure 6.18: Agrarian labour force by activity in the Wet region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

The percentage of workers in non agricultural activities represented on average 19 per cent of the labour force in Guadalajara. By regions the highest percentage was found in the Central region with 23.5 per cent, followed by the South with 21.2 per cent and the Mountains with 19.4 per cent. The other three regions were below the average, the lowest value located in the Wet region where only 8.4 per cent of the labour force was not directly involved in agriculture. In the Pre-Mountains region the percentage was 15.3 per cent and finally Molina with 18.7 per cent was slightly below the average.

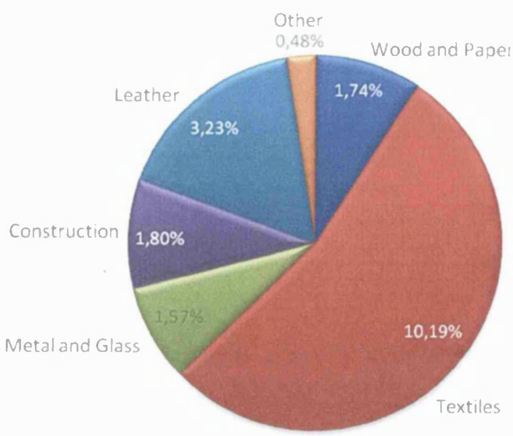
Figure 6.19: Percentage of non-agrarian workers by region, mid 18th century



Source: Own calculations from the Catastro de la Ensenada

This thesis does not cover in depth the structure of the non-agricultural workers. However, from the summaries of the Catastro de la Ensenada we can estimate the sector in which they were located. Taking into account the four early modern provinces that composed the modern province of Guadalajara (Guadalajara, Cuenca, Madrid and Soria) we calculated the percentage of non-agrarian workers in 6 main sectors, Wood and Paper, Textiles, Metal and Glass, Construction, Leather and Others. The results are presented in the following figure.

Figure 6.20: Distribution of non-agrarian workers by activity, mid 18th century



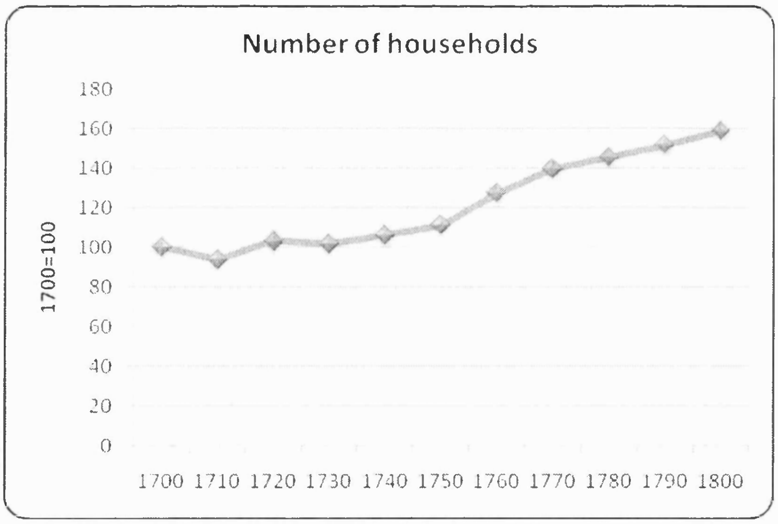
Source: Own calculations from the Catastro de la Ensenada

More than half of the non-agricultural workers were located in the textiles sector, which represented 10 per cent of the total labour force, followed by Leather with 3 per cent and then by Construction, Wood and Paper, Metal and Glass with values between 1.5 and 1.8 per cent.

6.3 Estimations of total population

There are also indirect ways of measuring the evolution of the total population, one of which is measuring the number of households. Figure 6.21 presents the number of households that were taxed by the church in 25 municipalities of Guadalajara during the eighteenth century. The results show that the number of households was relatively stable during the first half of the eighteenth century. The stability was broken in the 1750s when the number increased considerably and by the beginning of the nineteenth century the number of households would be 50 per cent higher than in the mid eighteenth century. If the number of persons living in each household was stable, then we can accept that the second half of the eighteenth century was a period of intense demographic growth, especially in comparison with the relative stagnation of the first half of the century.

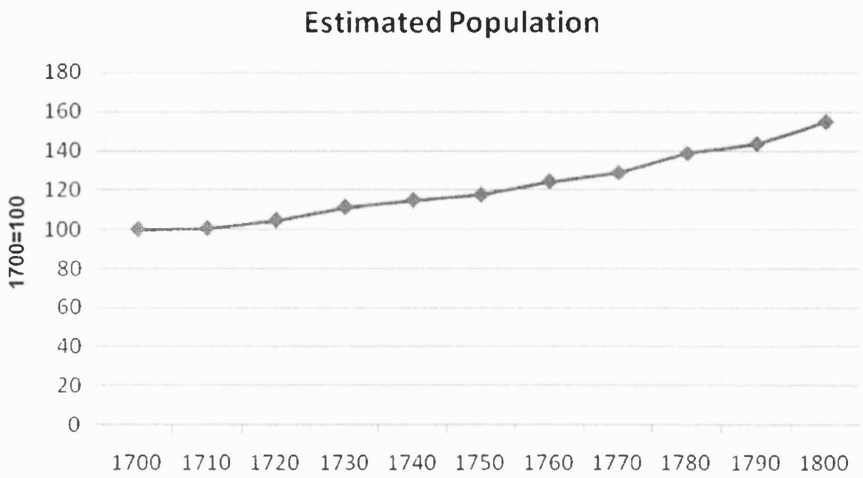
Figure 6.21: Estimated number of households in Guadalajara 1700-1800



Source: Tithe books – Dioceses of Sigüenza-Guadalajara

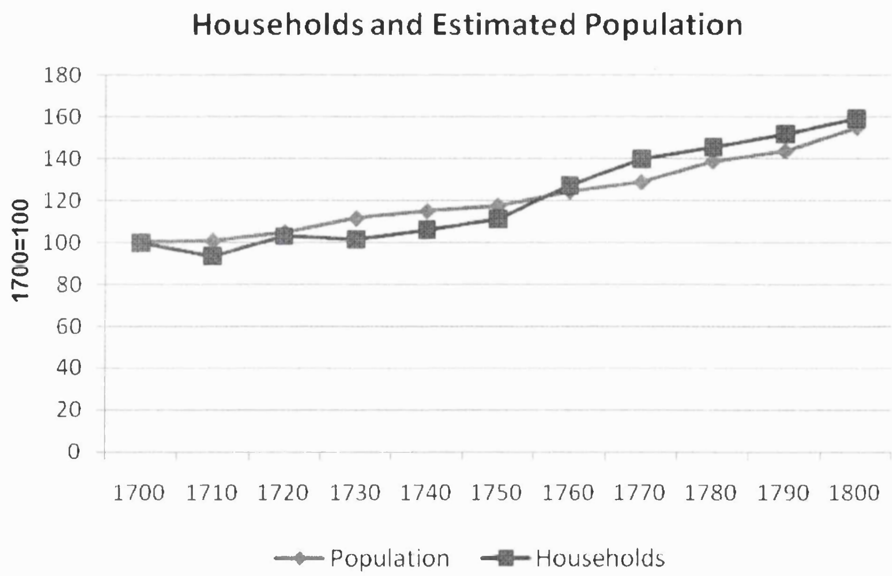
Another way of measuring the movements of total population is measuring the natural growth that is the difference between the number of births and the number of deaths. We count on baptismal and burial records for seven villages during the whole period. Figure 6.22 presents the estimation of population for the eight municipalities based on natural growth. The trend is very similar to households, with an intense growth that took place especially in the second half of the century.

Figure 6.22: Estimated population in Guadalajara 1700-1800 (1700=100)



Source: Same as footnote 6 and 10

Figure 6.23: Households v Population in Guadalajara 1700-1800 (1700=100)



Source: Same as footnotes 6,10 and tithe books for the dioceses of Sigüenza-Guadalajara

6.4 Fertility – Baptismal series

Fertility has been estimated using baptismal records kept by the local parishes. The dataset has been entirely extracted from the historical diocesan archive of Siguenza-Guadalajara and includes 25 municipalities from the province of Guadalajara.[137] The following figure presents the geographical distribution of the sample in the province of Guadalajara.

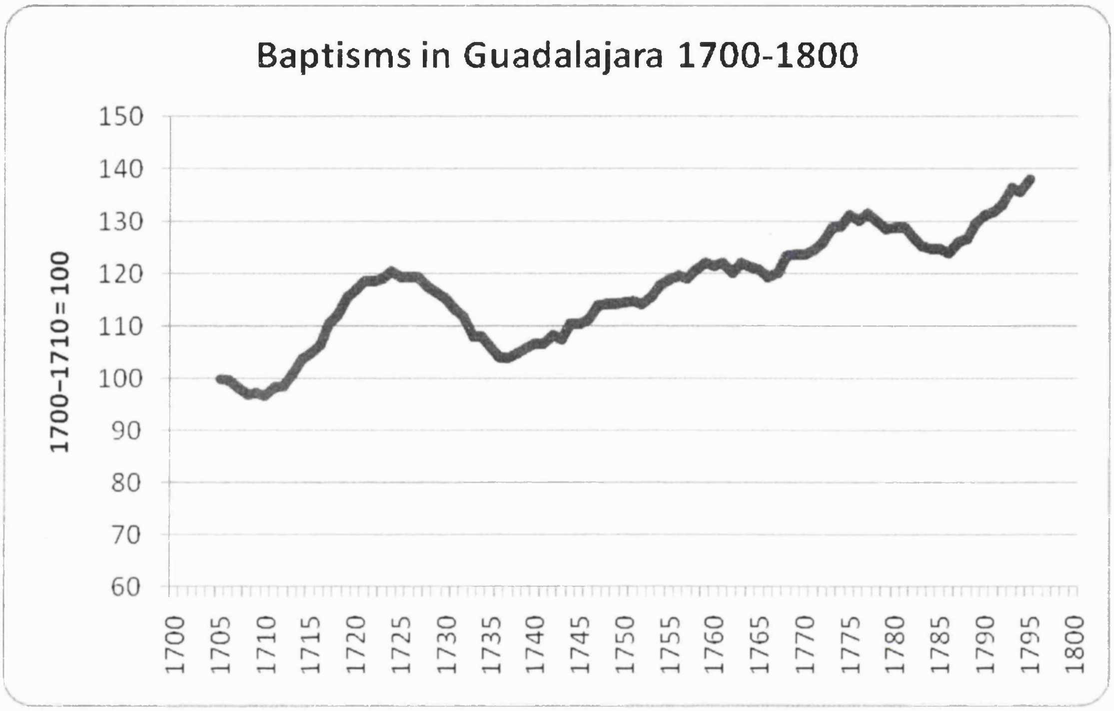
Figure 6.24: Geographical distribution of the baptismal series

Baptismal series show that the eighteenth century is a period of intense growth in fertility, a fact supported by an increase of 40 per cent in the total number of baptisms. However, the trend was not constant and systematic with three main stages being apparent. The first phase includes an intense growth that took place after the decline that began during the last decades of the seventeenth century. During the period 1710-1725 the number of baptisms increased by more than 20 per cent. A short although deep decline took place during the late 1720s until 1740 when the series fell by 10 per cent. Finally, the second half of the eighteenth century was a period of almost uninterrupted

[137] The series include the following municipalities and parishes: Albares/San Esteban, Anchuela del Pedregal/San Andres, Anquela del Ducado/San Martin, Arroyo/Inmaculada, Bañuelos/Asunción de Nuestra Señora, La Bodera/Santiago, Cantalojas/San Julian, Cañizares, Castilmimbre/Asunción de Nuestra Señora, Ciruelos del Pinar/Santa Magdalena, La Cobeta/ Asunción de Nuestra Señora, Concha/San Juan Bautista, Congostrina/Asunción de Nuestra Señora, Galve de Sorbe/Asunción de Nuestra Señora, Garbajosa/San Miguel, Hijes/Natividad, Milmarcos/San Juan Bautista, Olmeda de Jadraque/San Mateo, Peralejos de las Truchas/San Mateo, Renales/San Sebastián, Riba de Saelices/Santa Maria Magdalena, Setiles/Asunción de Nuestra Señora, Sienes/Santa Eulalia, Somolinos/Inmaculada and Torrubia/Asunción de Nuestra Señora.

growth in the number of baptisms of almost 30 per cent and in 1800 the series reached their absolute maximum.

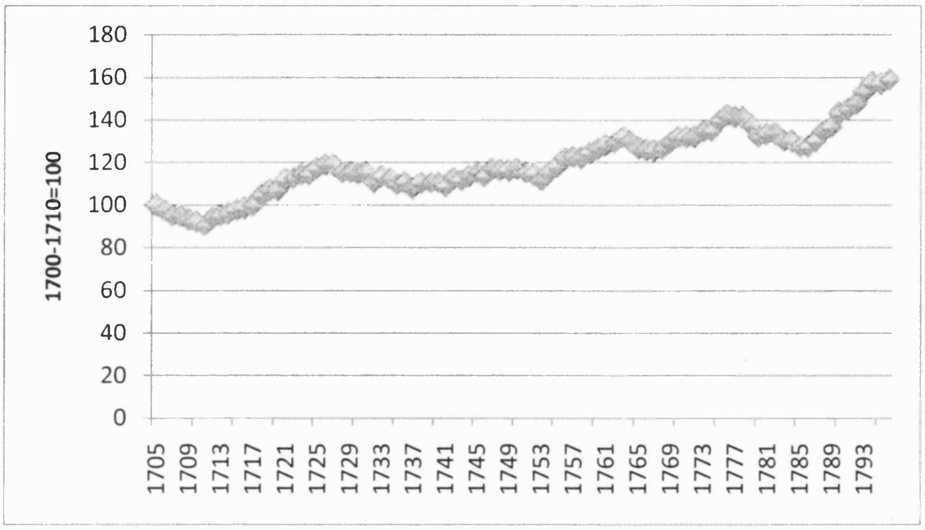
Figure 6.25: Baptisms Index in Guadalajara 1700-1800
(9 years moving average)



Source: Same as footnote 6

However, the trends of the series in the different regions of Guadalajara were not homogeneous. The region of the mountains presents one of the most intense and constant growth of the century. The number of baptisms increased by 60 per cent and the growth was constant in almost all the period being more intense during the last decade of the eighteenth century. The diversification of production and low population density of the Mountains can explain in part why the region was able to resist the production crises of the eighteenth century better than other parts of Guadalajara.

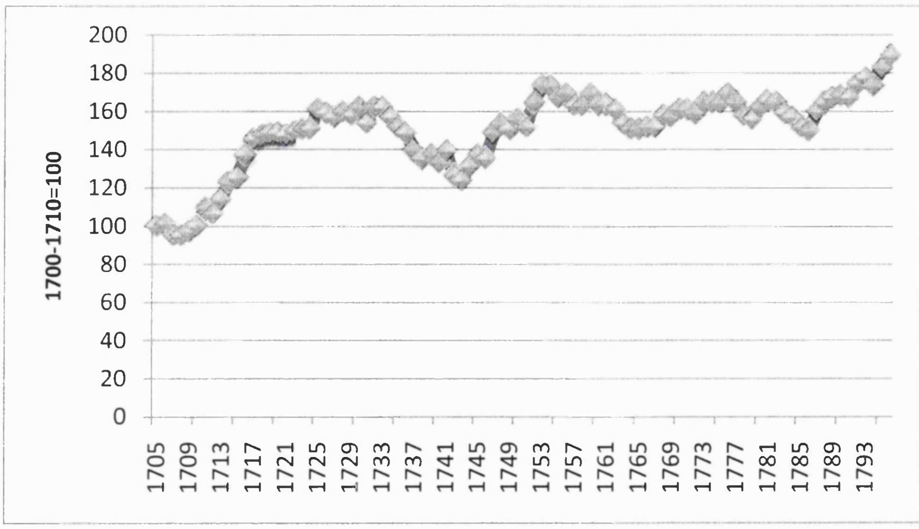
Figure 6.26: Baptisms in the Mountains Region 1700-1800
(9 years moving average)



Source: Same as footnote 6

The Pre-Mountains region is the area in Guadalajara that experienced the biggest increase in the number of baptisms, that during the eighteenth century increased by more than 80 per cent. The most intense growth took place during the first third of the century when baptisms increased by 60 per cent, followed by a long phase of stagnation until the 1780s when the series showed another increase of more than 20 per cent.

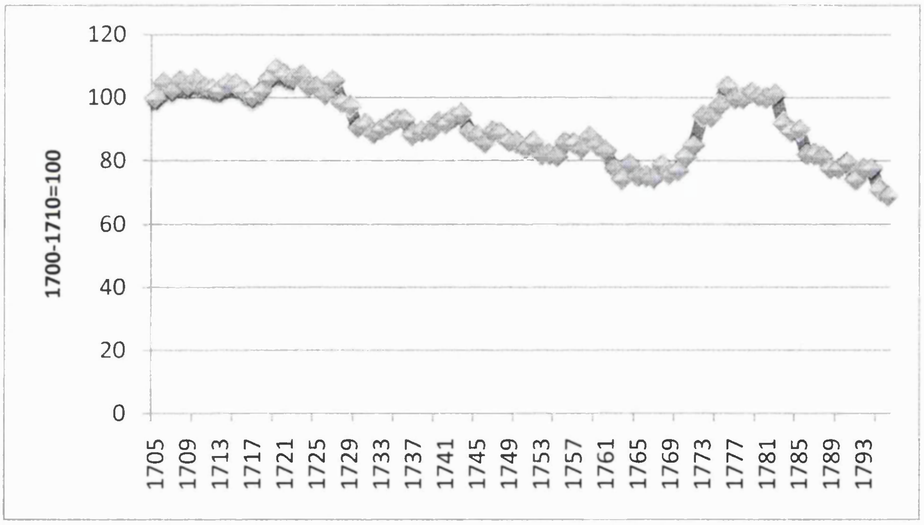
Figure 6.27: Baptisms in the Pre-Mountains region 1700-1800
(9 years moving average)



Source: Same as footnote 6

The South was the only region that had a decrease in the number of baptisms, showing a decrease of 30% by the end of the century. The fall was continuous except during the 1770s when baptisms increased by 20 per cent, a period that was followed by a sharp decline of 30 per cent until the end of the century. It is not surprisingly that as shown in chapter 5, the South region was the only one that suffered a shortage in the production of wheat. The South was not able to produce enough food that had to be imported from the surrounding areas. To make the situation worse, in times of severe shortages the region had to compete with other larger urban areas like Madrid. This disadvantageous position made the South region more vulnerable to the production crises of the eighteenth century.

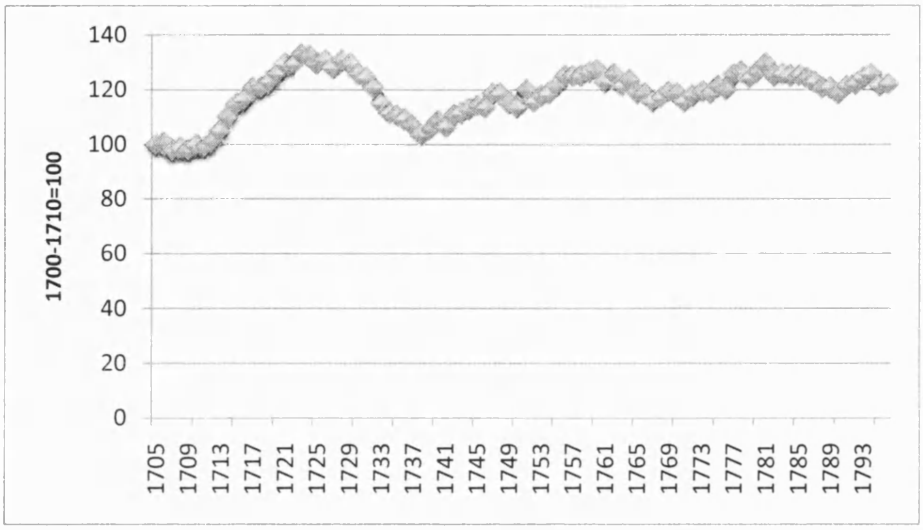
Figure 6.28: Baptisms in the South region 1700-1800
(9 years moving average)



Source: Same as footnote 6

The wet region increased the number of baptisms by just 20 per cent. The first quarter of the century was a period of intense growth of 30 per cent that was followed by a 20 per cent decrease until 1740. The 1740s were the last period of sustained growth and the second half of the century was characterized by stagnation in the number of baptisms that remained stable.

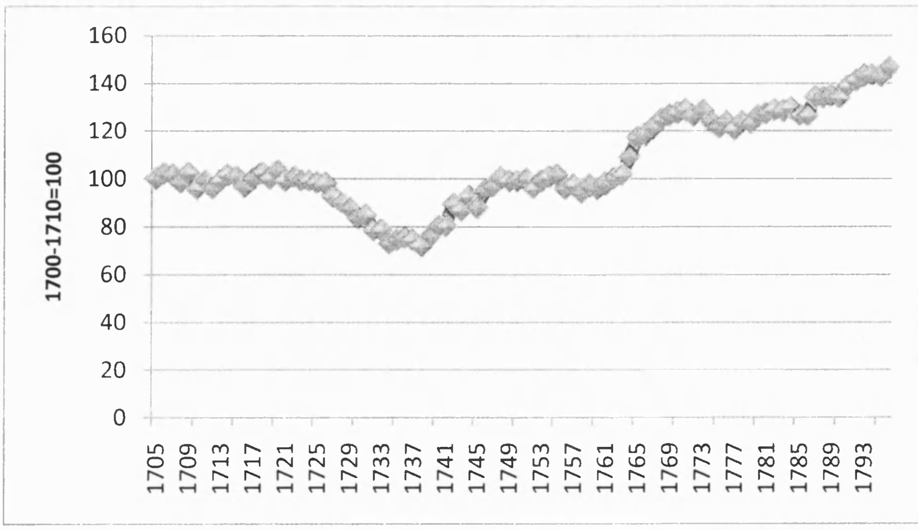
Figure 6.29: Baptisms in the Wet region 1700-1800
(9 years moving average)



Source: Same as footnote 6

The beginning of the period in the Central region was a time of stagnation and later decline in the number of baptisms that by 1735 had fallen by more than 20 per cent. The situation however was quickly reversed and a long period of recovery started in 1740 with an increase in the number of baptisms until the end of the century of more than 60 per cent.

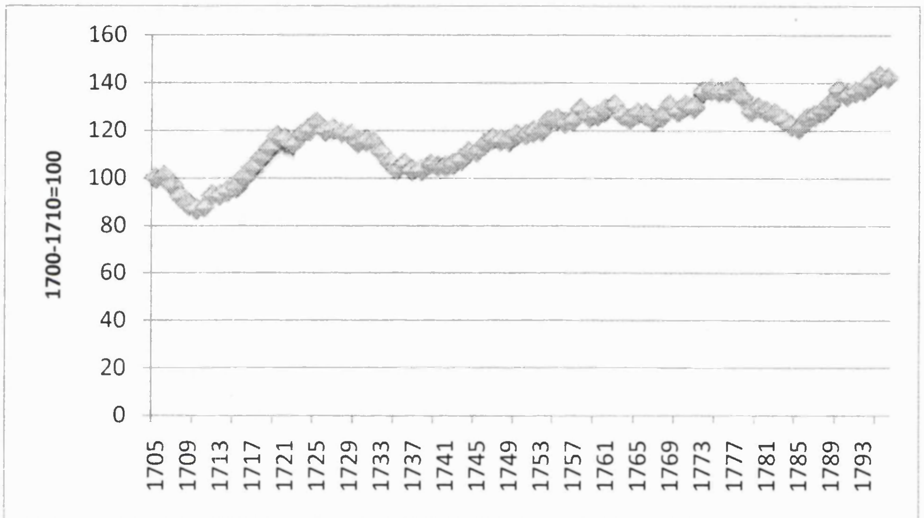
Figure 6.30: Baptisms in the Central region 1700-1800
(9 years moving average)



Source: Same as footnote 6

In the region of Molina the number of baptisms increased with an almost uninterrupted growth. At the end of the eighteenth century baptisms had increased by more than 40 per cent. The region along with the Wet region and the Mountains enjoyed an average volatility that was smaller than the province of Guadalajara as a whole. In addition to the low average volatility, the variance in the number of baptisms presented a positive trend, decreasing from a coefficient of variation of more than 20 per cent to values close to 10 per cent at the end of the century.

Figure 6.31: Baptisms in the Molina region 1700-1800
(9 years moving average)



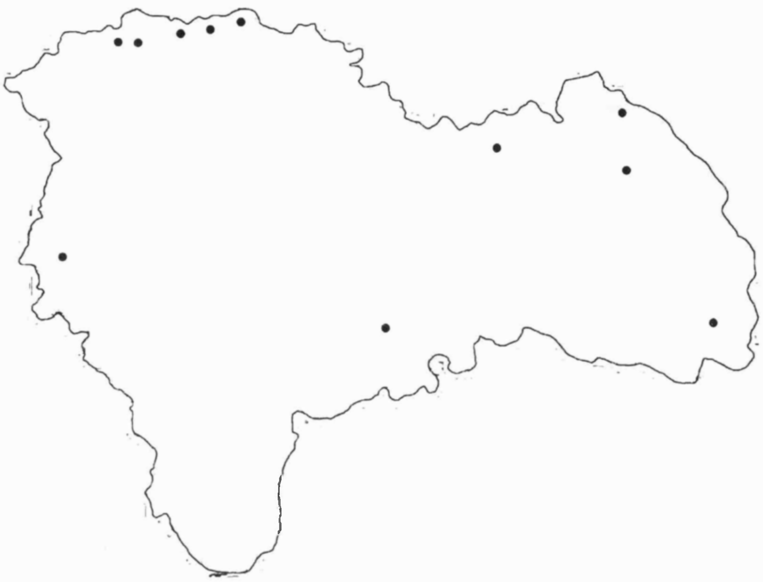
Source: Same as footnote 6

6.5 Mortality – Burial series

Mortality has been estimated using the burial records available in 11 municipalities of Guadalajara.[138] As in the case of baptismal series, the records were extracted from the historical diocesan archive of Siguenza-Guadalajara and in all the cases the series included yearly values for the entire eighteenth century. The accuracy of burial records as a proxy of mortality is very high, as all the deaths were recorded by the local priest as well as the services that were given (or not) by the local parish. The sample was significantly smaller than the one presented in the case of baptisms, although we tried to spread it geographically to make it as representative as possible.

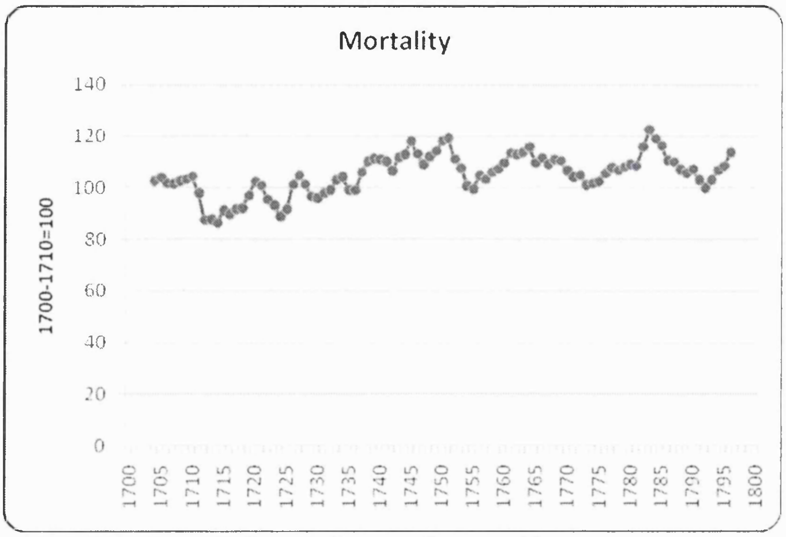
[138] Cantalojas, Hijes, Galve de Sorbe, Bañuelos, Somolinos, Milmarcos, Valdelcubo, Torrubia, Adobes y Azañon.

Figure 6.32: Geographical distribution of the burial series



The results show that the number of deaths reached the absolute minimum in the mid 1710s, followed by a constant increase until the early 1750s. The second half of the eighteenth century is a period of relative stagnation, and around 1800, the number of burials was similar to those presented in the middle of the century.

Figure 6.33: Mortality index in Guadalajara 1700-1800
(9 years moving average)



Source: Same as footnote 10

The trends are different if the series are divided by region. In the case of registered deaths, the number of series is significantly lower than in the case of baptisms and therefore the division by region was not possible. On the other hand, it is possible to divide the series into three consistent areas. The first one is Urban which includes those series in the South of the province that are more urbanized than the rest of Guadalajara. The second sample includes the series in the Mountains, an area that coincides with the same region analysed in the case of baptisms. Finally, the last sample includes those municipalities in the East of the province of Guadalajara and that includes municipalities in the Wet and Molina regions.

Figure 6.34: Regional samples of burial registers in Guadalajara

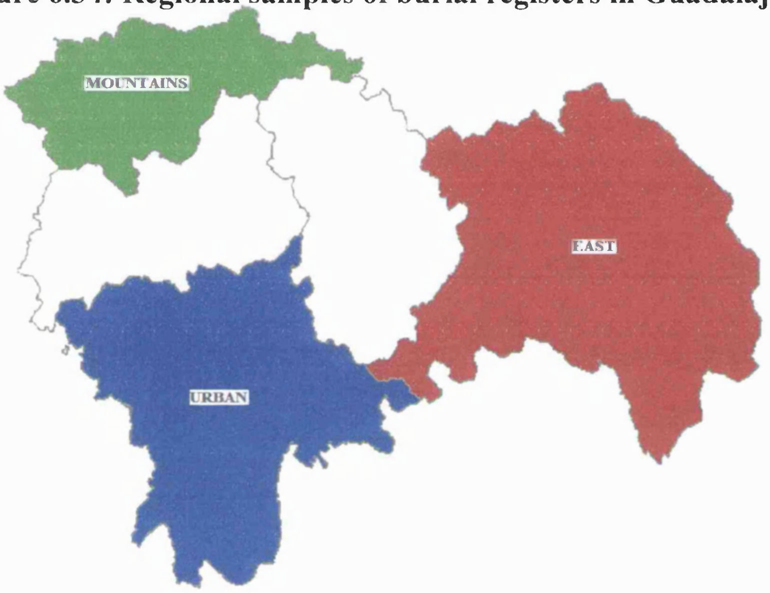
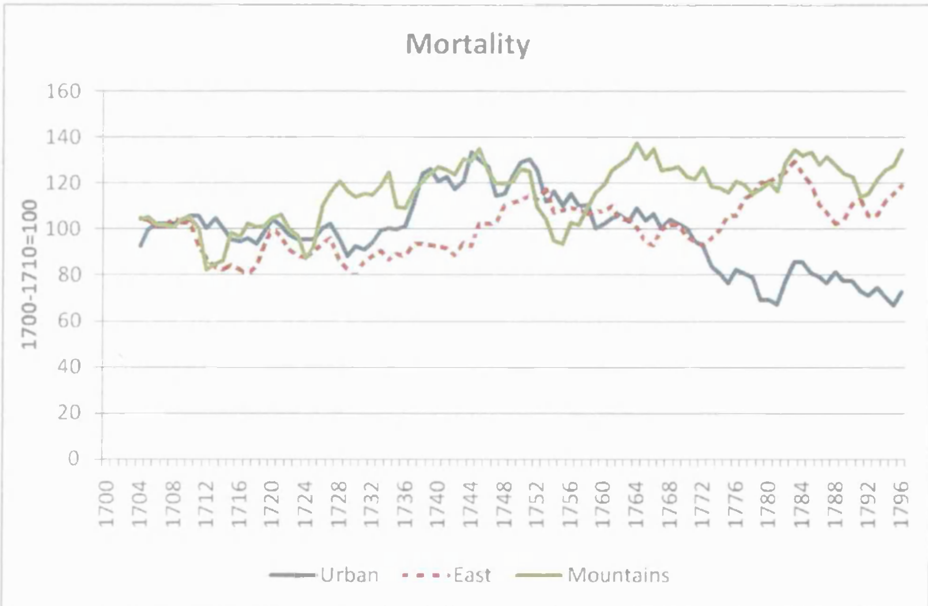


Figure 6.35: Regional mortality indexes 1700-1800 (9 years moving average)

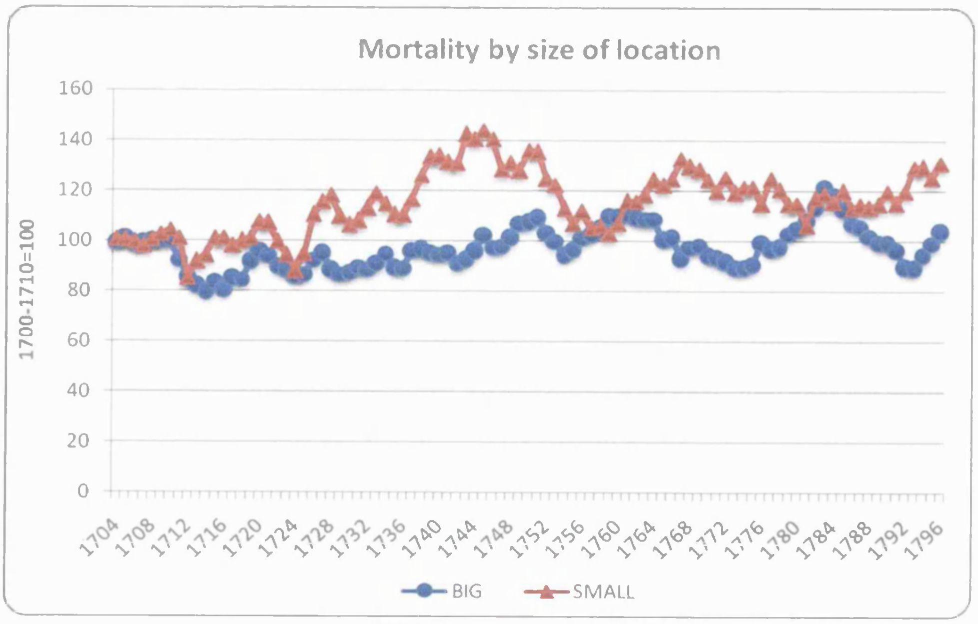


Source: Same as footnote 10

The results show that the lack of trends in the aggregated series disappear when they are divided by region. In the case of the urban series, the number of deaths increased until the mid eighteenth century by 30 per cent, a trend that was reversed during the second half of the century when the series decreased by 60 per cent. The series in the Mountains increased almost systematically with the only significant decrease taking place in the 1750s. The general balance of the century is however an increase of more than 30 per cent in the number of deaths. Although with a more erratic trend, the series in the East presents a similar trend to that of the Mountains, and the number of deaths by the end of the century had increased by 30 per cent.

If the series are divided by size of the municipality the trends also present some significant differences. In the big villages, the first half of the eighteenth century is a period of intense growth in the number of deaths that increased by 40 per cent to be followed by a sharp decrease recovering the positions lost and a later period characterized by stagnation. The small villages show a trend that is more similar to the case of Guadalajara as a whole. The number of deaths was relatively constant and by the end of the century the levels were the same that at the beginning. The maximum peak was reached in 1790 when the series were 20 per cent superior to those present at the beginning of the century.

Figure 6.36: Mortality series by size of municipality, 1700-1800



Source: Same as footnote 10

Conclusion

In summary, a cross section analysis of population distribution shows that most of the population was concentrated in the Southwest and West of the province. Guadalajara in the mid eighteenth century was a territory where the most common municipality was a small village with not more than 200 inhabitants. However, urbanization rates were different depending on the region, and although the average size of the settlements was relatively similar in the different areas, the South was an outlier with urbanization rates that were far above those presented in the rest of Guadalajara. One of the main factors driving the size of the populations was access to the main roads network. On average, municipalities with direct access to the roads were 70 per cent bigger than those that were not connected. Howeve,r with an increase in size there was also an increase in poverty levels and social differences. Being connected to a road doubled the probabilities of being a poor person from 0.99 per cent of total population to more than 2.5 per cent. Size also mattered in terms of social stratification, the bigger the population the higher the proportion of poor people and also the percentage of aristocrats.

An analysis of the distribution of labour force shows that on average more than 80 per cent of the population worked in agriculture and that the majority owned or rented the land that they cultivated. Non-agrarian activities were mainly focused on the production of textiles and leather, and to a lesser extent they were involved in the wood, metal, glass and construction sectors.

The eighteenth century was a period of strong demographic growth that was especially intense during its second half. The study of the number of households and population estimations based on natural growth suggests that during the eighteenth century population in Guadalajara increased by 60 per cent. While the total number of baptisms increased by 40 per cent, mortality levels remained relatively constant.

The most striking result of the demographic analysis is the population growth that intensified during the second half of the eighteenth century, at the same time that Guadalajara was suffering a severe production crisis. The other interesting result is the evolution of baptismal series in the region of the South, suggesting that unlike the rest of Guadalajara, the area suffered a depopulation process. The cross section analysis suggests that this is probably a consequence of the urban nature of the South. The big towns and cities suffered the production crisis because their inhabitants had to rely on their salaries in order to acquire the food that they had consumed. As was shown previously, real wages in urban areas fell significantly during the period, meaning that the living standards of urban workers fell and therefore that they were not able to increase their population in a traditional Malthusian cycle. The countryside of Guadalajara on the other hand was able to escape the effects of the crisis and one of the main forces behind the resistance that they showed was the reduction in economic inequality that will be analysed in the following chapter.

7. Changes in income inequality

This chapter studies the evolution of income inequality in Guadalajara during the eighteenth century. The first part studies inequality levels every 10 years concluding that income inequality in Guadalajara decreased and that this process was especially intense during the second half of the eighteenth century. The second section of the chapter studies the internal dynamics of this decrease in inequality concluding that it was in the bigger villages where inequality fell more, while small villages already enjoyed relatively high levels of egalitarianism.

7.1 Income inequality in Guadalajara, 1700-1800

To carry out a study of income inequality we decided to use the information provided in the tazmia books that kept the information about the production of grain in every village. As explained previously, the books kept information about the amount of grain taxed to every producer every year. Estimating incomes through grain production can present some problems; however there are good reasons to follow that procedure. First, grains represented the bulk of the agrarian economy of Guadalajara. According to the information available, the other main source of agrarian output was the production of wool. A survey of a sample of municipalities in Guadalajara showed that in any case the value of the production of grains represented around 90 per cent of the value of the total agrarian production.[139] Guadalajara was also a rural and agrarian province, so the influence of urban activities was less important than in other provinces like Madrid. The towns that existed in Guadalajara were in fact agro-towns that in economic terms worked as big village and not like traditional urban centres.

However, in order to more accurately calculate how representative grain production was of total incomes, we used the information provided in the Catastro de la Ensenada to estimate the percentage that grain production represented of total income and not just on agrarian output. This calculation was carried out for the sample of municipalities that are presented in this chapter. To estimate agrarian production we used the main tithe records, grains and also wool and lambs were included in the answers to question 16 of the Catastro. We also include all the minor tithes that were

[139] The most recent estimations based on all the villages and towns of Guadalajara suggest that this number could increase from 90 to 95 per cent.

normally paid to the local priest and that contain a wide variety of products from vegetables to chickens, pigs, and honey. To be sure that the estimation included the production that was not taxed with the tithe, we used the answers to questions 10, 11 and 12 in the Catastro. Question 11 asked about the different products that were produced in the village. We used that information to check what was produced and what did not appear in the information about tithes. However, the question does not reveal the amount of each item that was actually being produced. We can nevertheless estimate this amount indirectly through the information provided in questions 10 and 12 of the Catastro. Question 10 explained the different types of land including quality, the size of each plot and more importantly the products that were being cultivated on each one. Question 12 explains the productivity of each sort of land depending on what product was cultivated on them. Therefore, combining the land that was being dedicated to each product and the productivity, we were able to estimate the production that was not included in the tithes. Finally, the information in question 14 presented the average prices of the products cultivated in the municipality that were used to transform the production from kind to cash.

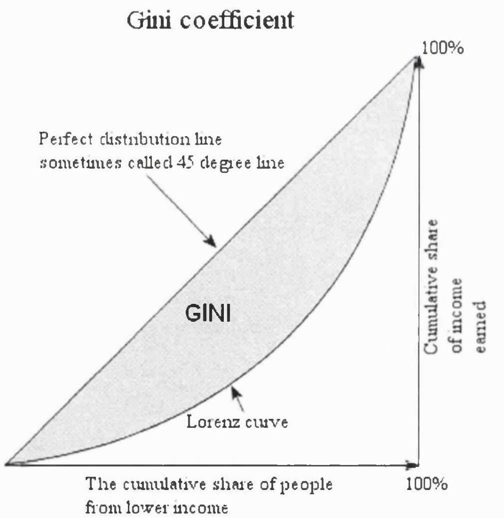
However, to complete the estimation of income we also included information about salaries. In every village there was normally a priest, baker, etc. and their income was not included in the previous calculations. The Catastro presents information about the wages and incomes of that part of the population that was added to agrarian production. To complete the estimation we also included the information about part time jobs carried out by peasants while they were not directly engaged in agriculture. Some of the salaries were paid in kind (normally wheat) and in those cases, as in agrarian production, the salaries were transformed into cash to be aggregated. Although the information from the Catastro could be improved, the estimation of total income is the best that is available given the sources and therefore the best possible proxy. The results show that in the early 1750s grain production represented almost 70 per cent (68%) of the total income in the sample presented in this chapter. The following decades were a period of rapid inflation of grain prices that rose more than the composite price index, a situation that reduced real wages. Therefore we should believe that this percentage grew during the period and that 68 per cent should be taken as a minimum for the second half of the eighteenth century. We therefore believe that although not perfect, the use of grain production can be used as a good proxy of income.

The Gini Coefficient measures the dispersion of the observations in a sample and has been widely used to measure inequality. The coefficient takes values between 0 and 1 attributing a value of 0 to perfect equality and a value of 1 to perfect inequality. In other words and in the case that we are studying, the Gini Coefficient would be 0 if all the producers produce exactly the same amount of grain and 1 if one single peasant owns all the production. In mathematical terms the Gini Coefficient can be defined as:

$$G_1 = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})(Y_k + Y_{k-1}) \tag{1}$$

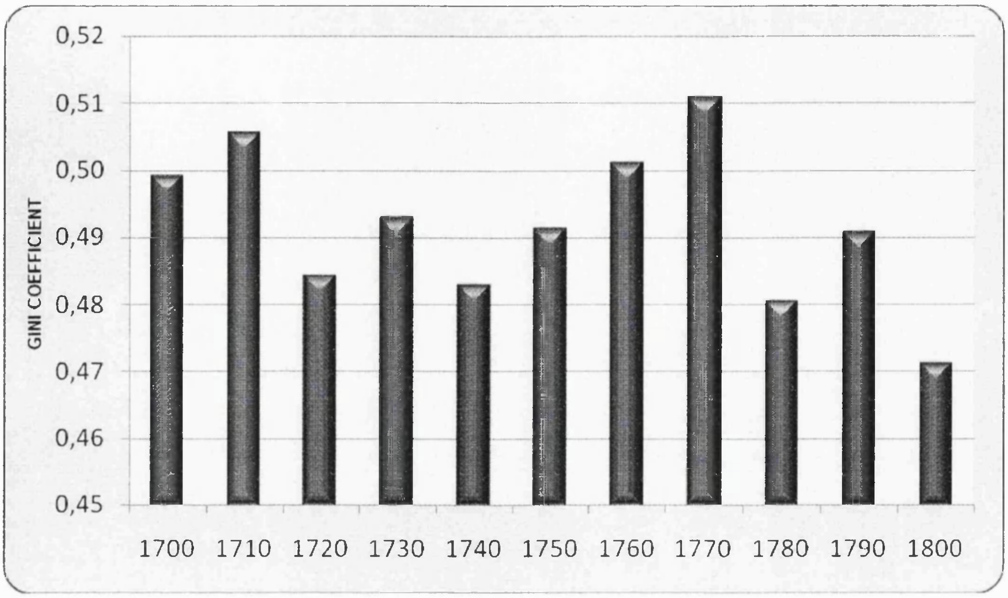
Where G is the Gini coefficient, X is the cumulated proportion of the population variable, Y is the cumulated proportion of the production of cereals and G is the Gini coefficient. In its graphical expression it measures the area between the Lorenz curve and a 45° line.

Figure 7.1: Graphical representation of the Gini coefficient



Using the information provided by the *Tazmias* books and following the methodology presented above, we can generate decadal calculations of the Gini coefficient for cereal production in Guadalajara. The results are displayed in the next figure.

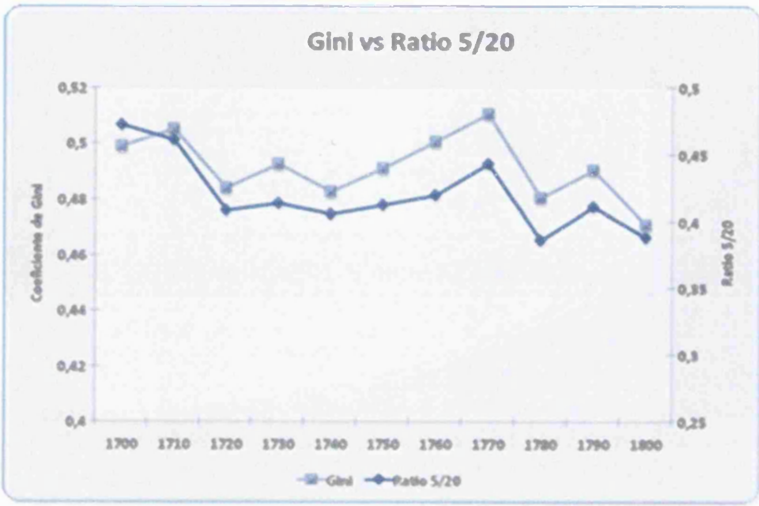
Figure 7.2: Decadal Gini coefficient in Guadalajara 1700-1800



Sources: Own calculations from note 2.

The results show three long term trends during the eighteenth century. The first one is a period of convergence and inequality reduction from 1710 until 1740. The second one shows an increase of the inequality starting around 1750 and ending around 1770. The last period is again a convergence between producers that took place from 1770 until the end of the century. Globally the trend during the eighteenth century is a period of convergence between small and big producers, when inequality in cereal production was reduced. Other inequality proxies present a very similar behaviour. The next graph shows the relationship between the Gini coefficient previously presented and the ratio between the production of the top 5 per cent and the bottom 20 per cent producers. The results indicate that the trends are the same, reinforcing the conclusions obtained from the Gini coefficient.

Figure 7.3: Average Gini v Ratio 5/20, 1700-1800



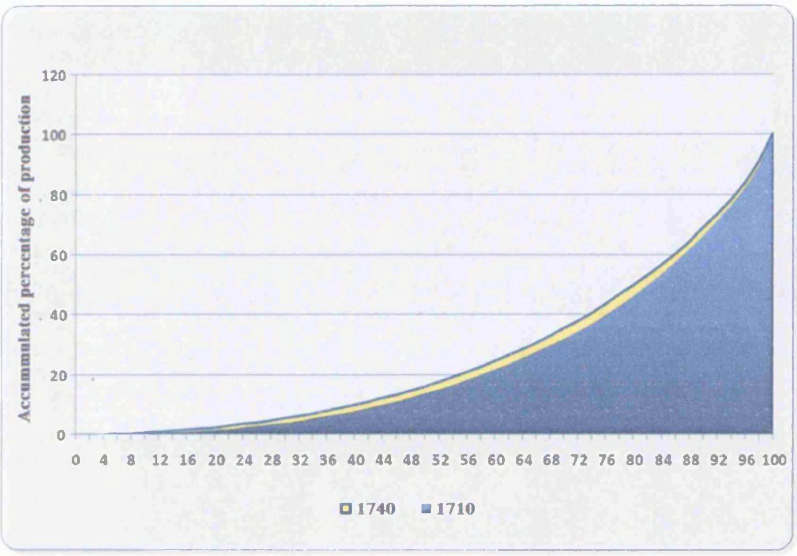
Source: same as footnote 2.

There are therefore three main trends defined by the periods 1710-1740, 1740-1770 and 1770-1800. The next figures show the changes in the Lorenz Curves in Guadalajara during those three periods. As explained above, the Gini Coefficient is also measured as the area between the Lorenz Curve and the 45° line, and its change is represented in the graphs as the yellow area between the two curves.

Table 7.1: Main inflexion points

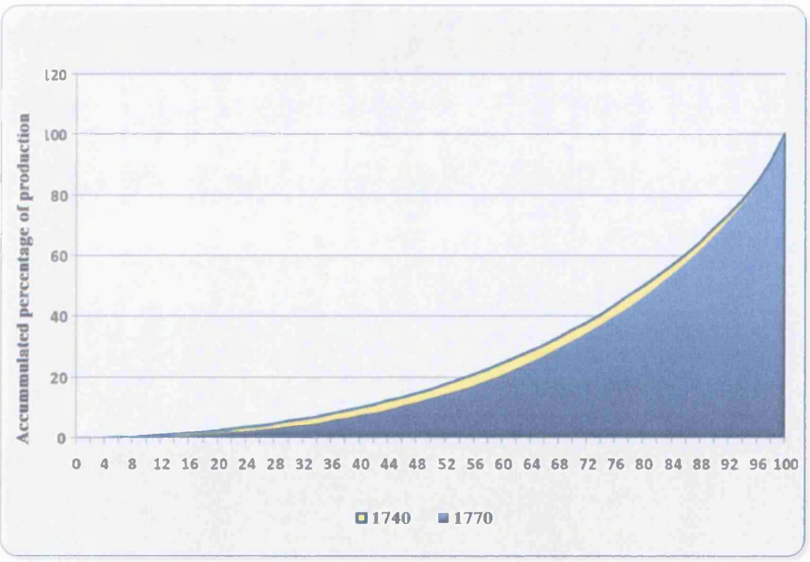
	Gini Coefficient
1710	0.50
1740	0.48
1770	0.51
1800	0.47

Figure 7.4: Lorenz curves 1710 and 1740



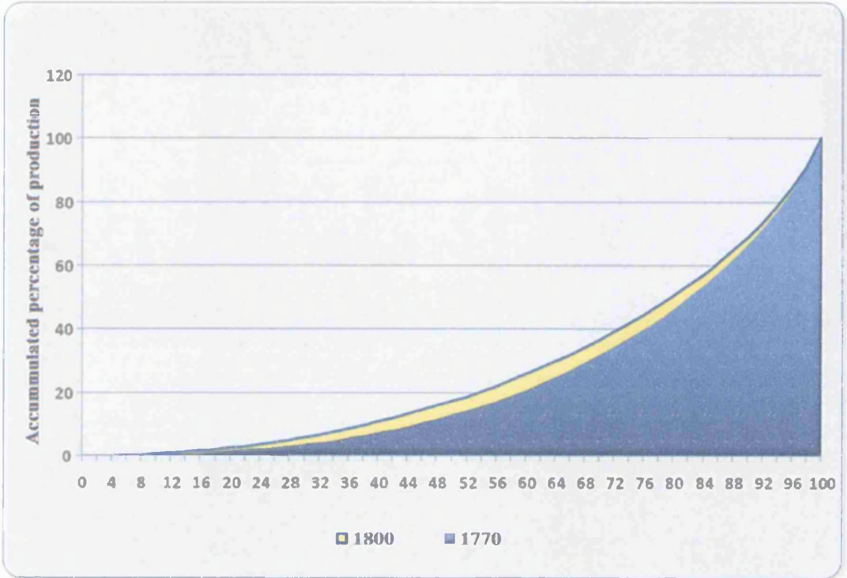
Source: same as footnote 2.

Figure 7.5: Lorenz curves 1740 and 1770



Source: same as footnote 2.

Figure 7.6: Lorenz curves 1770 and 1800



Source: same as footnote 2.

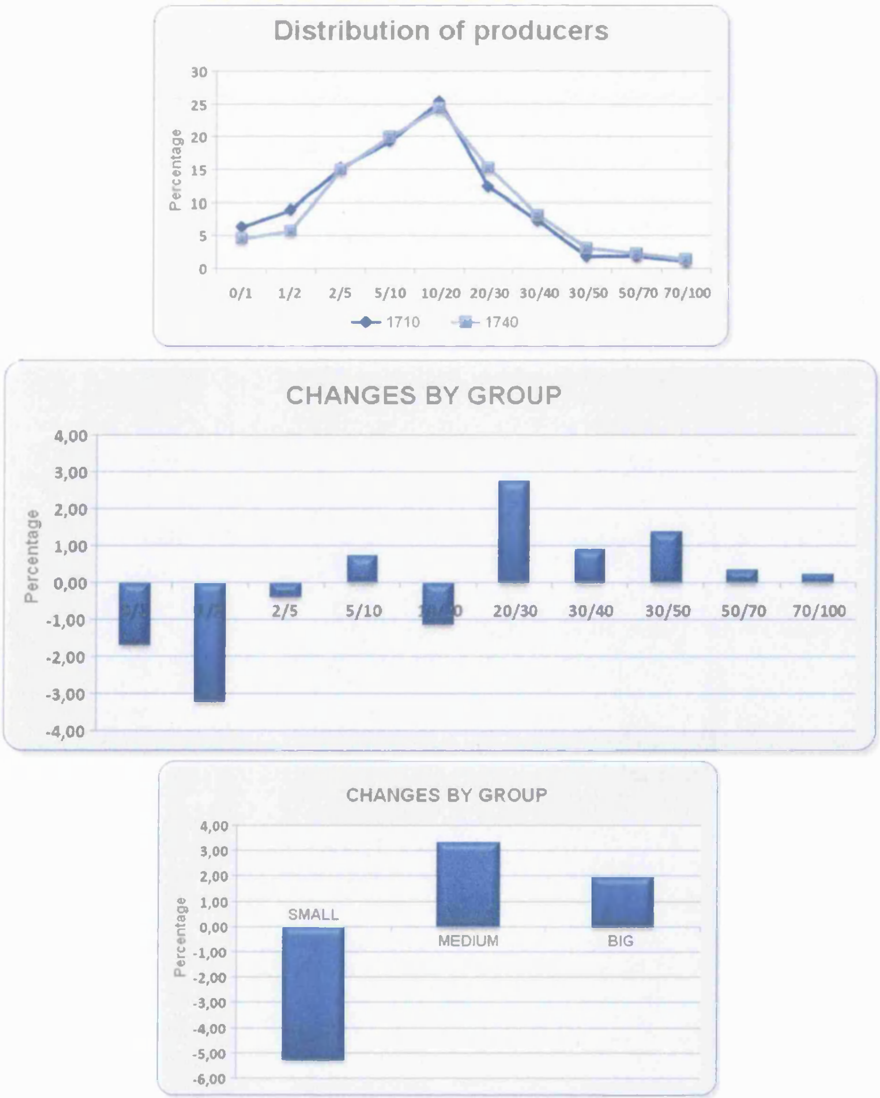
But what is the significance of these numbers? What was the effect of the reduction in the Gini coefficient from 0.51 to 0.47 that took place during the last third of the century? Is it a consequence of small producers catching up? We can provide some answer to these questions. In our sample, doubling the production of the bottom 12 per cent would reduce the Gini coefficient by 0.1 points. To reduce it by 0.4 points, that is the reduction that took place during the late eighteenth century, we would have to double the production of the bottom 33 per cent of the distribution. The next question is to understand why inequality levels were being reduced and if it really was based on small producers catching up. In order to answer this question we have to study what happened between the four main turning points 1710, 1740, 1770 and 1800.

All the producers at each turning point were divided into ten equal sized groups depending on their production levels. Taking index numbers and 100 as the output of the maximum producer the individuals were divided depending on their percentile in relation to this maximum. The first group includes the number of peasants whose production levels are between 0 and 1 per cent of the output of the biggest producer, etc.[140] Three graphs were created for each period, the first one with the distribution of the producers in each turning point, the second one with the variations in percentage in the number of individuals in each group and a third one with a summary of the second graph

[140] The ten groups are 0%-1%, 1%-2%, 2%-5%, 5%-10%, 10%-20%, 20%-30%, 30%-40%, 40%-50%, 50%-70% and 70%-100%.

containing not 10 groups but three, small, medium and big producers. Small producers were those within the first three groups (less than 5 per cent), medium producers were those within the following four groups (5 per cent to 40 per cent) and big producers those within the top three groups. (More than 40 per cent). Between 1710 and 1740 the results show a reduction in the value of the Gini coefficient of 2 points. The distribution curves show that there was a reduction in the number of small producers that the second graph measures as a fall of 5 per cent. These small producers went probably to the group of medium producers and some of these probably moved upward to join the big producers. As the second graph shows, it was in the groups of the very small producers where the reductions were more important while the biggest increase took place in the group of medium producers.

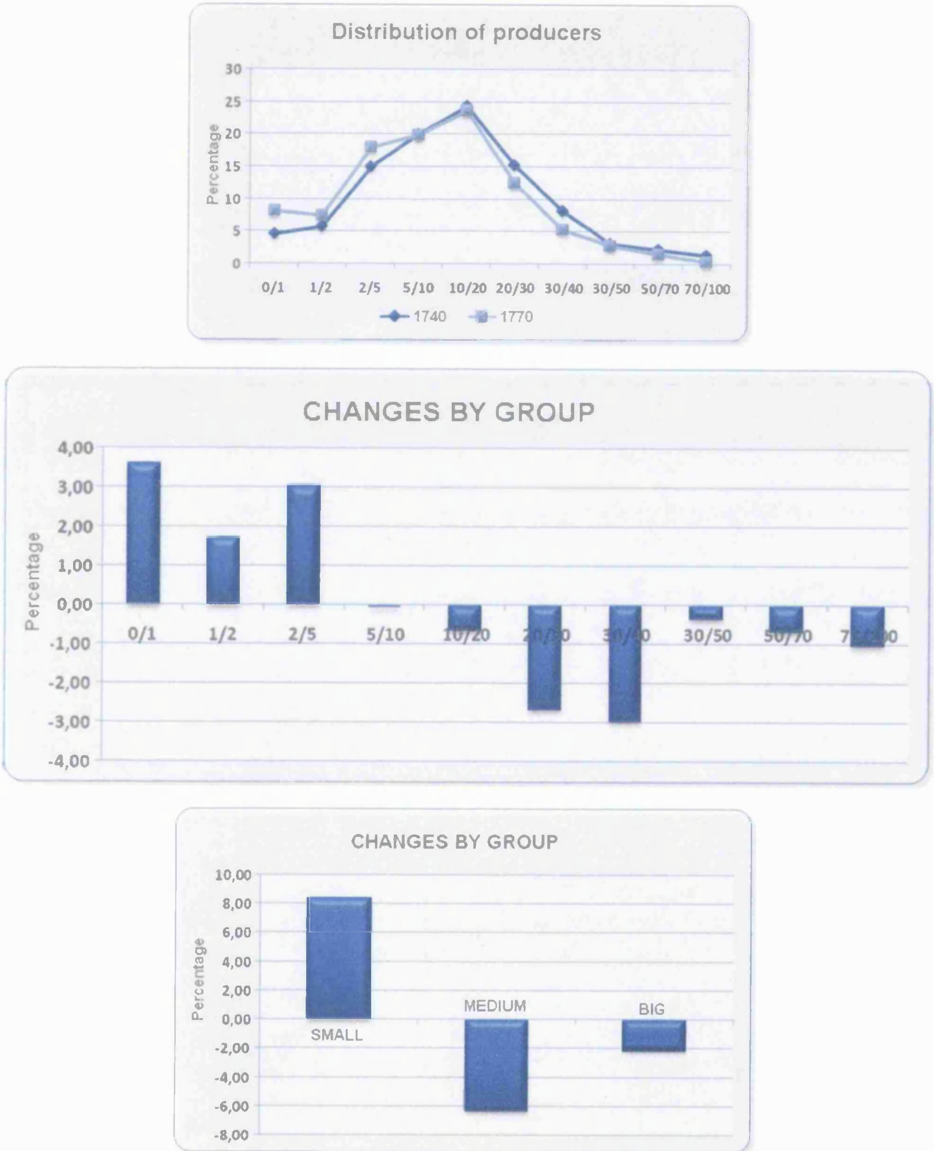
Figure 7.7: Changes in the distribution of the production 1710/1740



Source: same as footnote 2.

1740-1770 is a period of strong divergence, with the Gini coefficient growing three points from 0.48 to 0.51. This increase was so intense that the positions gained during the previous period were lost and inequality rose to the absolute maximum of the century. The number of small producers grew more than 8 per cent, 3 points more than the reduction between 1710 and 1740. It was in the group of medium producers were the biggest fall took place, especially in the 20/40 percentiles.

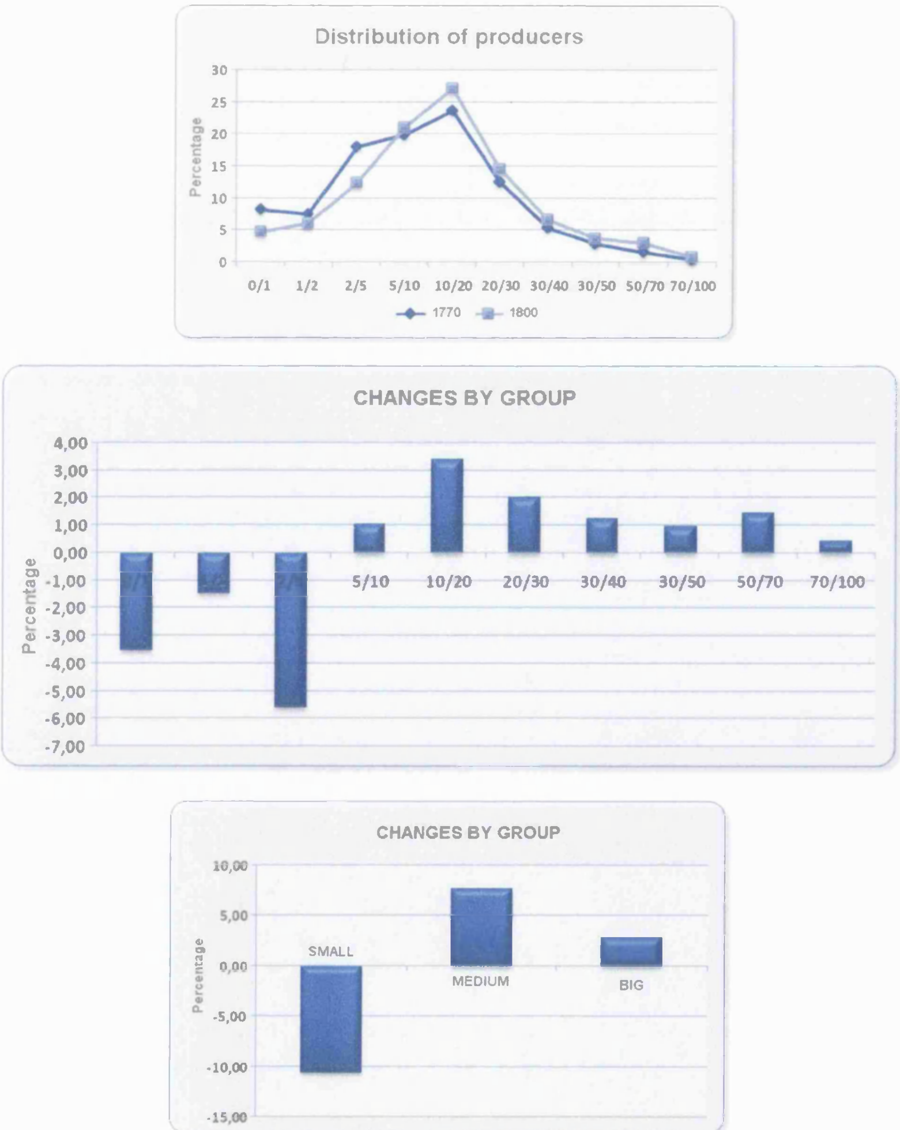
Figure 7.8: Changes in the distribution of the production 1740/1770



Source: same as footnote 2.

The last period between 1770 and 1800 shows very clear convergence between producers, with the Gini coefficient falling four points from 0.51 to 0.47. The situation in 1770 was reversed and inequality levels reached its absolute minimum in 1800. The number of small producers was reduced by more than 10 per cent while the number of medium producers grew by 7 per cent. As in the case of the first half of the century, the fall in inequality was mainly a consequence of very small producers improving their positions and many of them probably joining the group of medium producers once more. The biggest fall was in the 2/5 and 0/1 percentiles while the biggest rise took place in the 5/20 and 20/30 percentiles.

Figure 7.9: Changes in the distribution of the production 1770/1800



Source: same as footnote 2.

Although the Gini coefficient is a good way of measuring the changes in total inequality, it also has limitations. A different way of measuring inequality levels is the use of generalized entropy measures like the Theil Index, a measurement that has also been widely used in the literature of income inequality. [141] Although the properties of the Theil Index are very similar to those of the Gini coefficient, it allows deeper analysis of the data and it can be easily decomposed. In other words, if we divide our sample of producers in different groups by village, by production, etc. the Theil index will show us if the changes in inequality identified are a consequence of changes of inequality within those groups or between them. Its calculation is defined by the formula:

$$T = \frac{1}{n}\sum_{i=1}^{n}\frac{w_i}{\mu}\ln\left(\frac{w_i}{\mu}\right) \qquad (2)$$

In our case, n would be the number of producers, w_i the production of the individual i and μ the arithmetical average of the sample. As it has been explained before, the Theil index can be decomposed. If we divide the observations of a sample in different groups, the Theil index can tell us what the changes in inequality within and between each group are . In our case we decided to divide the producers in the sample by villages grouping them by size. Therefore, three groups were created with small, medium and big villages. There are good reasons to support this division, as the size of the village also defined its economic and social structure as it has been proved in chapter 6. Small villages were mainly occupied by a homogenous group of small peasants that were owners, while big villages included also manufactures producers and workers that did not own land. We can therefore expect differences between in inequality between the three groups that can be explored by the Theil index. Following the methodology presented above, for every group g, μg is the average production, ng the number of producers and Tg is the Theil index for that specific group. Then the new formula for the Theil index would be:

$$T = \sum_{g=1}^{G}\frac{n_g\mu_g}{n\mu}T_g + \sum_{g=1}^{G}\frac{n_g\mu_g}{n\mu}\ln\left(\frac{\mu_g}{\mu}\right) \qquad (3)$$

Being

$$T_g = \frac{1}{n_g}\sum_{i=1}^{ng}\frac{w_i}{\mu_g}\ln\left(\frac{w_i}{\mu_g}\right) \qquad (4)$$

[141] Steckel, R.H. and Moehling, C.M., "Rising Inequality: Trends in the Distribution of Wealth in Industrializing New England", *Journal of Economic History*, (2001) and Mora Sitja, N., "Exploring Changes in Earnings Inequality During Industrialization: Barcelona, 1856-1905", *Discussion Papers in Economic and Social History*, University of Oxford, N.61, April (2006)

The first term in (3) corresponds to the weighted addition of the Theil indexes of every group and therefore presents inequality within each group, in other words it measures the inequality within small, medium and big villages. The second term shows the inequality between the three groups.

Finally, the Theil index can be also decomposed into three elements; changes in the proportion of the population of the groups (4), changes in the relative average of the groups (5) and finally changes in the dispersion of the production within groups (6)

$$\Delta T_n^{t,s} = \Delta T_{within,n}^{t,s} + \Delta T_{between,n}^{t,s} = \sum_{g=1}^{G}\left[\left(\frac{n_g^t}{n^t} - \frac{n_g^t}{n^s}\right)\frac{\mu_g^t}{\mu^t}T_g^t\right] + \sum_{g=1}^{G}\left[\left(\frac{n_g^t}{n^t} - \frac{n_g^s}{n^s}\right)\frac{\mu_g^t}{\mu^t}\ln\left(\frac{\mu_g^t}{\mu^t}\right)\right] \quad (4)$$

$$\Delta T_\mu^{t,s} = \Delta T_{within,\mu}^{t,s} + \Delta T_{between,\mu}^{t,s} = \sum_{g=1}^{G}\left[\left(\frac{\mu_g^t}{\mu^t} - \frac{\mu_g^s}{\mu^s}\right)\frac{n_g^s}{n^s}T_g^t\right] + \sum_{g=1}^{G}\left[\frac{\mu_g^t}{\mu^t}\ln\left(\frac{\mu_g^t}{\mu^t}\right) - \frac{\mu_g^s}{\mu^s}\ln\left(\frac{\mu_g^s}{\mu^s}\right)\right]\frac{n_g^s}{n^s} \quad (5)$$

$$\Delta T_T^{t,s} = \sum_{g=1}^{G}\frac{n_g^s\mu_g^s}{n^s\mu^s}\left(T_{gs}^t - T_g^s\right) \quad (6)$$

Therefore, for the period 1770-1800 we can measure if the reduction of inequality was a consequence of reduction in inequality within or between groups. The results are presented in the following table.

Table 7.2: Inequality changes decomposed by size of village

	1710-1740	1740-1770	1770-1800
Inequality within groups	69.23%	40.00%	106.25%
	-5.00%	-4.69%	-4.69%
	71.67%	73.44%	73.44%
	-26.67%	37.50%	37.50%
Inequality between groups	30.77%	60.00%	-7.81%
Total inequality	**100%**	**100%**	**100%**

Source: same as figure 2

The results are diverse, as during the convergence period of 1710-1740, the reduction in inequality was mainly driven by the decrease of inequality within groups, mainly in those villages with a small number of producers. Therefore, it was within the smaller villages that a process of convergence took place between small and big producers. The period 1740-1770, as shown above, was characterised by increasing inequality that was based on increasing divergence between groups of an increasing inequality between the small and big villages. Finally, during the period 1770-1800, the reduction of inequality was mainly driven by group convergence, especially in medium and big villages. On the other hand, there was a small increase in the inequality within small villages. The reason was that in small villages inequality levels were already low in 1770, and that the following three decades saw a catch up from high inequality levels by medium and big villages.

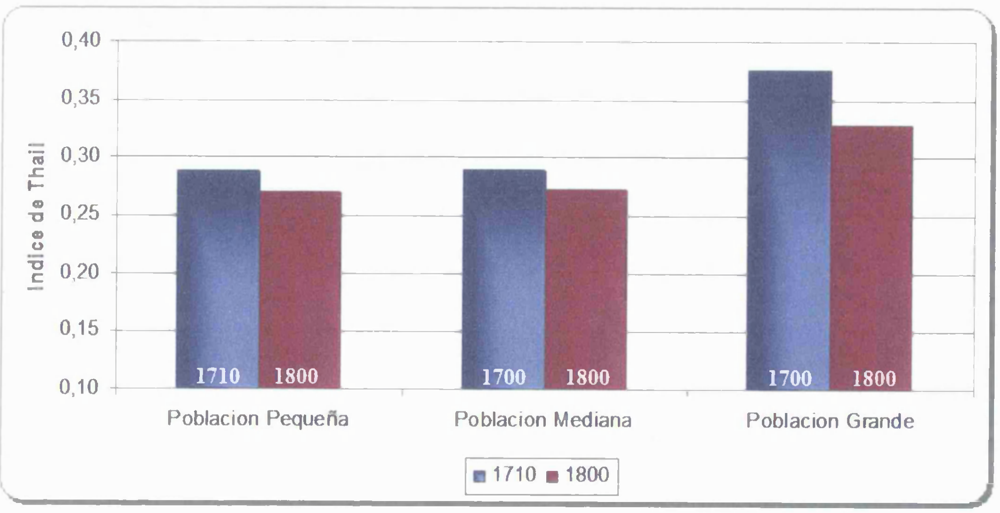
Table 7.3: Theil index by size of village 1770 and 1800

	Theil 1770	Theil 1800
Big Villages	0.43	0.33
Medium Villages	0.42	0.18
Small Villages	0.34	0.36

Source: same as footnote 2

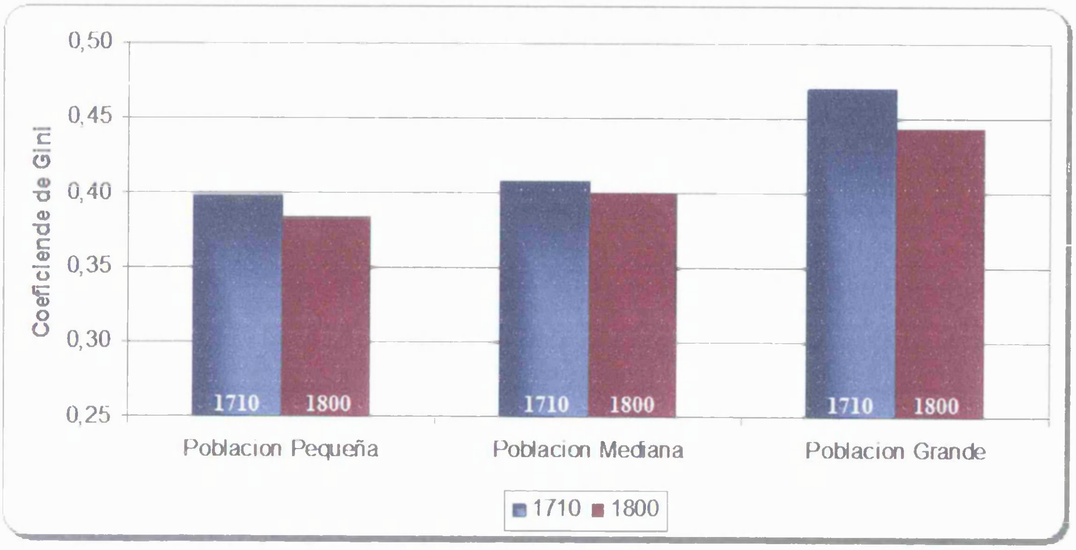
Overall the eighteenth century was a period of convergence in the three groups of villages, although the intensity of that catching up was stronger in the bigger ones where the Theil Index fell by 5 points. On the other hand, the decline of inequality in small and medium villages was more moderate with a reduction of 1 point. Most of the reduction in big villages took place during the late eighteenth century when the Theil index in the group fell by 10 points between 1710 and 1800. The study of the Gini coefficient shows very similar results with a fall of 1 point in medium villages between 1710 and 1800, 2 point in small ones and again a considerable decrease in big villages were the Gini coefficient fell by 3 points during the same period.

Figure 7.10: Theil Index by size of village 1710-1800



Source: same as footnote 2

Figure 7.11: Gini Coefficient by size of village 1710-1800



Source: same as footnote 2

Conclusion

The first half of the eighteenth century is a period of economic growth that was followed by a production crisis and economic stagnation. However, the analysis of demographic variables shows that the second half of the century is characterised by a strong demographic growth that took place even when the production of grain per capita was decreasing. This demographic puzzle can be explained through reductions in income inequality that took place during the last decades of the eighteenth century.

The study of the Gini Coefficient and the distribution of grain producers indicate that this convergence was characterised by a significant reduction in the number of very small and small producers. Small villages enjoyed low levels of income inequality during most of the century and therefore there was almost no room for catch up. However, in the bigger municipalities, income inequality levels were higher and there was still room to reduce the gap between big and small producers. A detailed analysis of changes in inequality shows that this was the case and that most of the reductions of income inequality were based on catch up of small producers in the bigger villages.

Although income inequality was probably the major force behind the demographic growth of the second half of the eighteenth century, there were other forces that also helped the province and the

Crown of Castile to avoid some of the worst effects of the production crisis, like the evolution of economic integration.

8. Transport and economic integration

This chapter is a study of the infrastructure that connected the interior of Spain with the rest of the country. It also includes a study of economic integration of wheat markets in New Castile in 1750 using information provided by the Catastro de la Ensenada and road maps of the eighteenth century. Roads were almost the only way of transporting goods in eighteenth century Spain, as the development of canals was practically inexistent, especially in the interior of Castile. The study of the transport network within New Castile will unveil the relative situation of Guadalajara within the network and the possibilities of further economic integration with the rest of the region.

The first section will present the evolution of the road network in Spain from the sixteenth to eighteenth centuries and its connection with the roads that were created by the Roman Empire hundreds of years before. The section will also include a study of the transport costs during the eighteenth century and their changes over time depending on the sort of transport that was being used.

The second section of the chapter introduces the wheat price dataset extracted from the Catastro de la Ensenada for New Castile which includes information for 1,100 towns and villages of New Castile. The results will show the clear differences in price levels and the strong influence of Madrid not just as the political capital but also as the indisputable growth hub of the region.

The third section will study the levels of economic integration of wheat markets in New Castile. The price dataset presented before will be the basis to carry out a statistical analysis of economic integration, analysing the influence that the development of the road network had in the integration process of the eighteenth century. The section will analyse economic integration levels with a cross section study of the mid eighteenth century and a time series analysis of the eighteenth century as a whole.

The fourth section of the chapter will present a study of the effects that access to the road network had on the levels of prices and price volatility in New Castile. The section will include the effects of the proximity to the closest main road of the network as well as the direct access to it.

Finally, the last section will try to give an answer to the existence of two price anomalies that took place in the mid eighteenth century, one in the north of Guadalajara where prices were lower than expected and another in Albacete, a region with surprisingly high prices. The study will conclude that the role of the distribution of urban centres and demand forces can explain the anomaly.

8.1 Transports in 18th Century Spain

8.1.1 The road network

The study of internal communications in Spain during the pre-industrial age, inexorably leads us to the study of the road network. Given the geographical and climatic characteristics of Spain, the use of canals as the only alternative to road transport in pre-modern times was not a plausible option. As explained in previous chapters, Spain is and was a dry country with a lack of navigable rivers. In addition to the lack of water, the topography of the country is filled with mountain and hilly terrains that make the building of canals expensive and inefficient. It is therefore not surprising that an eighteenth century employee of the Spanish court noted that:

"Because there cannot be neither navigable rivers nor canals everywhere, this deficiency has to be compensated with good roads."[142]

However, although the theoretical solution to the lack of infrastructure was clear, its practical implementation was more complicated. The geographical characteristics of Spain did not just make the use of canals for navigation impossible but it also increased the cost of building and maintaining a network of roads. Spain is practically isolated by land from Europe by the Pyrenees and the coast lacks the natural ports and gulfs to facilitate the construction of ports. In addition to those obstacles

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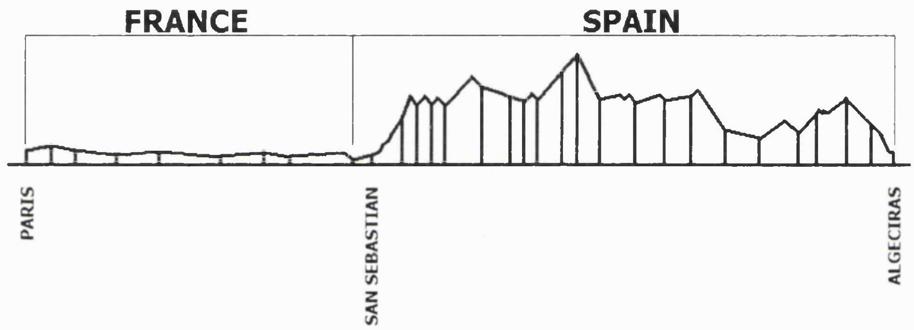
[142]Uriol, J.I. "Apuntes para una historia del transporte en España (II) Las carreteras y los canales de navegación en los reinados de Fernando VI y Carlos III. El auge de la construcción de carreteras y canales. Carlos III" *Revista de obras publicas*, Agosto (1978) p.626.

that isolate Spain from other countries, there are strong internal barriers that divide the nation. Spain contains several chains of mountains with more than 104 peaks higher than 2,000 meters. Therefore, it is not surprising that the average altitude of Spain is the second highest in Europe with 660 meters, just after Switzerland. The third in the list is France with an average altitude of just 342 meters.[143] The following figure that shows the layout of the railroad between Paris and Algeciras, in Southern Spain, illustrates the natural obstacles that Spanish travellers had to face.[144]

Figure 8.1: Paris-Algeciras railroad layout

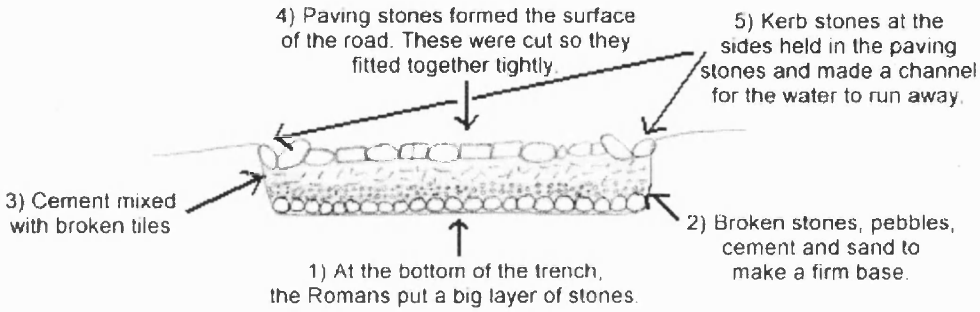


These problems were a constant in Spanish history and can also be observed in the origins of the Spanish communications system two thousand years ago. The foundations of the road network in modern Spain are based on the influence of the Roman roads that were built hundreds of years prior. The transport network of the eighteenth century was a direct consequence of the design and construction works that took place during the sixteenth and seventeenth centuries, which were based on the network of roads that the Romans built centuries before. The transport network that the Romans built in the Iberian Peninsula were surprisingly large, especially given the high cost of construction involved. The construction process was time consuming and required important amounts of resources. Roman roads were built by digging a ditch that was then filled by several layers. The first one was formed by big stones, the second step included a layer of broken stones, sand, cement and pebbles. After that another layer of cement and tiles was added to finally cover

[143]Madrazo, S., *El Sistema de Transportes en España*, 1750-1850 (Madrid: Ediciones Turner, 1984) p.21.
[144] Madrazo, ., *El Sistema,* p.30.

the surface of the road with paving stones. The last step included the incorporation of stones on the sides to secure the road and to protect it from the effects of rainfall.[145]

Figure 8.2: Road construction techniques



This extensive network was supported by construction works like bridges that in many cases are still being used at present. The network reached 6,953 roman leagues or 10.290 kilometres divided into 34 main roads shown on the following map.[146]

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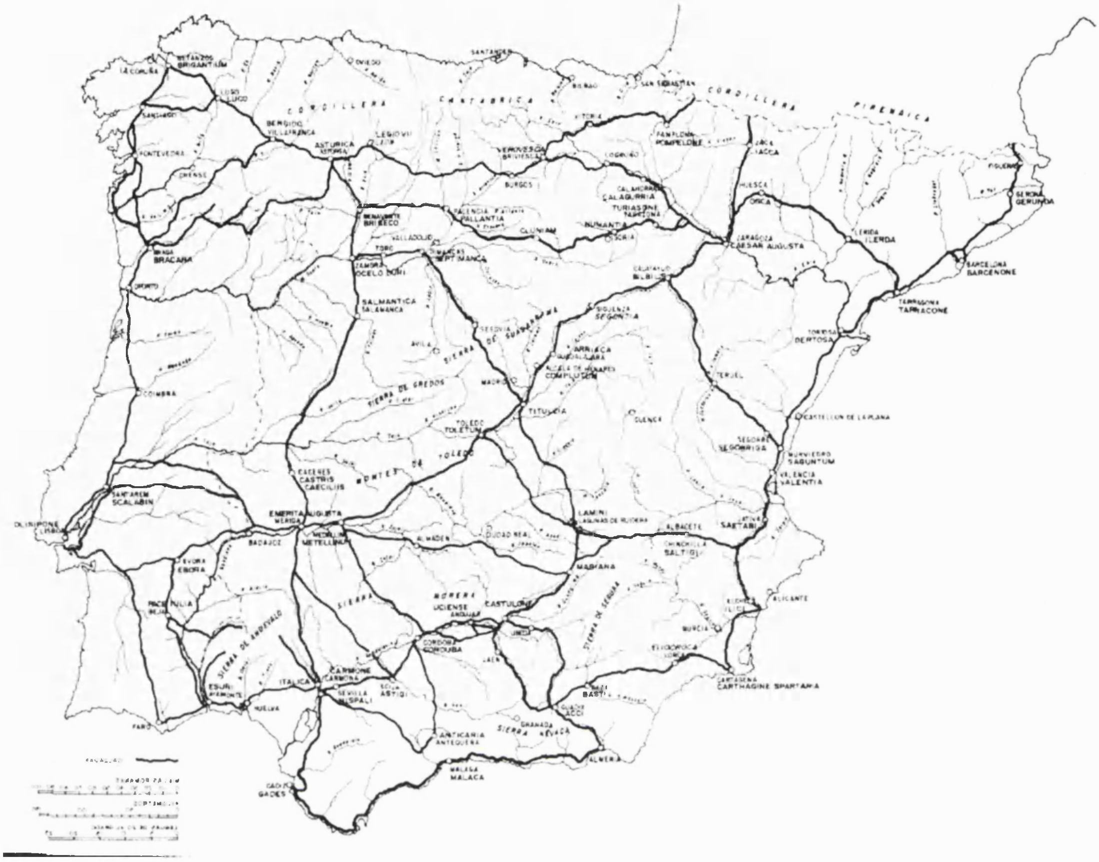
[145] http://www.teachingideas.co.uk/history/romanrd.htm

[146] Uriol Uriol, J.I. "Las calzadas romanas y los caminos del siglo XVI" *Revista de Obras Publicas*, July (1985) The roads were Italy to Spain, From Narbona, Corduba to Cazlone, Corduba to Calzone (II), Cazlone to Malaga, Malaga to Cadiz, Cadiz to Corduba, Seville to Corduba, Seville to Italica, Seville to Merida, Corduba to Merida, Lisbon to Merida, Asella to Faro, Lisbon to Merida, Lisbon to Merida (II), Lisbon to Braga, Braga to Astorga, Braga to Astorga (II), Braga to Astorga (III), Braga to Astorga using the coast, Ayamonte to Beja, Ayamonte to Beja (II), Guadiana to Merida, Merida to Zaragoza, Merida to Zaragoza (II), Astorga to Zaragoza, Astorga to Zaragoza through Cantabria, Tarazona to Zaragoza, Merida to Zaragoza through Lusitania, Ruidera Lagoons to Toledo, Ruidera Lagoons to Toledo (II), Astorga to Tarragona, Zaragoza to Bearn and Astorga to Burdeos.

Figure 8.3: Roman road network



Source: Uriol (1985)

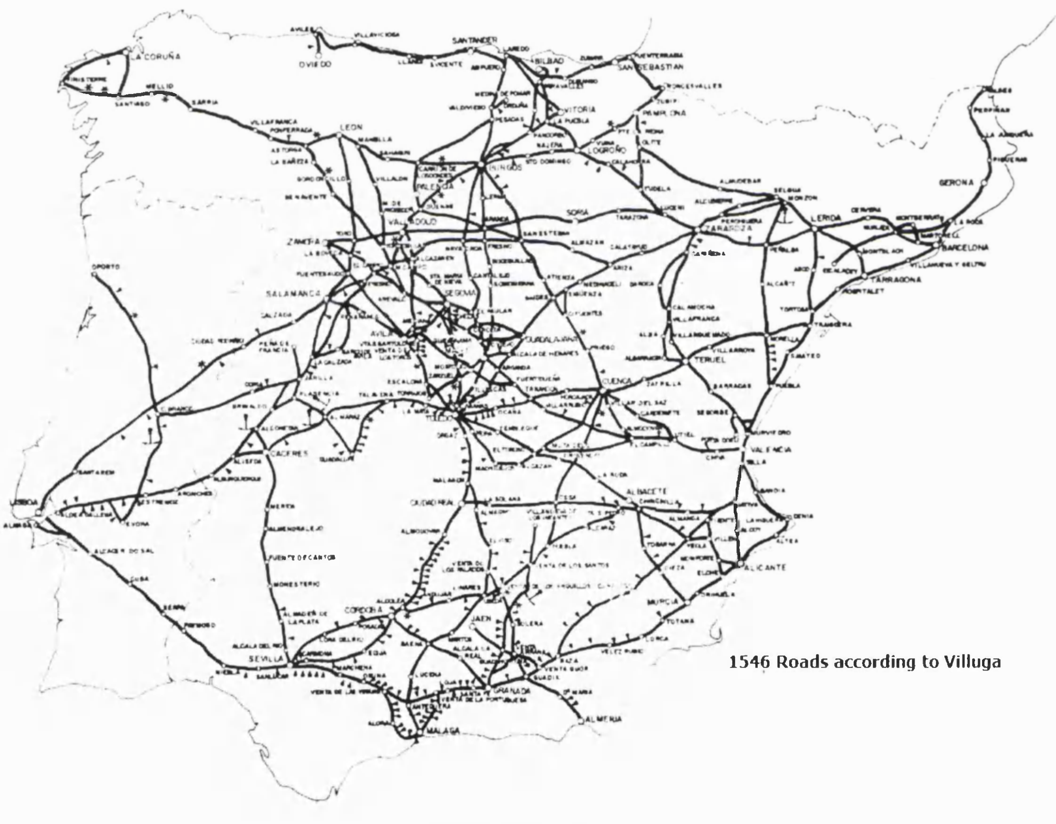
This system was good enough for the military purposes of the Roman Empire that required quick movement of troops through roads that did not need special maintenance and that could therefore be easily preserved without permanent supervision. However, the Roman roads were not very suitable for commercial enterprises. They were so hard and rigid that they reduced significantly the speed of the horses or wagons that used them, a cost that outweighed the benefits of their durability. In addition to that, the routes were primarily built for the movement of people and therefore some of the slopes were too high for the use of wagons. Therefore, the fact that the roads of early modern Spain were based on Roman designs did not facilitate the economic integration of a large country where transport costs were considerably higher than in other parts of Europe.

The network of roads that appeared in the sixteenth century was considerably longer than the Roman, measuring around 19,000 kilometres. The transport system was also supported by the existence of 214 bridges, 6 ferries and 214 inns.[147] The most striking difference is the increasing density in the interior of the peninsula as a consequence of the importance of Castile. During the

[147] Uriol, "Las calzadas", p.557.

Roman colonization, the main settlements had been based on the Mediterranean coast, giving Roman roads in the periphery a vital role. However, the sixteenth century presents a completely different panorama where the rise of Castile in economic and political terms gave an increasing importance to the interior. Some of the roads along the Southern coast of Spain were abandoned, in part as consequence of the activities of the North African Muslim pirates. On the other hand, the network was extended to the provinces of the North that had been largely neglected by Roman authorities. The following map presents the road network in Spain during the sixteenth century.[148]

Figure 8.4: Sixteenth century road network

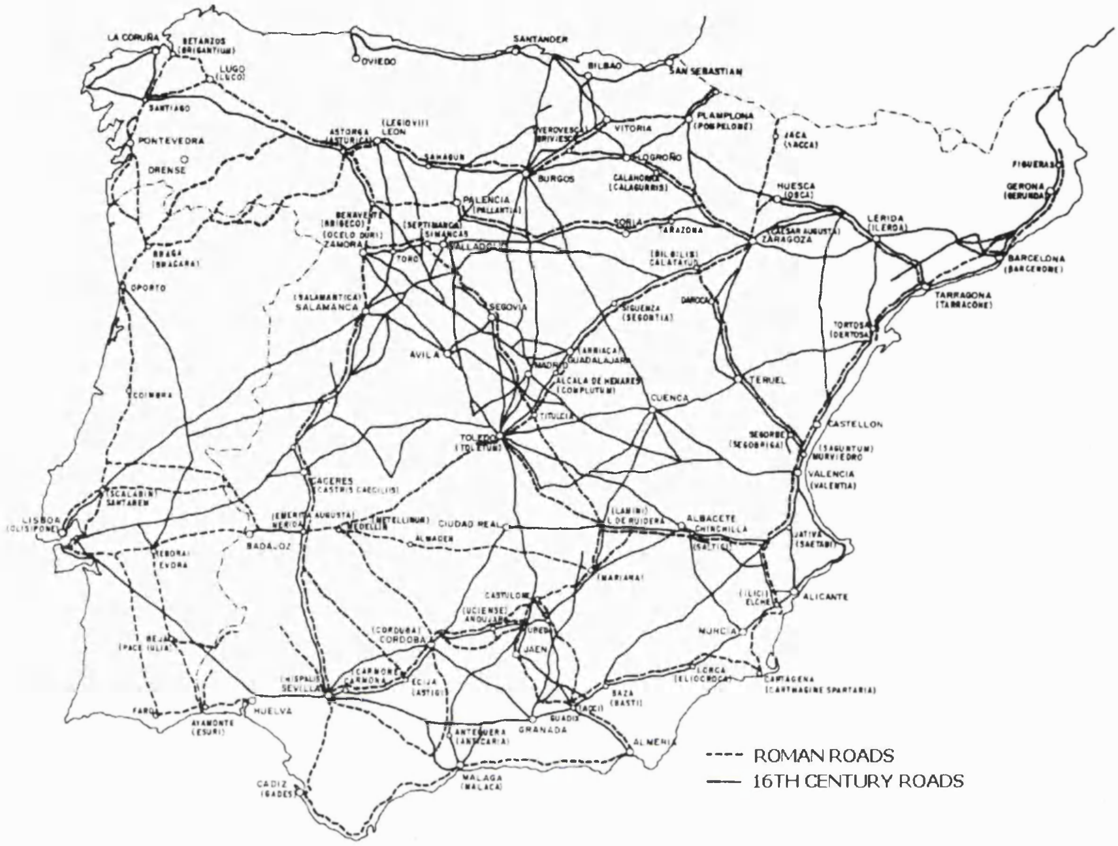


Source: Uriol (1985)

However, taking these differences into account, the main roads in both periods followed the same layout that was the pattern created in the Roman era. The following map presents the Roman network along with the roads network that existed in Spain during the sixteenth century.[149]

[148] Uriol, "Las calzadas", p.556.
[149] Uriol, "Las calzadas", p.560.

Figure 8.5: Roman and Sixteenth century road networks

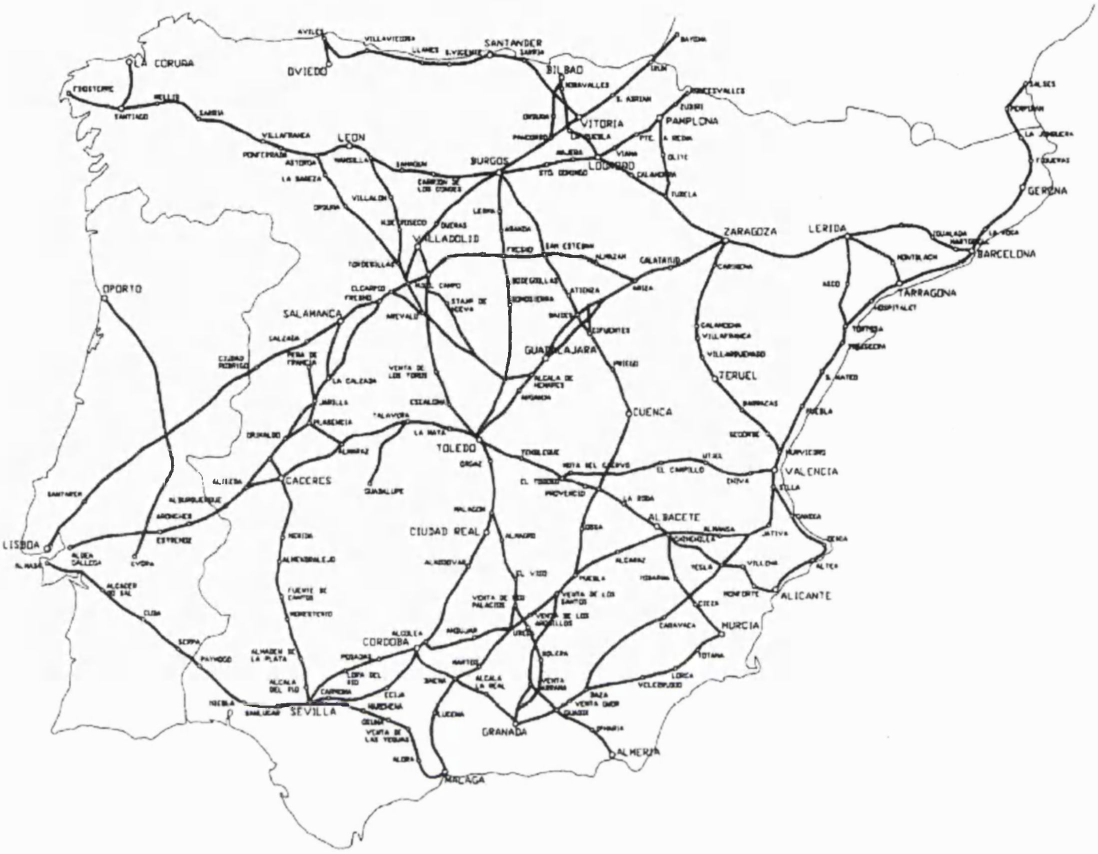


Source: Uriol (1985)

In many cases, these roads suffered the same problems as their Roman predecessors, making it unsurprising that the situation during the early eighteenth century was not promising either. The lack of maintenance and investments had terrible effects and the network that had reached 19,000 kilometres during the sixteenth century had been reduced to not more than 11,368 kilometres in the early eighteenth century.[150] The road guide of Pedro Ponton, published in 1705 and printed again in 1727, indicates that in comparison with the studies of Villuga and Meneses for the sixteenth century, the number of bridges had been reduced from eighteen to fifteen. In the same way, the number of ferries also suffered a reduction from five to three.[151] The following map presents the situation of the road network according to Ponton in the early eighteenth century:[152]

[150] Uriol, J.I. "Guia de caminos de Pedro Ponton" *Revista de Obras Publicas*, February (2003) p.61.
[151] Uriol, "Guia", p.61.
[152] Uriol, "Guia", p.60.

Figure 8.6: Eighteenth century road network



Source: Uriol (2003)

However, the problem was not just limited by the size of the network but also by the quality of the existing roads. This was also the feeling of contemporary writers who were alarmed about the bad state of the Spanish transport system. In early eighteenth century Spain, many of the roads were not even paved and their surface consisted of natural soil that produced dust in summer and mud in winter. This meant that they could only be used seasonally and therefore that they were impracticable for long periods of time. The eighteenth century marks a turning point when the use of wagons started to be more common and therefore when the old roads for animals became obsolete. The preoccupation reached the highest political spheres and in 1750 King Carlos III sent Bernardo Ward, an Irish who worked for the Spanish Crown overseas in order to study what other countries had done to accelerate the progress of their economies. Ward wrote that:

"Philip II, even before the conquest of Portugal, was the most powerful prince of Europe. Today Spain possess the same states than during those times, except those in Italy and the Low Countries ,

that never added strength or wealth to this Crown, but the situation is that ever since, all the neighbouring powers have advanced, and we have been falling behind"[153]

Ward also saw that the old roads based on Roman designs were too inefficient for the transport of bulky goods and that the new infrastructure should allow the use of wagons instead of pack animals.

"Six animals can carry more weight in a wagon than twelve on their backs, and in a good road maybe only four of them are needed ... so we can see that the cost of transporting our goods through land can be reduced to one third, and therefore, the peasant that is 45 leagues away from the sea will have the same advantage than the one that is 15 leagues away, and it is easy to understand how this would help us to develop our agriculture, commerce and circulation"[154]

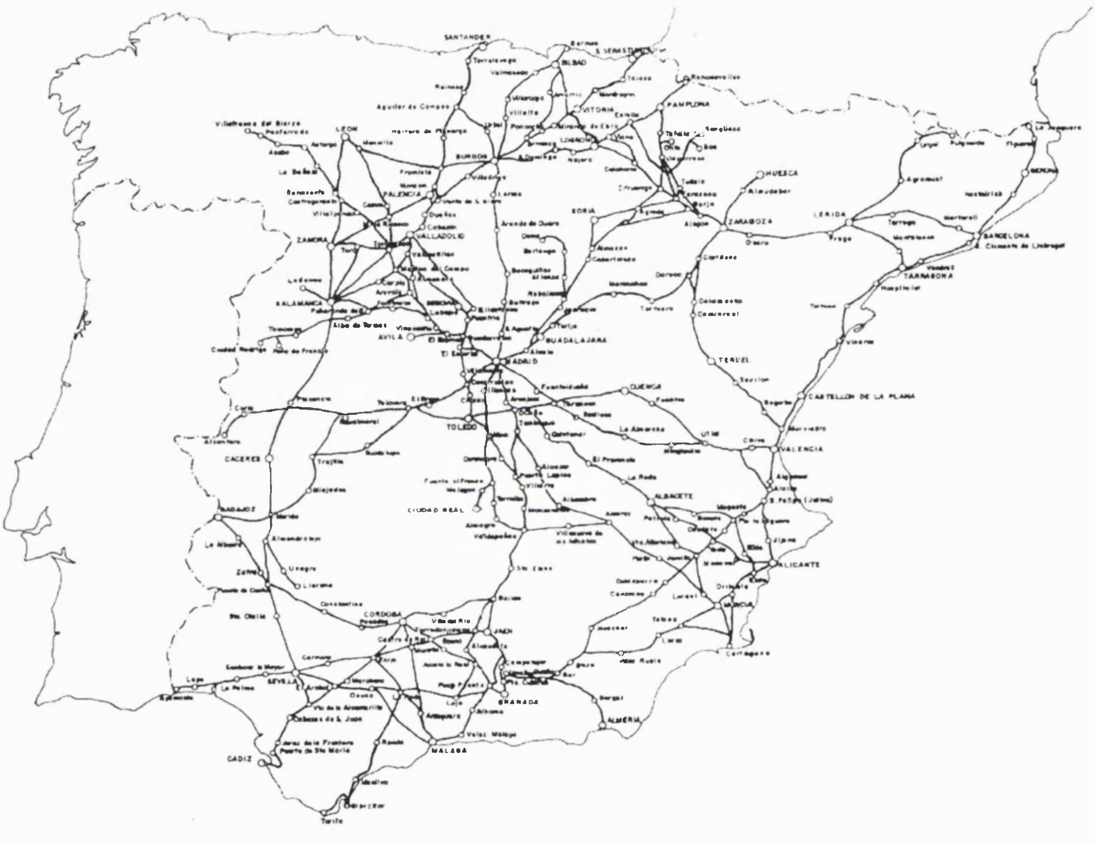
There were therefore improvements to transform some of the old roads into modern ones more able to accomodate wagons. In the case of Madrid, there were also important construction works to improve the communications of the capital with the surrounding areas. In 1732 the bridge of Toledo was open in the south of the metropolis, a key piece of infrastructure that connected Madrid with the South of Castile and especially with the big towns of Andalusia, like Seville, Cadiz, Granada or Malaga. There were also important improvements in the northern communications of the capital. Ferdinand VI ordered the construction of a new link with the North through the Guadarrama Mountains, a natural obstacle that isolated Madrid from the grain producers of Old Castile. The works were strongly supported by Bernardo Ward who had been named minister by the king and who on his "Economic Project" defended the necessity of the new road. The result was the "Alto del León", a paved pass that was finished in 1749 and that improved considerably the communications of Madrid with the North of Castile.

The network was not only improved in quality but also in extension. By the mid eighteenth century it reached 12,500 kilometres according to the information provided by Matias Escribano. In his writing *"Itinerario español o guía de caminos par air desde Madrid a todas las ciudades y Villas mas importantes de España y para ir de unas ciudades a otras, y a algunas cortes de Europa*",

[153] Uriol, "Las carreteras", p.625.
[154] Uriol, "Las carreteras", p.626.

published in 1758, Escribano presents a very detailed account of the main Spanish roads.[155] The following map presents the Network described by Escribano:

Figure 8.7: Escribano's road map



Source: Uriol (1977)

The evolution of the network since the early sixteenth century was not a linear process of constant increase but rather a tumultuous roller coaster with crises and advances. According to Santos Madrazo, the seventeenth century crisis had strong effects not just on the Spanish population but also on its infrastructure. It was not until the eighteenth century when the positions lost would be recovered and finally surpassed.[156]

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[155] The translation of the title is "Spanish itinerary or road guide to go from Madrid to all the major cities and towns of Spain and to go from some cities to others, and to some courts in Europe"

[156] Madrazo, *El sistema*, p.50. The number included for 1760 includes not only the 12.500 kilometres of roads for wagons, but also 12.000 for animals.

Table 8.1: Length of the Spanish road network

Year	Km	Km/1.000 Km2	Km/1.000 Inhabitants
1546	18,000	36	2.2
1576	18,000	36	2.2
1608	7,300	15	0.9
1684	8,900	18	1.2
1705	11,200	23	1.5
1720	5,400	11	0.7
1760	24,000	49	2.5

However, taking these improvements into account, the situation of the Spanish roads in the early 1750s was still considered backward. Chronicles from travellers of the time expressed the lack of paved roads and the bad state of bridges and ferries.

"Hills, slopes, jumps, cliffs, fake torrents, distrustful fords, dangerous bridges, broken or insecure ferries, not populated by any being or vegetable, without being able to get protection, from sun or tempests or rains; uncertainty in the way in the crossroads, in the distance of the places, and their names, about the course, the time, etc. All this is a bunch of discomforts that the traveller has to suffer, even when he is coming to the Court..."[157]

Nevertheless, this situation was not limited to secondary roads. The lack of maintenance and bad quality also affected the main roads, even those that reached Madrid. Complaining about this fact Tomas Fernandez Mesa would wrote in 1755,

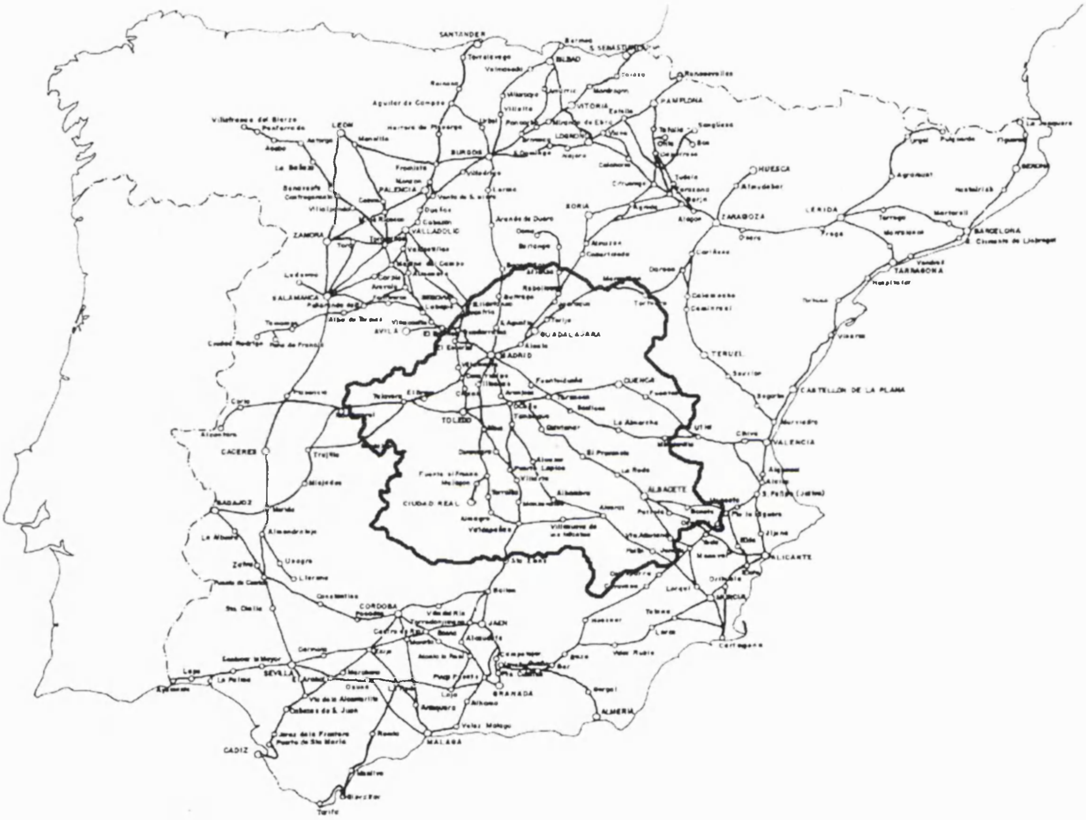
"It is certainly sad, and almost incredible, that to go to the Spanish Court, from an such an opulent kingdom as Valencia, there is not a more direct way that one that is called "for the little goats", without a doubt because it is only suitable for those animals."[158]

There were important renovation projects that only took place during the second half of the eighteenth century, especially under the kingdom of Carlos III. However, the price dataset that is used in this chapter includes information for the first half of the 1750s. Therefore, although important, there is not room in this work to analyze the extension of these improvements. For that reason the situation of the roads in Spain that will focus this chapter is the one described by

[157] Madrazo, *El sistema*, p.235.
[158] Madrazo, *El sistema*, p.236.

Escribano in his work and by his contemporaries in chronicles like the ones that have been presented above. The geographical extension of the price dataset includes the modern provinces of Madrid, Guadalajara, Toledo, Cuenca, Ciudad Real and Albacete, an area known as New Castile. The following map presents the extension of the region and its relationship with the road map of Escribano, that will be the base of the road network studied.

Figure 8.8: New Castile in the Spanish road network



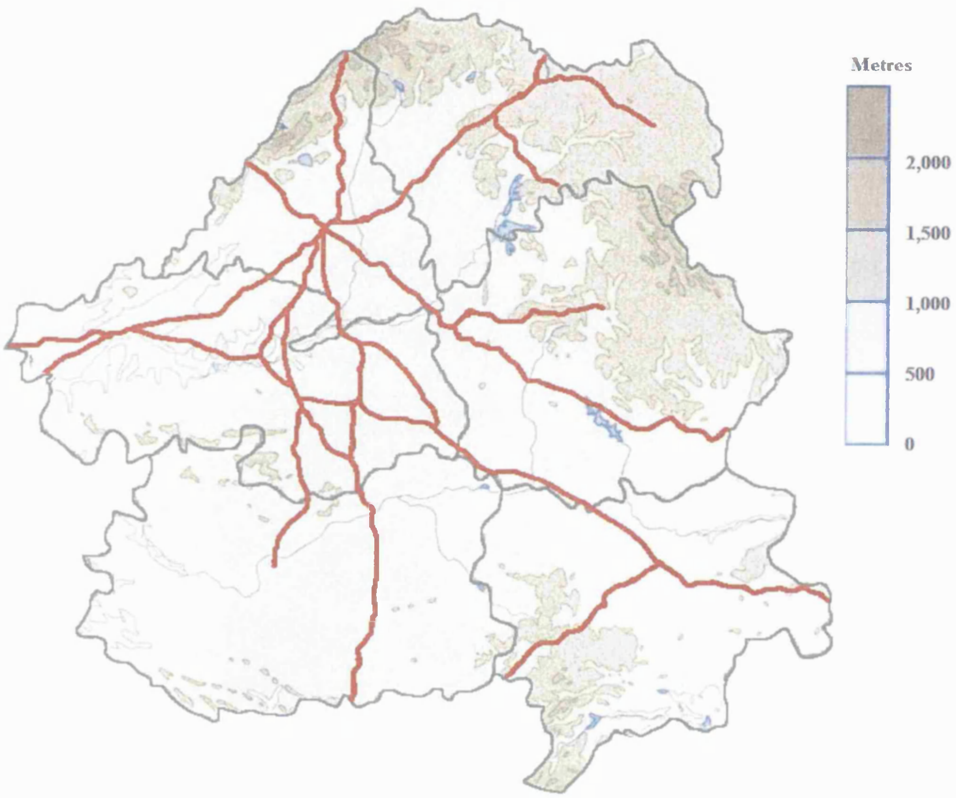
Source: Uriol (1977)

As the map reveals, the network in New Castile are centred around Madrid, a not surprising fact that is explained by the demographic and political weight of the capital. Madrid, with an estimated population of more than 140,000 inhabitants, acted like a growth hub extracting resources from the surrounding provinces.[159] Therefore, the design and construction of the road network in the interior of Spain was almost entirely dedicated to the maintenance and development of the capital. However, the development of the road network did not depend just on economic factors as the geography of New Castile also played an important role. The region is literally isolated from the rest of Spain by chains of mountains that surround it and that increase the difficulty of exchanging

[159] Ringrose, D.R., *Madrid and the Spanish Economy* (Berkeley-Los Angeles: University of California Press, 1983) p.28.

goods between the centre of Spain and its periphery. The next figures present topographical map of New Castile and the main roads in the region according to the works of Escribano.

Figure 8.9: Geography of New Castile and the road network



There are eight main roads that connect Madrid with the rest of the country, although some of them such as the ones to Valladolid and Burgos are identical in New Castile. Those main roads connected the capital with Barcelona, Cuenca, Valencia, Murcia, Cadiz, Badajoz and Leon.

The Madrid-Barcelona road connected the two cities via Alcala, Guadalajara, Daroca, Zaragoza, Lerida and Cervera. The journey took fourteen days with nights in Alcala, Torija, Algora, Maranchon, Tortuera, Daroca, Cariñena, Zaragoza, Osera, Venta de Fraga, Lerida, Tarrega, Igualada, Martorell and finally Barcelona. The main rivers were crossed using bridges, although some small rivers had still to be crossed using fords that were dangerous in periods of heavy rains.

In any case, the road was able to sustain the use of wagons according to the chronicles of the monk Norberto Caino who travelled from Barcelona to Madrid in 1755.[160]

The road Madrid-Cuenca consisted of a journey of three days with nights in Fuentidueña, Carrascosa and Cuenca. In this case and unlike Barcelona, the pass of the rivers has to be done using boats given the lack of infrastructure.

The road Madrid-Valencia (through Utiel) took seven days with stops in Fuentidueña, Saelices, La Almarcha, Minglanilla, Utiel and Valencia. The first kilometres of the road were shared with the road to Cuenca, although the quality of the infrastructure improved and there were bridges to cross three more rivers.

The road Madrid-Murcia that also reached Cartagena consisted of ten days with nights in Valdemoro, Villatobas, Quintanar de la Orden, El Provencio, La Roda, Albacete, Venta de Albatana, Venta de Roman, Murcia and Cartagena. The road used the new bridge of Toledo to cross the Manzanares River along the exterior of Madrid and there were also bridges to cross the Tagus River and the Zancara. However, from there the rivers had to be crossed using fords as there were no bridges.

The road Madrid-Valencia-Alicante was an alternative to the road Madrid-Valencia, although longer in length with two more days of travelling. It shares the same layout with the road to Murcia until Albacete. It took nine days to complete the journey with stops inValdemoro, Villatobas, Quintanar de la Orden, El Provencio, La Roda, Albacete, El Bonete, Mogente, Alcira and Valencia. In the case of Alicante the road changed in Albacete with stops in Petrola, Yecla, Monovar and Alicante.

The road Madrid-Cadiz was one of the main roads as it connected the capital with the South of Spain. It consisted of fourteen days with stops in Aranjuez, Tembleque, Villarta, Manzanares, Venta de las Virtudes, Santa Elena, Bailen, Villa del Rio, Cordoba, Ecija, Marchena, Cabezas de San Juan, Jerez de la Frontera and Cadiz. The rivers were crossed using bridges, with the roads being

[160] Uriol, J.I., "Apuntes para una historia del transporte en España. Los caminos de ruedas del siglo XVIII" *Revista de obras publicas,* (1977) p.148.

especially good between Madrid and Aranjuez. Antonio Ponz, an illustrated and usual traveller wrote that,

"All the way from Aranjuez to Madrid is one of the greatest works that have been done and one of the most useful"[161]

The road Madrid-Badajoz-Lisbon takes eight days to reach Badajoz and from there four and a half more to arrive to Lisbon. The stops to Badajoz included Casarrubios, El Bravo, Venta Peralvanega, Navalmoral, Trujillo, Miajadas, Merida and Badajoz. At least eight rivers are crossed using bridges in all the cases, although the quality is very diverse from bad quality wooden bridges like the one crossing the Alberche River to magnificent stone ones like the bridge of Almaraz to cross the Tagus River and built in 1552.

The road Madrid-Leon was the key axis connecting the capital with the north of Spain. It consisted of seven days and a half of journey to Leon with stops in Guadarrama, Labajos, Arevelo, Medina del Campo, Torre Lobaton, Ceinos, Santas Martas and Leon. The seven rivers mentioned by Escribano were crossed in all the cases using bridges, and the Guadarrama Mountains in the north of Madrid using the new pass, the "Alto del Leon" built in 1749.

The development of the network was, according to Santos Madrazo, based on pure economic factors. New roads were created to cover the increasing demand of Madrid that had a strong backwash effect over the surrounding provinces. A consequence of the centralization in Madrid was the decline in demographic and economic terms of many Castilian towns. Places like Segovia or Salamanca lost not only economic importance, but also the physical communication links with the road network (Table 8.2). The clearest example is the decline of Toledo, the old capital that suffered the proximity of Madrid. By 1600 both cities exceeded 60,000 inhabitants. However, by 1757 Toledo had shrunk to around 17,000 while Madrid had grown to over 140,000. The result of this process was a road map with Madrid like the unquestionable centre and many areas of Old and New Castile being increasingly isolated. The number of links per town went down from 3.3 in 1546 to 1.1 in 1720. Even in 1760 and after the new construction works of the mid eighteenth century, the number of links per town would not return to the sixteenth century figures, rising just to 2.17.[162]

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[161] Uriol, "Los caminos", p.153.
[162] Madrazo, *El sistema*, p.59.

Table 8.2: Links of the Spanish road network

Town	1528 households	1546 links	1712/17 households	1720 links	1753 households	1760 links
La Coruña	554	2	1,165	2	2,000	0
Santiago	948	3	-	2	-	2
Gijon	180	2	-	0	1,959	1
Oviedo	429	2	772	0	1,750	1
Leon	918	4	584	0	1,482	1
Salamanca	4,953	7	1,500	3	4,000	4
Toro	2,314	4	757	0	1,487	0
Zamora	1,695	3	741	2	1,804	1
Avila	2,826	5	830	0	1,250	1
Burgos	2,665	8	1,057	3	-	6
Logroño	933	4	967	0	1,614	4
Medina del	2,760	5	689	3	1,000	4
Santander	558	2	-	0	680	1
Segovia	5,548	5	2,000	0	2,502	1
Soria	1,279	2	650	0	722	0
Valladolid	8,112	5	3,538	2	-	5
Alcala de	2,445	3	600	2	-	2
Alcazar de	2,057	2	1,191	0	-	0
Ciudad	2,049	3	445	2	1,700	2
Cuenca	3,095	7	1,019	0	1,692	1
Guadalajara	1,900	4	450	2	1,300	3
Madrid	7,500	5	24,344	6	39,800	7
Ocaña	3,150	0	644	0	1,100	3
Talavera de	2,035	3	806	2	1,600	4
Toledo	10,933	7	2,436	2	4,775	2
Caceres	1,669	4	895	0	1,712	3
Almeria	966	1	1,182	0	-	1
Antequera	4,041	2	3,881	0	4,500	2
Cadiz	612	0	4,043	1	-	1
Cordoba	6.257	4	6,115	2	10,000	2
Granada	13.757	5	10,072	0	13,650	3
Huelva	1.090	0	625	0	-	0
Malaga	3.375	3	4,851	0	-	2
Osuna	2.460	3	2,282	0	4,000	2
Seville	18.000	4	-	3	18,000	3
Ubeda	4.672	2	1,463	0	-	0
Jaen	5.595	1	3,126	0	5,000	2
Albacete	1.380	3	911	2	-	5
Cartagena	1.034	0	2,041	1	6,400	1
Murcia	3.370	3	6,028	2	4,850	4

Sources: For Madrid 1753 the data comes from Ringrose (1983) p. 28. and corresponds to 1757

8.2 Transport costs

The road transport of goods was carried out by pack animals or by wagons. Ringrose estimated that during the eighteenth century there was a stock of 142,000 pack animals and 14,000 wagons. It is interesting to note that horses could not be used as pack animals by law and therefore pack animals consisted mainly of donkeys and mules.[163] Each animal could on average transport 91 kilograms and travel around 25 to 30 kilometres every day.[164] For pack animals, Ringrose distinguishes four types of carriers; small peasants who traded with their surrounding areas when work in the fields was not intense, professional carriers that made small journeys to the main cities with routes almost fixed, small companies specialized in transportation, and finally the big carriers that carried out long distance trade. Most of the grain transactions were normally carried out by the first group, small peasants with a low opportunity cost that could travel up to 100 kilometres to transport their goods. However, long distance trade also existed, even for these small carriers that once every year were able to reach Madrid and even the ports.[165] The following table presents the number of pack animal owners and the number of animals per owner in the main provinces of Castile.

Table 8.3: Owners of pack animals by province

Region	Province	Owners	Animals/Owner
Old Castile	**Avila**	374	3.14
	Burgos	844	3.25
	Leon	801	3.13
	Palencia	61	3.48
	Salamanca	287	1.85
	Segovia	107	3.05
	Soria	91	3.05
	Toro	40	4.95
	Valladolid	91	4.68
New Castile	**Zamora**	-	-
	Cuenca	967	3.59
	Extremadura	738	4.12
	Guadalajara	63	3.06
	Madrid	33	4.00
	La Mancha	452	3.19
	Murcia	-	-
Andalusia	**Toledo**	428	3.52
	Corduba	320	4.04
	Granada	910	2.41
	Jaen	47	3.47
	Seville	449	4.88

Sources: Uriol (1980)

[163] Uriol, J.I., "Los transportes interiores de mercancías en el siglo XVIII y en los primeros años del siglo XIX. I. Transportes a lomo y en carro", *Revista de Obras Publicas* (1980) p.641.
[164] Uriol, "Los transportes", p.645.
[165] Uriol, "Los transportes", p.642.

The "Real Cabaña de Carreteros" (Royal Association of Carriers) was created in the late fifteenth century to preserve and defend the rights of the carriers that used wagons. The wagons that were still being used during the eighteenth century were quite primitive. Wheels did not have spokes and consisted of four pieces of a circle united with an approximated diameter of 1.2 meters.[166] Ringrose estimates that the average capacity of an oxen wagon was 460 kilograms and that they could travel between three and four leagues every day.[167] As in the case of the pack animal carriers, wagon carriers could be divided into different groups. The peasant whose main job was in the countryside but that sometimes could work as carrier, and the professional carrier, specialized and integrated in the organization of carriers. In this case however, the bulk of the transport was carried by professional carriers. The number of wagon carriers and the total number of wagons in the main provinces of Castile are presented in the next table.[168]

Table 8.4: Owners of wagons by province

Region	Province	Owners	Wagons
Old Castile	**Avila**	2	6
	Burgos	553	3,006
	Leon	50	-
	Palencia	1	16
	Salamanca	349	916
	Segovia	472	168
	Soria	361	2,161
	Toro	-	223
	Valladolid	28	60
New Castile	**Zamora**	11	-
	Cuenca	12	515
	Extremadura	24	1
	Guadalajara	111	456
	Madrid	131	166
	La Mancha	24	-
	Murcia	363	481
Andalusia	**Toledo**	-	-
	Corduba	32	140
	Granada	144	168
	Jaen	10	3
	Seville	796	931

Sources: Uriol (1980)

166 Uriol, "Los transportes", p.647.
167 Uriol, "Los caminos" p.709. Although its length changed since the middle ages, during the eighteenth century one league was defined to be 5,572.7 meters.
168 Uriol, "Los transportes" p.649.

The percentage of goods that were transported by each system is a key element in understanding the flows of internal trade in Spain. Ringrose estimated that in late June 1784, 700 wagons and 5,000 pack animals entered in Madrid every day bringing basic supplies to the city. His estimation brings the yearly numbers to 55,000 wagons and 380,000 pack animals to maintain the capital.[169] If those estimations are correct and we take into account the maximum weight that could be transported by each wagon and animal, then the results indicate that up to 25,300 tons of goods could have been transported by wagons and 34,580 by pack animals.[170] Therefore, more than half of the trade with the capital was carried out by pack animals while the weight of transport using wagons was slightly smaller.

Having explained the supply of transport available in eighteenth century Spain, the next step is assessing the cost of transporting wheat with each sort of carrier. According to Ringrose, during the period 1773-1787, moving grain to Madrid using pack animals cost an average of 15 to 21 maravedis per fanega and league. Using wagons to move wheat to Madrid in 1773 cost 10 to 12 maravedis per fanega and league.[171] However the sample of prices that is being analyzed in this chapter is based on 1750, so we multiply these figures by 1.11 in line with the movement in the commodities price index for New Castile created by Hamilton.[172]

Table 8.5: Wheat price series 1750-1799=100

	Price		Price		Price		Price		Price
1750	-	**1760**	85.9	**1770**	97.9	**1780**	105.8	**1790**	127.7
1751	87.3	**1761**	83.1	**1771**	99.3	**1781**	110.5	**1791**	122.0
1752	89.4	**1762**	85.5	**1772**	98.9	**1782**	112.3	**1792**	125.1
1753	97.9	**1763**	93.4	**1773**	97.0	**1783**	108.6	**1793**	130.7
1754	107.3	**1764**	99.1	**1774**	99.6	**1784**	111.9	**1794**	130.5
1755	101.4	**1765**	106.0	**1775**	98.1	**1785**	115.3	**1795**	139.3
1756	91.4	**1766**	104.4	**1776**	98.3	**1786**	117.0	**1796**	141.0
1757	87.6	**1767**	99.8	**1777**	99.5	**1787**	116.1	**1797**	155.5
1758	89.5	**1768**	99.9	**1778**	101.4	**1788**	118.1	**1798**	165.6
1759	85.1	**1769**	99.3	**1779**	102.8	**1789**	119.6	**1799**	154.6

Sources: Hamilton (1947)

The new costs would then be 13.5 to 18.9 maravedis per fanega and league in the case of pack animals and 9 to 10.8 maravedis per fanega and league in the case of wagons. We can use other

169 Uriol, "Los transportes" p.649.
170 The calculation is based on a maximum weight of 460 kilograms per wagon and 91 kilograms per pack animal.
171 Uriol, "Los caminos" p.710.
172 Hamilton, *War*, p.155.

evidence to check to what extent this deflation is or is not realistic. Uriol showed that for the year 1795, moving grain from Palencia to Santander using wagons cost an average of 15.2 maravedis per fanega per league. If we deflate that price by Hamilton's commodities price index, the transport cost for wagons in 1773 would be 10.6 maravedis per fanega and league, within the 10 to 12 range observed. Therefore, we can accept the transport costs described above:

Table 8.6: Transport costs in maravedis per fanega per league

	Pack animals	Wagons
1751	13.5 – 18.9	9.0 – 10.8
1773	15.0 – 21.0	10.0 – 12.0
1794	-	15.2

Sources: Own calculations

We can now calculate the real effects that transport costs could have on the price of wheat in New Castile. To standardize the results and make them more comprehensible for the reader, leagues will be transformed into modern kilometres. The capacity measurement will remain in fanegas for pure logistical reasons, as the price dataset is also presented in that measurement and the complete transformation would probably create more confusion than clarification. In the same way and for obvious reasons, the currency will remain in eighteenth century maravedis and reales with every real containing 34 maradevis. Transformations to modern measurements are not an easy task, especially when the standardization so common nowadays was not so ordinary in previous times. [173]

Transforming leagues to current kilometres is complicated given the high diversity of types of league in different regions of Spain. There were two sorts of leagues in eighteenth century Spain, the long league that consisted of 6,687 kilometres and the short league, also known as common league, with 5,571 kilometres.[174] Both leagues were commonly used even within the same province. However, for the period that is being analyzed, the common league was the most widely used and therefore will be the one used for the standardization. The following table shows how the price of wheat increased in 1751 with increases in distance in maravedis and reales after the standardization.

[173] The fanega was a capacity measurement, and consisted on 55.5 litres.
[174] Madrazo, *El sistema*, p.224.

Table 8.7: Transport costs in maravedis and reales per fanega per league

	Pack animals	Wagons
5 Km	12.1 – 16.1	8 – 9.7
10 Km	24.2 – 32.2	16 – 19.4
50 Km	121 – 161	80 – 97
100 Km	242 - 322	160 - 194

	Pack	Wagons
5 Km	0.35 – 0.47	0.23 – 0.28
10 Km	0.72 – 0.95	0.47 – 0.57
50 Km	3.56 – 4.73	2.35 – 2.85
100	7.11 – 9.47	4.70 – 5.70

Sources: Own calculations

Therefore, the use of wagons to move wheat in Castile during the early 1750s was on average 35 per cent cheaper than the use of pack animals. The reasons behind the high volume of trade that was carried out by pack animals is therefore a consequence of transactions realised by small carriers, mainly peasants who did not have access to the use of wagons but that had a small opportunity cost in the use of pack animals.

To better understand these results we can compare them with the average prices of wheat in the six provinces of New Castile included in the study. The highest price of the sample corresponds to the province of Albacete with 19.6 reales per fanega. The second position is for Madrid with 17.7 reales followed by Toledo and Ciudad Real both with 17.4 reales, Cuenca with 16.9 and finally Guadalajara with 15.1 reales per fanega. Therefore, taking the mean values of the previous tables, moving one fanega of wheat 50 kilometres using pack animals would increase the price by 21 per cent in Albacete, 23 per cent in Madrid, 24 per cent in Toledo and Ciudad Real, 25 per cent in Cuenca and 27 per cent in Guadalajara. On the other hand, using wagons the increases would have been considerably lower, a 13 per cent in Albacete, 15 per cent in Madrid, Toledo, Ciudad Real and Cuenca and 17 per cent in Guadalajara.

According to Ringrose, free unregulated markets for wheat could be found in a radius as wide as 75 miles or 120 kilometres, as beyond that limit transport costs began to be prohibitive.[175] However, Ringrose also admits that most of the exchange should have taken place within a distance not longer than 80 kilometres.[176] In a more recent study in Old Castile, Enrique Llopis mentions that in rare occasions the trade of wheat reached distances longer than 150 or 200 kilometres.[177]

The situation of Madrid was nevertheless different. The increasing population of the capital had to be fed and the distances reached by the carriers transporting wheat would increase as did the

[175] Ringrose, *Madrid,* p.154.
[176] Ringrose, *Madrid,* p.185.
[177] Llopis and M. Jerez, "El mercado", p.39.

demand for bread. Despite the lack of water transport, according to Llopis, Madrid had one of the largest areas of wheat suppliers in Europe that could reach 150 kilometres.[178] In comparison, Paris with five times the population of Madrid, had a supply radius of around 85 kilometres while the one for Rome was close to 60 kilometres.[179] Ringrose estimates that the wheat supplies to Madrid came from up to 160 kilometres away.[180]In years of particular need, this distance could be as large as 320 kilometres and as the author explains, wheat would be imported from areas as remote as Andalusia 400 kilometres away.[181] Ringrose presents cases where wheat had been transported to Madrid from 320 kilometres by wagon.[182]In many occasions, when the transport costs led to excessively high prices, the authorities of Madrid subsidized the transport of wheat. One of the ways of doing so was by reducing the transport costs giving incentives to the carriers. Examples of this behaviour are for example the right awarded to the carriers to make use of the pasture available along the roads. With this sort of indirect subsidies the provision of food in the capital was guaranteed in periods of scarcity.

Apart from the subsidized importations of wheat imposed by the government, the supply of Madrid at a private level would only be guaranteed if the producers in the surrounding provinces could see a benefit in the exchange. Before that however, there had to be a surplus of production to be dedicated to the market. It has been estimated that peasants used on average 37 per cent of the harvest in order to pay the tithe, rents and other taxes. The peasant commercialized himself around 13 per cent of his own harvest, while this number was considerably superior in the case of big landowners, aristocrats or ecclesiastical institutions. Therefore, an estimated 35 per cent of the total harvest probably reached the markets in Castile.[183]

However, were the economic incentives high enough to convince the producer to put his production surplus into the market? Madrid was clearly the most important grain market of the region, with an average price of wheat in the early 1750s of 20 reales per fanega. Taking a 50 kilometres radius from the capital, we can observe municipalities where the prices went down to 15 and 16 reales per fanega. However, most of these municipalities were isolated from the main roads of Madrid, making the movement of wheat more difficult. If the radius is extended to 100 kilometres, the situation is even more striking. The prices of wheat in some municipalities within that radius go

[178] Llopis, "Antes", p.17.
[179] Llopis, "Antes", p.18.
[180] Ringrose, *Madrid,* p.190.
[181] Ringrose, *Madrid,* p.150.
[182] Ringrose, *Madrid,* p.150.
[183] Llopis, and Jerez, "El mercado", p.25.

down to 15 and even 14 reales per fanega and in many of the cases, they are connected by road to Madrid. That is the case of many villages and towns in the province of Guadalajara connected to the capital by the road Madrid-Barcelona described above.

According to the information displayed in table 8.7, the transport costs of moving one fanega of wheat 100 kilometres would reach 7 to 9 reales using pack animals and 4 to 5 reales using wagons. The price gap between Madrid and some of the municipalities within the 100 kilometres radius could easily reach 6 reales. There was therefore enough room for trade between peripheral areas and Madrid. This situation is not surprising and is supported by Ringrose who points to the provinces of Madrid, Toledo and Guadalajara as the key providers of wheat for the capital.[184]

8.3 Wheat prices in New Castile

The dataset used in this section includes the 1,118 towns and villages in the provinces of Madrid, Guadalajara, Toledo, Cuenca, Ciudad Real and Albacete that are presented in the following map.

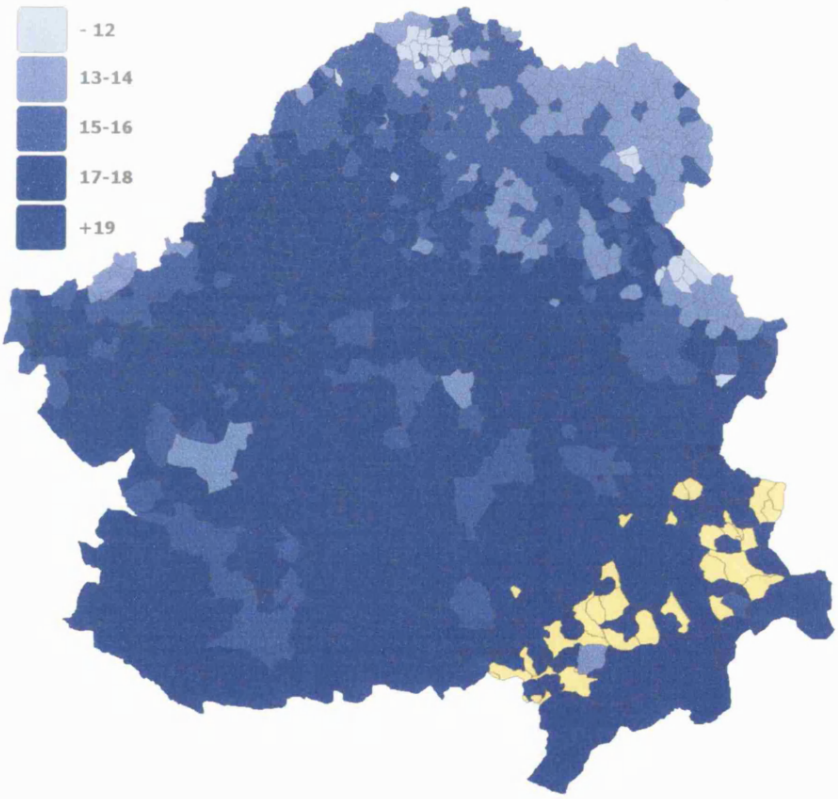
Figure 8.10: New Castile (current boundaries)

The dataset includes 1,118 towns and villages and contains the average price of wheat in the 5 years previous to the visit of the authorities of the Catastro. There were some cases where the information could not be gathered. This was mainly due to two reasons; the first one because the information about prices was not available in the document, the second because the village or town was just not included in the Catastro. Anyhow, those cases represented a minority in the sample, probably not

[184] Ringrose, *Madrid*, p.146.

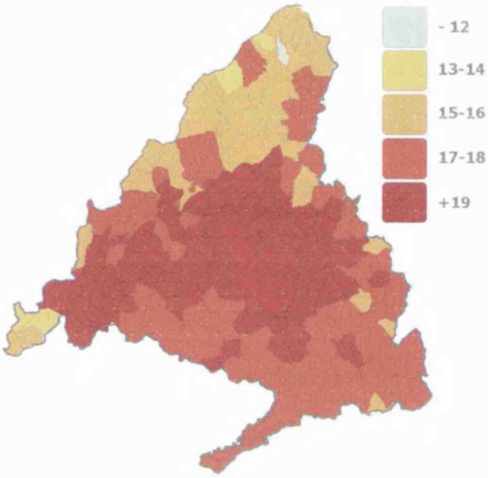
more than 30 representing around a 2 per cent of all the municipalities in the six provinces. The results of the study are presented in the following map, which shows the average prices in reales per fanega of wheat by municipality, collected by the employers of the Catastro for the six provinces mentioned above. The locations that are not available are displayed in yellow.

Figure 8.11: Prices of wheat by village in New Castile, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

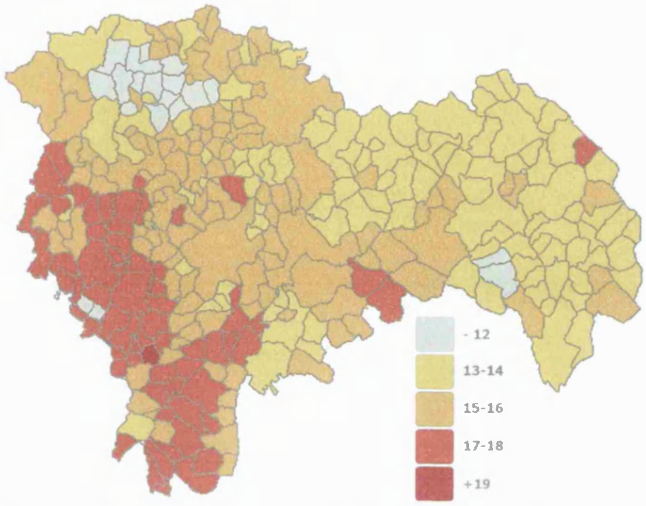
Figure 8.12: Prices of wheat by village in the province of Madrid, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

The sample in the province of Madrid includes 158 observations. The average price is 17.8 reales per fanega and the coefficient of variation of the sample 10.8 per cent. The distribution of prices in the province of Madrid is, as expected, highly influenced by the presence of the capital. The 20 reales per fanega that are reached in Madrid is a price common in the hinterland of the city that is also reached in areas of the South West of the province. As we move away from Madrid, prices are reduced in all directions (except the previously mentioned South West). In the south prices reach 17 and 18 reales, two less than in the capital, while the north and the villages located in the Guadarrama Mountains maintain price levels even lower, that in many of the cases reach 15 reales per fanega.

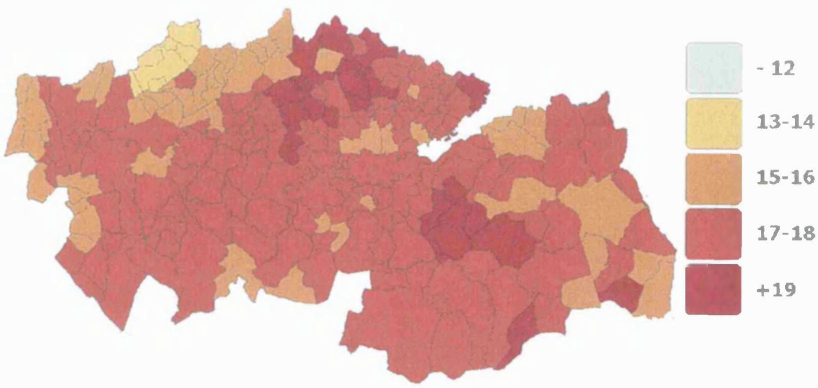
Figure 8.13: Prices of wheat by village in Guadalajara, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

The province of Guadalajara includes 284 observations. The average price in the area is 15 reales per fanega and the coefficient of variation of the sample 11.2 per cent. The effects of Madrid in the Castilian economy are clear in the province of Guadalajara. Prices in the western border, which divides Guadalajara from the province of Madrid, have the highest levels in the province. In the same way as in the province of Madrid, prices were reduced as we move away from the Capital. They reach 15 and 16 reales in the centre of Guadalajara and only 13 and 14 in Molina, the eastern area of the province. It is also interesting to note the surprisingly low prices in a group of villages in the north of Guadalajara, located in the middle of the mountains.

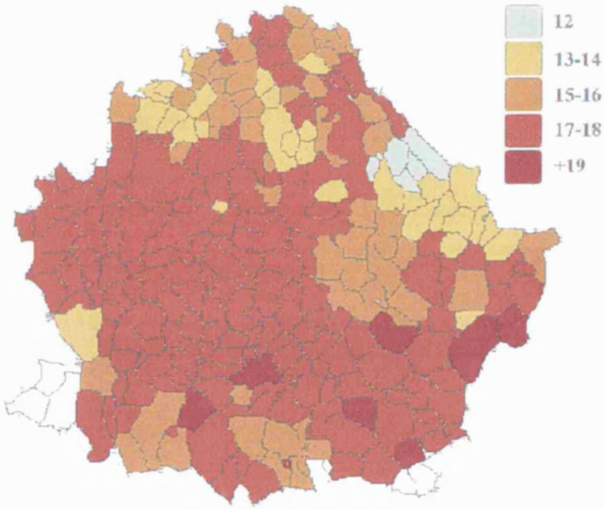
Figure 8.14: Prices of wheat by village in Toledo, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

In the case of Toledo, the sample includes 192 observations. The average price in the province is 17.4 reales per fanega and the coefficient of variation of the sample is 9.1 per cent. Being the other province of the sample that shares a physical border with the province of Madrid, it is not surprising that the effects of Madrid are also clear in Toledo. The prices in the north closer to the capital are the ones that have the highest levels, while they are reduced as we move away from the sphere of influence of Madrid. Prices in the villages located in the mountains of the North West present the minimum values of the province, between 13 and 14 reales per fanega.

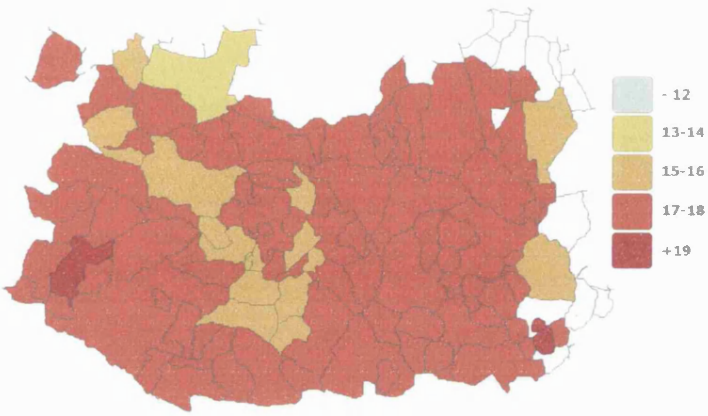
Figure 8.15: Prices of wheat by village in Cuenca, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

The province of Cuenca comprises 224 observations. The average price of the sample is 16.8 reales per fanega and the coefficient of variation of the prices is 10.4 per cent. Although sharing a very small border with the province of Madrid, the price sample in Cuenca does not show any influence of the high prices of the capital. In fact, the maximum values are reached in the southeast while the border with Madrid is located in the opposite side of the province. Prices are relatively stable along the province reaching 17 and 18 reales per fanega. However, the centre-east and northeast of Cuenca present prices that are lower than the average, with levels of 14, 13 and in some cases even 12 reales per fanega. As in the case of Madrid, Guadalajara and Toledo the minimum prices can be found on the villages in the mountains, which in the case of Cuenca are located along the eastern border.

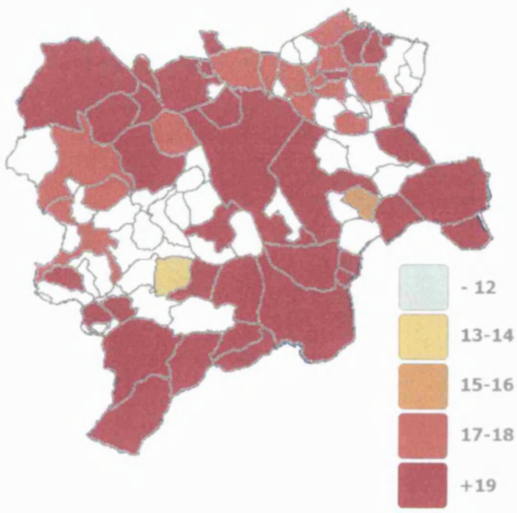
Figure 8.16: Prices of wheat by village in Ciudad Real, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

The sample in Ciudad Real includes 81 observations. The average price in the province reaches 17.4 reales per fanega and the coefficient of variation comes to 6.7 per cent. The spatial distribution of the prices is very homogenous and in most of the cases the prices reach 17 and 18 reales. Only a small group of villages in the centre of the province present different values that in any case are close to the rest of the sample with 15 and 16 reales per fanega.

Figure 8.17: Prices of wheat by village in Albacete, mid 18th century (reales per fanega)



Sources: Own calculations from the Catastro de la Ensenada

Finally, the province of Albacete includes 60 observations. The average price in the sample is 19.6 reales per fanega and the coefficient of variation is 10.1 per cent. Albacete presents some problems; the most important one is the lack of information for a considerable number of municipalities. For those available, the manuscripts show that the prices were considerably high, in cases higher even than those in the city of Madrid even reaching 24 reales per fanega.

Table 8.8: Average prices and volatility by province, mid 18th century

	Average Price	Coefficient of Variation
Guadalajara	15.0	11.2
Cuenca	16.8	10.4
Toledo	17.4	9.1
Ciudad Real	17.4	6.7
Madrid	17.8	10.8
Albacete	19.6	10.1

Sources: Own calculations from the Catastro de la Ensenada

The main aggregated results of the study are presented in Table 8.8. The most striking figure is without a doubt the unexpected high average price in the province of Albacete, almost two reales higher than Madrid, second on the list. The lowest price is found in Guadalajara with only 15 reales per fanega of wheat. The lowest coefficient of variation can be found in Ciudad Real, followed by Toledo, Albacete and Cuenca and Madrid. The highest volatility is in this case located in the province of Guadalajara. The reasons behind these results and their explanation will be analyzed in the following section.

8.4 Integration of wheat markets in mid 18th century New Castile

8.4.1 Integration of grain markets in the literature

The existence of an internal grain market has been a controversial issue in the economic history of modern Spain. The traditional bibliography argued that it was not until the mid nineteenth century, with the transport revolution, when the creation of an internal grain market was achieved. However, this view has been disputed in the works published during the last ten years. An increasing consensus is growing around the idea that strong economic integration existed as early as the first decades of the eighteenth century. Studies like the ones published by Llopis and Jerez point to this direction indicating that, in fact, the eighteenth century saw levels of economic integration in the grain markets superior to those achieved in later dates.[185]

Llopis has studied the integration process of grain markets in Spain, with a special interest in the provinces of Old and New Castile.[186] His conclusions challenge the traditional view, arguing that the economic integration levels of grain in Spain were considerably higher in the eighteenth century than what the traditional bibliography suggested. With Sotoca he proved that high levels of integration could be observed during the period 1725-1750.[187] They also argue that the process was not a linear and continuous one, but that it rather experienced different stages of integration and disintegration. For example, grain markets were more consolidated in Spain in 1750 than in 1780.[188]

In a similar study, David Reher argues that the economic integration of grain markets in early modern Spain was low but that it would increase progressively, especially during the eighteenth century.[189] In wide sample covering most of Spain, Reher argues that during the eighteenth century the volatility of the prices of grains was reduced in all the cases under study. In the case of New Castile, Reher uses the price series of Toledo created by Hamilton. The results indicate that the reduction in the volatility in Toledo was less than to the best performer, Andalusia, but that it was in line with the behaviour of other series like Segovia and Leon in Old Castile or Navarra in the north. According to Reher, the process of economic integration was stronger in Andalusia than in both Castiles during the eighteenth century.[190] However, this convergence was in part a consequence of catching up given the very high volatility levels that existed in Andalusia during the seventeenth century. Other series of the sample like Barcelona or Valencia already had relatively stable price series, so the room for improvement in these cases was clearly smaller than in the Andalusian case. Another aspect studied by Reher was the existence of subsistence crises, identified as those years when the price of wheat surpassed the 11 years moving average by 40 per cent. In this case, the series for New Castile suffers more than the rest of the sample with a subsistence crisis taking place once every 9.8 years. The periodicity increases to 10.6 years in the case of Andalusia, 36.8 in Navarra and 69 years in the case of Barcelona.[191] The results of Reher suggest that an internal grain Market in New and Old Castile did indeed exist in the eighteenth century. The proof is a clear

[185] Llopis, and Jerez, "El mercado"
[186] Llopis, and Socota, "Antes"
[187] Llopis, and Socota, "Antes", p.30.
[188] Llopis, and Socota, "Antes", p.25.
[189] Reher, "Producción"
[190] Reher, "Producción", p.550.
[191] Reher, "Producción"

correlation between the variations of prices in Toledo, Segovia and Leon. In fact the production of grain in each region also has an influence in the price series of the neighbouring provinces, pointing to the existence of an internal grain market.

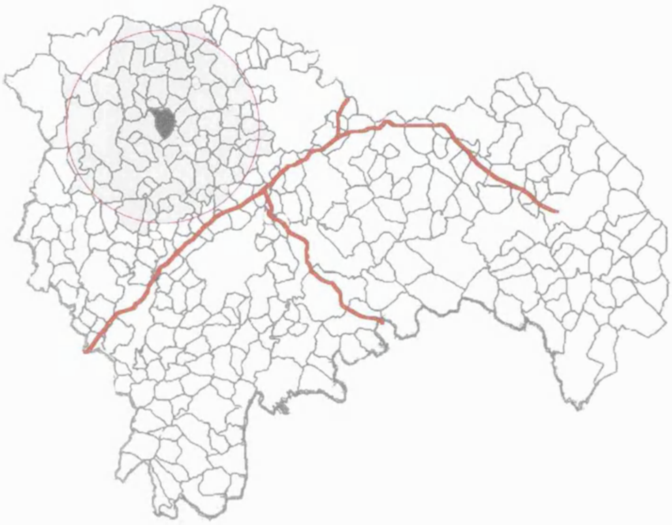
8.4.2 Economic integration analysis. A cross section approach.

The results in section 8.3 presented the existence of a puzzle, showing that a province like Guadalajara with the highest coefficient of variation of wheat prices had at the same time the lowest average price. The answer to this puzzle can shed some light on the distribution of wheat prices in New Castile. The level of prices depends on two factors; the supply of grain and its demand. In other words the exchanges carried out in the markets define the price levels of the product that is being exchanged. In order to check the state of the grain markets in New Castile, we decided to carry out a study of economic integration of wheat prices. The methodology was simple, taking a radius around each village and town and measuring the volatility of the prices within it. There are several volatility measurements, like the variation or the standard deviation. However, to allow fair cross section comparisons, we decided to use the coefficient of variation that standardizes volatility in percentages. The size of the radius chosen was 50 kilometres, for which there are good reasons for this choice. According to Ringrose, most of the trade of wheat took place within this range and it allows us to also include the effects of the "peasant carrier" defined by Uriol.[192]

The following map presents an example of how the coefficient of variation is calculated for a municipality. A circle with a 50 kilometres radius is located with its centre in the geographical centre of the municipality that is under analysis. Then all the villages and towns whose geographical centre is included within the circle are considered and a coefficient of variation of the prices in all these municipalities is calculated. That coefficient is then associated to the municipality that is in the centre of the circle. The exercise is repeated for each one of the 1,119 municipalities in the six provinces.

[192] Ringrose, *Madrid*, p.25.

Figure 8.18: Example of calculation of economic integration levels



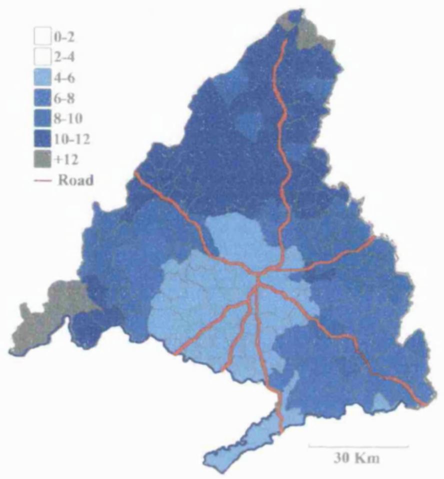
The results for the six provinces of New Castile are presented in the following map, together with the main roads that had been identified by the road map of 1751 from Martin Escudero.

Figure 8.19: Coefficient of variation of wheat prices in New Castile, mid 18th century

Sources: Own calculations from the Catastro de la Ensenada

The results present very clear patterns and the integration effects of some of the main roads are equally clear. As in the case of the analysis of the distribution of prices, a provincial analysis can help us to better understand the results for New Castile as a whole.

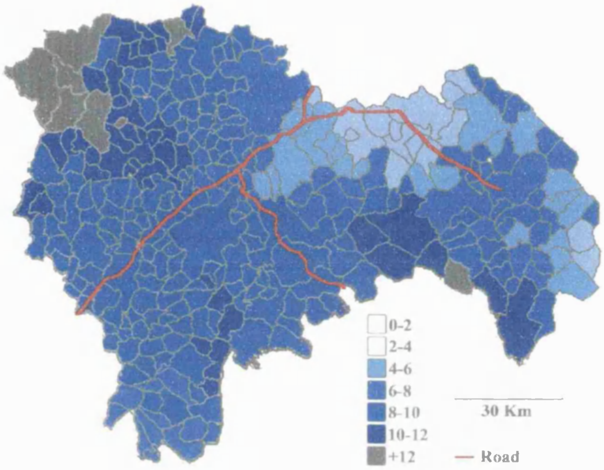
Figure 8.20: Coefficient of variation of wheat prices in Madrid, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

In the province of Madrid, the integration effects of the capital in the provincial economy are very clear. The maximum levels of economic integration are reached in the city of Madrid and its hinterland, which decreases as distance increases from the capital. This effect is especially strong in the north and west of the province. A possible and probable explanation of this situation is the geographical nature of the area. The western border of Madrid contains the Guadarrama Mountains that historically have divided Madrid from Old Castile. It is easy to understand how the existence of this barrier could increase transport costs producing a negative impact in the integration levels of the area.

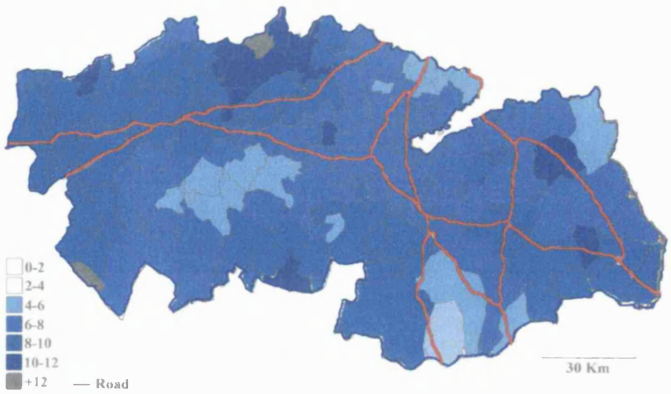
Figure 8.21: Coefficient of variation of wheat prices in Guadalajara, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

In the case of Guadalajara the highest levels of integration are located in the northern centre of the province. The other extreme can be found, as in the case of Madrid, in the north-western area that again coincides with a natural barrier. In this case the Guadalajara Mountains that connect with the Guadarrama Mountains in the north of Madrid. Transport costs may again play an important role given the difficulties of moving grain through the rough lands of northern Guadalajara.

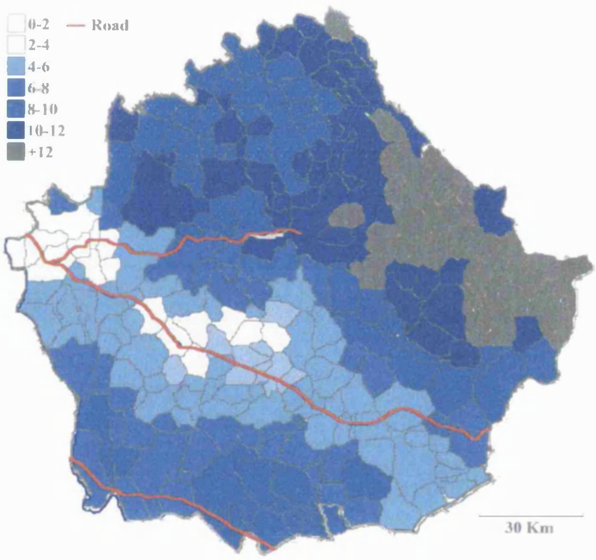
Figure 8.22: Coefficient of variation of wheat prices in Toledo, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

Although the picture in the province of Toledo is more heterogeneous, some clear patters can also be identified. The centre of the province presents the highest levels of economic integration as well as the villages bordering the province of Madrid in the north where the integration effects of the capital are still present. On the other hand, the highest volatility levels are located in the northwest of the province, coinciding once more with a natural barrier, the southern continuation of the Guadarrama Mountains in Madrid. The effect of the other chain of mountains in the south of the province is also clear, the Mountains of Toledo in the southern centre.

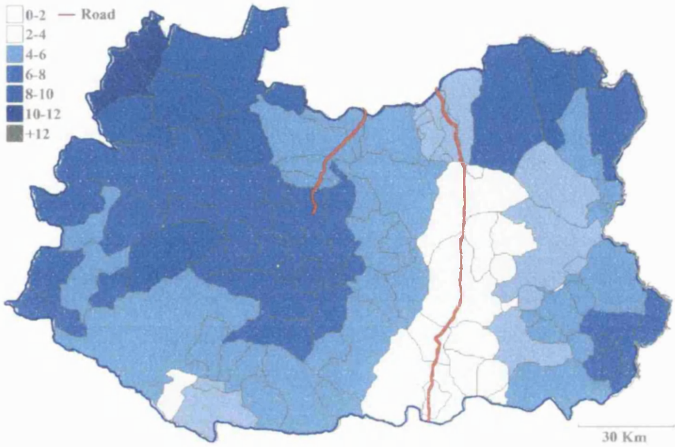
Figure 8.23: Coefficient of variation of wheat prices in Cuenca, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

In the province of Cuenca the centre and south of the province present the highest levels of economic integration, in many cases so high that the coefficients of variations of the prices are 0. The volatility of prices increases as we move away from the centre, especially in the north and east of the province. The lowest levels of economic integration again coincide with the existence of mountains, in this case the Iberian Mountains that occupy all the eastern border of Cuenca and that cover an important extension of the province.

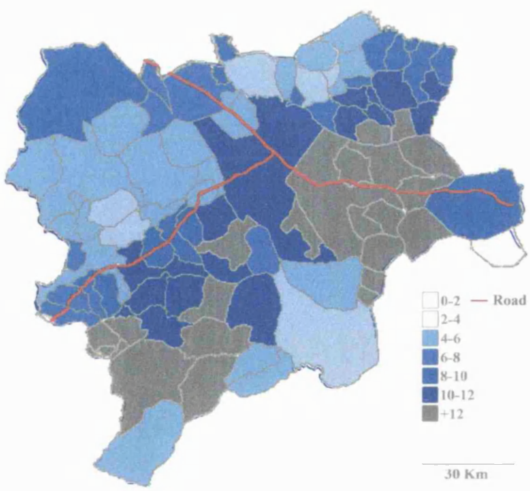
Figure 8.24: Coefficient of variation of wheat prices in Ciudad Real, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

Ciudad Real is according to the results the province with the lowest volatility in wheat price of New Castile. The provincial map clearly highlights this fact, with coefficients of variation relatively low. The only exception is the north-western corner of the province that is the southern continuation of the Mountains of Toledo previously described.

Figure 8.25: Coefficient of variation of wheat prices in Albacete, mid 18th century

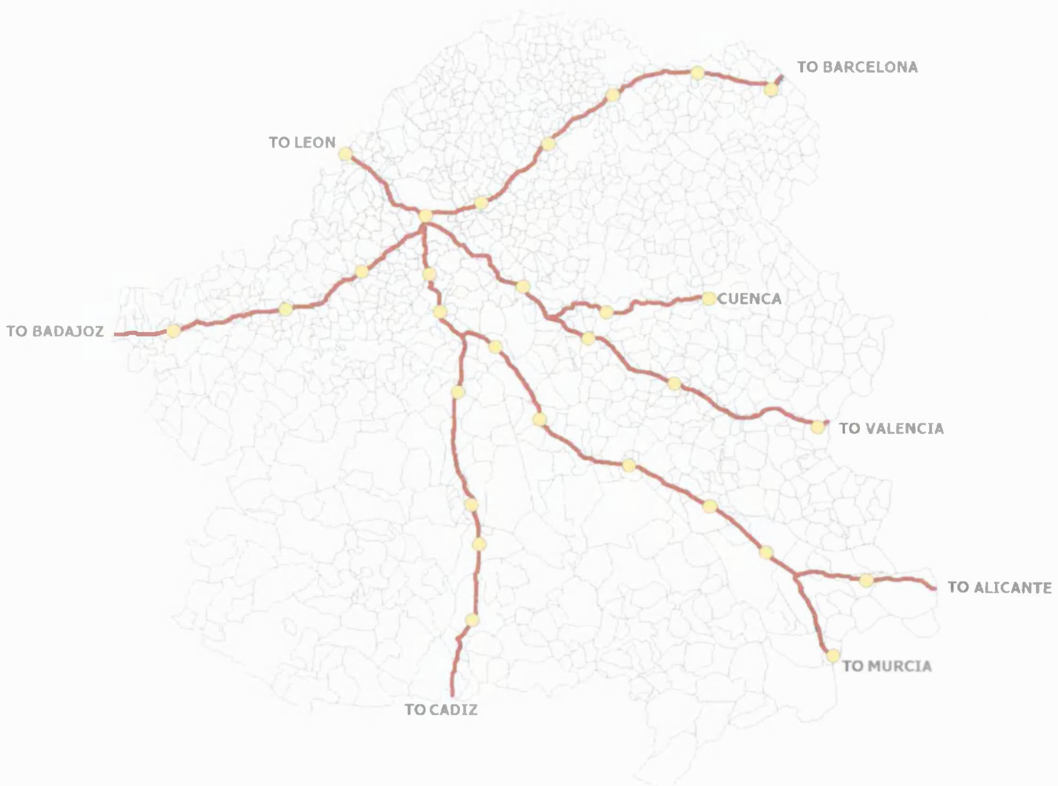


Sources: Own calculations from the Catastro de la Ensenada

Finally, as in the case of prices, the province of Albacete is the most striking of the six. Most of the province has very high volatility values, mainly located around a straight line that divides the province by half from southwest to northeast. The North however enjoys lower volatility, as do some of the municipalities in the south. The explanation of this situation however can be the same as the low integration values in the other five provinces, namely geography. The darker areas in the provincial map are the regions occupied by the Mountains of Alcaraz that compose the northern border of the Betic Mountains and therefore are areas where we expect higher transport costs and therefore lower economic integration levels.

However, the economic integration along the roads is as interesting as the one around a municipality. To what extent were the different roads being used to transport wheat? As it was explained in section 8.1, the eight main roads connecting Madrid with the rest of Spain are the ones that go from the capital to Barcelona, Cuenca, Valencia (through Utiel), Murcia, Alicante-Valencia, Cadiz, Badajoz-Lisbon and Leon. We have analyzed the layout of the eight main roads in New Castile, including the number of days that were necessary to complete the journey as well as the municipalities where the daily stops were recommended. The following map summarizes the results where the yellow dots indicate the daily stops.

Figure 8.26: Main roads in mid-eighteenth century New Castile



Sources: Uriol (1980)

The average prices of wheat and the coefficient of variation of the prices along each road were also measured. The results are presented in the following table taking into account the prices in all the municipalities that exist along the roads in the six provinces.

Table 8.9: Integration of wheat prices along the main roads of New Castile, mid 18th century

	Barcelona	Cadiz	Valencia	Alicante
Coefficient of Variation	14.1	8.3	6.6	11.7
Average Price	15.7	18.2	18.3	18.1
	Murcia	**Badajoz**	**Leon**	**Cuenca**
Coefficient of Variation	12.5	6.7	9.6	10.1
Average Price	18.3	18.2	18.9	18.3

Sources: Own calculations from the Catastro de la Ensenada and Uriol (1980)

As table 8.9 shows, the maximum volatility was located in the road connecting Madrid with Barcelona, while the lowest variability in prices took place in the road between Madrid and Valencia. The road with the highest average price is the one to Leon with 18.9 reales per fanega of wheat, while the one with the lowest average price is Barcelona with just 15.7 reales. All the average prices are very similar in all the roads and with the exception of Barcelona the range is very small between the 18.1 reales of Alicante to the 18.9 reales of Leon. We can therefore conclude that having a smaller coefficient of variation, the road to Leon had a stronger integration power than, for instance, the road to Barcelona. However, this comparison would be biased by the size of the price sample in each road. The road to Leon has not more than 50 km in New Castilian territory, while the road to Barcelona crosses Madrid and most of Guadalajara. It is therefore not surprising to see a higher volatility on the road to Barcelona that may be nothing but a simple statistic effect, a consequence of a calculation that includes more observations.

To solve this problem we decided to divide all the roads into comprehensible and more importantly into comparable segments, two days of journey being the standardized unit. Therefore, each road was divided into segments of two days of journey starting in Madrid. The problem with this standardization is that it minimizes the effects of very long distance trade, while it highlights the importance of short and mid distances trade. We know that most of the grain trade that took place in eighteenth century New Castile was short and medium range and that most of that was carried out by peasants in pack animals. A carrier with pack animals could travel as much as 8 leagues every day and most of the commercial exchanges took place within a radius of 100 kilometres. Therefore, the choice of two days of travel or 100 km would be ideal to calculate the effects of most of the internal grain trade in New Castile. Each one of the recommended stops in Escrivano's road guide that are displayed in figure 8.26, were separated by one day of journey in each road. Therefore, we used these stops as a benchmark to gather the price samples for every segment in every road. Then we calculated the coefficients of variations for the prices in each segment. The results are presented in the following table.

Table 8.10: Coefficients of Variation for every 2 days of journey, mid 18th century

	Barcelona	Cadiz	Valencia	Alicante
1st and 2nd day	9.1	10.0	9.9	8.6
2nd and 3rd day	12.5	11.3	0.0	8.6
3rd and 4th day	6.5	6.0	0.0	7.7
4th and 5th day	2.2	0.0		11.0
5th and 6th day		0.0		9.5
6th and 7th day				8.6
	Murcia	**Badajoz**	**Leon**	**Cuenca**
1st and 2nd day	8.6	5.4	9.6	10.3
2nd and 3rd day	8.6	7.3		4.4
3rd and 4th day	7.7	6.2		
4th and 5th day	11.0			
5th and 6th day	9.5			
6th and 7th day	7.6			

Sources: Own calculations from the Catastro de la Ensenada and Uriol (1980)

In many cases, the volatility of prices increase as we move away from Madrid, until reaching a maximum value that in the case of Barcelona, Badajoz and Cadiz takes place in the 2nd and 3rd day. In the case of Murcia and Alicante, this increase does not take place until the 4th day of the journey. However, in all the cases and after this maximum the volatilities tend to be reduced to reach values even smaller to those next to the capital.

A good way to compare the volatility of the prices along the whole roads is to average the coefficients of variation for every segment. After following this system, the results for every road are presented in the next table.

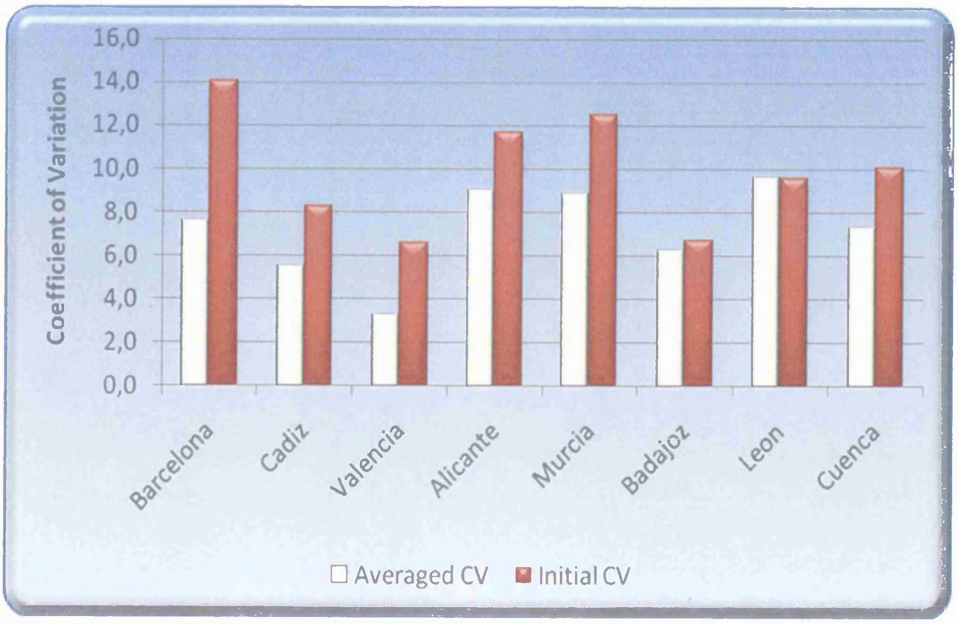
Table 8.11: Integration of wheat prices along the main roads of New Castile, mid 18th century

	Barcelona	Cadiz	Valencia	Alicante
Averaged CV	7.6	5.5	3.3	9.0
	Murcia	**Badajoz**	**Leon**	**Cuenca**
Averaged CV	8.8	6.3	9.6	7.4

Sources: Own calculations from the Catastro de la Ensenada and Uriol (1980)

If we compare these results with the initial coefficients of variation presented in table 8.9, we can see that there was in fact a statistical effect that overvalued the volatility in some of the longer roads, especially in the one to Barcelona, but also to Cadiz, Valencia, Alicante, Murcia and Cuenca. In the case of Badajoz, the volatility remains practically at the same levels, while in the case of Leon being exactly the same sample for just one day of journey, the results are also the same.

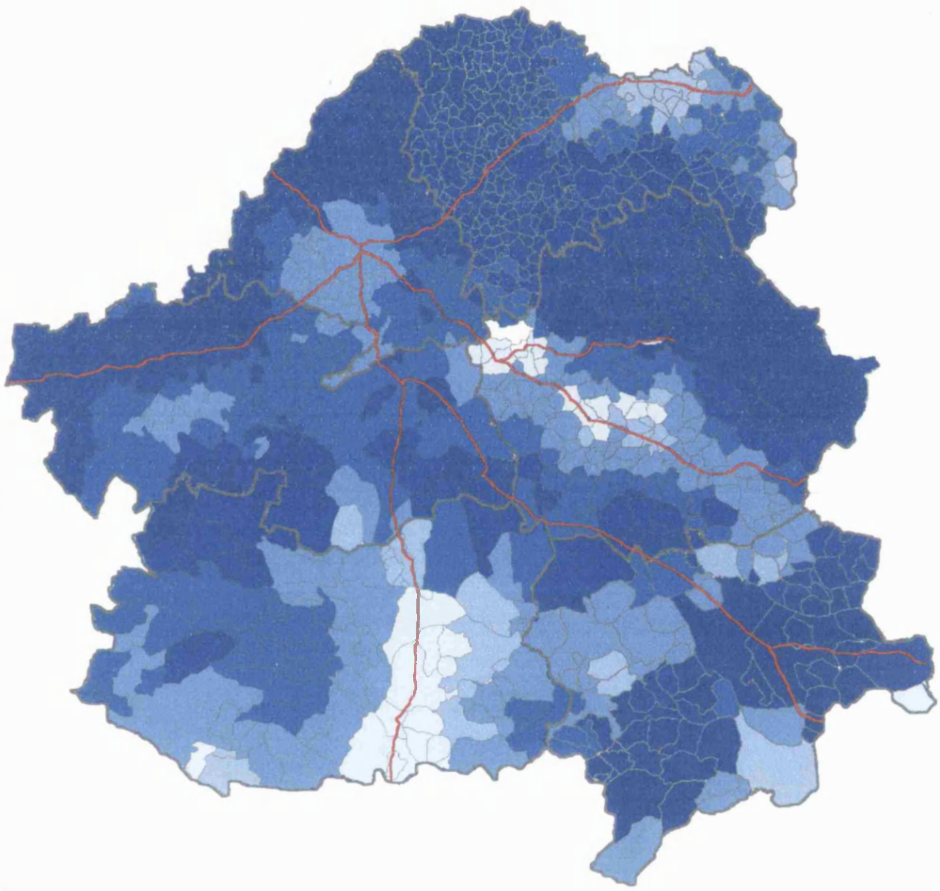
Figure 8.27: Integration of wheat prices along the main roads of New Castile, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada and Uriol (1980)

Therefore, the new averaged coefficient of variation is a good instrument to measure the levels of economic integration along the eight roads. The conclusions indicate that the road to Valencia is the most integrated in the grain markets of New Castile, followed by the road to Cadiz, Badajoz and Barcelona. Finally the roads to Murcia and Alicante are the ones that have higher volatility levels, followed by the roads to Cuenca and Leon. The following map presents the coefficients of variation in every municipality and the eight main roads.

Figure 8.28: Coefficient of variation of wheat prices in New Castile, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

8.4.3 Economic integration. Time series

The creation of railroads in the nineteenth century has been considered by the literature to be the driving force that integrated previously isolated markets in Spain. Commercial transactions within a country are based on price differences and therefore the possibility of arbitrage. In a market economy, the price differential between two locations is defined by transport and transaction costs of moving a particular good between both places. Therefore, a reduction in transport costs like the appearance of the railway should have increased the internal trade of grain and therefore the levels of economic integration. However, recent studies suggest that contrary to the traditional belief, grain markets in Spain already have high integration levels as early as the first decades of the eighteenth century. [193]

The integration process continued during the three first quarters of the eighteenth century, taking advantage of the liberalization of grain trade supported by the laws of 1755, 1756 and 1765. It was around the 1770s when the maximum levels of economic integration were achieved in the Spanish economy.[194] One of the most important consequences of this integration was the reduction of price volatility.[195] The integration process at a national level stopped in the last quarter of the century when the national market of wheat collapsed between then northern and the southern series. However, if the series are divided into two different groups, then the trends are different. The correlations between the series in Andalusia, the eastern coast and the interior increased during the late eighteenth century, while prices in Catalonia and the north of Spain diverged from the rest of the country.[196] A possible explanation of this process is the rise of international grain trade, especially in Catalonia.[197]

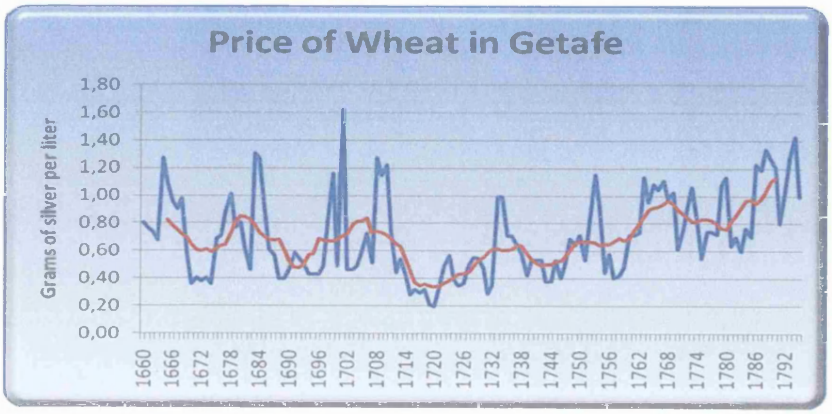
The information from the Catastro is ideal for a cross section analysis of economic integration, but is not suited to time series analysis. There are no long term price series for wheat in Madrid and the closest available series is the one gathered by Hamilton for Toledo.[198] To solve this problem and allow a time series analysis of economic integration, we gathered an original price series for wheat for Madrid.

The sources are the accounting books of the parish of Getafe, in the south of Madrid. On its accounting book, the parish kept records of different transactions to maintain itself including the sales of grain that had been collected from its own domains directly or in form of taxes like the tithe. The records provide yearly information of these transactions including the amount of grain sold in the market, as well as the payment that was received in exchange. The original series were collected in reales per fanega of wheat sold. To make the series comparable with other series available in Spain, all the values were transformed into grams of silver per litre of wheat, a transformation that also solves the problems that could appear with having the series in currency

[193] Llopis and Socota, "Antes"
[194] Llopis and Socota, "Antes"
[195] Llopis and Socota, "Antes", p.246.
[196] Llopis and Socota, "Antes", p.234.
[197] Llopis and Socota, "Antes", p.250.
[198] Hamilton, *War*

instead of its proper value in precious metals. The series obtained for wheat in the parish of Getafe are presented in the following figure including a nine years moving average.

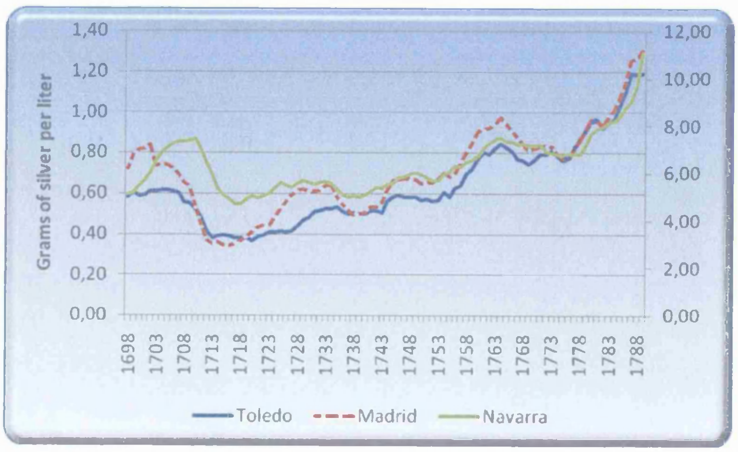
Figure 8.29: Price of Wheat in Getafe (Madrid) 1660-1800



Sources: Accounting books of the church of Santa Maria Magdalena (Getafe)

The series show two main trends; the first one between 1660 and 1720 when the prices of wheat where falling from 0.8 grams of silver per litre to 0.4 grams, and a second one of increasing inflation from the previous value of 0.4 to more than 1 gram of silver per litre in the late eighteenth century. However, how well does this series relate to the other available in the interior of Spain? We can compare it with the series for Toledo from Hamilton previously mentioned in the text and with the series of Navarra collected by Arizcun Cela.[199] The results for the period 1698-1788 are presented in the next figure.

Figure 8.30: Price of Wheat in Madrid, Toledo and Navarre 1698-1788 (9 years moving average)



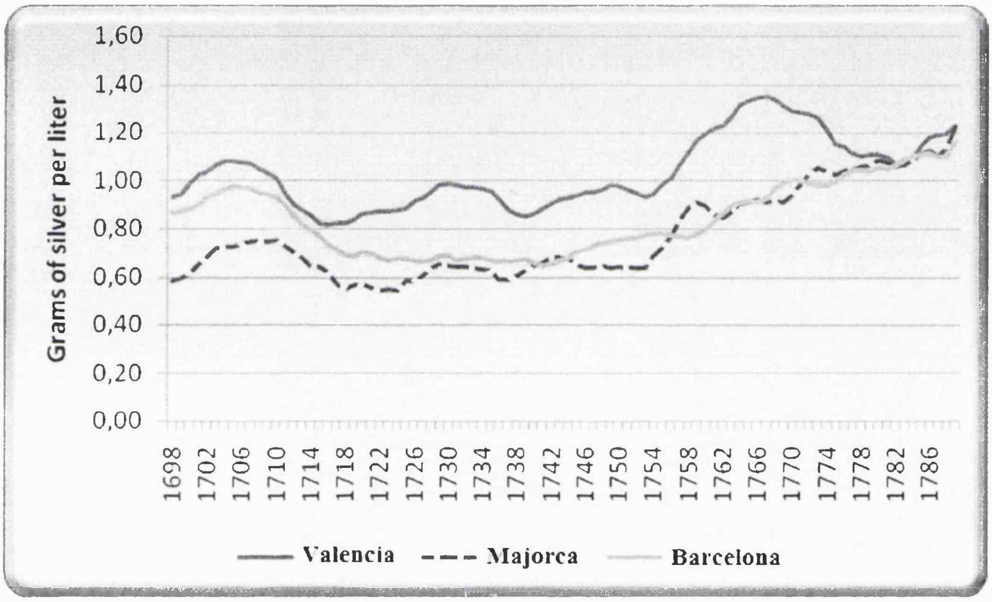
Sources: For Toledo Hamilton (1947), For Madrid own estimation, for Navarre Arizcun Cela (1989)

199 Arizcun Cela, A., *Series Navarras de Precios de Cereales: 1589-1841* (Madrid: Ed. Banco de España, 1989)

In all the cases, the series reaches an absolute minimum in the years surrounding 1720, followed by a sustained inflationary process that will end up seeing prices in Toledo multiplied by three and the ones in Navarra more than doubled.

To widen the analysis of long distance trade of wheat in Madrid, we added three more coastal series, from Barcelona, Valencia and Majorca. The three series for the period 1698-1788 are presented in the following figure.

Figure 8.31: Price of Wheat in Valencia, Majorca and Catalonia 1698-1788 (9 years moving average)



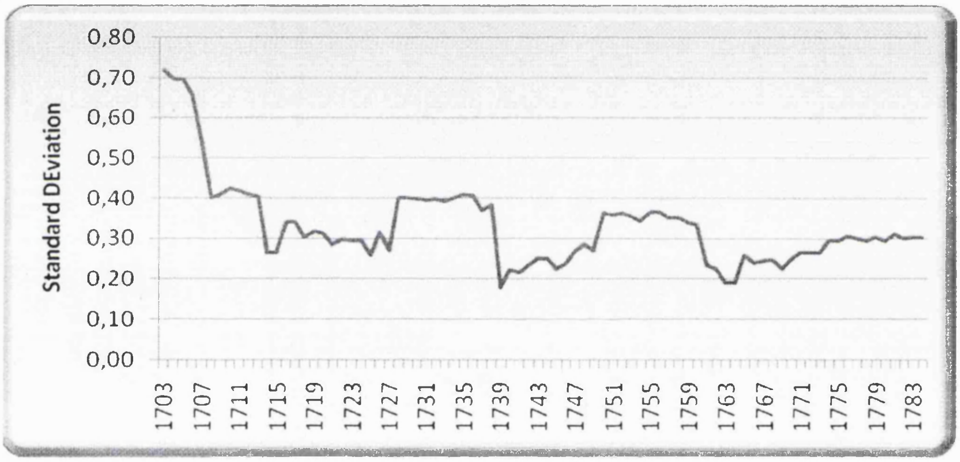
Sources: Feliu (1991), Ardit (Personal Communication) and Hamilton (1947)

As in the case of the inland series, the series in Valencia and Majorca reach an absolute minimum in the early second decade of the eighteenth century that is delayed to the 1740s in the case of Barcelona. After the decline, the series increase substantially in each case until the end of the eighteenth century, with wheat prices in Valencia increasing by 50 per cent, in Majorca by 100 per cent and in Barcelona by 70 per cent.

There are several ways to measure the levels of economic integration between different price series. If a place like Madrid is becoming more integrated with other markets, then we can expect a reduction in the volatility of the series. In the same way, we would expect an increasing synchronization of the prices between the different markets with similar movements. We decided to measure the volatility by calculating the standard deviation of the logarithmic rates of variation, and the synchronicity of every pair of markets with the correlation coefficient of the same logarithmic rates of variation. This methodology has been extensively used by academics to measure integration processes in modern Spain and its properties and benefits largely explained in the available literature.[200]

The standard deviation for the logarithmic rates of variation of the Getafe series is presented in figure 8.32 using a 9 years moving average. The results show a very high volatility during the first decade of the eighteenth century. However, the situation changes rapidly and in the second decade of the century volatility levels fell considerably, to levels that would prevail until the end of the series in the 1780s. There are however two peaks in the periods 1727-1738 and 1750-1760 when the volatility of prices increased.

Figure 8.32: Standard deviation of wheat prices in Getafe (Madrid) 1703-1783



Sources: Own calculations from accounting books of the parish of Santa Maria Magdalena (Getafe)

The different price series presented above were analysed by dividing the time series in four different periods and the criterium to select them has mainly been a political one. The series start in 1698 and therefore that was the reason for the starting point and the years 1725, 1745, 1760 and 1789 where the years with a change of monarch in Spain. This was important because every ruler had a different view and produced different legislations about improvements of transport, creation of national grain markets, or taxation that where deeply influenced by the counsellors and ministers. The four rulers of Spain whose reigns have been analysed are Philip V, Louis I, Ferdinand VI and Charles III.

The analysis of the six series by different periods present different trends. The three inland series, Madrid, Toledo and Navarra have an average volatility higher to the levels reached in the coastal

[200] Llopis and Jerez, "El mercado", Llopis, "Antes"

series. However, the eighteenth century was a period of convergence, especially in the case of Madrid that reduced the gap with the coastland regions by half.

Table 8.12: Standard deviation of wheat price series

	MADRID	TOLEDO	NAVARRA	VALENCIA	MAJORCA	BARCELONA
1698-1725	0.50	0.35	0.24	0.14	0.13	0.19
1725-1745	0.32	0.27	0.17	0.12	0.14	0.27
1745-1760	0.33	031	0.24	0.10	0.08	0.24
1760-1789	0.26	0.30	0.16	0.13	0.10	0.18

Sources: Own calculations from Hamilton (1947), Arizcun Cela (1989), Feliu (1991) and own estimations.

Table 8.13 presents the cross correlation coefficients of the logarithmic rates of variation for every price series with the prices from Madrid, that is a proxy of the level of economic integration. The series were transformed into logarithms and the distance between the different locations if considerable, so correlations above 0.3 could be considered a moderate level of economic integration.[201] In the case of Toledo, the correlation was already high in the early eighteenth century, although the connection between both markets would be significantly reduced during the late reign of Philip V and the reign of Ferdinand VI only to recover strongly during the period 1760-1789 under Charles III. Valencia and Barcelona do not have a high correlation with the prices in Madrid during most of the eighteenth century and it was not until the reign of Charles III when the correlation coefficients seem to indicate moderate integration between the capital city and the two coastlal locations. As in the case of Toledo, there was also a strong correlation between the prices in Madrid and the prices in Majorca until the late eighteenth century when the relationship is broken. However, given the lack of integration between the mediterranean coast and Madrid, it is unlikely that the correlation between Madrid and Majorca was consequence of real trade between both locations. Finally, the series of Navarra only presented a significant correlation during the second reign of Philip V between 1725 and 1745, loosing any contact with Madrid before and after that period.

Table 8.13: Cross correlation coefficients with the Madrid series

	TOLEDO	VALENCIA	BARCELONA	MAJORCA	NAVARRA
1698-1725	0.40	0.01	-0.24	0.46	0.01
1725-1745	0.25	0.21	0.14	0.44	0.49
1745-1760	0.29	-0.17	-0.43	0.39	-0.20
1760-1789	0.68	0.31	0.34	-0.07	0.03

Sources: Own calculations from Hamilton (1947), Arizcun Cela (1989), Feliu (1991) and own estimations.

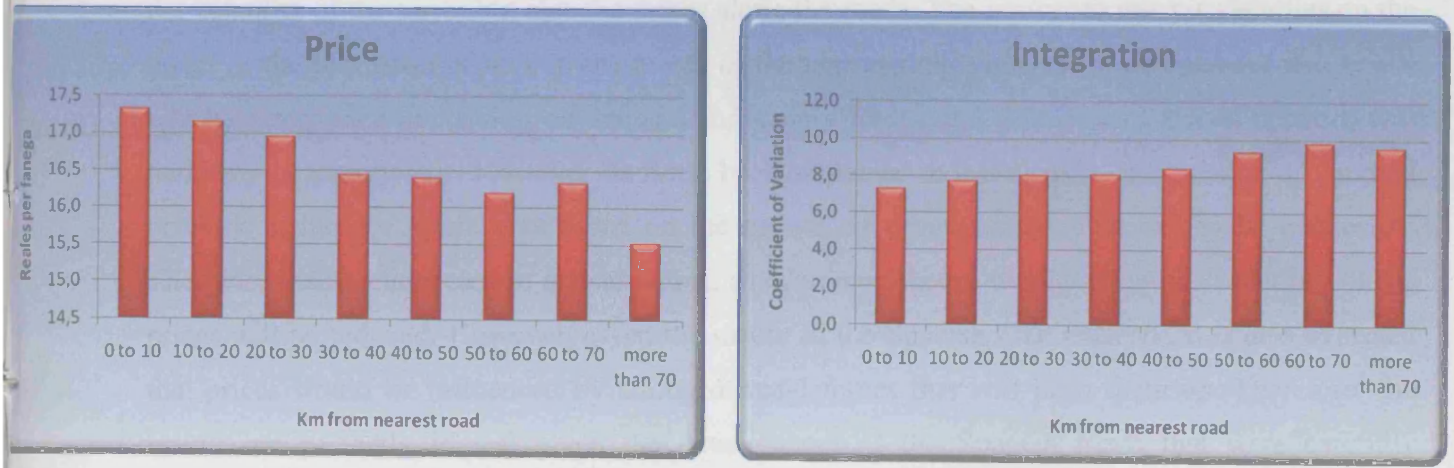
[201] Llopis and Jerez, "El mercado"

Therefore, in summary, it was not until the reign of Charles III between 1760 and 1789 when the capital of Spain intensified its commercial links with some of the main cities of the country, including the ones in the eastern Mediterranean coast like Barcelona and Valencia. The reasons are probably the intense construction works that where carried out by Charles III and that dramatically improved the connections of the capital with the periphery.

8.5 The geography of wheat prices in New Castile

After studying the transport network and the economic integration of wheat prices in New Castile, we can move a step further trying to explain the distribution of the prices in the six different provinces and the forces behind it. Economic intuition predicts that the further we move from a road, the lower the level of economic integration will be as a consequence of increasing transport costs. To test this hypothesis we divided the 1,118 municipalities according to their distance from the nearest road, and then in a cross section analysis calculated the average price levels and the coefficient of variation of the sample. The results are presented in the following figures.

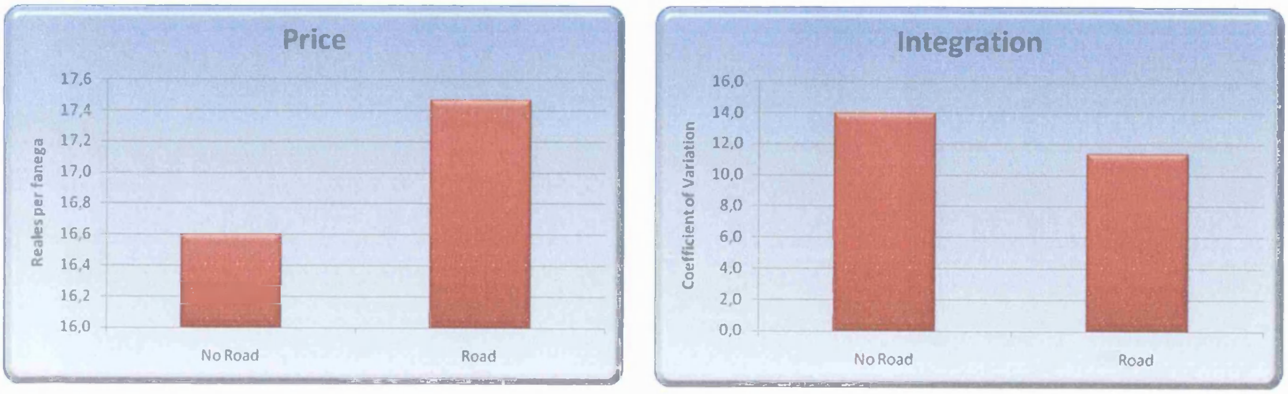
Figure 8.33: Price and economic integration by distance to road (New Castile) early 1750s



Sources: Own calculations the Catastro de la Ensenada.

As expected, the volatility of the series constantly increases as we move away from the nearest road. In the case of average price levels, the situation is interesting, as it is those municipalities that are closest to the roads the ones that have higher prices. A more interesting analysis would be the comparison between two subsamples, one including those municipalities that have a road and a second one with those municipalities that did not have direct access to one. The results for the average price and coefficient of variation of both subsamples are presented in the following figures.

Figure 8.34: Price and economic integration by access to road (New Castile) early 1750s

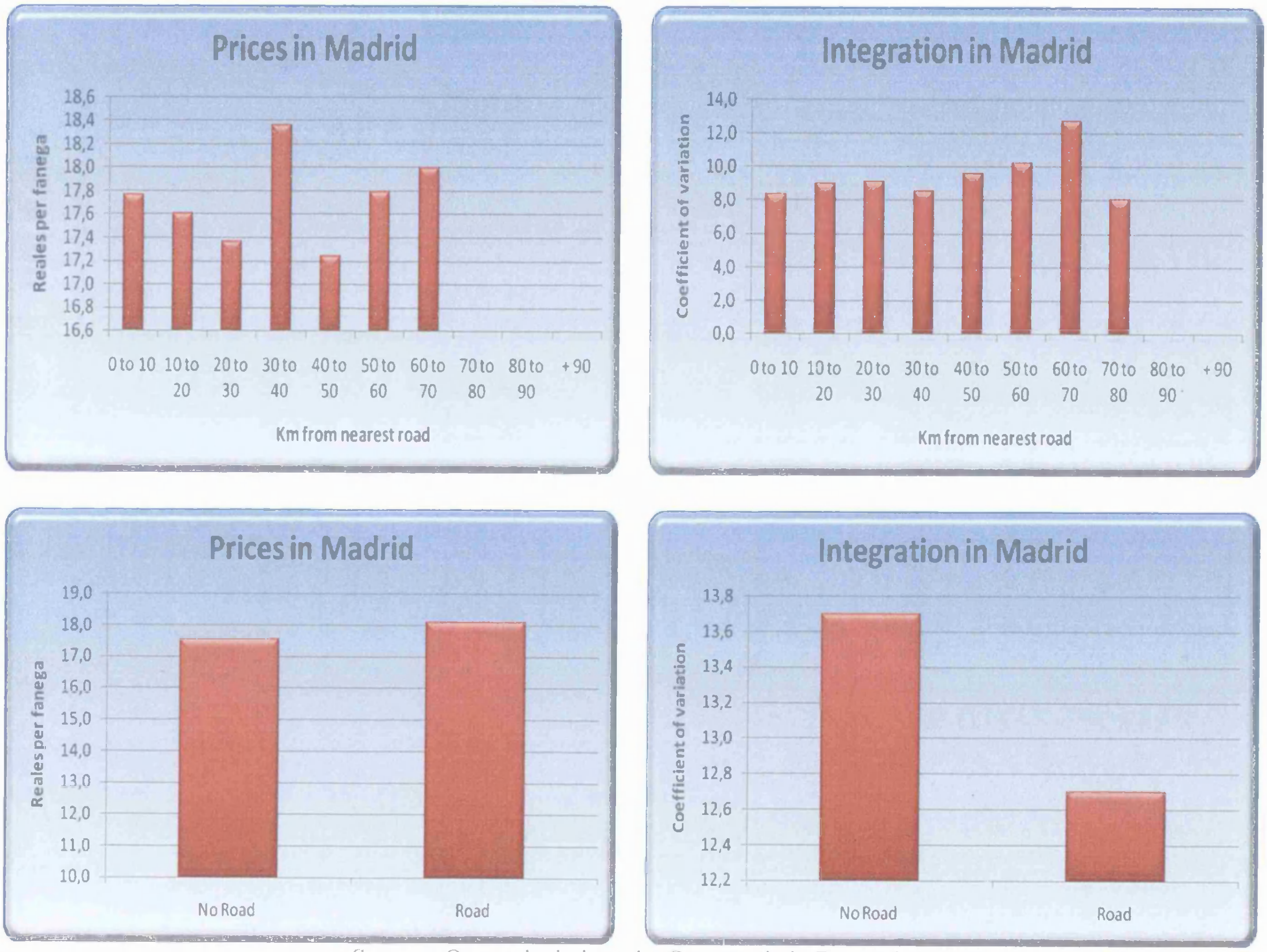


Sources: Own calculations the Catastro de la Ensenada.

As expected from the previous figures, the economic integration in the municipalities that have direct access to a road is higher than the integration in municipalities that do not have it. In the case of average prices, also as predicted by the previous figures, the prices are higher in municipalities with roads, while those without direct access to one enjoy lower price levels. This situation is puzzling, as we would expect that increasing levels of economic integration would not only reduce the volatility of the series but also the prices along the roads. The answer to this puzzle relies on the effect of the big urban centres in the prices of the surrounding villages. If we consider that prices will be determined depending on demand and supply forces, the existence of a road network will facilitate the supply side. However, as it has been explained in this chapter, the creation of the road network in interior Spain was based on the growth of urban centres that had to be connected. Therefore, being connected to a road meant, as economic theory predicts, that the volatility of the prices will be reduced. However, given the nature of the Spanish road network, it is also expected that prices would be influenced by strong demand forces that will push them up. Therefore, the results are perfectly logical given the development of the Spanish roads that were carefully explained above. Being connected to the network had some positive effects in terms of volatility, although it also meant that the municipality had higher prices affected by the influence of the big urban centres that were the core of the transport network.

Moving the analysis to the provincial level, in the province of Madrid prices were strongly affected by the effects of the capital. The high prices that can be seen in the range of 30-40 kilometres reflect the effect of the capital on the villages that surround it but that are not directly connected to the main road network. The volatility of prices on the other hand behave as expected, with economic integration being more intense in those villages that are closer to the main roads. If we divide the sample into villages with and without a road, then the results are clearer, with the effects of Madrid increasing the average price of wheat in the villages connected to it and the reduction in the volatility as consequence of lower transport costs. In Madrid, being connected to the road network meant that prices were on average a 3 per cent higher. However, being part of the network also means that price volatility was 1 per cent lower than in those municipalities without roads.

Figure 8.35: Price and economic integration by proximity and access road (Province of Madrid) early 1750s

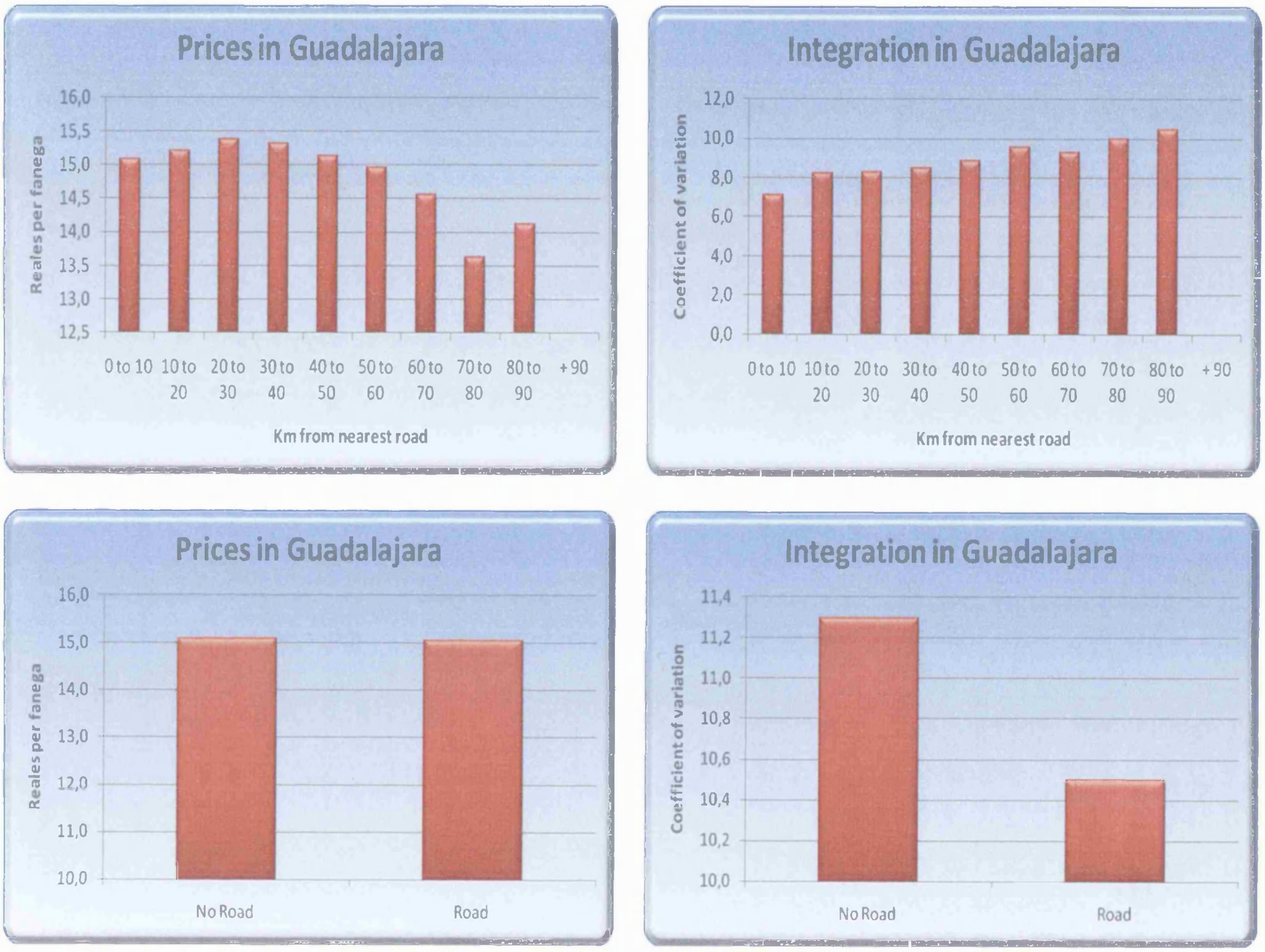


Sources: Own calculations the Catastro de la Ensenada.

Sources: Own calculations the Catastro de la Ensenada.

The case of Guadalajara follows the general pattern more clearly. The maximum prices however are not reached in the villages closest to the roads but rather in those situated within 20 to 30 kilometres to the main road network. In terms of volatility, the effect of the roads is however clearer and those villages located close to the roads are the ones that have lower coefficients of variation. On average, prices and volatilities in villages with and without a road are practically the same, with prices being 0.2 higher per cent in municipalities without a road and volatilities 0.8 per cent higher.

Figure 8.36: Price and economic integration by proximity and access to the road (Guadalajara) early 1750s



Sources: Own calculations the Catastro de la Ensenada.

In Toledo prices are clearly higher in the villages that are closer to the road network, with the maximum price being reached in those that either had a road or had one within 10 kilometres. The volatility of the sample however has a different pattern, being the minimum achieved in the municipalities that were within 50 to 60 kilometres away from the nearest road. If we divide the sample by direct access to a road then the results are the same than in previous cases, being the price of the municipalities with a road a 3.6 per cent higher and their volatility 0.2 per cent lower.

Figure 8.37: Price and economic integration by proximity and access to road (Toledo) early 1750s

Sources: Own calculations the Catastro de la Ensenada.

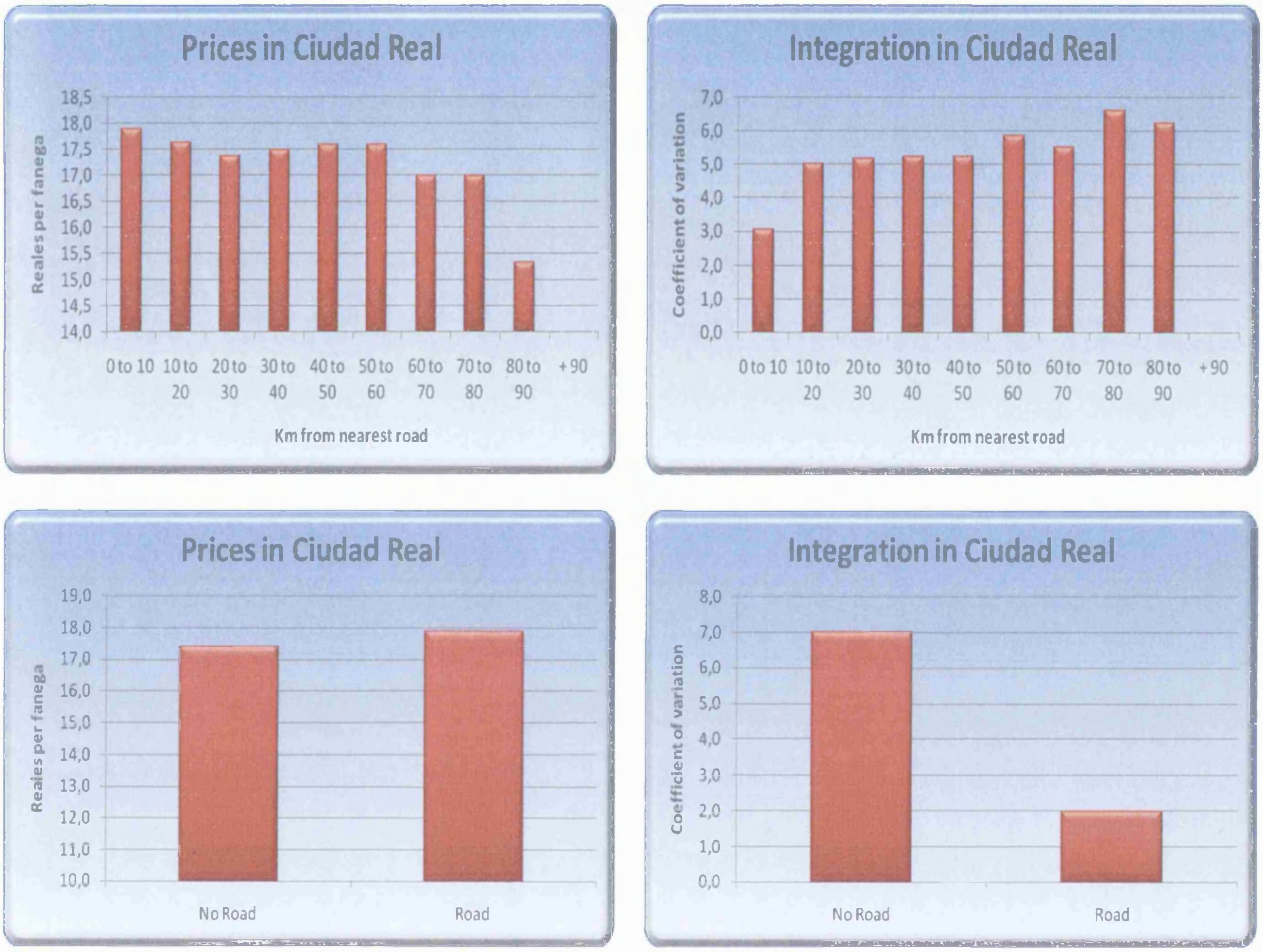
The province of Cuenca is one of the clearest cases of the study. The effect of the Madrid-Valencia road is very strong and the prices in the villages closer to the road were higher and also had lower volatilities. Being directly connected to the road network was associated with a 6 per cent rise in price and a volatility that decreased by two thirds.

Figure 8.38: Price and economic integration by proximity and access to road (Cuenca) early 1750s

Sources: Own calculations the Catastro de la Ensenada.

Ciudad Real, as in the case of Cuenca, is a clear case where the effect of a main road is strong, the road in question being that connecting Madrid with the south of Spain. The prices near to the road were higher and the volatility lower. Where there was direct access to a road, the prices increased by 2.7 per cent but on the other hand volatility decreased by 5 per cent.

Figure 8.39: Price and economic integration by proximity and access to road (Ciudad Real) early 1750s



Sources: Own calculations the Catastro de la Ensenada.

Finally, the province of Albacete is again the most puzzeling. There is no clear relationship between the distance to the nearest road and the level of prices or the volatility of the series. If we divide the sample between municipalities with and without direct access to the main roads, then the situations are also very similar. Those villages connected to a road had prices that were 1 per cent higher and volatilities that were 1 per cent lower.

Figure 8.40: Price and economic integration by proximity and access to road (Albacete) early 1750s

Sources: Own calculations the Catastro de la Ensenada.

The conclusions of the provincial analysis can be summarised in the results presented in table 8.14. The variable handicap price measures the how the price of wheat changes in percentage if the municipality is connected to a road. In the same way the variable bonus road measures how the coefficient of variation changes when the municipality is connected to the road network. For instance, in the province of Cuenca the price of wheat was 6.1 per cent higher in the villages and towns connected to a road, and the coefficient of variation of wheat prices 6.8 points lower.

Table 8.14: Bonus and handicap of having access to the road network

	Madrid	Cuenca	Toledo	Guadalajara	C. Real	Albacete
Handicap Price	1	6.1	3.6	-0.2	2.7	1
Bonus Road	-1.0	-6.8	-0.2	-0.8	-5.0	-1.3

Sources: Own calculations the Catastro de la Ensenada.

The villages in Cuenca and Ciudad Real that connected to the road network have to face a higher price. However, they also benefited from the integration advantage that the roads provided and had lower volatilities than the villages that were not connected. The cases of Madrid and Albacete were similar but for different reasons. In Madrid, the proximity of the capital and the extension of the road network limited its effects on the gap between connected and unconnected municipalities. In the case of Albacete, the reason was probably the lack of use of its roads, a hypothesis that has been supported in this previous sections and that also seems to be sustained by these results. Villages connected to the network in Toledo had to pay higher prices but the bonus received in terms of reduced volatility were smaller. Finally, as in the case of Albacete, Guadalajara was almost not affected by the presence of roads and in fact was the only province where those villages without a road had higher prices than those with direct access to one.

We can however present a more detailed analysis of the six provinces. The following table presents the main variables included in the dataset for New Castile.[202] For each province 8 variables were analysed; the average distance of a village to the nearest road in km (Km Road), the reduction in the volatility of prices for having a road (Bonus Road), the number of big towns within a 50 kilometres radius (50), the number of big towns within a 100 kilometres radius (100), the average time in hours to walk one league (Hours),[203] the coefficient of variation of the price of wheat within a 50 kilometres radius (Integration), the average price of wheat in the province (Price), and a road index that takes the value 1 if all the municipalities are connected to a road and 0 if none of them are (Roads).

Table 8.15: Main economic indicators by province, mid 18th century

	Madrid	Cuenca	Toledo	Guadalajara	C. Real	Albacete
Km Road	16.5	33.5	17.6	32.9	56.6	37.2
Bonus Road	1.0	6.8	0.2	0.8	5.0	1.3
50	0.9	0.1	0.8	0.2	1.4	0.9
100	3.2	1.3	3.1	1.2	4.8	3.9
Hours	1.6	2.2	1.4	1.5	2.0	15
Integration	8.9	7.9	7.9	8.6	5.4	8.9
Price	17.7	16.9	17.4	15.1	17.4	19.6
Roads	0.2	0.18	0.3	0.1	0.1	02

Sources: Own calculations the Catastro de la Ensenada.

[202] The information was extracted from the Catastro de la Ensenada and from personal calculations.
[203] In the Catastro de la Ensenada, one of the questions requested information about the size of the village. In the answer to this question it was very often mentioned the not just the size of the village in leagues, but also the amount of hours that were necessary to cover one league. I collected this information and created an average for each of the six provinces. The variable should be a proxy of the physical and geographical difficulties of the terrain.

The results show that Toledo was the province that was better connected to the road system, with a road index of 0.32 indicating that almost one third of all the villages and towns in Toledo were connected to the road network. Madrid and Albacete are the next with 23 per cent of their municipalities connected followed by Cuenca with 18 per cent, Guadalajara with 12 per cent and Ciudad Real with 10 per cent. However, the ranking is different if we take into account the average number of kilometres of a typical municipality to the nearest road. In that case, the best position is for Madrid with just 16.5 kilometres on average followed by Toledo with 17.6, Guadalajara with 32.9, Cuenca with 33.5, Albacete with 37.2 and finally Ciudad Real again last with 56.6 kilometres. The province most affected by big urban areas is Ciudad Real with an average of 1.4 cities within 50 kilometres and 4.8 within 100 kilometres. The next on the list is Albacete with 0.9 and 3.9 towns respectively, followed by Madrid, Toledo, Guadalajara and Cuenca.

We checked the statistical correlations between the different variables in the six provinces. The results are presented in the following table.

Table 8.16: Correlation coefficients of the main economic indicators

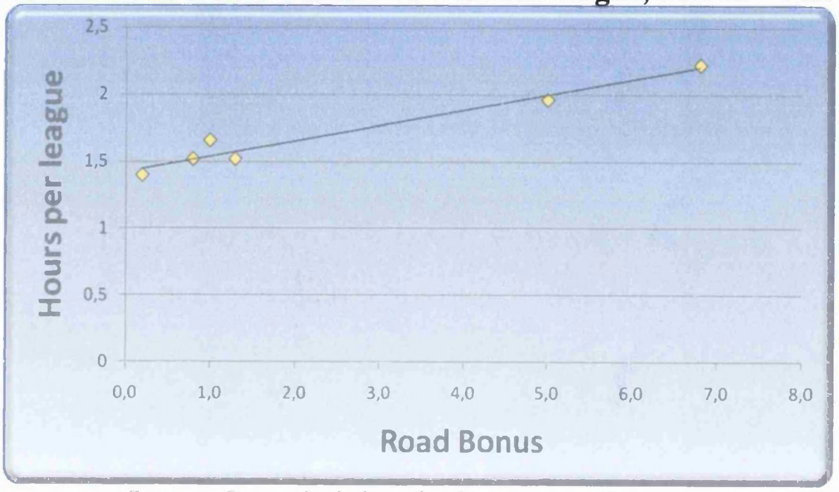
	Bonus	c100	c50	Hours	Integration	Km	Price	Roads
Bonus		-0.07	-0.11	0.97	-0.56	0.58	-0.06	-0.50
		0.89	0.82	0.00	0.24	0.22	0.89	0.30
c100			0.98	-0.12	-0.49	0.38	0.67	0.07
			0.00	0.81	0.32	0.45	0.13	0.89
c50				-0.15	-0.52	0.34	0.55	0.03
				0.77	0.28	0.50	0.25	0.95
Hours					-0.48	0.47	-0.11	-0.50
					0.33	0.34	0.83	0.30
Integration						-0.73	0.09	0.47
						0.09	0.85	0.34
Km							0.03	-0.76
							0.94	0.07
Price								0.45
								0.36

There are only two statistically significant correlations, between cities within 50 kilometres and cities within 100 kilometres and between the bonus for having a road and the number of hours to walk a league

The other relationship revealed by table 8.16 is the one between the advantage of having a road and the number of hours spent in walking a league. As explained before, "Road Bonus" measures how much the volatility of the price of wheat is reduced when a municipality is connected to a road. On the other hand, the amount of hours to walk one league is as explained before a proxy of how difficult the terrain is to travel in each province. The correlation is as expected strong and positive.

Those provinces that have a rougher and complicated landscape are also those where the benefit of having a road is higher, while flatter and easier provinces take less advantage from the presence of a road.

Figure 8.41 Road Bonus v Hours to walk one league, mid 18th century



Sources: Own calculations the Catastro de la Ensenada.

Sources: Own calculations the Catastro de la Ensenada.

8.6 Solving the puzzle of price anomalies

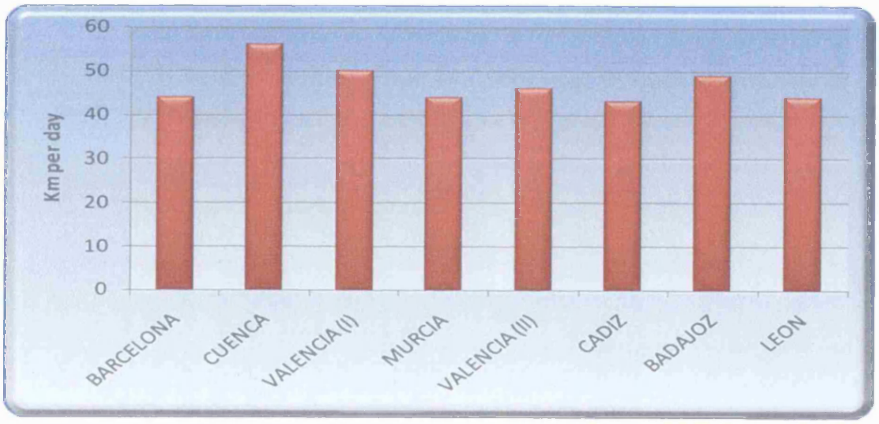
One of the questions that arise from the study of figure 8.40 is the situation in Albacete. The province has some of the highest prices of all New Castile and also some of the highest coefficients of variation. The lack of economic integration could explain in part the high prices of Albacete. The roads that crossed the province finished at the Mediterranean coast and therefore were direct competitors of the Madrid-Valencia road. The reasons behind this situation are several. First, in order to reach the coast the road to Valencia was considerably quicker, consisting of just 347 kilometres or 7 days of journey against the 418 kilometres and 9 days of the Madrid-Alicante-Valencia road or the 401 kilometres and 9 days of journey of the Madrid-Murcia road. In fact the journey to Valencia was not just quicker in absolute terms but also relatively. Table 8.17 presents the journey time in days and the distance in km for the main roads between Madrid and their final destination. The results indicate that for every day of journey in the Madrid-Valencia road the traveller could cover 50 kilometres while the number of kilometres per day goes down to 46 in the case of Madrid-Alicante-Valencia and 44 for Madrid-Murcia. A possible explanation is that the road to Murcia and Alicante crossed the province of Albacete, whose southern half was mountainous. This is probably one of the reasons that explain the relative abandonment of the road and the pre-eminence of the direct connection between Madrid and Valencia.

Table 8.17: Km covered in one day by main road, mid 18th century

DESTINATION	DAYS OF JOURNEY	KM	KM/DAY
BARCELONA	14	621	44
CUENCA	3	167	56
VALENCIA (I)	7	347	50
MURCIA	9	401	44
VALENCIA (II)	9	418	46
CADIZ	14	603	43
BADAJOZ	8	392	49
LEON	7.5	333	44

Sources: Own calculations the Catastro de la Ensenada and Uriol (1980)

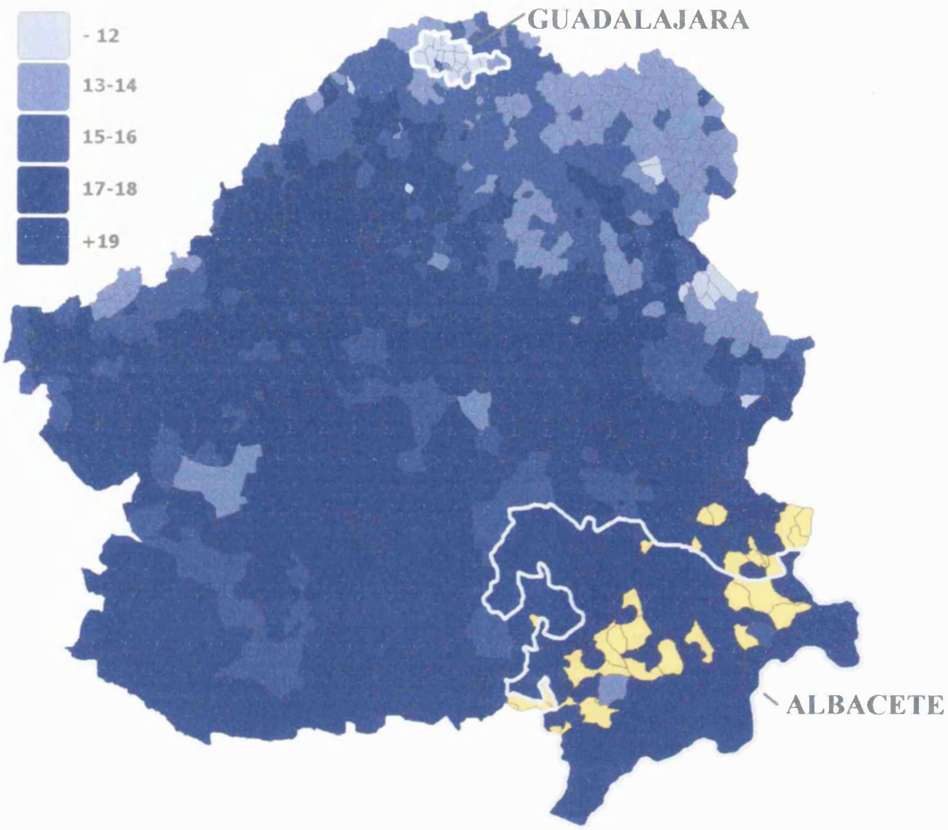
Figure 8.42: Km covered in one day by main road, mid 18th century



Sources: Own calculations the Catastro de la Ensenada and Uriol (1980)

However, the solution to the anomaly in Albacete can also be found on another price anomaly that is not so easy to identify in the map. In the north of the province of Guadalajara, a group of villages in the middle of the mountains present unexpected low wheat prices, both in absolute terms and also relative to their surrounding area. To facilitate its location, both anomalies are highlighted in the following map.

Figure 8.43: Price Anomalies. Prices in reales per fanega, mid 18th century



Sources: Own calculations the Catastro de la Ensenada

The information provided by figure 8.43 reveals that both anomalies are located in regions with very low levels of economic integration. This situation could help to explain why the prices in Albacete are so high but would increase the uncertainty of the anomaly in Guadalajara. To solve the puzzle we decided to take the municipalities in both anomalies and carry out a deeper analysis of the economic and social conditions of every village and town. The variables that form part of the analysis include:

Prices: Wheat, barley, rye, oats, wool. In the case of the grains the prices are presented in reales per fanega, while in the case of wool the prices are in reales per pound.

Production: Wheat, barley, rye, oats, wool, lambs. The production of the four grains was collected in fanegas, the wool in pounds and the lambs in number.

Demography: Inhabitants, poors, peasants, labourers without land. The number of inhabitants has been estimated by multiplying the number of neighbours (the information provided in the Catastro) by four. Poors, peasats and lacourers without land are quantified in total numbers.

Taxes: Royal taxes paid by each village. The information appears in total reales paid by each village and has been transformed to per capita levels using the number of inhabitants.

Land: Total size of the village, total arable land used to produce grains and pastures. In all the cases the variables are measured in fanegas. The arable land used to produce grains is divided in four samples, total, good quality, medium quality and bad quality. These quality levels are the ones that the Catastro uses, and are based on the productivity of the land.

Other: Cities within 50 km, cities within 100km. There are reasons to choose these perimeters; according to Ringrose most of the internal trade of wheat took place within 50 miles or 80 kilometres.[204] However other authors including Ringrose accept that these exchanges could easily reach 100 kilometres.[205] For that reason we decided to choose a minimum range of 50 kilometres and a maximum of 100, being the most representative thresholds according to the literature.

The villages analysed included 27 municipalities in Albacete and 10 in Guadalajara.[206] The information was again gathered from the Catastro de la Ensenada and personal calculations.
The average results for the main variables for every anomaly are presented in the following table.

Table 8.18: Production of grains and wool pc, mid 18th century

	Wheat pc	Barley pc	Rye pc	Oats pc	Wool pc	Wheat	Barley	Rye	Oats
Guadalajara	0.67	0.09	0.57	0.00	1.8	11.9	7.5	9.5	-
Albacete (High	0.17	0.10	0.09	0.00	0.06	21.0	9.1	14.0	5.4

Sources: Own calculations the Catastro de la Ensenada and Uriol (1980)

Table 8.19: Quality of land, mid 18th century

	% 1st class land	% 2nd class land	% 3rd class land	Arable land pc	Wheat pc
Guadalajara (Low Prices)	2.6%	14.9%	15.0%	8.6	2.5
Albacete (High Prices)	6.3%	10.6%	8.9%	3.0	5.2

Sources: Own calculations the Catastro de la Ensenada and Uriol (1980)

204 Ringrose, *Madrid*, p.185.
205 Ringrose, *Madrid*, p.39.
206 Hellin, Tobarra, Ontur, Fuente-Alamo, Chinchilla, La Roda, Alpera, Montealegre, Caudete, Lietor, Elche de la Sierra, Ferez, Albatana, Villapalacios, Lezuza, La Gineta, Minaya, Albacete, Villarobledo, El Bonillo, Socovos, Yeste, Cillaverde de Guadalimar, Riopar, Nerpio, Letur and Cotillas in Albacete and Galve de Sorve, Condemios de Abajo, Condemios de Arriba, El Ordial, Bustares, Gascueña de Bornova, Zarzuela de Jadraque, Villares de Jadraque, Hiendelaencina and La Bodera in Guadalajara.

Table 8.20: Economic indicators, mid 18th century

	Taxes pc	Poors/1000	Workers/1000	C50	C100
Guadalajara (Low Prices)	6.6	0.4	11	0	0.1
Albacete (High Prices)	1.3	11.7	148	1	4

Sources: Own calculations the Catastro de la Ensenada and Uriol (1980)

The values obtained in both samples present a very different panorama for Albacete and Guadalajara. Both regions are isolated, but the production capacities of each is very different. The most direct data is the production of wheat in fanegas per capita. In the case of Guadalajara each inhabitant produces 0.67 fanegas of wheat while in the case of Albacete the number is just 0.17. There is therefore a very clear supply problem that, given the lack of economic integration, cannot be solved by importing grain from neighbouring provinces. One may believe that the lack of wheat may force the consumers to move their preferences to inferior grains like barley and rye. This however was not the case in New Castile where white bread was a staple. In fact the per capita productions of barley and rye in Guadalajara and Albacete do not present big differences and were used mostly to feed animals.

Conclusion

The road network in early modern and modern Spain was very heavily influenced by the construction and distribution of the Roman roads built hundreds of years before. Their development was not continuous and it was not until the second half of the eighteenth century when the governments decided that a significant improvement in the state of the Spanish roads was necessary. Grain was moved along the network by using pack animals and wagons, transport costs being higher in the case of the animals and much cheaper using wagons.

Although transport costs were high, they still made possible the movement of grain from the producers in the periphery of New Castile to the capital. The distribution of wheat prices was dominated by the presence of Madrid where prices reached high levels. A close analysis of the communications shows that access to the road network did have a strong influence in the volatility of prices. Although prices along the roads were more stable, they were also higher. This was a consequence of demand factors, as roads tended to connect the most important cities and therefore the effect of urban demand increased the level of prices. This demand was also responsible for the existence of price anomalies like Albacete that had high prices and that were direct consequence of the lack of transport infrastructure.

We can therefore conclude that the eighteenth century in New Castile is a period of increasing economic integration that took place especially during the second half of the century thanks to the improvements in the road network. The communications were good enough to facilitate commercial transactions between the grain producers in regions like Guadalajara, with Madrid as the most important growth hub. Demand factors also played an important role and the price differential between urban and rural areas was high enough to facilitate and encourage the movement of wheat. The development of an internal grain market in New Castile and the surpluses from the producers in Guadalajara were factors that allowed its population to avoid the effects of a production crisis according to the theoretical framework of a Malthusian model.

9. Guadalajara and the escape from the Malthusian trap

This chapter analyses the relationships between the climatic and economic variables that have been presented in the previous chapters. The starting theoretical framework will be a traditional Malthusian model that has been widely used in the literature about climate changes and economic crises. The first section of the chapter will briefly discuss the evolution of the literature on economic effects of past climate changes, including the work of Galloway that will provide the model. Then the most important links between climate and the economy of the model will be analyzed, including not just a theoretical explanation but also empirical data from the case of Guadalajara to contrast their validity. Finally, the last part of the chapter will introduce the demographic puzzle that Malthusianism failed to predict, present two new concepts that were not included in the initial model; the role of economic integration and income inequality. Both variables will be key to understanding why the theoretical model failed in the case of the Malda Anomaly and its effects in eighteenth century Guadalajara.

9.1 Climate and economy under a traditional Malthusian model

The influence of climate in human history has been a long and passionate debate. In the beginning of the twentieth century the most relevant academics of a school of thought, later known as environmental determinism, occupied positions in some of the most important and prestigious academic institutions of the world. Ellsworth Huntington was without a doubt the most important member of the group. Educated in Harvard and Yale, it was in the latter where he developed his theories from 1917 until his death in 1947. His version of environmental determinism was in some cases so radical that Huntingdon even tried to connect the effects of different climates on the mental activity of human beings.[207] Arguments such as the links between climate and pureness, intelligence or honesty made him the objective of numerous critics that considered his studies racist and that consequently dismissed and rejected his work.[208] On the other hand, although some of the ideas defended by Huntington can be criticized as too radical, part of his work has also been accepted by the academic community. He proposed connections between the rise and fall of several civilizations and climate changes. Some of these cases were very clear for Huntington such as the rise of the Mongol empire during the thirteenth century, the conquests of the Mogul empire during the sixteenth century or the decadence of classical Greece and the development of Egypt during Alexandrian rule.[209]

The ideas of this school of thought were recovered by Charles Brooks who in 1948, a year after the death of Huntington, published a volume connecting the activity of some civilizations in the Mediterranean during the last millenniums with climate changes.[210] Since then the popularity of environmental interpretation of history decreased, although recently some publications like the work of Jared Diamond or Brian Fagan have increased the interest in the influence of climate and the environment in the writing of history.[211]

Economic history has not been isolated from the climatic debate, and authors such as Patrick R. Galloway have written various studies that relate climate and population. One of his papers used solar activity as a proxy of temperatures.[212] Galloway argues that climate was a driving force of demographic movements, and concludes that an increase of a 10% in solar activity produces an increase of a 4% of population in China and Europe, an effect that was more intense in marginal lands with an increase of 7%[213].

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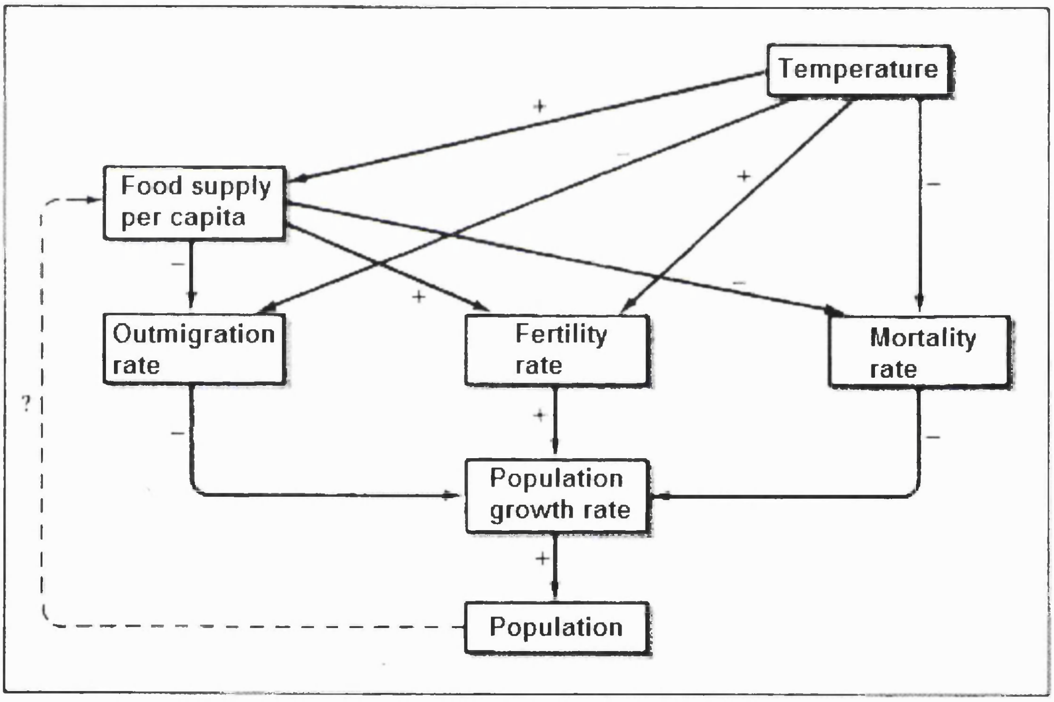
[207]Huntington, E., *Mainsprings of civilization,* (Nueva York, John Wiley and sons, 1945) p.343.
[208]Huntington, E., *Civilization and climate,* (New Haven, Yale University Press, 1924) p.411.
[209] Huntington, *Civilization*, p.391.
[210] Brooks, C.E.P., *Climate through the ages: a study of the climatic factors and their variations,* (Londres: Ernest Benn, 1949) p.314.
[211] Diamond, J., *Collapse, how societies cose to fail or succeed* (Nueva York : Viking, 2005) see alsohis previous publication J. Diamond, *Guns, germs, and steel : the fates of human societies* (New York; London : W.W. Norton & Co.: Jonathan Cape, 1997) Fagan, B., *The Little Ice Age: How Climate Made History 1300-1850*, (Nueva York: Basic Books, 2000) There are also case studies such as the fall of the Akkdian Empire, Cullen, H.M., et al, "Climate change and the collapse of the Akkadian empire: evidence from the deep sea", *Geology,* Abril (2000)
[212] Galloway, P.R., "Long term fluctuations in climate and population in the preindustrial era", *Population and Development Review,* Volume 12, Issue 1 (1986)
[213] Galloway, "Long term", p.18.

Recently, Morgan Kelly wrote a working paper studying population growth and climate between 1100 and 1800 in Europe and from 1541 to 1800 in England[214]. This paper introduces new interesting results. As Galloway did, Kelly concludes that climate was a very strong factor to explain demographic growth, and that climate in a given decade determines marriage rates and fertility in the following[215].

Most of the studies present a Malthusian world where a climatic crisis triggers an economic one through a reduction in harvests. A fall in the supply of food acts indirectly in the main demographic variables such as fertility, mortality and emigration while at the same time climate acts on the same variables reducing population. A classical Malthusian model including climate is presented in the following figure taken from Galloway.[216]

Figure 9.1: The Galloway-Malthusian model



Source: Galloway (1986)

The relationship between climate and health and therefore population growth always existed in history. According to Hippocrates, considered the father of medicine *"Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces for they are not at all alike, but differ much from*

[214]Kelly, M., "Climate and pre-industrial growth", Working Paper, Department of Economics, University College Dublin.

[215] Kelly, "Climate", p.15.

[216] Galloway, "Long term", p.4.

themselves in regard to their changes. Then the winds, the hot and the cold, especially such as are common to all countries, and then such as are peculiar to each locality." The development of Hippocrates' ideals ended up in the creation of biometeorology, a field that was especially developed during the twentieth century.[217]

9.1.1 Climate and mortality

The most important and clear link between climate and population is the one between weather and mortality. There are indirect effects like the diminishing supply of food as consequence of climatic extremes. A reduction in the amount of food available produces not just direct deaths through famines and malnutrition, but also weaknesses human body and makes it more vulnerable to diseases.

The direct effects of climate on human mortality are also significant. Cold temperatures increase mortality rates even in advanced modern societies with a better availability of housing and isolation. Momiyama and Katayama found that in Japan and Western Europe mortality was still concentrated during the cold months of the year and therefore its seasonal behaviour was still present.[218] The diseases that appear as consequence of cold temperatures range from simple colds to more complicated illnesses. Mannino and Washburn found a direct correlation between cold temperatures and an increase in the number of deaths by myocardial infarction.[219]

Extreme heat also contributes to increase mortality rates, especially in the form of dehydration and heat strokes. Recent studies show a correlation between heat and mortality and also morbidity levels, especially during the heat waves that affected Europe and the United States.[220]

Although most of the studies are related to the connection between extreme temperatures and mortality, other climatic events such as floods are also closely connected with increases in mortality. Gastroenteritis can appear when individuals drink flood water; dysentery in floodwater also contaminates water supplies and food, and can cause an epidemic. Typhoid fever was also

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[217] Höppe, P., "Aspects of Human Biometeorology in Past, Present and Future", *International Journal of Biometeorology* (1997) p.19.

[218] Momiyama, M. and Katayama, K., "Deseasonalization of Mortality in the World", *International Journal of Biometeorology* (1972) p.329.

[219] Mannino, J.A. and Washburn, R.A., "Environmental Temperature and Mortality from Acute Myocardial Infarction", *International Journal of Biometeorology* (1989) p.32.

[220] Golden, J.S., et al, "A Biometeorology Study of Climate and Heat-Related Morbidity in Phoenix from 2001 to 2006", *International Journal of Biometeorology* (2008) p.471 and Smoyer, K.E., "A Comparative Analysis of Heat Waves and Associated Mortality in St. Louis, Missouri – 1980 and 1995", *International Journal of Biometeorology* (19982006) p.44.

related to floods and lack of hygiene that is difficult to maintain in cases of extremes rainfall. Cholera and Giardiasis are other diseases that are connected to floods. On the other hand there are also indirect effects, rodents are driven out from their shelters and find refugee in houses increasing the transmission of parasites and therefore, of the diseases that they transmit.[221]

However, while facing a constant and long period of cold or heat the behaviour of people and their own biology can adapt to the new climatic conditions. The Eurowinter Group established regional differences in Europe where people in northern countries showed a higher resistance to lower temperatures. When the temperature reached levels below 18°C mortality rates increased by 2.15% in Athens, but only by 0.27% in Finland, partially as consequence of an infrastructure that is better adapted to cold temperatures.[222] However a rapidly changing climate from extreme to extreme can be difficult to predict and also to confront. Tromp found that climate variability was the most important climatic factor connected to increases in mortality.[223] Bull and Morton showed similar results with short term changes in temperatures.[224] The situation is not different in Spain where a study concluded that extreme weather has a significant impact in mortality levels in the 45-64 age-group, showing that the effects of climate existed and not only within risk groups such as elderly or children.[225]

9.1.2 Climate and fertility

The relationship between climate and fertility is far more complicated than with mortality but not less intense. The indirect effects are mainly related again to the lack of food supplies, less food means malnutrition and higher levels of sterility, abortions, amenorrhea, and a decrease in libido. The economic distress created by poor harvests can also influence fertility indirectly by postponing the age of marriage and therefore decreasing fecundity.[226] However, even controlling by economic factors such as grain prices, there is a correlation between a worsening climate and a reduction in fertility.[227]

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[221] World Health Organisation, http://www.who.int/globalchange/climate/summary/en/index4.html
[222] European Comission. Information published by the Directorate General for 'Health and Consumers' http://ec.europa.eu/health/ph_information/dissemination/unexpected/unexpected_8_en.htm
[223] Galloway, "Long term", p.10.
[224] Bull, G.M and Morton, J., "Relationships of Temperature with Death Rates from all Causes and from Certain Respiratory and Arteriosclerotic Diseases in Different Age Groups", *Age and Ageing* (1975) p.232.
[225] Diaz, J., Linares, C. and Tobias, A., "Impact of Extreme Temperatures on Daily Mortality in Madrid (Spain) Among the 45-64 Age-Group, *International Journal of Biometeorology* (2006), p.342.
[226] Galloway, "Long term", p.10.
[227] Galloway, "Long term", p.10.

Changes in temperature affect the neuroendocrine system that is the responsible of controlling fecundity. When temperatures move away from the optimum fecundity decreases, a situation proven by the fact that winters cooler than average winters and hotter than average summers reduce fecundity.[228] The relationship between climatic variables also presents a connection during very short term changes in weather conditions and parturitions.[229]

9.1.3 Climate and emigrations

According to Galloway a production crisis would strike in rural areas more than in urban ones. The reason is that the social security network provided by some institutions like the church or the local councils allowed poor people in towns a higher probability of acquiring the food necessary to avoid starvation. On the other hand poor people living in the countryside would have more problems in accessing charity and therefore will tend to move to the towns looking for help. The difference in Guadalajara is the nature of the inhabitants of the small rural municipalities. Unlike in many other parts of Spain, especially in the South, the people in the countryside of Guadalajara had some sort of legal control over the land that they worked. The amount of rural workers that worked for a salary was small and most of the peasants owned or rented land. In addition to that, the percentage of poor people that inhabited small rural areas was considerably smaller than in the towns of Guadalajara. It is therefore important to understand that facing a production crisis when prices of food increase dramatically, a rural community mainly composed by peasants will be able to resist better than the working classes living in the towns. When the supply of grain diminished, peasants in Guadalajara were able to secure at least their own supply, while workers in the towns had to face increasing food prices and therefore a severe reduction in their real incomes. The main reason is that nominal wages did not keep the pace of the inflationary process reducing real wages.[230] Therefore the crisis would trigger the effects opposite to those predicted by the Galloway model, and in fact instead of increasing, the amount of people emigrating from the province of Guadalajara would decrease.

9.1.4 Climate and food production

Changes in climatic conditions can have severe consequences on agricultural production. However, the same change in climate can have very different consequences on different types of soil, plants, etc. Therefore, we have to investigate the effects that changes in temperatures and rainfall can have

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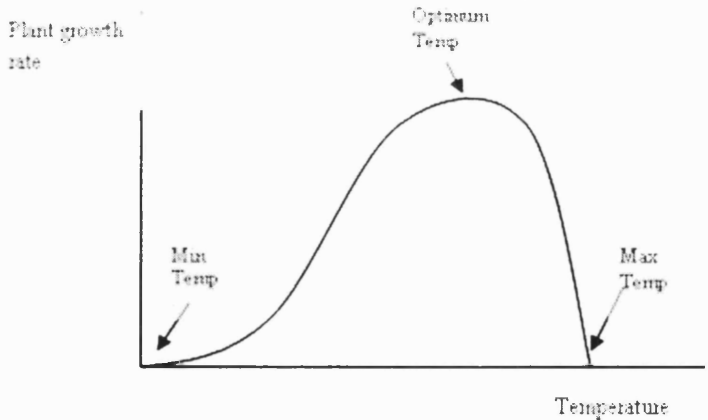
[228] Galloway, "Long term", p.11.
[229] Driscoll, D.M. and Merker, D.G., "A Search for Associations Between Weather and the Onset of Human Parturition", *International Journal of Biometeorology* (1984) p.223.
[230] Hamilton, *War*

on the development of cereals, the most important product in the production system of modern Spain and especially significant in the case of eighteenth century Guadalajara.

The first part of this section studies how changes in temperatures affect the metabolism of plants as well as other biological processes such as photosynthesis, transpiration or the production, and accumulation of biomass. The second part will cover the effects that a climate change have in the development of the main cereals that are the core of the thesis.

A rise of temperature is associated to positive effects on the growth of a plant through the effects that increasing heat has in their metabolism.[231] Cold temperatures produce a reduction in nutrient uptake of the plant and its transport from the root to the rest of the organism. However the benefits of increasing temperature suffer diminishing returns that became negative when an optimum temperature is reached. Then the negative effects of overheating reduce the growth of the plant and "*denaturation of photoplasmic proteins, cellular enzymes, or membranes may cause rapid declines in or cessation of reaction rates and cytoplasmic streaming*"[232] The relationship between temperature and plant growth is presented in the next graph.

Figure 9.2: Plant Growth and temperature



Source: Rosenzweig (1998)

Therefore, there is an optimum point where the growth of the plant is maximized while lower or higher temperature would produce a reduction in its development.[233] This situation can be

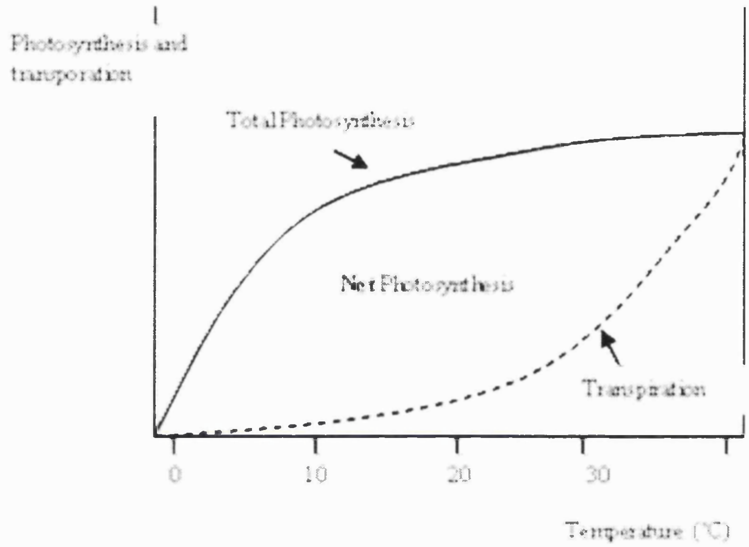
[231] Rosenzweig, C., *Climate Change and the Global Harvest :Potential Impacts of the Greenhouse Effect on Agriculture,* (New York : Oxford University Press, 1998) p.87.

[232] Rosenzweig, C., *Climate Change*

[233] Parry, M.L., *Climate Change and World Agriculture*, (London : Earthscan Publications in association with the International Institute for Applied Systems Analysis, United Nations Environment Programme, 1990) p.42.

explained by the existence of a tradeoff of two forces that work in different directions. An increase of temperature produces an increase of the brute photosynthesis rate fostering cellular growth in the plant. However, more heat also increases the respiration rate of the plant that reduces the accumulation of biomass. The following graph shows the tradeoff between both processes and their effect on net photosynthesis.

Figure 9.3: Photosynthesis, transpiration and temperature



Source: Rosenzweig (1998)

The graph shows the behaviour of a standard plant. According to the study the minimum required temperature is 0°C, the optimum level is 20°C and the maximum tolerated temperature is 40°C. However, there is a difference between the optimum temperature for photosynthesis and the optimum temperature to maximise the production of grain. If the photosynthesis rate is too high, the maturation of grain can be too quick and therefore the final yields can actually being reduced.[234] For that reason, the optimum temperature that maximizes yields is smaller than the optimum temperature for the photosynthesis process. In the case of the main species of cereals the optimum temperature for the development and biomass accumulation is 10°C, a value supported by the research carried out by Pitovranov and Nikonov[235].

[234] Rosenzweig, *Climate Change* , p.89.
[235] Parry, *Climate Change and World Agriculture*, p.45.

There is a second way in which temperature can have an influence in the yields of cereals. The growth period is defined as the time between the last frost in spring and the first frost in autumn.[236] In other words it is the period when the plant has to grow. Therefore, if the growth period is sufficiently long cereals can be planted earlier and the producer could even have the possibility of obtaining two harvests the same year. [237] Very small changes in climatic conditions can have very significant consequences in this growth window. A reduction of just 1°C like the one suffered during the seventeenth century can reduce the growth period from three to four weeks. [238]

Although less popular and studied than direct ones, the indirect effects of climate on agricultural output are also important. In traditional economic models of growth, the factor land has always been given as a constant and not as a variable one like labour or capital. However the supply of land is not a constant and can change due to several reasons, such as the overexploitation of the soil that can led to the depletion of nutrients. Changes in climatic conditions also alter the supply of land and have similar effects to overexploitation.

In marginal lands the performance of a plant is heavily influenced by changes in climatic conditions, especially temperature. They are characterized by low quality soils, high altitudes or proximity to very cold areas. An increase of temperature can improve the productivity of marginal lands and even make productive areas that had been previously abandoned as unfertile.[239] M.L. Parry proved that in the marginal lands of south-east Scotland, an area with an average altitude of 300 meters, a decrease of 0.3°C in temperature doubled the probability of harvest failure.[240] The next graph shows the exponential relationship between the probability of harvest failures and temperature presented in day degrees.[241]

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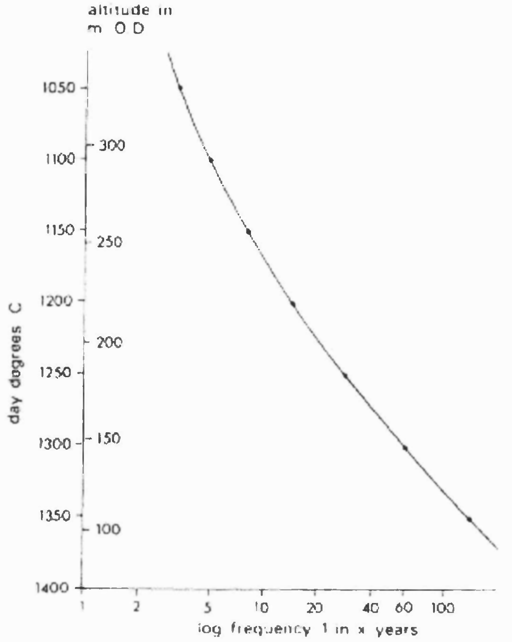
236 Parry, *Climate Change and World Agriculture*, p.89.
237 Parry, *Climate Change and World Agriculture*, p.89.
238 Parker, G., *The General Crisis of the Seventeenth Century*, (London : Routledge and Kegan Paul, 1997)
239 Parry, *Climate Change and World Agriculture,* p.44.
240 Parry, M.L. and Delano, C., *Consequences of Climatic Change*, (Nottingham: Dept. of Geography, University of Nottingham, 1981) p.12.
241 Parry, M.L., "Secular Climatic Change and Marginal Agriculture", *Transactions of the Institute of British Geographers*, 0:64 (1975) p.5.

Figure 9.4: Harvest failure and temperature in marginal lands



Frequency of harvest failure, by altitude, in south-east Scotland

Source: Parry (1975)

Parry used the temperature estimations of H.H. Lamb and analyzed the effects of climatic variability on the Scottish harvests during the last 600 years. The results show that at the beginning of the thirteenth century, only one out of twenty years experienced a harvest failure. During the seventeenth century the probability of suffering a harvest failure grew to one every two years.[242] Parry showed that during the coldest episodes of the last millennium, the crises of the fourteenth and the seventeenth centuries, the same areas identified as climatically marginal in Scotland were abandoned and considered unfertile for the cultivation of cereals. [243]

More general studies show that in terms of altitude a reduction of 1°C in temperature reduces the cultivation limit by 150 meters. [244] In Great Britain an increase of 1°C would allow the cultivation of one third of the unfertile moorland that could be used to produce crops. In the Alps the same change of 1°C would raise the limit of cultivation by 150 meters, while in the Andes the limit would raise by 200 meters. [245] Similar effects have been described in investigations studying the relationship between temperatures and the cultivation of rice in Japan.[246] Warmer temperatures

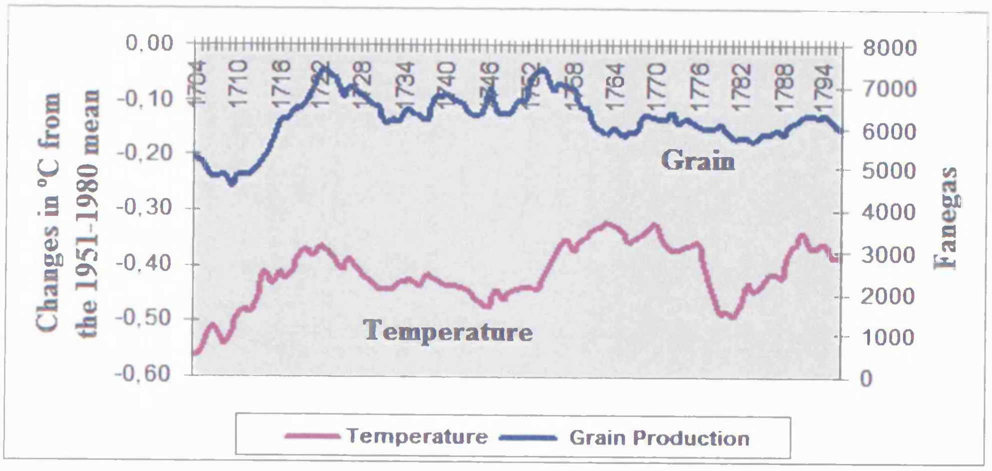
[242] Parry, "Secular", p.7.
[243] Parry, M.L., "Climatic change and the agricultural frontier: a research strategy", in Wigley, T.M.L., *Climate and History : Studies in Past Climates and their Impact on Man*, (Cambridge : Cambridge University Press, 1981) p.319.
[244] Parker, *The General Crisis*, p.8.
[245] Parry, *Climate Change and World Agriculture*, p.74.
[246] Parry, *Climate Change and World Agriculture*, p.68.

allow not just the cultivation of lands in superior altitudes, but also in higher latitudes. [247] In northern Europe an increase of 1°C in temperature would expand the cultivation limit in the north by 200 kilometres. [248]

We can check now the relationship between climate and grain production in the province of Guadalajara during the eighteenth century. In climatic terms and as it was explained previously, the eighteenth century can be divided into two clear periods; the first half until 1760 is of relative climatic stability, the second phase started around 1760 when the Malda Anomaly took place, and is characterized by a dramatic increase in climate volatility not just from year-to-year but even month-to-month.

The following figure shows the evolution of grain production in Guadalajara compared to the evolution of temperatures. The series show very similar trends except during the period 1760-1780 when the worst years of the Malda Anomaly took place.

Figure 9.5: Temperature and grain production, 1700-1800



Source: Crowley and Lowery (2000) and same as footnote 2

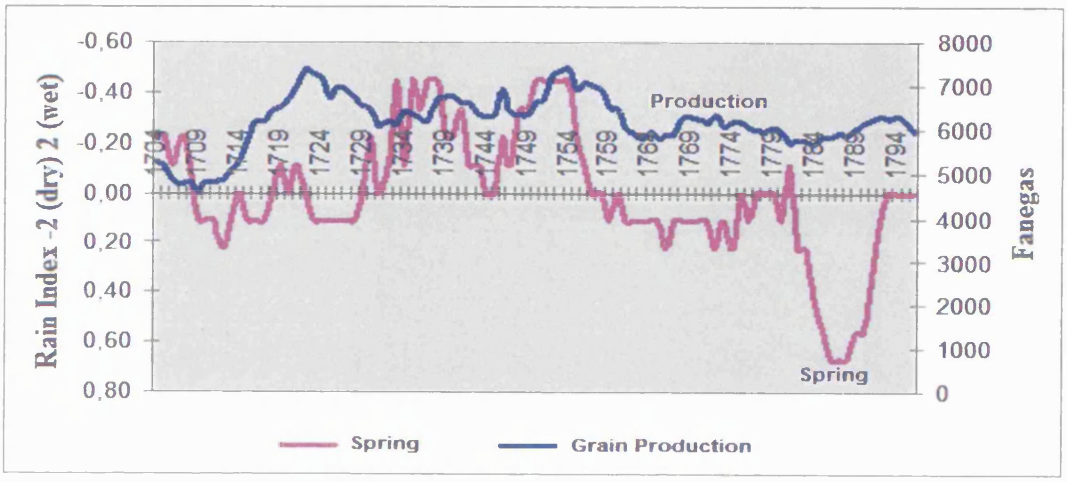
It has been proven that the most influential rainfalls of the year in grain production are autumn and spring rains. The following figures show how spring and autumn rainfall changed during the eighteenth century and their relationship with grain production. Although the visual connection

[247] Rosenzweig, C., *Climate Change and the Global Harvest :Potential Impacts of the Greenhouse Effect on Agriculture,* (New York : Oxford University Press, 1998) p.91.

[248] Peter, D., *Course on Climate Change Impact on Agriculture and Forestry*, (Luxembourg: Office for Official Publications of the European Communities, 1998) p.149.

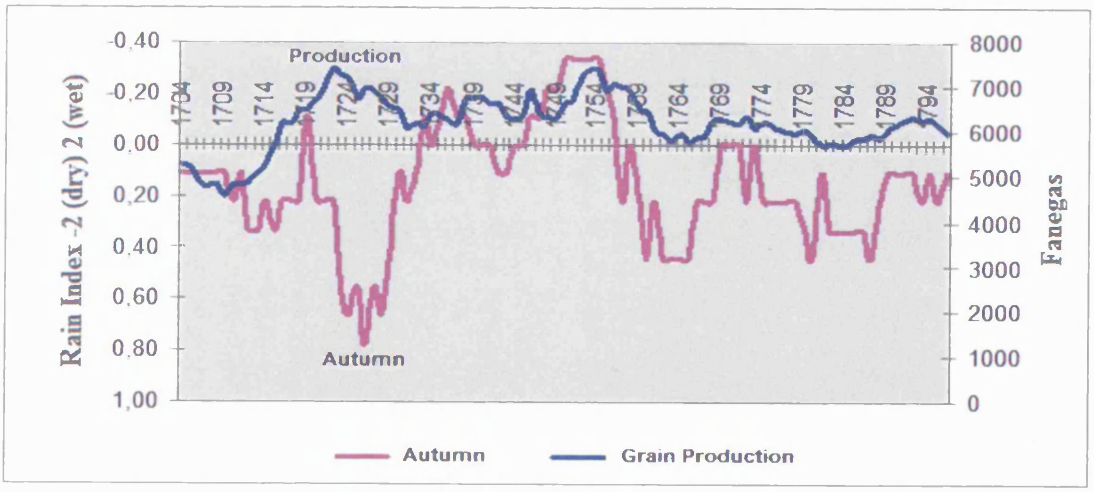
between the series is more complicated than in the case of temperatures, the series show similar movements with common maximums and minimums.

Figure 9.6: Spring rains and grain production, 1700-1800



Source: Rodrigo et at. (1999) and same as footnote 2

Figure 9.7: Autumn rains and grain production, 1700-1800



Source: Rodrigo et at. (1999) and same as footnote 2

Therefore and summarizing, during the second half of the eighteenth century, the province of Guadalajara suffered a major climatic crisis called the Malda Anomaly. The production of grain fell as a consequence of the climatic distress and remained stagnant until the nineteenth century. Therefore, using the model described by Galloway, the population in a rural area like the province of Guadalajara should have suffered a significant fall. The first effects would appear from the influence on fertility and mortality, and secondly through the emigration of part of its rural population to towns like Madrid. However the population in Guadalajara did not fall, and according to our estimations it was during the second half of the century when it experienced the most intense growth. Fertility increased during the whole period and mortality instead of increasing remained constant. Therefore the question that we have to answer is:

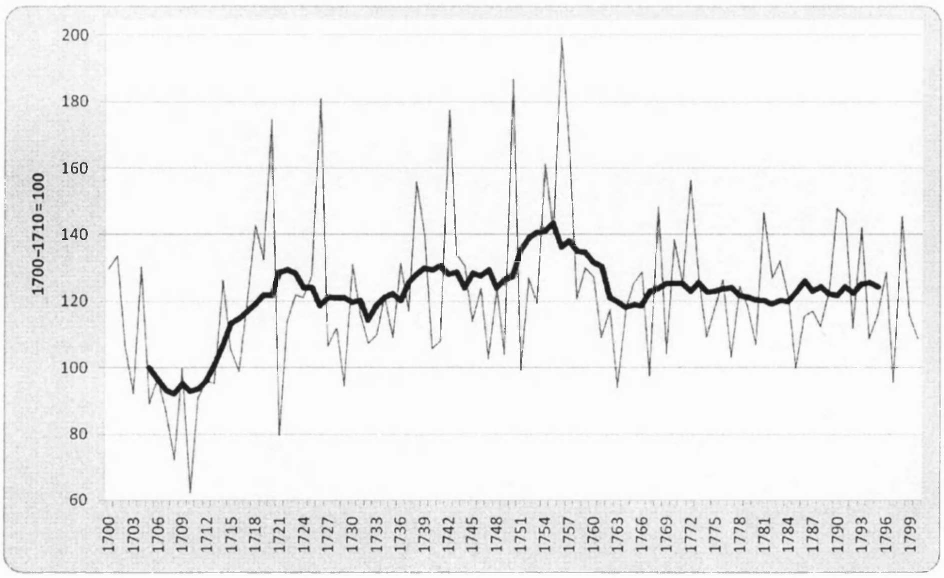
Where did the model fail?

9.2 The failure of Malthusianism in eighteenth century Guadalajara

9.2.1 The demographic puzzle

In agrarian terms, the eighteenth century is a period of very modest growth. The crisis of the late seventeenth century extended its effects until the first year of the eighteenth century. After the economic slump, a quick and consistent recovery started in 1710 and the positions that had been lost during the crisis were clearly recovered and even surpassed, with an increase in grain production of nearly 50 per cent in only ten years. The following forty years were a period of stagnation with brief crises and recoveries that finished with the crisis of the late eighteenth century. The crisis began in the second half of the century and was marked by an early decline of grain production during the 1750s and a later stagnation in the production of grain that would last until the end of the century. These trends are similar to those in other regions of Spain and are presented in the next figure including a 9 years moving average.[249]

Figure 9.8: Grain Production in Guadalajara, 1700-1800

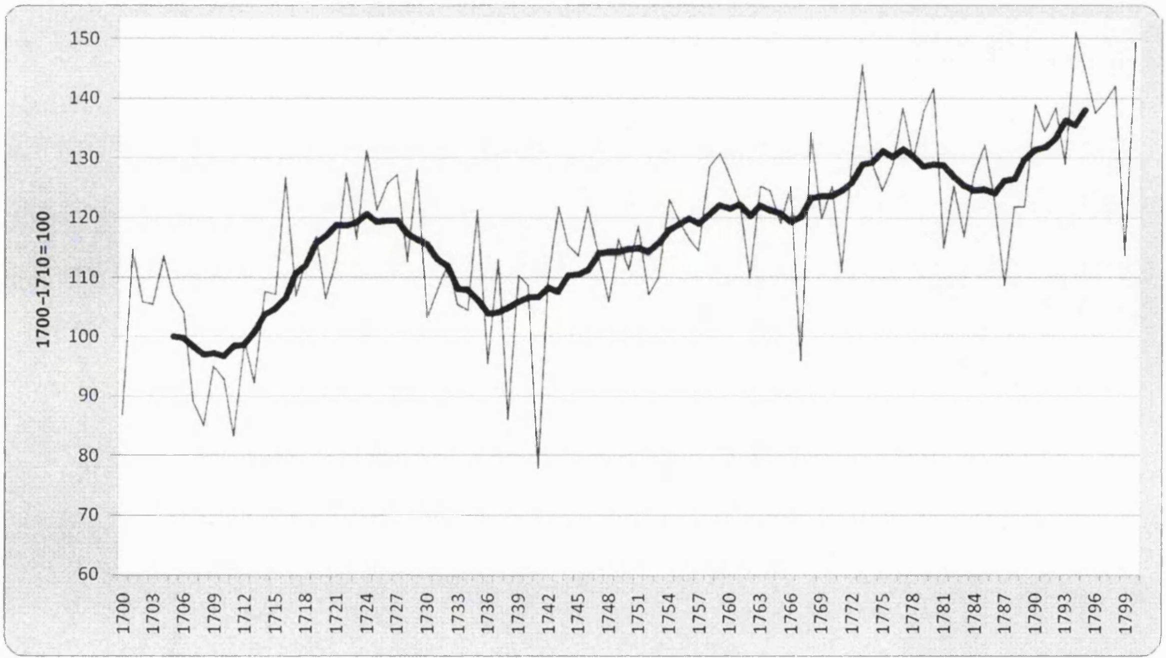


Source: same as footnote 2.

[249] Gonzalez Enciso, *Historia económica*, p.229.

In demographic terms, baptismal series show that the eighteenth century was a period of intense fertility growth, a fact supported by a growth of 40 per cent in the number of baptisms during the eighteenth century. Figure 9.9 presents the data including a 9 years moving average and shows three main trends. The first one was a period of growth that started in 1710 and that reached its peak in the mid 1720s, to be followed by a decline until the late 1740s with a decrease of almost 20 per cent in the number of baptisms. The last period was a constant and long process of demographic growth that started in the 1740s and continued during the rest of the century, with an increase in the number of baptisms of nearly 35 per cent.

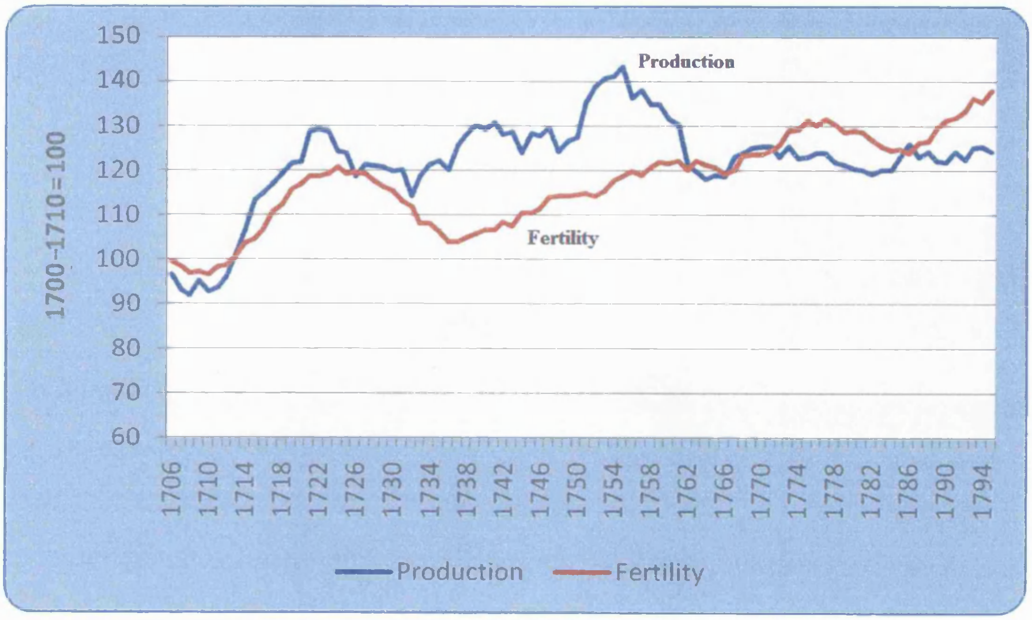
Figure 9.9: Baptisms in Guadalajara, 1700-1800



Source: same as footnote 6.

Combining the information from both graphs the most striking feature is the difference between the demographic growth and the stagnant production during the second half of the century. Figure 9.10 presents the evolution of fertility and grain production. The data show that during the second half of the eighteenth century grain production remained constant while population grew. Therefore in per capita terms the availability of grain diminished. So the question is: How can population grow when the supply of food per capita declined? A possible explanation is that the distribution of that production became more equal, or in other words that distribution is as important as production itself.

Figure 9.10: The demographic Puzzle, 1700-1800 (9 years moving average)



Source: same as footnotes 2 and 6.

9.2.2 Inequality

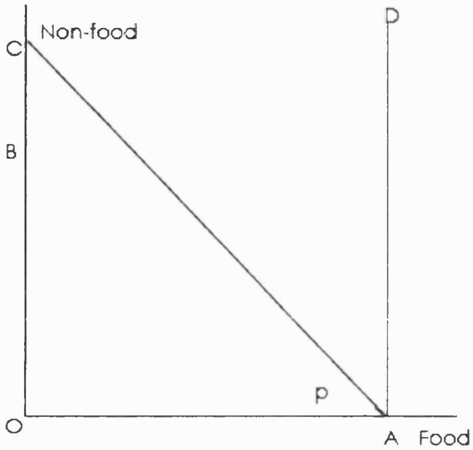
According to Amartya Sen the distribution of food production is a key element in order to explain the effects that famines have in population. In his entitlements theory Sen states that:

"The entitlement approach to starvation and famines concentrates on the ability of people to command food through the legal means available in the society, including the use of production possibilities, trade opportunities, entitlements vis-à-vis the state, and other methods of acquiring food".[250]

For Sen there are four ways of commanding food, through trade, own production, own labour, and inheritance. To study the relationship between food production and demographic movements, we should look not just at the total levels of food production, but also at the ability of every individual to command his own supply.[251] The next figure summarises the main points of the entitlements approach.

[250] Sen, A., *Poverty and famines: An essay on entitlement and deprivation* (Clarendon Press, Oxford, 1981) p.45.
[251] Sen, A.,"Starvation and exchange entitlements: a general approach and its application to the great Bengal famine", Cambridge Journal of Economics, 1977, p.33.

Figure 9.11: The entitlements approach



The graph shows the Possibilities of Consumption Frontier (PCF) for an individual in an economy where there are only two sort of goods, food and non-food ones. If that is the case, then the frontier given depends on the relative prices of both goods (p).[252] *A* is the minimum amount of food necessary to survive, and therefore under the price *p* the starvation region is defined by the triangle *OAC*. This region can change if prices change, for instance if *p* grows meaning that now food is more expensive and therefore less accessible. The individual will only be immune to price changes if he is able to produce himself an amount of food superior to *A*.

Sen's theories appeared to explain the emergence of famines in cases where the production of food did not suffer a reduction. We can also use the same theory but not to explain a famine, but to explain the opposite, how the demographic growth of the late eighteenth century and Guadalajara took place when total production of food remained constant and per capita levels diminished. The study of real wages during the eighteenth century in New Castile where Guadalajara was located, reveal that the value of *p* suffered a considerable fall. Real wages in terms of wheat of unskilled workers and master carpenters fell by 50 per cent from the mid to the end of the eighteenth century.[253] The reason is that although nominal wages increased as well, their rise was overwhelmed by the increase in the price of food producing a fall in real terms.[254]

As figure 9.12 shows, the comparison between wheat prices and the Consumer Price Index (CPI) in New Castile, confirms that prices of wheat grew faster than the CPI during the second half of the eighteenth century. Figure 9.13 shows the accumulated difference in percentage between wheat

[252] Sen, A., "Ingredients of Famine Analysis: Availability and Entitlements, The Quarterly Journal of Economics, Vol. 96, No. 3. (Aug., 1981), p.437.
[253] Hamilton, *War*
[254] Hamilton, *War*

prices and CPI. The results suggest that between 1700 and 1760 price changes in both series were very similar, but that in 1760 the situation changed and the price of wheat increased more rapidly that CPI. This trend was maintained during the rest of the century and during the last years of the 1790s the price differential between the price of wheat and the CPI shows an accumulated difference of almost 20 percentage points.

Figure 9.12: Wheat Prices and CPI in New Castile, 1700-1800 (9 years moving average)

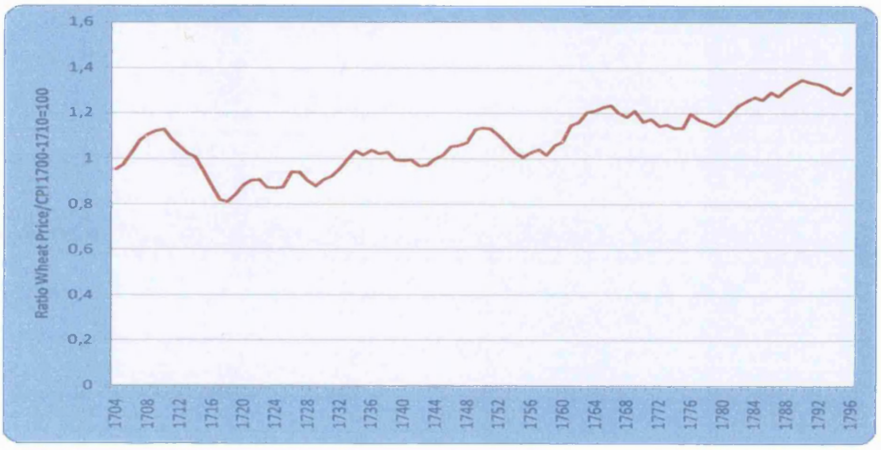
Source: Hamilton (1947) and accounting book from the parish of Santa Maria Magdalena (Getafe)

Figure 9.13: Wheat Prices - CPI, 1700-1800 (9 years moving average)

Source: Hamilton (1947) and accounting book from the parish of Santa Maria Magdalena (Getafe)

Using the theoretical framework proposed by Sen, we can study how the situation of the population in New Castile changed in terms of food entitlements and accessibility to its supply. Dividing the price index of wheat by the CPI we can obtain a ratio that estimates the value of p in the entitlements theory. The following graph shows how this ratio changed during the eighteenth century.

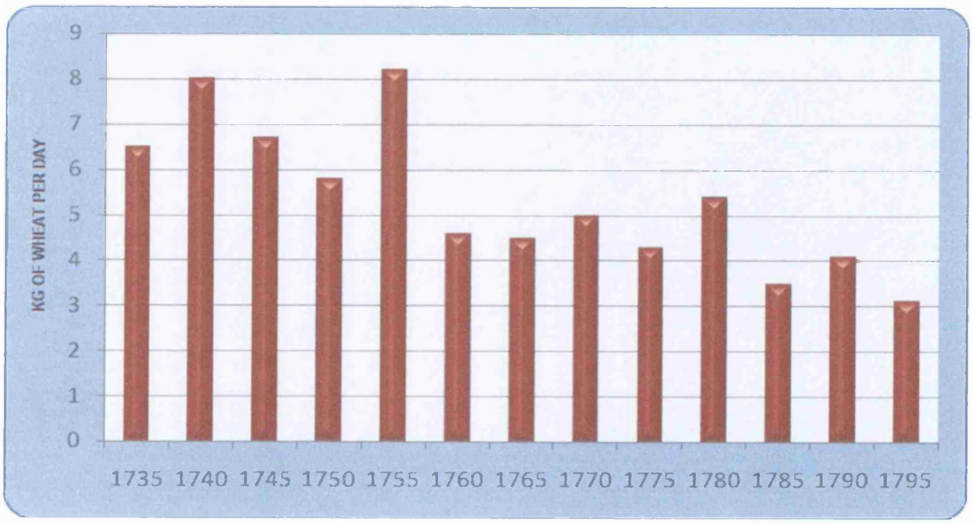
Figure 9.14: Wheat Prices/ CPI, 1700-1800 (9 years moving average)



Source: Hamilton (1947) and accounting book from the parish of Santa Maria Magdalena (Getafe)

The results show that during the eighteenth century the ratio increased from a minimum of 0.8 in 1720 to 1.3 in the 1790s. The increase was especially intense during the second half of the century when most of the growth took place. This meant that the situation of those that had to rely on the market to acquire their supply of food worsened considerably during this period. This situation is supported by the decrease of real wages in terms of wheat of unskilled workers in New Castile that fell by 60 per cent from 1755 until 1795 and that are presented in the next figure.

Figure 9.15: Real wages of unskilled workers in New Castile, 1736-1795



Source: Hamilton (1947)

The change in the model suggested by Sen is presented in the following figure where prices of food increased from p to p* increasing the starvation region in the graph by the area CBA.

Figure 9.16: Effect of change in relative prices (I)

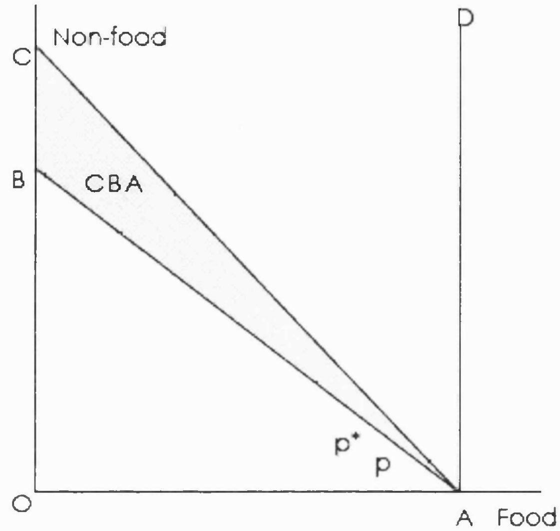
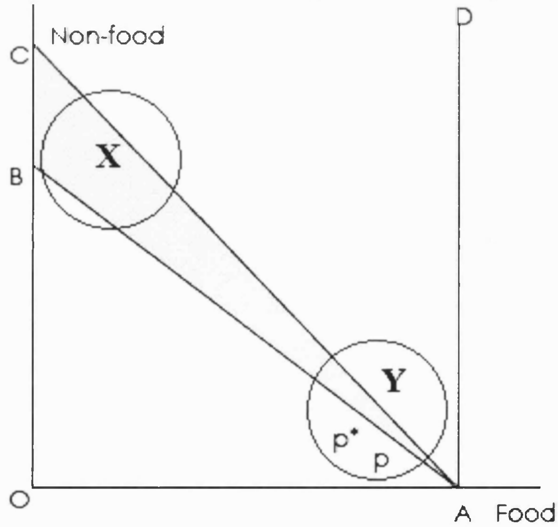


Figure 9.17: Effect of change in relative prices (II)



However the consequences of this increase in prices would not be the same for everyone. A worker living from a salary would tend to be in the area X, where the personal supply of food is small and most of the consumption has to be based on products bought from the market. A peasant on the other hand would tend to be on the area Y, where the personal production of food is large. Therefore within this theoretical framework an increase of food prices like the one that took place in eighteenth century Spain affects workers more than peasants. The strong demographic growth in the second half of the eighteenth century in Guadalajara therefore, can be explained by a movement of producers in the region Y to the right, through an improvement in the personal production of food that at the same time reduced the inequality between small and big producers. This possible explanation is completely supported by the analysis of inequality in chapter 7 and by the structure of the population in Guadalajara presented in chapter 6.

9.2.3 Economic Integration

When climate worsens reducing the supply of food, the most obvious alternative is importing it from other places. Therefore, the levels of economic integration are a key factor in facing the negative consequences of a climate crisis. As it was presented in chapter 5, the production of Guadalajara was closely connected to the prices in Toledo and also in Madrid. The region worked as a supplier of grain for the capital and the levels of economic integration between Guadalajara and Madrid in the eighteenth century were therefore significant.

Llopis argued that during the second half of the eighteenth century the links between the cities in the interior of Castile and the northern coast weakened. However he also points out that the economic integration between the interior and the cities in Andalusia in the South and the east coast increased.[255] This situation is again supported by the conclusions in chapter 8 that points out that the levels of economic integration between the interior and the south and east increased during the second half of the eighteenth century. Guadalajara therefore was not just integrated with the economies of the interior of Spain, but also and as it was shown in chapter 5, it also had the surplus to provide the necessary grain that could supply the big cities like Toledo and Madrid. The trade of grain between the producing Guadalajara and the demanding big cities surely provided a significant amount of cash for the producers in Guadalajara in a century when the price of wheat tripled.

However, in order to move grain from Guadalajara a transport network able to carry out that task was necessary. The road that connected Guadalajara with the interior of Castile was part of the one that connected Madrid with Barcelona. As presented in chapter 8, during the early 1750s the coefficient of variation of wheat prices along the road was lower than 8 per cent. This value was in a mid range between the maximum of the road Madrid-Leon and the minimum of the road Madrid-Valencia. Therefore, we can assume that in the early 1750s the road was used to move grain probably to Madrid, although not as intensively as other connection between the capital and the Mediterranean coast.

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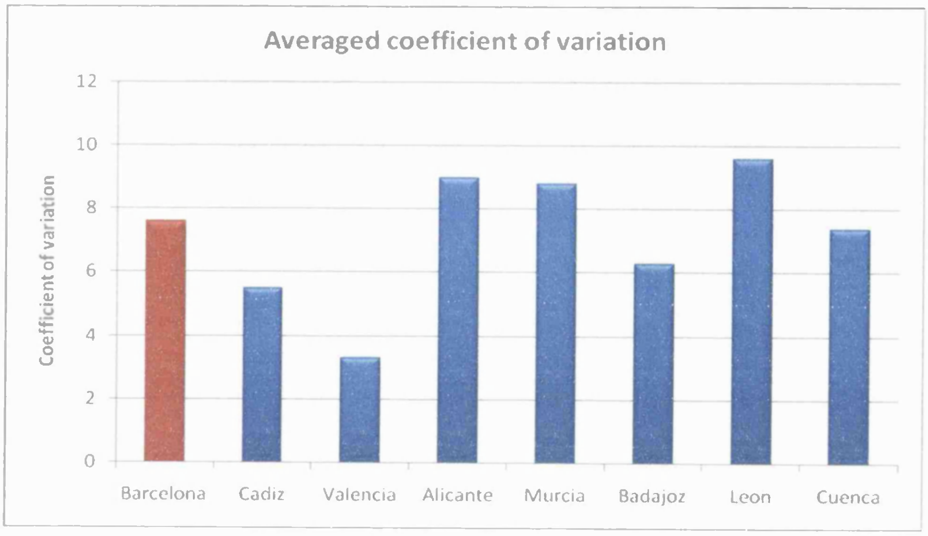
[255] Llopis and Socota, "Antes"

Figure 9.18: Volatility of grain prices in different roads, mid 18th century



Sources: Own calculations from the Catastro de la Ensenada

On the other hand we should also analyse what happened to the road after the 1750s. Some of the chronicles available give us information about the state of the road and the amount of time that was necessary to cover it. In 1758 Matias Escribano published his "Itineratio", a guide of the main roads of Spain as well as the number of days and main stops in each one.[256] In the case of the Madrid-Barcelona road, Escrivano estimated that fourteen and a half days were necessary to cover the distance between both cities. In 1769 the Italian poet Victorio Alfieri visited Spain and travelled from Barcelona to Madrid in a coach with two horses spending fifteen days[257]. In 1786 Townsend did the same trip in just fourteen days, including one day that he rested in Zaragoza.[258] Can we then assume that these two cases reflect an improvement in the state of the roads between 1769 and 1786? The mere example of two isolated chronicles may not be enough robust to confirm this improvement. On the other hand, the existence of quantitative information on transport costs can offer us a more reliable answer. The following table presents the transport costs of moving wheat in Spain during the second half of the eighteenth century that have been presented in chapter 7. The values for 1751 and 1773 that were given in a price range have been averaged.

[256] The complete name of the book is "Itinerario español o guia de caminos par air desde Madrid a todas las ciudades y Villas mas importantes de España y par air de unas ciudades a otras, y a algunas cortes de Europa" "Spanish initerary or road map to go from Madrid to all the cities and main towns of Spain and to go from some cities to others, and to some courts of Europe".
[257] Uriol, "Los caminos", p.149.
[258] Uriol, "Los caminos", p.149.

Table 9.1: Nominal transport costs in maravedis per fanega per league

	Pack animals	Wagons
1751	16.2	9.9
1773	18.0	11.0
1794	-	15.2

Sources: Own calculations

Table 9.2: Deflated transport costs in maravedis per fanega per league

	CPI [259]	Pack animals	Wagons
1751	130	12.5	7.6
1773	149	12.1	7.4
1794	211	-	7.2

Sources: Own calculations

According to the first table, transport costs increased in Spain during the second half of the century. However when we transform these nominal values into real ones deflating by our consumers price index in New Castile, the results show a very different picture. Between 1751 and 1794 real transport costs of moving wheat fell steadily, suggesting that transport conditions improved during the second half of the eighteenth century. The story of falling transport costs match with the increasing economic integration of grain markets in Castile and therefore suggest that the movements of grain within Castile increased during that period.

However the effects of decreasing transport costs are nullified if there is nothing to move through the roads. If the production crisis that affected Guadalajara affected also other parts of Castile, then the possibilities of importing grain would be low. In the same way if Guadalajara did not produce enough wheat, the access to an alternative source of income through exports to other provinces like Madrid would be limited. Guadalajara was traditionally one of the granaries of Madrid and therefore the improvements in transport would have encouraged exports from the province to the rest of Castile. The following table presents the total production of wheat for each one of the main regions of Guadalajara, as well as population, production of wheat per year in fanegas, consumption per capita per year, and total surplus or deficit.

[259] Consumer Price Index (CPI) as in Figure 9.12 for New Castile, 1700=100

Table 9.3: Production and consumption of wheat per region in Guadalajara, mid 18th century

	Wheat (Fanegas)	Population (Inhabitants)	Wheat pc (Fanegas)	Consumption (Fanegas)	Surplus (Fanegas)
Wet	124,855	9,616	13.0	6.0	67,160
Pre-Mountains	143,700	13,947	10.3	6.0	60,018
Mountains	55,900	8,573	6.5	6.0	4,462
Molina	92,860	10,219	9.1	6.0	31,543
South	267,640	57,655	4.6	60	-78,292
Central	65,480	5,845	11.2	6.0	30,412
Total	750,435	105,855	7.1	6.0	115,303

Source: Catastro de la Ensenada

The more urban and populated South was, as expected, the only region with a deficit in the production of wheat. This situation was however more than compensated by the surplus presented in the other five regions. The price differential between the regions with grain surplus and the deficit in the South was 4 reales per fanega, from an average of 14 in the Wet region to an average of 18 in the South. However in extreme cases the difference could even reach up to 6 reales from 13 in the minimum to 19 in the maximum. The distance between the Wet and the South regions was 60 kilometres and the transport cost of moving wheat this distance was 2.5 to 4 reales per fanega depending on the use wagons or backpack animals. Therefore, the price differential made possible and profitable the movement and supply of the urban south from the more rural east.

The province of Guadalajara had a surplus of 115,303 fanegas that could be exported to the surrounding areas, very probably to Madrid. Given an estimated consumption per capita of 6 fanegas per year per inhabitant, the surplus in Guadalajara would be enough to maintain a population of almost 20,000 people. Ringrose estimates that by 1757 the city of Madrid had a population of 109,753 inhabitants.[260] Therefore, the surplus of Guadalajara would be enough to maintain a 17 per cent of the population of Madrid. However, was it profitable to move wheat from Guadalajara to the capital? The price differential between the surplus regions of Guadalajara and Madrid in the period under analysis was 6 reales per fanega on average, although it could reach up to 10 reales per fanega. The distance between the fertile Wet Region and the capital was 100 kilometres and the cost of moving one fanega of wheat that distance between 4.1 and 6.7 reales per

[260] Ringrose, *Madrid*, p.331 .

fanega. Therefore, as in the case of internal trade in Guadalajara, moving wheat from Guadalajara to Madrid was again profitable. In a region where the price of wheat tripled, the intra-regional trade in New Castile gave an additional income to the peasants of Guadalajara and this surely had a positive impact on the standards of living of its population.

10. Conclusion

Guadalajara was in the eighteenth century an agrarian and underdeveloped province of the Crown of Castile. Its population was small and the proximity of Madrid acted like a growth pole whose effects were felt not only around the capital but in all the neighbouring provinces. Guadalajara had a geography and climate that were hostile to agrarian production, being indeed one of the most climatically vulnerable areas of Spain. In 1760 one of the most intense and unexpected climate changes of the last 500 years hit the kingdom of Spain, an anomaly with extreme climatic volatility that combined catastrophic floods and droughts within the same year. The characteristics of Guadalajara suggested that the province would suffer a serious production crisis and therefore a significant reduction on its population. Following the appearance of the climate change, grain production fell by 30 per cent during the 1760s. At the same time the prices of grain increased and real wages in New Castile decreased by 50 per cent, reducing the possibility of migrating to the cities as a possible escape to the crisis. The people of Guadalajara should have suffered severely from the consequences of this economic shock. However, the population in Guadalajara did not diminish, and against all the predictions during the second half of the eighteenth century it maintained a strong and sustained demographic growth.

This thesis has tried to find the answers to this puzzle and the most probable explanation relies on several factors. First and as it has been proved, Guadalajara was a province with a low population density that enjoyed a surplus in the production of grain. Although the geography and climate of the province were not the most favourable, the demographic pressure on resources was therefore small. This allowed Guadalajara to maintain and even increase its population when the production of grain diminished. The more urban areas like the South region suffered the consequences of being more densely populated and having a deficit in the production of food. This situation has been suggested by the baptismal series of the region, being the South the only region in Guadadalajara were the number of baptisms diminished during the eighteenth century.

However, low population density and high grain production per capita were only part of the story. The reduction of income inequality that took place during the second half of the eighteenth century also played a role in the case of Guadalajara. Following Sen's entitlements theory as framework we presented an estimation of income inequality during the eighteenth century, showing that during the production crisis inequality levels decreased with small peasants being the biggest beneficiaries. The development of the road network during the same period also increased the links between

Guadalajara and the surrounding provinces, allowing the peasants of Guadalajara to sell their surplus at prices that had tripled under the pressure of both supply and demand forces.

Therefore, the main finding of the thesis is the unexpected behaviour of a pre-modern economy when it faced an external shock. Guadalajara suffered a climatic crisis and instead of falling into the Malthusian trap as was predicted, it was able to reverse its effects. The role played by income inequality and economic integration were central to explain the process. The second important finding is based on the analysis of income inequality. While most of the literature remarks that the eighteenth century in Spain was a period of increasing income inequality, the analysis in Guadalajara shows that income inequality decreased. Another important result of the thesis shows that economic integration levels in Castile were higher than traditionally presented in the literature. Chapter 8 suggests that the second half of the eighteenth century was a period of increasing integration between the towns in the interior of Castile and the east coast of Spain. Finally one of the major contributions of the thesis is the gathering of a substantial dataset that includes new series of grain production, baptisms, burials and prices for the eighteenth century as well as economic and social indicators for thousands of towns and villages in New Castile. The thesis also includes the creation of a consumer price index for eighteenth century New Castile, income inequality calculations and estimations of economic integration.

The research also leaves open numerous lines of research related to several issues. The most important is probably the debate on income inequality in eighteenth century Spain and its contribution to broader international studies. The study of tithe records in rural areas and taxation records in urban centres can provide a definitive answer to the discussion. Further research can also be carried out in the case of the Catastro de la Ensenada and the priceless information that it provides. In this case the most obvious lines of study are the economic integration studies by using the price data by municipality that can also be combined with the road maps of Spain, in order to check the routes that were used more often to move different goods.

In the words of Thomas Malthus:

"The power of population is so superior to the power of the earth to produce subsistence for man that premature death must in some shape or other visit the human race." [261]

Guadalajara should have suffered the effects of a famine that would have reduced its population to levels according the new levels of food supply. However, the people of Guadalajara not only survived, but prospered in a completely hostile environment. Guadalajara did not just prove Malthus wrong, it also gave us a roadmap for the millions of people that today live in the same pre-modern agrarian societies. The current global warming and the droughts and extreme climate associated to it are destroying the subsistence economies of millions of farmers dragging them into starvation. The study of Guadalajara shows a clear path, and although the road to an equal and open society is not an easy one, policy makers would be wise in listening to an old lesson; that the knowledge of our past will help us to better face the challenges of our future.

[261] Malthus, T., *An Essay on the Principle of Population*, (1798) p.55.

11. Bibliography

11.1 Primary Sources

The archival sources that have been consulted for the thesis, have not been catalogued and therefore making a proper reference to each manuscript is impossible. We therefore provide the archive from where the source was extracted as well as a description of the volume that was consulted.

Books of Tithes: Obtained from the Historical Diocesan Archive of Sigüenza-Guadalajara, and the books of the following parishes.

Parish	***Municipality***
San Andres	*Alboreca*
San Pedro	*Alcuneza*
Asunción de Nuestra Señora	*Alpedroches*
Santa Catalina	*Angon*
Asunción de Nuestra Señora	*Anquela del Pedregal*
Nuestra Señora de la Paz	*Aragosa*
Asunción de Nuestra Señora	*Bañuelos*
San Cristóbal	*Canales de Molina*
San Julian	*Cantalojas*
San Miguel	*Castejon de Henares*
Santa Magdalena	*Ciruelos del Pinar*
Asunción de Nuestra Señora	*La Fuensaviñan*
Asunción de Nuestra Señora	*Galve de Sorbe*
Asunción de Nuestra Señora	*Herreria*
Natividad	*Hijes*
Asunción de Nuestra Señora	*Ledanca*
Natividad	*Miedes de Atienza*
San Cristóbal	*Mojares*
Santa Maria Magdalena	*Riba de Saelices*
Santo Domingo de Guzman	*Rillo de Gallo*
Transfiguración	*Santiuste*
Santa Eulalia	*Sienes*
Asunción de Nuestra Señora	*Torrubia*
Asunción de Nuestra Señora	*Trillo*
Santiago	*Valdelcubo*
Natividad	*Villares de Jadraque*
San Blas	*Villaseca de Henares*

<u>Baptisms</u>: Obtained from the Historical Diocesan Archive of Sigüenza-Guadalajara, and the books of the following parishes.

Parish	***Municipality***
San Esteban	*Albares*
San Andres	*Anchuela del Pedregal*
San Martin	*Anquela del Ducado*
Inmaculada	*Arroyo de las Fraguas*
Asunción de Nuestra Señora	*Bañuelos*
Santiago	*La Bodera*
San Julian	*Cantalojas*
Santa Catalina	*Cañizares*
Asunción de Nuestra Señora	*Castilmimbre*
Santa Magdalena	*Ciruelos del Pinar*
Asunción de Nuestra Señora	*La Cobeta*
San Juan Bautista	*Concha*
Asunción de Nuestra Señora	*Congostrina*
Asunción de Nuestra Señora	*Galve de Sorbe*
San Miguel	*Garbajosa*
Natividad	*Hijes*
San Juan Bautista	*Milmarcos*
San Mateo	*Olmeda de Jadraque*
San Mateo	*Peralejos de las Truchas*
San Sebastián	*Renales*
Santa Maria Magdalena	*Riba de Saelices*
Asunción de Nuestra Señora	*Setiles*
Santa Eulalia	*Sienes*
Inmaculada	*Somolinos*
Asunción de Nuestra Señora	*Torrubia*

<u>Books of Burials</u>: Obtained from the Historical Diocesan Archive of Sigüenza-Guadalajara, and the books of the following parishes.

Parish	***Municipality***
Santa Cristina	*Adobes*
Asuncion de Nuestra Señora	*Azañon*
Asuncion de Nuestra Señora	*Bañuelos*
San Julian	*Cantalojas*
Asuncion de Nuestra Señora	*Galve de Sorbe*
Natividad	*Hijes*
San Juan Bautista	*Milmarcos*
Inmaculada	*Somolinos*
Asuncion de Nuestra Señora	*Torrubia*
Santiago	*Valdelcubo*

Prices: Obtained from the Historical Diocesan Archive of Getafe, from the accounting books of the parish of Santa Maria Magdalena.

Information from the Catastro: The digital copies of the books for the different municipalities were consulted online through the website of the Spanish Ministry of Education (pares.mcu.es) The books of the municipalities that were consulted by province were:

PROVINCE OF ALBACETE				
Abengibre		Elche de la Sierra		Ossa de Montiel
Alatoz		Férez		Paterna del Madera
Albacete		Fuensanta		Peñas de San Pedro
Albatana		Fuente-Álamo		Peñascosa
Alborea		Fuentealbilla		Pétrola
Alcadozo		Golosalvo		Povedilla
Alcalá del Júcar		Hellín		Pozohondo
Alcaraz		Higueruela		Pozo-Lorente
Almansa		Hoya-Gonzalo		Pozuelo
Alpera		Jorquera		Riópar
Ayna		La Gineta		Robledo
Balazote		La Herrera		Salobre
Balsa de Ves		La Recueja		San Pedro
Barrax		La Roda		Socovos
Bienservida		Letur		Tarazona de la Mancha
Bogarra		Lezuza		Tobarra
Bonete		Liétor		Valdeganga
Carcelén		Madrigueras		Vianos
Casas de Juan Núñez		Mahora		Villa de Ves
Casas de Lázaro		Masegoso		Villalgordo del Júcar
Casas de Ves		Minaya		Villamalea
Casas-Ibáñez		Molinicos		Villapalacios
Caudete		Montalvos		Villarrobledo
Cenizate		Montealegre del Castillo		Villatoya
Chinchilla de Monte-Aragón		Motilleja		Villavaliente
Corral-Rubio		Munera		Villaverde de Guadalimar
Cotillas		Navas de Jorquera		Viveros
El Ballestero		Nerpio		Yeste
El Bonillo		Ontur		

PROVINCE OF CIUDAD REAL				
Abenójar		Ciudad Real		Pozuelo de Calatrava
Agudo		Corral de Calatrava		Puebla de Don Rodrigo
Alamillo		Cózar		Puebla del Príncipe
Albaladejo		Daimiel		Puerto Lápice
Alcázar de San Juan		El Robledo		Puertollano
Alcoba		Fernancaballero		Retuerta del Bullaque
Alcolea de Calatrava		Fontanarejo		Ruidera
Alcubillas		Fuencaliente		Saceruela
Aldea del Rey		Fuenllana		San Carlos del Valle
Alhambra		Fuente El Fresno		San Lorenzo de Calatrava

Almadén		Gránatula de Calatrava		Santa Cruz de los Cáñ
Almadenejos		Guadalmez		Santa Cruz de Mudela
Almagro		Herencia		Socuéllamos
Almedina		Hinojosas de Calatrava		Solana del Pino
Almodóvar del Campo		Horcajo de los Montes		Terrinches
Almuradiel		La Solana		Tomelloso
Anchuras		Las Labores		Torralba de Calatrava
Arenas de San Juan		Los Cortijos		Torre de Juan Abad
Argamasilla de Alba		Los Pozuelos de Calatrava		Torrenueva
Argamasilla de Calatrava		Luciana		Valdemanco del Esteras
Arroba de los Montes		Malagón		Valdepeñas
Ballesteros de Calatrava		Manzanares		Valenzuela de Calatrava
Bolaños de Calatrava		Membrilla		Villahermosa
Brazatortas		Mestanza		Villamanrique
Cabezarados		Miguelturra		Villamayor de Calatrava
Cabezarrubias del Puerto		Montiel		Villanueva de la Fuente
Calzada de Calatrava		Moral de Calatrava		Villanueva de los Infantes
Campo de Criptana		Navalpino		Villanueva de San Carlos
Cañada de Calatrava		Navas de Estena		Villar del Pozo
Caracuel de Calatrava		Pedro Muñoz		Villarrubia de los Ojos
Carrión de Calatrava		Picón		Villarta de San Juan
Carrizosa		Piedrabuena		Viso del Marqués
Castellar de Santiago		Poblete		
Chillón		Porzuna		

PROVINCE OF CUENCA				
Abia de la Obispalía		Fuente de Pedro Naharro		Quintanar del Rey
Alarcón		Fuentelespino de Haro		Rada de Haro
Albaladejo del Cuende		Fuentelespino de Moya		Reíllo
Albalate de las Nogueras		Fuentes		Rozalén del Monte
Albendea		Fuertescusa		Saceda-Trasierra
Alcalá de la Vega		Gabaldón		Saelices
Alcantud		Garaballa		Salinas del Manzano
Alcázar del Rey		Gascueña		Salmeroncillos
Alcohujate		Graja de Campalbo		Salvacañete
Alconchel de la Estrella		Graja de Iniesta		San Clemente
Algarra		Henarejos		San Lorenzo de la Parrilla
Aliaguilla		Honrubia		San Martín de Boniches
Almendros		Hontanaya		San Pedro Palmiches
Almodóvar del Pinar		Hontecillas		Santa Cruz de Moya
Almonacid del Marquesado		Horcajo de Santiago		Santa María de los Llanos
Altarejos		Huélamo		Santa María del Campo Rus
Arandilla del Arroyo		Huelves		Santa María del Val
Arcas del Villar		Huérguina		Sisante
Arcos de la Sierra		Huerta de la Obispalía		Solera del Gabaldón
Arguisuelas		Huerta del Marquesado		Sotorribas
Arrancacepas		Huete		Talayuelas
Atalaya del Cañavate		Iniesta		Tarancón
Barajas de Melo		Jábaga		Tébar
Barchín del Hoyo		La Alberca de Záncara		Tejadillos

Bascuñana de San Pedro	La Almarcha	Tinajas
Beamud	La Cierva	Torralba
Belinchón	La Frontera	Torrejoncillo del Rey
Belmonte	La Hinojosa	Torrubia del Campo
Belmontejo	La Parra de las Vegas	Torrubia del Castillo
Beteta	La Peraleja	Tragacete
Boniches	La Pesquera	Tresjuncos
Buciegas	Laguna del Marquesado	Tribaldos
Buenache de Alarcón	Lagunaseca	Uclés
Buenache de la Sierra	Landete	Uña
Buendía	Las Majadas	Valdemeca
Campillo de Altobuey	Las Mesas	Valdemorillo de la Sierra
Campillos-Paravientos	Las Pedroñeras	Valdemoro-Sierra
Campillos-Sierra	Las Valeras	Valdeolivas
Canalejas del Arroyo	Ledaña	Valdetórtola
Cañada del Hoyo	Leganiel	Valhermoso de la Fuente
Cañadajuncosa	Los Hinojosos	Valsalobre
Cañamares	Los Valdecolmenas	Valverde de Júcar
Cañaveras	Mariana	Valverdejo
Cañaveruelas	Masegosa	Vara de Rey
Cañete	Minglanilla	Vega del Codorno
Cañizares	Mira	Vellisca
Carboneras de Guadazaón	Monreal del Llano	Villaconejos de Trabaque
Cardenete	Montalbanejo	Villaescusa de Haro
Carrascosa	Montalbo	Villagarcía del Llano
Carrascosa de Haro	Monteagudo de las Salinas	Villalba de la Sierra
Carrascosa del Campo	Mota de Altarejos	Villalba del Rey
Casas de Benítez	Mota del Cuervo	Villalgordo del Marquesado
Casas de Fernando Alonso	Motilla del Palancar	Villalpardo
Casas de Garcimolina	Moya	Villamayor de Santiago
Casas de Guijarro	Narboneta	Villanueva de Guadamajud
Casas de Haro	Olivares de Júcar	Villanueva de la Jara
Casas de los Pinos	Olmeda de la Cuesta	Villar de Cañas
Casasimarro	Olmeda del Rey	Villar de Domingo García
Castejón	Olmedilla de Alarcón	Villar de la Encina
Castillejo de Iniesta	Olmedilla de Eliz	Villar de Olalla
Castillejo-Sierra	Osa de la Vega	Villar del Humo
Castillo de Garcimuñoz	Pajarón	Villar del Infantado
Castillo-Albaráñez	Pajaroncillo	Villar Y Velasco
Cervera del Llano	Palomares del Campo	Villarejo de Fuentes
Chillarón de Cuenca	Palomera	Villarejo de la Peñuela
Chumillas	Paracuellos	Villarejo-Periesteban
Cuenca	Paredes	Villares del Saz
Cueva del Hierro	Pinarejo	Villarrubio
El Acebrón	Pineda de Gigüela	Villarta
El Cañavate	Piqueras del Castillo	Villas de la Ventosa
El Herrumblar	Portalrubio de Guadamajud	Villaverde Y Pasaconsol
El Hito	Portilla	Víllora
El Pedernoso	Poyatos	Vindel
El Peral	Pozoamargo	Yémeda
El Picazo	Pozorrubielos de la Mancha	Zafra de Záncara
El Pozuelo	Pozorrubio de Santiago	Zafrilla

El Provencio		Priego		Zarza de Tajo
Enguídanos		Puebla de Almenara		Zarzuela
Fresneda de Altarejos		Puebla de Don Francisco		
Fresneda de la Sierra		Puebla del Salvador		

PROVINCE OF GUADALAJARA				
Abánades		Esplegares		Pozo de Guadalajara
Ablanque		Establés		Prádena de Atienza
Adobes		Estriégana		Prados Redondos
Alaminos		Fontanar		Puebla de Beleña
Alarilla		Fuembellida		Puebla de Vallés
Albalate de Zorita		Fuencemillán		Quer
Albares		Fuentelahiguera de Albatages		Rebollosa de Jadraque
Albendiego		Fuentelencina		Renera
Alcocer		Fuentelsaz		Retiendas
Alcolea de las Peñas		Fuentelviejo		Riba de Saelices
Alcolea del Pinar		Fuentenovilla		Rillo de Gallo
Alcoroches		Gajanejos		Riofrío del Llano
Aldeanueva de Guadalajara		Galápagos		Robledillo de Mohernando
Algar de Mesa		Galve de Sorbe		Robledo de Corpes
Algora		Gascueña de Bornova		Romanillos de Atienza
Alhóndiga		Guadalajara		Romanones
Alique		Henche		Rueda de la Sierra
Almadrones		Heras		Sacecorbo
Almoguera		Herrería		Sacedón
Almonacid de Zorita		Hiendelaencina		Saelices de la Sal
Alocén		Hijes		Salmerón
Alovera		Hita		San Andrés del Congosto
Alustante		Hombrados		San Andrés del Rey
Angón		Hontoba		Santiuste
Anguita		Horche		Sauca
Anquela del Ducado		Huérmeces del Cerro		Sayatón
Anquela del Pedregal		Huertahernando		Selas
Aranzueque		Hueva		Semillas
Arbancón		Humanes		Setiles
Arbeteta		Illana		Sienes
Argecilla		Iniéstola		Sigüenza
Armallones		Irueste		Solanillos del Extremo
Armuña de Tajuña		Jadraque		Somolinos
Arroyo de las Fraguas		Jirueque		Sotodosos
Atanzón		La Bodera		Tamajón
Atienza		La Hortezuela de Océn		Taragudo
Auñón		La Huerce		Taravilla
Azuqueca de Henares		La Mierla		Tartanedo
Baides		La Miñosa		Tendilla
Baños de Tajo		La Olmeda de Jadraque		Terzaga
Bañuelos		La Toba		Tierzo
Barriopedro		La Yunta		Tordellego
Berninches		Las Inviernas		Tordelrábano
Brihuega		Ledanca		Tordesilos
Budia		Loranca de Tajuña		Torija

Bujalaro	Lupiana	Torre del Burgo
Bustares	Luzaga	Torrecuadrada de Molina
Cabanillas del Campo	Luzón	Torrecuadradilla
Campillo de Dueñas	Majaelrayo	Torrejón del Rey
Campillo de Ranas	Málaga del Fresno	Torremocha de Jadraque
Campisábalos	Malaguilla	Torremocha del Campo
Canredondo	Mandayona	Torremocha del Pinar
Cantalojas	Mantiel	Torremochuela
Cañizar	Maranchón	Torrubia
Casa de Uceda	Masegoso de Tajuña	Tórtola de Henares
Casas de San Galindo	Matarrubia	Tortuera
Caspueñas	Matillas	Tortuero
Castejón de Henares	Mazarete	Traid
Castellar de la Muela	Mazuecos	Trijueque
Castilforte	Medranda	Trillo
Castilnuevo	Megina	Uceda
Cendejas de Enmedio	Membrillera	Ujados
Cendejas de la Torre	Miedes de Atienza	Utande
Centenera	Millana	Valdarachas
Checa	Milmarcos	Valdearenas
Chequilla	Mirabueno	Valdeavellano
Chillarón del Rey	Miralrío	Valdeaveruelo
Chiloeches	Mochales	Valdeconcha
Cifuentes	Mohernando	Valdegrudas
Cincovillas	Molina	Valdelcubo
Ciruelas	Monasterio	Valdenuño-Fernández
Ciruelos del Pinar	Mondéjar	Valdepeñas de la Sierra
Cobeta	Montarrón	Valderrebollo
Cogollor	Moratilla de los Meleros	Valdesotos
Cogolludo	Morenilla	Valfermoso de Tajuña
Condemios de Abajo	Muduex	Valhermoso
Condemios de Arriba	Navas de Jadraque	Valtablado del Río
Congostrina	Negredo	Valverde de los Arroyos
Copernal	Ocentejo	Viana de Jadraque
Corduente	Olmeda de Cobeta	Villanueva de Alcorón
Driebes	Orea	Villanueva de Argecilla
Durón	Pálmaces de Jadraque	Villanueva de la Torre
El Cardoso de la Sierra	Pardos	Villares de Jadraque
El Casar	Paredes de Sigüenza	Villaseca de Henares
El Cubillo de Uceda	Pareja	Villaseca de Uceda
El Olivar	Pastrana	Villel de Mesa
El Ordial	Peñalén	Viñuelas
El Pedregal	Peñalver	Yebes
El Pobo de Dueñas	Peralejos de las Truchas	Yebra
El Recuenco	Peralveche	Yélamos de Abajo
El Sotillo	Pinilla de Jadraque	Yélamos de Arriba
Embid	Pinilla de Molina	Yunquera de Henares
Escamilla	Pioz	Zaorejas
Escariche	Piqueras	Zarzuela de Jadraque
Escopete	Poveda de la Sierra	Zorita de los Canes
Espinosa de Henares	Pozo de Almoguera	

PROVINCE OF TOLEDO				
Ajofrín		Garciotún		Orgaz
Alameda de la Sagra		Gerindote		Oropesa
Albarreal de Tajo		Guadamur		Otero
Alcabón		Herreruela de Oropesa		Palomeque
Alcañizo		Hinojosa de San Vicente		Pantoja
Alcaudete de la Jara		Hontanar		Paredes de Escalona
Alcolea de Tajo		Hormigos		Parrillas
Aldea En Cabo		Huecas		Pelahustán
Aldeanueva de Barbarroya		Huerta de Valdecárabanos		Pepino
Aldeanueva de San Bartolomé		Illán de Vacas		Polán
Almendral de la Cañada		Illescas		Portillo de Toledo
Almonacid de Toledo		La Calzada de Oropesa		Puerto de San Vicente
Almorox		La Estrella		Pulgar
Añover de Tajo		La Guardia		Quero
Arcicóllar		La Iglesuela		Quintanar de la Orden
Argés		La Mata		Quismondo
Azután		La Nava de Ricomalillo		Recas
Barcience		La Puebla de Almoradiel		Retamoso
Bargas		La Puebla de Montalbán		Rielves
Belvís de la Jara		La Pueblanueva		Robledo del Mazo
Borox		La Torre de Esteban Hambrán		San Bartolomé de las Abierta
Buenaventura		La Villa de Don Fadrique		San Martín de Montalbán
Burguillos de Toledo		Lagartera		San Martín de Pusa
Burujón		Las Herencias		San Pablo de los Montes
Cabañas de la Sagra		Las Ventas Con Peña Aguilera		San Román de los Montes
Cabañas de Yepes		Las Ventas de Retamosa		Santa Ana de Pusa
Cabezamesada		Las Ventas de San Julián		Santa Cruz de la Zarza
Calera Y Chozas		Layos		Santa Cruz del Retamar
Caleruela		Lillo		Santa Olalla
Camarena		Lominchar		Santo Domingo-Caudilla
Camarenilla		Los Cerralbos		Sartajada
Camuñas		Los Navalmorales		Segurilla
Cardiel de los Montes		Los Navalucillos		Seseña
Carmena		Los Yébenes		Sevilleja de la Jara
Carranque		Lucillos		Sonseca
Carriches		Madridejos		Sotillo de las Palomas
Casarrubios del Monte		Magán		Talavera de la Reina
Casasbuenas		Malpica de Tajo		Tembleque
Castillo de Bayuela		Manzaneque		Toledo
Cazalegas		Maqueda		Torralba de Oropesa
Cebolla		Marjaliza		Torrecilla de la Jara
Cedillo del Condado		Marrupe		Torrico
Cervera de los Montes		Mascaraque		Torrijos
Chozas de Canales		Mazarambroz		Totanés
Chueca		Mejorada		Turleque
Ciruelos		Menasalbas		Ugena
Cobeja		Méntrida		Urda
Cobisa		Mesegar		Valdeverdeja
Consuegra		Miguel Esteban		Valmojado
Corral de Almaguer		Mocejón		Velada

Cuerva		Mohedas de la Jara		Villacañas
Domingo Pérez		Montearagón		Villafranca de los Caballeros
Dosbarrios		Montesclaros		Villaluenga de la Sagra
El Campillo de la Jara		Mora		Villamiel de Toledo
El Carpio de Tajo		Nambroca		Villaminaya
El Casar de Escalona		Navahermosa		Villamuelas
El Puente del Arzobispo		Navalcán		Villanueva de Alcardete
El Real de San Vicente		Navalmoralejo		Villanueva de Bogas
El Romeral		Navamorcuende		Villarejo de Montalbán
El Toboso		Noblejas		Villarrubia de Santiago
El Viso de San Juan		Noez		Villaseca de la Sagra
Erustes		Nombela		Villasequilla
Escalona		Novés		Villatobas
Escalonilla		Numancia de la Sagra		Yeles
Espinoso del Rey		Nuño Gómez		Yepes
Esquivias		Ocaña		Yuncler
Fuensalida		Olías del Rey		Yunclillos
Gálvez		Ontígola		Yuncos

PROVINCE OF MADRID				
Ajalvir		Galapagar		Rascafría
Alameda del Valle		Garganta de los Montes		Redueña
Alcalá de Henares		Gargantilla del Lozoya		Ribatejada
Alcobendas		Gascones		Rivas-Vaciamadrid
Alcorcón		Getafe		Robledillo de la Jara
Aldea del Fresno		Griñón		Robledo de Chavela
Algete		Guadalix de la Sierra		Robregordo
Alpedrete		Guadarrama		Rozas de Puerto Real
Ambite		Horcajo de la Sierra		San Agustín de Guadalix
Anchuelo		Horcajuelo de la Sierra		San Fernando de Henares
Aranjuez		Hoyo de Manzanares		San Lorenzo de el Escorial
Arganda del Rey		Humanes de Madrid		San Martín de la Vega
Arroyomolinos		La Acebeda		San Martín de Valdeiglesias
Batres		La Cabrera		San Sebastián de los Reyes
Becerril de la Sierra		La Hiruela		Santa María de la Alameda
Belmonte de Tajo		La Olmeda de las Fuentes		Santorcaz
Berzosa del Lozoya		La Serna del Monte		Serranillos del Valle
Boadilla del Monte		Las Rozas de Madrid		Sevilla la Nueva
Braojos		Leganés		Somosierra
Brea de Tajo		Loeches		Soto del Real
Brunete		Los Molinos		Talamanca de Jarama
Buitrago del Lozoya		Los Santos de la Humosa		Tielmes
Bustarviejo		Lozoya		Titulcia
Cabanillas de la Sierra		Lozoyuela-Navas-Sieteiglesias		Torrejón de Ardoz
Cadalso de los Vidrios		Madarcos		Torrejón de la Calzada
Camarma de Esteruelas		Madrid		Torrejón de Velasco
Campo Real		Majadahonda		Torrelaguna
Canencia		Manzanares el Real		Torrelodones
Carabaña		Meco		Torremocha de Jarama
Casarrubuelos		Mejorada del Campo		Torres de la Alameda

Cenicientos		Miraflores de la Sierra		Valdaracete
Cercedilla		Montejo de la Sierra		Valdeavero
Cervera de Buitrago		Moraleja de Enmedio		Valdelaguna
Chapinería		Moralzarzal		Valdemanco
Chinchón		Morata de Tajuña		Valdemaqueda
Ciempozuelos		Móstoles		Valdemorillo
Cobeña		Navacerrada		Valdemoro
Collado Mediano		Navalafuente		Valdeolmos
Collado Villalba		Navalagamella		Valdepiélagos
Colmenar de Oreja		Navalcarnero		Valdetorres de Jarama
Colmenar del Arroyo		Navarredonda		Valdilecha
Colmenar Viejo		Navas del Rey		Valverde de Alcalá
Colmenarejo		Nuevo Baztán		Velilla de San Antonio
Corpa		Orusco		Venturada
Coslada		Paracuellos de Jarama		Villa del Prado
Cubas		Parla		Villaconejos
Daganzo de Arriba		Patones		Villalbilla
El Alamo		Pedrezuela		Villamanrique de Tajo
El Atazar		Pelayos de la Presa		Villamanta
El Berrueco		Perales de Tajuña		Villamantilla
El Boalo		Pezuela de las Torres		Villanueva de la Cañada
El Escorial		Pinilla del Valle		Villanueva de Perales
El Molar		Pinto		Villanueva del Pardillo
El Vellón		Piñuécar		Villar del Olmo
Estremera		Pozuelo de Alarcón		Villarejo de Salvanés
Fresnedillas de la Oliva		Pozuelo del Rey		Villaviciosa de Odón
Fresno de Torote		Prádena del Rincón		Villavieja del Lozoya
Fuenlabrada		Puebla de la Sierra		Zarzalejo
Fuente el Saz de Jarama		Puentes Viejas		
Fuentidueña de Tajo		Quijorna		

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12. Appendix: selection of data:

This appendix includes a sample of the dataset that is included in the CD-ROM, presenting the most important time series and examples of the cross section database. Given the space limitations it was not possible to include all the dataset in the printed copy of the thesis, and therefore it has been included in a CD-ROM. The appendix however does include some examples of the dataset, in order to make the reader understand better the nature and characteristics of the database.

12.1 Production of grain in the province of Guadalajara, 1700-1800 (1700-1710=100)

	Wheat	*Barley*	*Rye*	*Oats*
1700	130	94	145	96
1701	133	97	124	78
1702	107	105	104	83
1703	92	90	92	81
1704	130	146	136	114
1705	89	108	85	71
1706	97	91	73	106
1707	87	81	71	97
1708	72	71	65	154
1709	100	116	105	120
1710	62	91	65	123
1711	91	94	99	167
1712	96	105	107	99
1713	95	74	85	78
1714	126	126	126	170
1715	106	81	106	109
1716	99	65	109	68
1717	121	109	111	87
1718	143	114	168	101
1719	133	161	183	160
1720	175	200	188	188
1721	80	161	113	202
1722	114	176	159	163
1723	122	175	182	175
1724	121	159	136	192
1725	128	167	150	174
1726	181	207	166	211
1727	107	158	136	203
1728	112	153	146	172
1729	95	118	117	89
1730	131	173	117	232
1731	117	119	98	178
1732	107	147	107	170
1733	110	95	70	135
1734	122	130	126	176
1735	109	135	115	213
1736	131	137	95	225
1737	117	115	105	200
1738	156	156	113	154
1739	139	135	91	172
1740	106	100	58	102
1741	108	97	72	105
1742	177	238	135	232
1743	134	155	63	193
1744	131	111	102	92
1745	114	118	84	75
1746	124	120	65	79
1747	103	126	46	160
1748	124	132	77	150
1749	104	143	87	198
1750	187	223	125	306

	Wheat	*Barley*	*Rye*	*Oats*
1751	99	110	52	145
1752	127	125	66	155
1753	119	159	62	302
1754	161	156	112	174
1755	140	109	102	101
1756	199	196	110	151
1757	165	140	97	117
1758	121	100	73	121
1759	130	136	50	142
1760	127	146	77	202
1761	109	119	58	134
1762	118	107	56	155
1763	94	91	37	160
1764	118	132	43	226
1765	125	131	65	204
1766	129	162	69	228
1767	97	100	39	165
1768	148	152	55	269
1769	104	95	34	145
1770	138	107	52	149
1771	125	120	54	181
1772	156	110	68	224
1773	127	128	50	234
1774	109	132	56	211
1775	118	149	52	304
1776	126	117	57	278
1777	103	93	52	243
1778	124	100	55	244
1779	119	115	28	336
1780	107	91	45	211
1781	147	144	64	297
1782	127	110	66	177
1783	132	138	83	253
1784	121	54	43	185
1785	100	73	45	159
1786	115	86	65	179
1787	117	95	48	237
1788	112	95	53	286
1789	123	121	61	333
1790	148	132	74	273
1791	145	139	60	287
1792	112	125	41	258
1793	142	109	76	229
1794	109	120	61	250
1795	116	137	87	405
1796	129	106	61	285
1797	96	87	40	188
1798	145	126	70	276
1799	116	84	66	259
1800	109	83	56	258

12.2 Baptisms and burials in the province of Guadalajara, 1700-1800 (1700-1710=100)

	Baptisms	*Burials*
1700	86	89
1701	114	93
1702	105	93
1703	104	60
1704	113	69
1705	106	57
1706	103	131
1707	88	187
1708	84	120
1709	94	101
1710	92	73
1711	83	91
1712	98	70
1713	91	75
1714	107	66
1715	106	76
1716	126	95
1717	106	121
1718	112	91
1719	116	115
1720	105	77
1721	112	87
1722	126	79
1723	115	109
1724	130	123
1725	120	82
1726	125	73
1727	126	71
1728	112	77
1729	127	101
1730	102	172
1731	107	108
1732	111	79
1733	104	82
1734	104	76
1735	120	92
1736	95	80
1737	112	110
1738	85	112
1739	109	127
1740	108	107
1741	77	141
1742	108	119
1743	121	85
1744	114	89
1745	113	73
1746	121	80
1747	113	157
1748	105	137
1749	115	150
1750	110	98

	Baptisms	*Burials*
1751	117	83
1752	106	111
1753	109	108
1754	122	107
1755	118	88
1756	115	87
1757	113	107
1758	127	91
1759	130	88
1760	126	128
1761	121	99
1762	109	133
1763	124	118
1764	123	107
1765	118	121
1766	124	103
1767	95	97
1768	133	107
1769	119	74
1770	124	116
1771	110	110
1772	130	134
1773	144	103
1774	128	89
1775	123	81
1776	128	104
1777	137	74
1778	129	79
1779	137	124
1780	140	137
1781	114	151
1782	124	95
1783	116	98
1784	126	91
1785	131	98
1786	122	138
1787	108	136
1788	121	94
1789	121	113
1790	138	102
1791	133	90
1792	137	73
1793	128	79
1794	150	112
1795	143	102
1796	136	109
1797	138	121
1798	141	147
1799	113	115
1800	148	136

12.3 Price of wheat and barley in Madrid, 1644-1796 (reales per fanega)

	Wheat	*Barley*
1644	18.0	9.0
1645	18.0	9.0
1646	18.0	9.0
1647	18.0	9.0
1648	18.0	9.0
1649	18.0	9.0
1650	18.0	9.0
1651	18.0	9.0
1652	18.0	9.0
1653	18.0	9.0
1654	18.0	9.0
1655	18.0	9.0
1656	18.0	9.0
1657	18.0	9.0
1658	18.0	9.0
1659	18.0	9.0
1660	22.0	10.0
1661	22.0	10.0
1662	23.0	14.0
1663	23.0	14.0
1664	46.0	28.0
1665	38.0	16.0
1666	38.0	18.0
1667	38.0	18.0
1668	43.0	24.0
1669	27.0	12.0
1670	17.0	8.0
1671	20.0	14.0
1672	19.0	11.0
1673	20.0	11.0
1674	18.0	19.0
1675	36.0	14.0
1676	38.0	12.0
1677	48.0	28.0
1678	56.0	30.0
1679	44.0	31.0
1680	26.0	17.0
1681	16.0	10.0
1682	12.0	8.0
1683	34.0	29.0
1684	33.0	16.0
1685	23.0	11.0
1686	18.0	8.0
1687	18.5	9.5
1688	13.0	8.5
1689	13.0	11.0
1690	15.0	9.0
1691	19.0	9.5
1692	17.8	8.5
1693	16.5	7.5
1694	14.0	3.0

	Wheat	*Barley*
1695	14.0	3.0
1696	14.0	10.0
1697	16.0	11.0
1698	29.2	15.4
1699	38.0	12.0
1700	16.0	12.0
1701	53.0	8.0
1702	15.0	10.0
1703	15.0	10.0
1704	16.0	6.5
1705	20.0	7.0
1706	23.9	13.8
1707	21.0	17.8
1708	52.0	16.0
1709	47.0	19.0
1710	50.0	18.0
1711	30.0	9.5
1712	18.0	10.0
1713	22.0	15.0
1714	17.0	13.0
1715	11.5	8.0
1716	13.0	9.0
1717	12.0	8.0
1718	13.0	9.0
1719	8.5	4.0
1720	8.0	4.0
1721	14.0	7.0
1722	20.0	8.0
1723	23.0	8.5
1724	16.0	8.0
1725	14.0	6.0
1726	15.0	7.0
1727	20.0	8.0
1728	23.0	8.5
1729	23.0	12.0
1730	20.0	9.3
1731	12.0	4.0
1732	15.0	7.5
1733	42.0	10.0
1734	42.0	15.0
1735	30.0	10.0
1736	30.0	10.0
1737	28.0	28.0
1738	26.0	18.0
1739	19.0	13.0
1740	24.0	14.9
1741	24.0	13.9
1742	24.0	13.0
1743	17.0	10.5
1744	17.0	11.0
1745	24.0	13.0

	Wheat	*Barley*
1746	18.0	12.3
1747	23.0	10.5
1748	31.0	13.0
1749	29.0	13.0
1750	32.0	16.4
1751	24.0	13.7
1752	37.0	17.0
1753	52.0	36.3
1754	41.0	32.0
1755	20.0	10.3
1756	26.0	22.0
1757	18.0	12.0
1758	19.0	10.0
1759	21.5	12.0
1760	32.0	12.0
1761	32.0	12.0
1762	33.0	12.5
1763	51.0	28.6
1764	43.0	29.0
1765	48.8	18.0
1766	47.0	16.0
1767	50.0	24.8
1768	44.0	16.5
1769	46.1	20.0
1770	27.5	13.3
1771	33.8	13.9
1772	42.0	19.2
1773	48.8	24.5
1774	37.0	19.3
1775	25.0	14.0
1776	34.0	15.0
1777	34.0	14.0
1778	33.0	12.9
1779	49.5	21.9
1780	52.0	25.7
1781	29.0	9.1
1782	32.0	15.0
1783	27.2	12.8
1784	35.0	22.6
1785	32.0	17.0
1786	56.0	24.4
1787	55.0	23.0
1788	62.0	24.2
1789	59.0	40.3
1790	56.0	18.8
1791	37.0	18.4
1792	47.9	21.6
1793	59.0	24.0
1794	66.0	11.0
1795	46.0	13.9
1796	50.0	37.0

12.4 Calculation of total income in the village of Bañuelos, early 1750s (in reales)

	Amount of land	Amount per unit of land	Produced	Price per unit produced	Value
Vegetables	10	25.0	250	3.0	75
Hemp	10	283.0	2,830	0.2	51
Hemp Seed	10	1.5	15	20.0	30
Fruit	3	10.0	30	5.0	15
Wheat			478	15.0	7,170
Barley			226	7.5	1,695
Oats			12	7.5	90
Lambs			46	8.0	368
Wool			197	1.0	197
Total					**96,909**
Wages					**20,665**
% Cereals					**76.16%**
Inhabitants					**66**
Reales per capita					**454**

12.5 Production of wheat, barley, rye and oats per identified producer in the village of Bañuelos (1700-1708)

		W	*B*	*R*	*O*		*W*	*B*	*R*	*O*		*W*	*B*	*R*	*O*
Juan Carrasco Ruiz	**1700**	22	9	4	0	**1701**	30	6	3	3	**1702**	18	6	4	0
Juan de Anton	**1700**	20	7	2	0	**1701**	16	9	3	0	**1702**	16	6	3	0
Miguel de Anton	**1700**	15	3	1	1	**1701**	19	4	2	1	**1702**	12	2	0	1
Miguel Gaxo	**1700**	15	3	4	1	**1701**	13	2	5	1	**1702**	12	3	4	2
Miguel Chicharro	**1700**	22	8	2	2	**1701**	26	10	1	1	**1702**	16	5	1	1
Juan Chicharro	**1700**	7	3	5	0	**1701**	16	3	20	0	**1702**	12	3	1	1
Andres Carrasco	**1700**	9	3	3	0	**1701**	12	0	0	0	**1702**	8	2	1	0
Migueno de iñigo	**1700**	13	4	1	0	**1701**	16	4	1	0	**1702**	12	5	0	0

		W	*B*	*R*	*O*		*W*	*B*	*R*	*O*		*W*	*B*	*R*	*O*
Juan Carrasco Ruiz	**1703**	20	8	3	2	**1704**	23	12	2	4	**1705**	21	10	2	2
Juan de Anton	**1703**	15	7	2	0	**1704**	19	8	2	1	**1705**	16	11	3	0
Miguel de Anton	**1703**	9	4	0	0	**1704**	16	4	2	0	**1705**	13	3	2	1
Miguel Gaxo	**1703**	9	2	0	0	**1704**	12	5	4	3	**1705**	9	4	1	2
Miguel Chicharro	**1703**	16	8	1	0	**1704**	20	9	1	1	**1705**	13	7	2	1
Juan Chicharro	**1703**	8	3	0	1	**1704**	12	4	1	1	**1705**	11	5	1	1
Andres Carrasco	**1703**	9	0	0	0	**1704**	11	7	0	1	**1705**	10	5	0	1
Migueno de iñigo	**1703**	15	5	0	0	**1704**	16	7	1	1	**1705**	15	5	0	0

		W	*B*	*R*	*O*		*W*	*B*	*R*	*O*		*W*	*B*	*R*	*O*
Juan Carrasco Ruiz	**1706**	24	10	5	5	**1707**	19	7	3	0	**1708**	16	8	2	4
Juan de Anton	**1706**	24	16	2	0	**1707**	18	6	1	1	**1708**	9	5	0	3
Miguel de Anton	**1706**	12	3	2	2	**1707**	18	4	0	0	**1708**	17	4	0	1
Miguel Gaxo	**1706**	14	5	5	3	**1707**	14	5	6	3	**1708**	14	4	5	4
Miguel Chicharro	**1706**	17	7	1	2	**1707**	11	4	3	2	**1708**	12	6	2	3
Juan Chicharro	**1706**	17	7	1	2	**1707**	12	4	2	2	**1708**	15	5	0	1
Andres Carrasco	**1706**	14	5	2	0	**1707**	14	5	2	0	**1708**	10	6	2	0
Migueno de iñigo	**1706**	18	5	0	2	**1707**	16	5	0	0	**1708**	15	6	0	2

13. Appendix: CD-ROM

Baptisms and burials in Guadalajara, 1700-1800
Calculation of total income in thesSample of Guadalajara, early 1750s
Consumer price index for New Castile, 1700-1800
Decadal grain production per producer, 1700-1800
Grain from sample of selected producers in Bañuelos, 1700-1800
Hours to walk 1 league
Prices of grain in Madrid, 1644-1796
Production of grain in Bañuelos per year and producer, 1700-1800
Wheat prices and coefficient of variation by village, early 1750s
Workers by wage in the villages nad towns of Guadalajara, early 1750s
Yearly grain production in Guadalajara, 1678-1816