Amartya Sen Re-visited: Population, Grain Production and Income Inequality in 18th Century Guadalajara (Spain)

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This paper presents new series of grain production, baptisms and prices to introduce the existence of a demographic paradox during the second half of the eighteenth century in the Spanish province of Guadalajara. The paradox was based on increasing population during a period of decreasing incomes. The study of income distribution reveals that the paradox can be explained by a reduction of income inequality, based on the improvement of the conditions of very small and small grain producers.

The analysis of income inequality and its effects of growth and development have been long and persistent issue studied by economic historians. This paper presents original series from the historical diocesan archives of Sigüenza-Guadalajara and Getafe, and includes baptismal records, grain production for the province of Guadalajara and grain prices for the province of Madrid for the eighteenth century. The research includes more than 200,000 observations from individual producers, households and ecclesiastical authorities. The main purpose of the paper consists in giving an answer to the demographic paradox that took place in Guadalajara during the second half of the eighteenth century when population maintained a sustained and intense growth while the production of cereals in the same province was kept constant and even declined.

The first section will present the baptismal record and cereal production series to show the existence of a demographic paradox. After describing the dataset, the paper will introduce a possible solution to this puzzle based on Amartya Sen’s entitlement theory and present the Gini coefficient of the cereal production series, and its relationship with the demographic and productive trends. The next section will look at the reasons behind the changes in inequality, concluding that the improvements made by small producers were the driving force of the process. Finally the chapter will analyse the changes in income inequality more in depth with the study of the Theil Index, concluding that it big villages where most of the reduction in inequality took place during the eighteenth century.

GRAIN PRODUCTION AND FERTILITY IN EIGHTEENTH CENTURY GUADALAJARA

Sources

The information presented in this chapter includes estimations from primary sources of grain production, fertility, mortality and grain prices for eighteenth century Guadalajara and Madrid. 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 and in the Historical Diocesan Archive of Getafe.
To proxy grain production we have used tithe records kept by the local priest in 25 towns and villages of Guadalajara. All the tithe series have been collected in the historical diocesan archive of Siguenza-Guadalajara. Tazmias books record the amount of the harvest that was taxed by the church and that was recorded in the books of each parish. For every year the priest recorded the amount of grain in quantity paid by every producer. Tithes have been the most common proxy to estimate grain production trends in early modern times, however there are two main objections to the use of the tithe for this purpose. The first one is related to the changes in taxation levels that could have happened in the long term or very specific times. The second considers the importance of cheating, and the problems that can appear when it is high and therefore the amounts recorded are not representative of real production. The first problem can be solved transforming the series using the different taxation levels in different times adjusting the dataset. The second one is more complicated and a calibration could be extremely difficult or just impossible. However none of these problems is a serious one in this case as tithe levels remained constant at 10 per cent and cheating was not significant until the early nineteenth century. One can therefore conclude that the tithe series presented in this paper are truly representative of grain production.

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 locations from the province of Guadalajara. Baptismal records have been widely used in the literature as the most important proxy of demographic changes in early modern times. Some authors as Nadal have indeed accepted baptismal series even as a good proxy of population trends. However in this case we will use baptisms to proxy fertility, an assumption more realistic and rigorous.

Finally new series of wheat and barley prices were produced for Madrid 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-

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1 The series correspond to the following locations and parishes: Alboreca/San Andres, Alcuneza/ San Pedro, Alpedroches/Asuncion de Nuestra Señora, Angon/Santa Catalina, Anquela del Pedregal/Asuncion de Nuestra Señora, Fragosa/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 Fuensaviñana/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, Sientes/Santa Eulalia, Torrubia/Asuncion de Nuestra Señora, Trillo/Asuncion de Nuestra Señora, Valdelcubo/Santiago, Villares de Jadraque/Natividad and Villaseca de Henares/San Blas.

2 For a more detailed discussion on the use of tithes see E. Ladurie and J. Goy, Tithe and agrarian history from the fourteenth to the nineteenth centuries: an essay in comparative history (Cambridge, Cambridge University Press, 1982)


4 The series include the following locations and parishes: Albares/San Esteban, Anchuela del Pedregal/San Andres, Anquela del Ducado/San Martin, Arroyo/Inmaculada, Bañuelos/Asuncion de Nuestra Señora, La Bodera/Santiago, Cantalojas/San Julian, Cañizares, Castilmimbre/Asuncion de Nuestra Señora, Ciruelos del Pinar/Santa Magdalena, La Cobeta/ Asuncion de Nuestra Señora, Concha/San Juan Bautista, Congostra/Asuncion de Nuestra Señora, Galve de Sorbe/Asuncion 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 Sebastian, Riba de Saelices/Santa Maria Magdalena, Setiles/Asuncion de Nuestra Señora, Sienes/Santa Eulalia, Somolinos/Inmaculada and Torrubia/Asuncion de Nuestra Señora.

5 V. Perez Moreda & D. Reher, Demografía histórica en España, (Madrid: Ediciones El Arquero, 1988) for the most recent study see E. Llopis Agelan, “Indices regionales y nacional de bautismos, 1700-1849”, Personal communication.
Guadalajara does not provide with 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 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 order to explore the effects of prices on incomes of the producers of Guadalajara. The series were extracted from the accounts of the parish of Santa María 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 demographic paradox

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 until 1720 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, that started in the second half of the century and that 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 presented in other regions of Spain.\(^6\)

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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. There were three very clear trends. The first one and after the last effects of the crisis of the late seventeenth century was a period of growth that started in 1710 and that was sustained until the mid 1720s when it reached its peak to be followed by a crisis 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 40 per cent.

**Figure 2: Baptisms in 18th century Guadalajara**

Combining the information from both graphs the most striking feature is how the demographic growth continued in Guadalajara during the second half of the century when the production remained stagnant or even declined in per capita terms. Figure 3 presents the evolution of fertility and grain production. The data show that during the second half of the eighteenth century, grain production was constant while after the analysis of baptismal series it is quite probable that total population grew in Guadalajara. Therefore in per capita terms the availability of grain diminished. So the question is how can population grow when the supply of food is constant or even declined? A possible explanation is that the distribution of that production became more equal, or in other words that distribution and entitlements are as important as the production levels themselves.

Source: same as footnote 2.
The entitlements approach

According to Amartya Sen, the distribution of food production is as important as the total production levels themselves. Therefore, the study of distribution of food is a key element in order to explain the demographic effects of changes in the supplies of food stocks. In the 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.” 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.

The next figure summarises the main points of the entitlements approach.

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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 \((p)\). \(^9\) 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 explicate the opposite, how the demographic growth of the late eighteenth century Guadalajara took place when total production of food remained constant and per capita levels were probably diminishing. 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. Real wages in terms of wheat of unskilled workers and master carpenters fell by 50 per cent from the mid of the end of the eighteenth century. \(^10\) The reason is that although nominal wages increased as well, that effect was overwhelmed by the increase in the price of food producing a fall in real wages. \(^11\)

As figure 5 shows, the comparison between wheat prices and the Consumer Price Index confirm that prices of wheat grew faster than the CPI during the second half of the eighteenth century in New Castile. Figure 6 shows the accumulated difference in percentage between wheat 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 wheat and the CPI showed an accumulated difference of almost 20 percentage points.

**Figure 5: Wheat Prices and CPI, 1700-1800 (9 years moving average)**

![Figure 5: Wheat Prices and CPI, 1700-1800 (9 years moving average)](image)

Source: Accounting book of the parish of Santa Maria Magdalena (Getafe) and own calculations from Hamilton (1947)

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\(^11\) Ibid.
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.

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.

Figure 8: Real wages of unskilled workers in New Castile, 1736-1795

![Figure 8: Real wages of unskilled workers in New Castile, 1736-1795](image)

Source: Hamilton (1947)

The situation is presented in the following figure were prices of food increased from p to p*, increasing the starvation region by CBA.

Figure 9: Effect of change in relative prices (I)

![Figure 9: Effect of change in relative prices (I)](image)
However the consequences of this increase of 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 will be the foundation of his consumption. Therefore within this theoretical framework an increase of prices like the one that took place in eighteenth century Spain the possibilities of survival of workers would be smaller than those for peasants. The strong demographic growth in the second half of the eighteenth century in Guadalajara therefore can only be explained by a movement of producers in the region Y to the right, through an improvement in the personal production of food.

INCOME INEQUALITY IN EIGHTEENTH CENTURY GUADALAJARA

The literature shows that one of the most common features of the eighteenth century in Spain is the increasing income inequality, especially in rural areas where big landowners tended to increase their properties at the expenses of the lack of protection, both legal and economic of the small producers. This section will try to throw some light on these affirmations with the support of quantitative evidence. The first part of the section will analyse the relative position of Guadalajara in relationship to the surrounding provinces with a cross section study of income inequality. The information to carry out the analysis will be based on the Catastro de la Ensenada, a general survey created in the early 1750s. The second part of the section will look at the evolution of income inequality within the province of Guadalajara during the whole eighteenth century.

Income inequality in Guadalajara and the Crown of Castile

The Catastro de la Ensenada offers information at a regional level about the number of workers in every economic activity, in a classification of 10 sectors including rural workers, wood, construction, textiles, leather, metal, glass, small items, consumption, services and finally a sandbox called others. The next two figures present the number of workers in every economic sector in Guadalajara and other provinces of the Crown of Castile, as well as the average wage in daily reales for every profession in the mid eighteenth century.
Table 1: Number of workers in the main sectors of the economy

<table>
<thead>
<tr>
<th>Sector</th>
<th>Zamora</th>
<th>Valladolid</th>
<th>Toro</th>
<th>Soria</th>
<th>Sevilla</th>
<th>Segovia</th>
<th>Salamanca</th>
<th>Palencia</th>
<th>La Mancha</th>
<th>Murcia</th>
</tr>
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<tbody>
<tr>
<td>Word</td>
<td>103</td>
<td>539</td>
<td>294</td>
<td>365</td>
<td>2.983</td>
<td>859</td>
<td>603</td>
<td>284</td>
<td>521</td>
<td>1.282</td>
</tr>
<tr>
<td>Building</td>
<td>85</td>
<td>518</td>
<td>225</td>
<td>362</td>
<td>3.270</td>
<td>449</td>
<td>584</td>
<td>435</td>
<td>549</td>
<td>826</td>
</tr>
<tr>
<td>Leather</td>
<td>166</td>
<td>1.206</td>
<td>364</td>
<td>894</td>
<td>5.534</td>
<td>839</td>
<td>915</td>
<td>719</td>
<td>1.307</td>
<td>1.880</td>
</tr>
<tr>
<td>Metal</td>
<td>138</td>
<td>767</td>
<td>242</td>
<td>376</td>
<td>1.851</td>
<td>430</td>
<td>912</td>
<td>89</td>
<td>130</td>
<td>38</td>
</tr>
<tr>
<td>Art</td>
<td>12</td>
<td>97</td>
<td>12</td>
<td>26</td>
<td>836</td>
<td>27</td>
<td>35</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Consumption</td>
<td>26</td>
<td>128</td>
<td>35</td>
<td>62</td>
<td>2.839</td>
<td>93</td>
<td>112</td>
<td>89</td>
<td>130</td>
<td>38</td>
</tr>
<tr>
<td>Services</td>
<td>24</td>
<td>120</td>
<td>6</td>
<td>47</td>
<td>863</td>
<td>27</td>
<td>57</td>
<td>18</td>
<td>158</td>
<td>151</td>
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<td>Others</td>
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<td>10.742</td>
<td>0</td>
<td>0</td>
<td>125</td>
<td>0</td>
<td>921</td>
</tr>
</tbody>
</table>

16.824 42.891 19.162 29.288 130.816 36.637 36.897 25.708 42.638 59.396

Source: Catastro de la Ensenada

Figure 11: Average daily earnings by province in reales per day in Castile

Source: Catastro de la Ensenada
The province of Madrid as the economic centre of Castile presents the highest incomes, followed by Murcia, Cuenca, and Guadalajara in the eastern border of the Crown. The provinces with the lowest incomes are Galicia, Valladolid, Toro and Leon in the west part of the crown. The information provided in table 1 and Figure 11 is enough to produce a Theil Index for every province. On its aggregated formulation the Theil Index can be measured by the next equation:

$$I_0 = \frac{1}{N} \sum_{i=1}^{n} \ln \left( \frac{\bar{y}}{y_i} \right)$$

Where $N$ is the number of observations, $y$ is the average income of the sample and finally $y_i$ is the income for the observation $i$. The Thiel Indexes obtained for each one of the provinces are presented in the next table where higher values indicate higher inequality.

However although the paper analyses the modern province of Guadalajara, the administrative borders that correspond today differ significantly to those defined in the mid eighteenth century, and that were gathered in the Catastro. The following figure presents the different provinces in New Castile as they are described in the Catastro and the present province of Guadalajara highlighted.
The old province of Guadalajara included only a proportion of the locations in present Guadalajara, and also comprised a high number of villages and towns in Madrid and some in Cuenca. Therefore we decided to estimate income inequality and average daily incomes in present Guadalajara by gathering information about workers, economic activities and incomes in the villages and towns that correspond to the current administrative borders. The study included a total of 263 towns and villages and 26,364 workers that were divided into 35 income levels. The results have been included in the calculations as Guadalajara II to separate them from the old province of the Catastro that is presented as Guadalajara. The results of the Theil index by province are showed in the following figure.

Table 3: Theil Index by province

![Table 3: Theil Index by province](chart.png)

Source: Own calculations

According to the results Seville is clearly the province of the sample that presents a higher level of income inequality with a Theil Index of 0.08, followed by Palencia, Valladolid and the old Guadalajara. The most equal provinces are Galicia, Jaen, Avila and Extremadura. The case of Galicia in the northwest of Spain can be explained by the nature of the area, with a high number of small peasants producing in small pieces of land. On the other hand the situation is especially surprising in the case of Jaen and Extremadura, areas that have been traditionally dominated by elites of very rich landlords and a high proportion of poor workers. However it is exactly this abundance of poor people that explains the low income inequality in the area, a low inequality does not necessarily means that the economic situation of the population is good. In fact there is not statistically significant correlation between income inequality and the average daily income presented above. The factor that drives income inequality is not income itself, but the level of economic specialization in every province. The more specialised an economy is, the most similar the incomes of its workers is. Such is the case of both Galicia and Jaen, where completely different property rights and production systems but under a homogenous agrarian economy lead to the same levels of income inequality. On the other hand the more heterogeneous economies of Seville, Palencia or Valladolid with a high number of people working in the manufactures sector increased income differentials and therefore inequality. Rural areas will therefore tend to be more equal while areas with higher urbanisation levels will also present higher differences in income levels.

Surprisingly the calculations for the modern province of Guadalajara do not differ from the results of the old province even when the sample of locations changed significantly. The average income in the old administrative borders was 3.56 reales per day, exactly the same
value estimated for the modern province. In the case of the Theil Index the values are also identical with an index of 0.062 in the case of the old province and 0.057 in the new one.

**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 it was explained above the books kept information about the amount of grain taxed to every producer every year. The decision of 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 locations in Guadalajara shows that in any case the value of the production of grains represented around a 90 per cent of the value of the total agrarian production. 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.

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 being 0 perfect equality and 1 perfect inequality, or 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:

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

(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 45ºC line.

**Figure 12: Graphical representation of the Gini coefficient**

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12 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.
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 13: Decadal Gini coefficient in Guadalajara 1700-1800**

The results show three clear 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 one 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 14: Average Gini v Ratio 5/20**

Source: same as footnote 1.
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 4: Main inflexion points

<table>
<thead>
<tr>
<th>Year</th>
<th>Gini Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1710</td>
<td>0.505</td>
</tr>
<tr>
<td>1740</td>
<td>0.483</td>
</tr>
<tr>
<td>1770</td>
<td>0.511</td>
</tr>
<tr>
<td>1800</td>
<td>0.471</td>
</tr>
</tbody>
</table>

Figure 15: Lorenz curves 1710 and 1740

Source: same as footnote 1.

Figure 16: Lorenz curves 1740 and 1770

Source: same as footnote 1.
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 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 in 0.4 points, the exact reduction that took place during the late eighteenth century, we would have to double the production of the bottom 33 per cent. The next question now 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 inflexion points with the relative and absolute minimums and maximums, 1710, 1740, 1770 and 1800.

All the producers in each inflexion point were divided into ten 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. Therefore 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.\textsuperscript{13} Three graphs were created for each period, the first one with the distribution of the producers in each inflexion 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 containing not 10 groups but three, small, medium and big producers. Between 1710 and 1740 the results show a reduction in the value of the Gini coefficient by 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 presents, 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.

\textsuperscript{13} 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%.
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 marked the absolute maximum of the century. The number of small producers grew in more than 8 per cent, 3 points more than the reduction between 1710 and 1740. It was in the group of medium producers that the biggest fall took place, especially in the 20/40 percentiles.
The last period between 1770 and 1800 shows a very clear convergence, falling the Gini coefficient 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. Once more and as in the case of the first half of the century, the fall in inequality was mainly consequence of very small producers improving their positions and many of them probably joining the group of medium producers. 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.
Although the Gini coefficient is a good way of measuring the changes in total inequality, it also presents some limitations. A different way of measuring inequality levels is the use of generalized entropy measures like the Theil Index, a measurement that has been widely used in the literature of income inequality.

Although the properties of the Theil Index are very similar to those of the Gini coefficient, it allows a more in-depth 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

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**Figure 20: Changes in the distribution of the production 1770/1800**

Source: same as footnote 1.

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are consequence of changes of inequality within those groups or between them. Its calculation is defined by the formula:

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

Where in our case $n$ would be the number of producers, $w_i$ the production of the individual $i$ and $\mu$ the arithmetical average of the sample. As it was 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 are the changes in inequality within each group and between them. 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, the size of the village also defined its economic and social structure. 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 $g$, $\mu_g$ is the average production, $n_g$ the number of producers and $T_g$ is the Theil index for that specific group. Then the new formula for the Theil index would be:

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

Being

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

The first term in (3) corresponds to the weighted addition of the Theil indexes of every group and therefore presents the 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 in 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).

$$\Delta T_n^{t,s} = \Delta T_{\text{within,}n}^{t,s} + \Delta T_{\text{between,}n}^{t,s} = \sum_{g=1}^{G} \left[ \left( \frac{n_{g}^{t}}{n^{t}} - \frac{n_{g}^{s}}{n^{s}} \right) \mu_{g}^{t} T_{g}^{t} \right] + \sum_{g=1}^{G} \left[ \left( \frac{n_{g}^{t}}{n^{t}} - \frac{n_{g}^{s}}{n^{s}} \right) \frac{\mu_{g}^{t}}{\mu^{t}} \ln \left( \frac{\mu_{g}^{t}}{\mu^{t}} \right) \right]$$  \hspace{1cm} (4)$$

$$\Delta T_{\mu}^{t,s} = \Delta T_{\text{within,}n}^{t,s} + \Delta T_{\text{between,}n}^{t,s} = \sum_{g=1}^{G} \left[ \left( \frac{\mu_{g}^{t}}{\mu^{t}} - \frac{\mu_{g}^{s}}{\mu^{s}} \right) n_{g}^{s} T_{g}^{t} \right] + \sum_{g=1}^{G} \left[ \frac{\mu_{g}^{t}}{\mu^{t}} \ln \left( \frac{\mu_{g}^{t}}{\mu^{t}} \right) - \frac{\mu_{g}^{s}}{\mu^{s}} \ln \left( \frac{\mu_{g}^{s}}{\mu^{s}} \right) \right] \frac{n_{g}^{s}}{n^{s}}$$  \hspace{1cm} (5)$$
Therefore for the period 1770-1800 we can measure if the reduction of inequality was consequence of reduction of inequality within or between groups. The size of a certain location has always being an important issue, being associated with urbanization rates and also with income distribution. Therefore the locations in the sample were divided by size in order to check if the number of inhabitants played any role in the changes in inequality. The results are presented in the following table.

### Table 5: Inequality changes decomposed by size of village

<table>
<thead>
<tr>
<th>Time Period</th>
<th>1710-1740</th>
<th>1740-1770</th>
<th>1770-1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inequality within groups</td>
<td>69.23%</td>
<td>40.00%</td>
<td>106.25%</td>
</tr>
<tr>
<td></td>
<td>-5.00%</td>
<td>-4.69%</td>
<td>-4.69%</td>
</tr>
<tr>
<td></td>
<td>71.67%</td>
<td>73.44%</td>
<td>73.44%</td>
</tr>
<tr>
<td></td>
<td>-26.67%</td>
<td>37.50%</td>
<td>37.50%</td>
</tr>
<tr>
<td>Inequality between groups</td>
<td>30.77%</td>
<td>60.00%</td>
<td>-7.81%</td>
</tr>
<tr>
<td>Total inequality</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: same as figure 1

The results are diverse, 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, an increasing inequality between the small and big villages. Finally during the period 1770-1800, the reduction of inequality was mainly driven by within groups convergence, and very especially in medium and big villages. On the other hand there was a small increase in the inequality within small villages. The reason is that in small villages inequality levels were already low in 1770, and that the following three decades would experience a catch up from high inequality levels by medium and big villages.

### Table 6: Theil index by size of village 1770 and 1800

<table>
<thead>
<tr>
<th>Size of Village</th>
<th>Theil 1770</th>
<th>Theil 1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Villages</td>
<td>0.43</td>
<td>0.33</td>
</tr>
<tr>
<td>Medium Villages</td>
<td>0.42</td>
<td>0.18</td>
</tr>
<tr>
<td>Small Villages</td>
<td>0.34</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Source: same as figure 1

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 were 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 21: Theil Index by size of village 1710-1800**

![Theil Index by size of village 1710-1800](image)

**Figure 22: Gini Coefficient by size of village 1710-1800**

![Gini Coefficient by size of village 1710-1800](image)

We can therefore conclude that the reduction of inequality during the eighteenth century in Guadalajara was mainly conditioned by a catching up of small producers that improved their situation in relationship to the biggest ones. This catching up was especially intense during the last third of the eighteenth century, and inside the biggest villages. Big villages reduced the inequality gap with the smaller ones that had enjoyed low inequality levels during most of the century.
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 paradox can be explained through reductions in income inequality that took place during the last decades of the eighteenth century. The theoretical framework of Sen’s entitlements theory proves to be useful in order to explain the existence of the paradox, using changes in income inequality as explanation to the diverging demographic and productive series.

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 to catch up. However in the bigger locations income inequality levels were higher and there was 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.
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