Cohort Reproduction Patterns in Small Italian Towns: Results from Stochastic Inverse Projection

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1 Introduction

A study of the demographic trends in a group of Latium municipalities between the 17th and 19th centuries[1], conducted with the Stochastic Inverse Projection (SIP) technique[2], has enabled us to achieve a detailed reconstruction of the reproductive systems in these populations. In this study, the time patterns of the population dynamics in twelve communities have been analysed

[1] See Sonnino and Parmeggiani [11], in particular Chapter 2. This study analyses the demographic trends of the city of Rome and other towns in Latium: Carpineto, Segni, Gavignano, Cori, Montefortino (Artena), Norma, Valmontone, Genzano, Velletri, Cisterna and Terracina.

[2] The stochastic inverse projection technique was proposed by S. Bertino and E. Sonnino. It enables us to study the demographic trends over a certain number of years, making a probability simulation of the age distribution of deaths, the age of mothers at the birth of their children and the age distribution of migration balances. The application of the simulation procedure enables us to obtain the desired number of estimates of the populations' demographic characteristics and the indicators of fertility and mortality for each of the years considered. Two computer programmes based on this technique were produced. The first one, is called SIPAV and is designed for a yearly estimate. Using a technique that allows proceeding forward in time, it estimates a population's age distribution and the indicators of its population dynamics; the second one, called SIPIN, obtains the same information by going back in time. Naturally, the choice of the programme is conditioned by the quantity and quality of the sources available to researchers. The paper quoted in Note 1 used these programmes, obtaining for each of the municipalities stated the average results of thirty simulations conducted to determine each indicator. In various publications, the authors have shown the procedure of stochastic inverse projection in the forward reconstruction in the SIPAV programme ([2, 12, 3]. Backward stochastic inverse projection used in the SIPIN programme is illustrated in [4], re-printed in this volume.

on the basis of the period analysis of fertility and mortality rates. The paper then re-examines these reconstructions in order to make a detailed analysis of the reproductive processes followed by the female cohorts of four small towns: Segni, Cori, Norma and Velletri. The illustrated results utilise the average values of the fertility and mortality estimates by generations (cohort analysis) obtained by thirty simulations of the dynamics of these populations. These simulations were conducted for each of the municipalities, applying the SIPIN computer programme for stochastic backward inverse projection.

2 The Municipalities

The municipalities studied in the historical period examined were part of the State of the Church. They are located to the south-east of Rome, in an area between the consular routes of the Via Casilina and Via Appia, 40 to 70 km from Rome. The Municipalities of Segni, Cori and Norma belong to the Lepini Mountains area. Segni has an altitude of 650 metres and at the end of the 19th century covered an area of 59 sq.km. Cori, also located on a spur of the Lepini Mountains, extends between 200 and 400 metres, with an area of 83 sq.km. Norma, covering 32 sq.km., has an altitude of 430 metres and is on the top of a high cliff. It has a view of the Pontine Plain and the remains of the abandoned medieval city of Ninfa are located below. Velletri, on the other hand, is located in the hilly area near Rome, and is at an altitude of 330 metres. It has an area of 139 sq.km. As shown in section 5, the different altitudes of the towns may help to explain their differential reproductive processes.

The four small towns (the origins of Cori, Segni and Velletri are very ancient while Norma dates to medieval times) have distinctive administrative, productive and environmental characteristics. Velletri and Segni were both diocesan seats and thus were towns of particular religious and political importance. Their economies, dominated by farming, was mainly based on crops such as olive groves in Cori and Norma and grape vines in Segni and Velletri, where this crop was particularly developed. The data available at the beginning of the 19th century document the high productivity of the area. A survey made during Napoleonic rule showed that in 1810, in the territory of the Municipality of Cori - belonging to the "arrondissement" of Velletri - there were 400,000 olive trees, i.e. 16-17% of the total of the "arrondissement". With regard to wine production for the same period, it can be concluded from Napoleonic statistics that the "arrondissement" of Velletri produced about 500,000 barrels, i.e. one third of the entire Latium production.[3] According to documentation at the end of the 19th century, olive groves covered 16.9% of

[3] The data on olive and wine production are shown in [5], pp. 74-75 and 78-79.

the cultivated area of Cori and 12.4% in Norma. During the same period, the vineyards accounted for 9% of the Segni area and as high as 32.8% of Velletri [8]. In the same years, the hygienic and health conditions of these towns was best in Segni, being free from malaria, while there was some malaria in Norma and Velletri and severe forms of the same infection occurred in Cori. The supply of drinking water was considered to be sufficient only in Velletri, and insufficient in the other towns. Cholera was absent in Cori and Norma, and occurred only sporadically in Segni and Velletri. All the municipalities had an authorised wet-nurse [9].

In Velletri, most farmland was owned by ecclesiastic bodies, by the lay bourgeois in Segni and Cori and by feudal families in Norma (see Parmeggiani and Sonnino, Chapter 1 [11]). The various quality and development levels of the local economy produced varied income levels in these towns. Segni (with an income of 14.7 lire per inhabitant) occupied in 1895 the penultimate position of the Municipalities of Latium, while Cori (with 16.5 lire per inhabitant) and Velletri (with 22.6 lire) belonged to the place immediately above this, coming close to the average regional rate; and finally, Norma (31.4 lire per inhabitant) took the second place [10].

3 Demographic Trends

The documentation available for the study of the four populations is preserved in the parish archives of the various municipalities. The diverse availability of records in some cases did not allow for complete uniformity in the periods of time considered for each community. Therefore, while in the case of Velletri it was possible to examine a demographic trend for the entire period of time considered (1595-1870) and for Norma from 1601 to 1870, for Segni the observation is limited to the period 1637-1870 and for Cori to 1661-1843.[4]

With regard to population size, the largest town was Velletri, with a population of about 10,000 at the end of the 17th century. During the same period, Cori had 4,500, Segni about 3,000 and, Norma, the smallest town, just 900 inhabitants. The demographic trends between the 17th and 19th centuries are shown in Figures 1 and 2, while Figures 3-8 show the long-term patterns of natural and migration dynamics in the four populations for the same period of time and longer-term periods. The main aspects highlighted in the annexed figures can be summarised as follows: the growth of the populations is, in general, rather slight and shows an annual average of 5 per 1,000 up to the last quarter of the 18th century (Figure 3). Subsequently, we observe a

[4] The authors would like to thank Antonio Parmeggiani who collected the information from parish registers of baptisms, burials, marriages and *Status Animarum*.

phase of population decline in all the towns, continuing up to 1814, the last year of French domination in Italy. This phase was followed by an overall population recovery during the 20-year period 1815-1834, and then by quite diversified trends in the various towns. The birth rates show an overall decline throughout the 18th century; mortality shows a long-term decrease, which is accentuated in the 19th century. Mortality was especially high at Velletri in the 17th century, when the town was seriously struck by the plague epidemic 1656-57[5]. In general, the mortality rate is lower in Segni and Norma and during the last phase in Segni and Velletri (Figures 4 and 5; natural balance in Figure 7). Nuptiality, after a general reduction during the last quarter of the 17th century, shows a long-term growth, increasing in the early 19th century and then levelling off (Figure 6). The migration balance (Figure 8) was positive in Velletri up to the end of the 17th century, due to the great expansion of wine production in this town. Throughout the next century, Velletri, like the other towns, showed a balance that was nil or slightly negative; the migration loss became generalised in the 19th century, although limited. On the whole, the study of the population dynamics in the four towns do not show marked differences except for the particular individual phases. From this analysis, it does not seem possible to derive sufficiently clear indications on the differences in the reproduction patterns of the single towns. It thus has been decided to conduct a study within the framework of this analysis of the reproduction of female cohorts born in these municipalities between the early 17th century and the early 19th century. This study was conducted by means of a longitudinal interpretation of the results obtained with the application of the stochastic backward inverse projection technique to the four populations.

4 Reproduction Patterns

Table 1 and Figure 9 show the trend in the average number of daughters per woman (Gross Reproduction Rates - GRR) in the four studied municipalities, of 5-year female cohorts, born between 1615-19 and 1815-19, for whom it was possible to estimate the descendants. The estimated GRR - which provide an indicator of the potential reproduction rate of the cohorts, calculated with the hypotheses of zero female mortality up to the age of 50 - show fertility rates typical of a natural reproduction system and high enough to theoretically ensure a strong increase in the cohorts. Although the trends are not uniform across the various cohorts, there is a certain consistency of time patterns of descendants in the towns concerned. However, the potential average number

[5] See Bertino-Sonnino [4]. For the illustration of the impact of this epidemic in Latium, see the information in Ago-Parmeggiani [1].

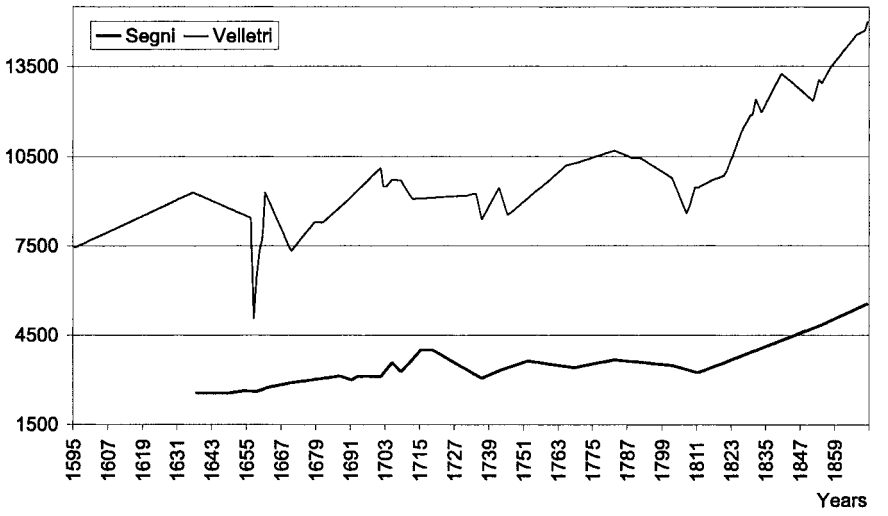

Figure 1. The population of Segni (1637-1870) and Velletri (1595-1870)

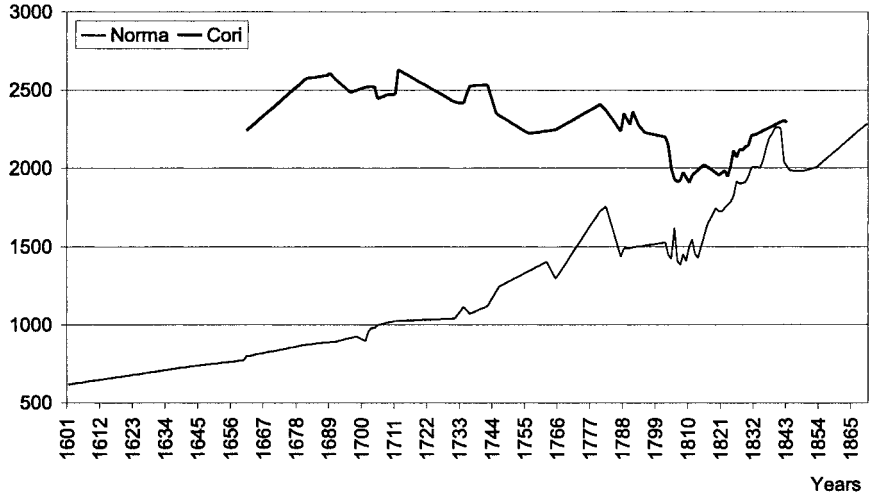

Figure 2. The population of Cori (1661-1843) and Norma (1601-1870)
Note: Data on Cori refer to three parishes of the town, which had a total of six, and regard 56% of total population.

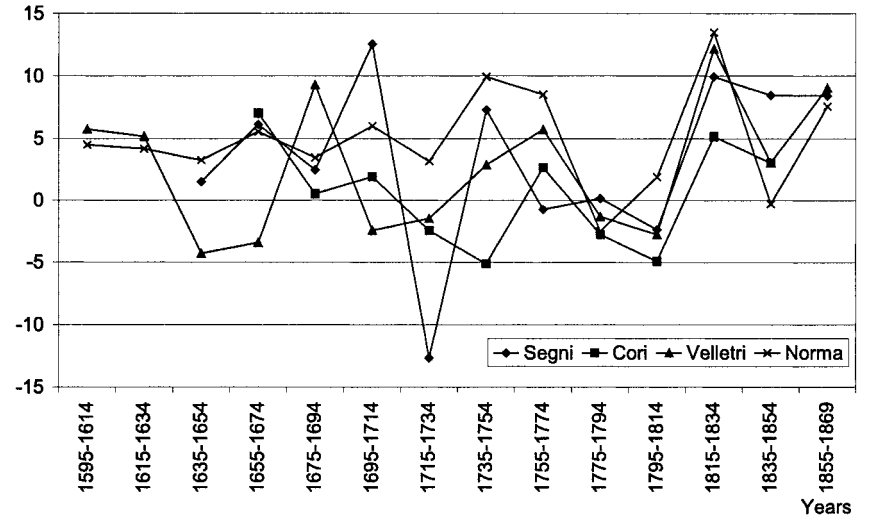

Figure 3. Rates of total increase per 1,000 inhabitants (average annual values for the period)

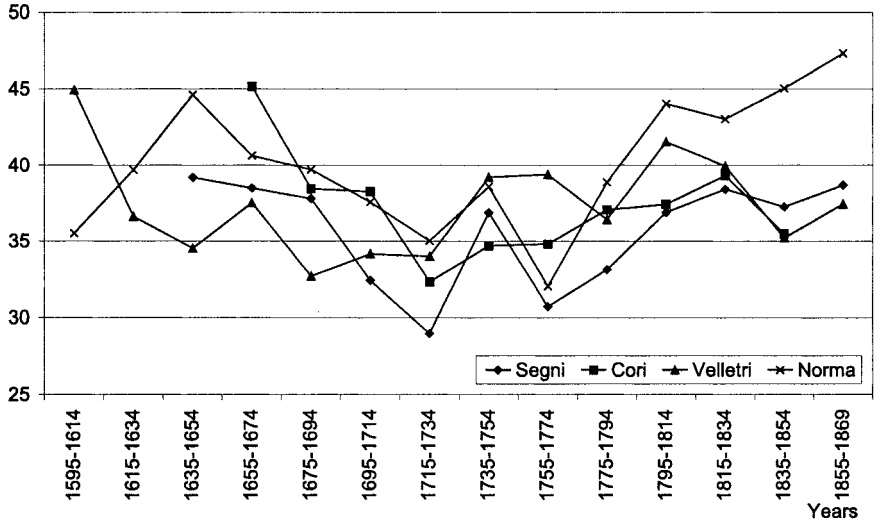

Figure 4. Birth rates per 1,000 inhabitants (average annual values for the period)

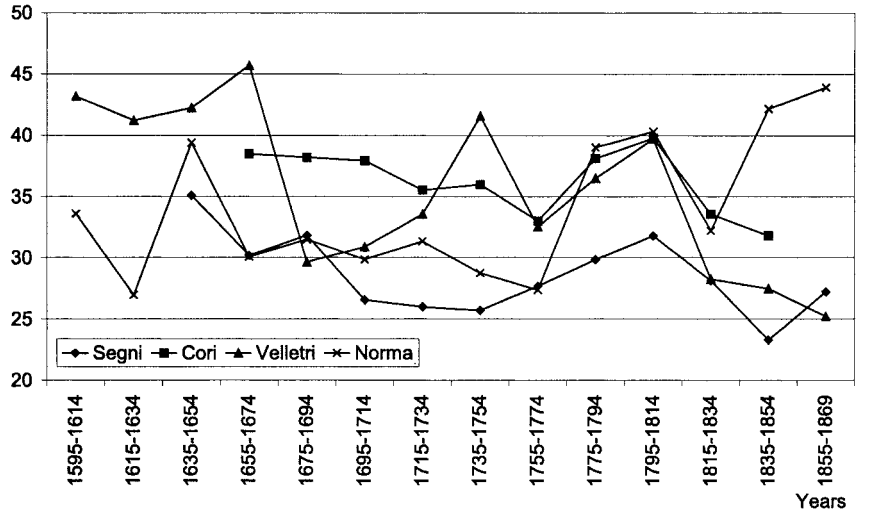

Figure 5. Death rates per 1,000 inhabitants (average annual values for the period)

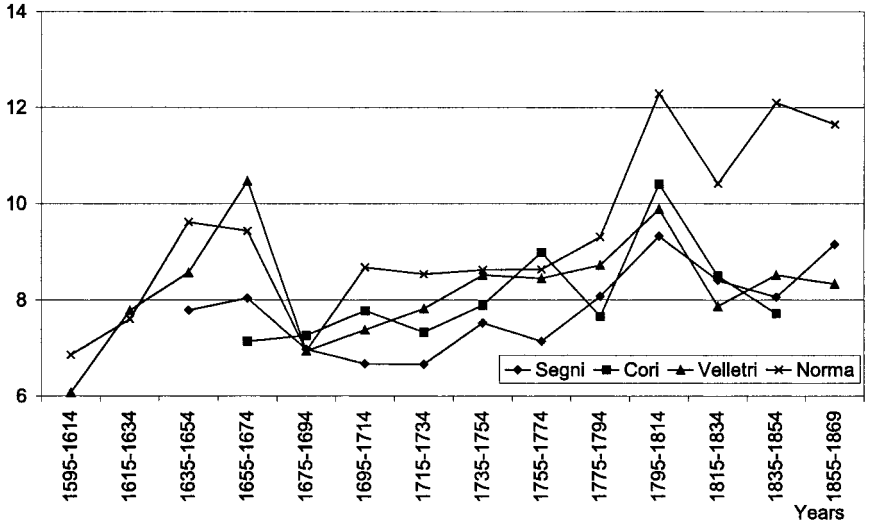

Figure 6. Marriage rates per 1,000 inhabitants (average annual values for the period)

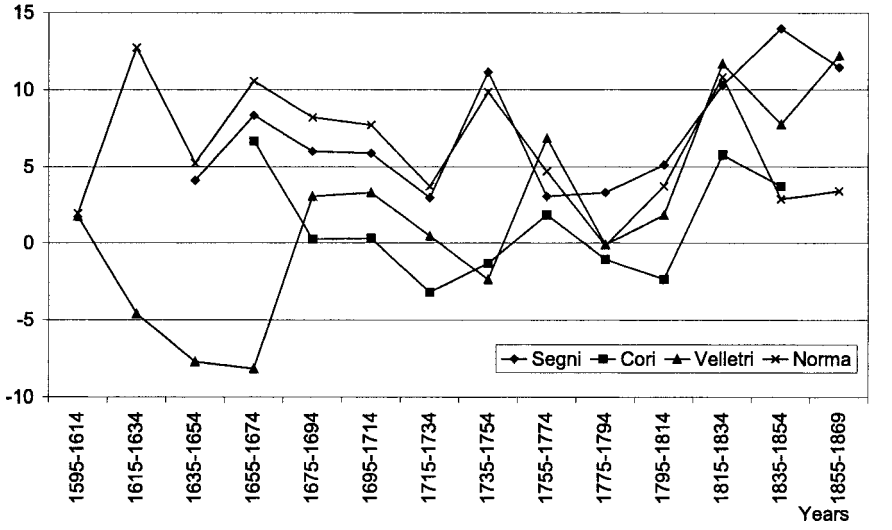

Figure 7. Rates of natural increase per 1,000 inhabitants (average annual values for the period)

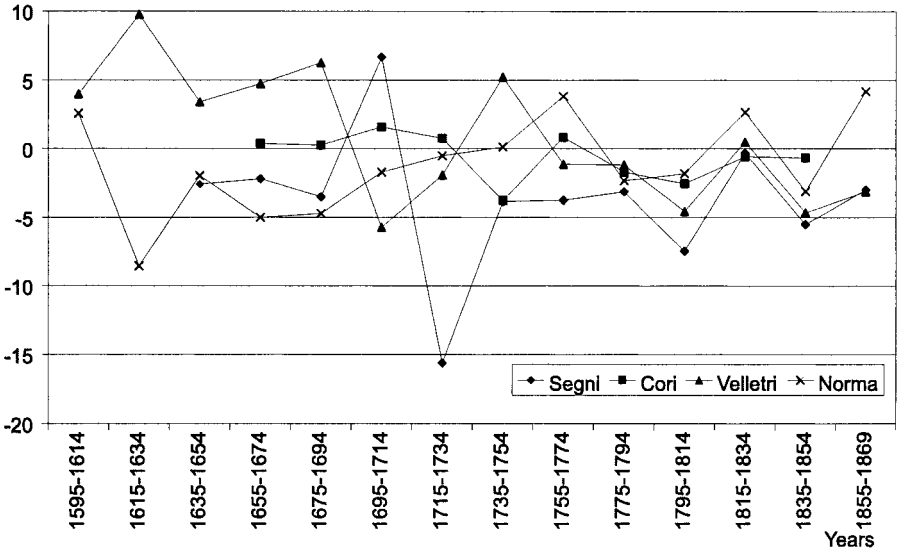

Figure 8. Migration balance per 1,000 inhabitants (average annual values for the period)

of daughters per woman remains within a range of between two and three, with slightly higher values than this maximum only for some cohorts born in Norma, a municipality which in general showed the highest fertility rates throughout the time period concerned.

Table 1. Fertility patterns in female cohorts, 1615-1819

Cohorts	Gross Reproduction Rates (R)				Mean age at birth			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1615-19	2.97			2.84	30.3			29.5
1620-24	2.86			2.67	30.4			29.6
1625-29	2.67			2.49	30.5			29.7
1630-34	2.40			2.31	30.6			29.8
1635-39	2.26			2.31	30.6			29.9
1640-44	2.16			2.30	30.6			29.8
1645-49	2.24			2.44	30.5			29.8
1650-54	2.27			2.43	30.5			29.8
1655-59	2.32			2.64	30.5			29.8
1660-64	2.27		2.32	2.70	30.5		30.2	29.9
1665-69	2.28	2.47	2.36	2.88	30.4	30.2	30.1	29.9
1670-74	2.23	2.47	2.58	2.85	30.3	30.3	30.1	29.8
1675-79	2.32	2.56	2.60	3.03	30.2	30.3	30.2	29.9
1680-84	2.32	2.68	2.67	3.12	30.2	30.3	30.2	30.0
1685-89	2.35	2.81	2.61	3.06	30.2	30.4	30.2	30.1
1690-94	2.37	2.84	2.59	3.04	30.2	30.4	30.2	30.2
1695-99	2.39	2.80	2.48	3.02	30.3	30.4	30.1	30.2
1700-04	2.37	2.69	2.44	2.88	30.3	30.4	30.1	30.2
1705-09	2.41	2.56	2.32	2.96	30.3	30.4	30.1	30.2
1710-14	2.39	2.61	2.29	2.89	30.3	30.4	30.1	30.3
1715-19	2.46	2.58	2.16	2.85	30.3	30.3	30.0	30.3
1720-24	2.41	2.49	2.08	2.55	30.3	30.3	30.0	30.2
1725-29	2.59	2.48	1.98	2.37	30.2	30.3	30.0	30.2
1730-34	2.55	2.38	1.99	2.25	30.1	30.3	30.1	30.1
1735-39	2.68	2.30	1.99	2.26	30.1	30.3	30.1	30.1
1740-44	2.66	2.27	2.15	2.40	30.0	30.3	30.2	30.2
1745-49	2.70	2.32	2.29	2.62	30.0	30.3	30.3	30.3
1750-54	2.67	2.35	2.40	2.72	30.0	30.2	30.3	30.2
1755-59	2.69	2.38	2.48	2.73	30.0	30.1	30.3	30.1
1760-64	2.64	2.39	2.56	2.77	30.0	30.1	30.2	30.0
1765-69	2.93	2.39	2.61	2.85	30.1	30.0	30.1	30.0
1770-74	2.77	2.47	2.51	2.92	30.1	29.9	30.1	30.0
1775-79	2.71	2.38	2.57	3.10	30.2	29.9	30.0	30.0
1780-84	2.51	2.47	2.50	3.16	30.2	30.0	30.0	29.9
1785-89	2.46	2.43	2.50	3.15	30.2	30.1	30.0	29.9
1790-94	2.32	2.58	2.38	3.00	30.2	30.3	29.9	29.9

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Table 1. *(continued)*

Cohorts	Gross Reproduction Rates (R)				Mean age at birth			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1795-99	2.35		2.42	2.94	30.1		30.0	30.0
1800-04	2.39		2.38	2.93	29.9		29.9	30.0
1805-09	2.56		2.49	2.99	29.9		29.9	30.0
1810-14	2.71		2.55	3.03	29.9		29.9	29.9
1815-19	2.81		2.62	3.08	29.9		29.9	29.9
1615-49	2.51			2.48	30.50			29.73
1650-99	2.31	2.66	2.53	2.88	30.35	30.34	30.16	29.95
1700-49	2.52	2.47	2.17	2.60	30.19	30.33	30.11	30.21
1750-99	2.61	2.43	2.49	2.93	30.11	30.07	30.09	29.99
1800-19	2.62		2.51	3.01	29.90		29.88	29.95

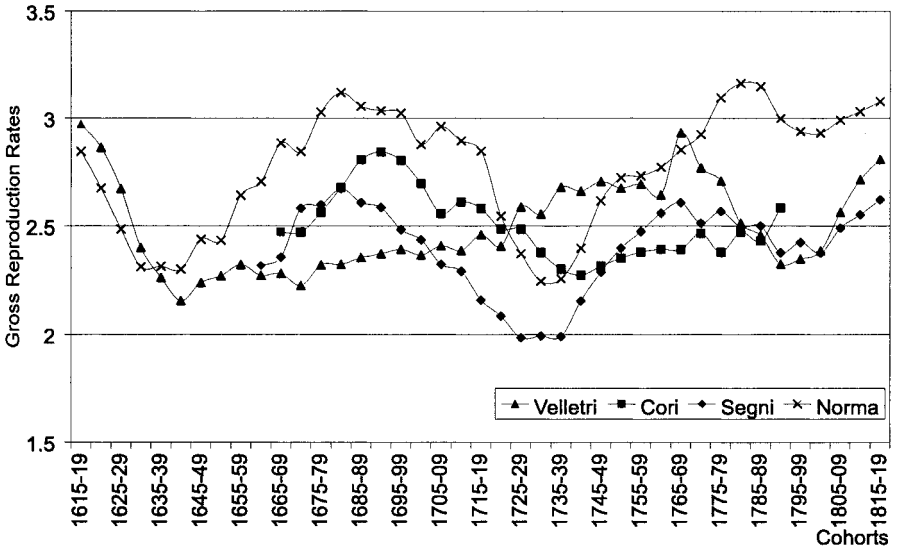

Figure 9. Gross reproduction rates by cohort

The reproductive capacity of the populations under the *ancien régime* was notoriously subject to considerable limitations due to high mortality rates that prevented a significant number of women belonging to a cohort to reach reproductive age or to participate in the entire period of potentially reproductive life (between the ages of 15 and 50). In the municipalities under study, mortality heavily affected the ages between infancy and adolescence. Out of the

female cohorts born in Velletri in the first half of the 17th century - a period characterised by a series of famines and health crises culminating in the plague epidemic of 1656-57 [1, 12, 4] -, only 40% were still alive at the age of 15 (Table 2 and Figure 10). In the same period, survival was definitely better in Norma, where 57% of women reached their 15th birthday. After the middle of the 17th century, the survival rate of the cohorts improved, thus raising it at the age of 15 to 60% of the components of the cohorts born in Segni, and, after 1825, those born in Velletri. It should be pointed out that Segni, for the entire time period considered, and Norma, up to the cohorts born in 1770-75, are characterised by a better survival rate. At the end of the 19th century, a sudden worsening occurred in the survival rate in Norma, and, by contrast, an improvement in Velletri. The cohorts born in Cori have always encountered higher mortality rates than those in the other towns.

Table 2. Survival patterns of female cohorts, 1615-1819

Cohorts	Surviving at age 15 (l_{15})				Surviving at age 50 (l_{50})				Probability of survival from 15 to 50			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1615-19	0.448			0.674	0.145			0.314	0.325			0.466
1620-24	0.465			0.654	0.130			0.217	0.279			0.332
1625-29	0.481			0.550	0.125			0.171	0.260			0.310
1630-34	0.478			0.568	0.131			0.202	0.273			0.355
1635-39	0.475			0.572	0.189			0.251	0.399			0.439
1640-44	0.308			0.503	0.237			0.273	0.769			0.542
1645-49	0.256			0.461	0.170			0.282	0.665			0.612
1650-54	0.420			0.520	0.264			0.326	0.628			0.627
1655-59	0.401			0.598	0.234			0.354	0.584			0.593
1660-64	0.555		0.573	0.590	0.355		0.470	0.403	0.639		0.820	0.683
1665-69	0.494	0.478	0.554	0.565	0.332	0.299	0.412	0.372	0.672	0.626	0.744	0.659
1670-74	0.508	0.479	0.559	0.543	0.339	0.289	0.323	0.355	0.667	0.604	0.578	0.654
1675-79	0.559	0.492	0.576	0.570	0.350	0.277	0.310	0.304	0.626	0.564	0.538	0.534
1680-84	0.556	0.471	0.561	0.579	0.325	0.252	0.252	0.323	0.585	0.535	0.450	0.558
1685-89	0.551	0.455	0.558	0.576	0.302	0.246	0.276	0.367	0.548	0.541	0.495	0.637
1690-94	0.566	0.475	0.555	0.572	0.312	0.248	0.350	0.347	0.550	0.522	0.630	0.606
1695-99	0.586	0.525	0.608	0.542	0.363	0.261	0.451	0.333	0.619	0.497	0.741	0.613
1700-04	0.576	0.508	0.588	0.587	0.386	0.262	0.435	0.386	0.670	0.516	0.740	0.658
1705-09	0.566	0.458	0.558	0.587	0.354	0.262	0.381	0.401	0.626	0.572	0.683	0.682
1710-14	0.528	0.501	0.598	0.558	0.315	0.319	0.410	0.392	0.596	0.637	0.687	0.702
1715-19	0.517	0.521	0.652	0.550	0.308	0.348	0.440	0.378	0.595	0.667	0.675	0.688
1720-24	0.528	0.540	0.659	0.603	0.333	0.347	0.481	0.458	0.630	0.643	0.730	0.759
1725-29	0.519	0.527	0.650	0.594	0.352	0.338	0.443	0.419	0.678	0.640	0.682	0.705
1730-34	0.513	0.493	0.621	0.590	0.307	0.293	0.416	0.354	0.598	0.594	0.670	0.599
1735-39	0.516	0.524	0.612	0.605	0.308	0.295	0.405	0.314	0.597	0.563	0.662	0.519
1740-44	0.509	0.554	0.614	0.604	0.295	0.297	0.388	0.315	0.579	0.537	0.633	0.522

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Table 2. *(continued)*

Cohorts	Surviving at age 15 (l_{15})				Surviving at age 50 (l_{50})				Probability of survival from 15 to 50			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1745-49	0.539	0.525	0.593	0.571	0.307	0.301	0.370	0.317	0.569	0.572	0.623	0.554
1750-54	0.523	0.541	0.569	0.599	0.296	0.311	0.343	0.331	0.566	0.576	0.603	0.552
1755-59	0.544	0.531	0.598	0.643	0.297	0.295	0.356	0.347	0.546	0.556	0.596	0.540
1760-64	0.554	0.532	0.610	0.609	0.334	0.298	0.403	0.326	0.602	0.561	0.662	0.535
1765-69	0.583	0.531	0.602	0.601	0.394	0.311	0.367	0.312	0.676	0.586	0.610	0.520
1770-74	0.540	0.532	0.599	0.605	0.373	0.366	0.411	0.357	0.691	0.689	0.687	0.590
1775-79	0.531	0.521	0.610	0.601	0.372	0.351	0.416	0.386	0.700	0.674	0.682	0.642
1780-84	0.530	0.505	0.594	0.565	0.359	0.298	0.395	0.350	0.677	0.590	0.664	0.620
1785-89	0.540	0.521	0.577	0.500	0.359	0.370	0.383	0.339	0.664	0.710	0.664	0.679
1790-94	0.515	0.538	0.572	0.522	0.322	0.336	0.373	0.357	0.625	0.625	0.653	0.683
1795-99	0.488	0.522	0.590	0.512	0.300		0.397	0.352	0.614		0.674	0.689
1800-04	0.484	0.526	0.608	0.528	0.312		0.443	0.350	0.644		0.728	0.663
1805-09	0.521	0.507	0.580	0.529	0.316		0.398	0.346	0.607		0.686	0.653
1810-14	0.553	0.553	0.595	0.543	0.384		0.449	0.334	0.695		0.754	0.615
1815-19	0.555	0.495	0.618	0.558	0.350		0.503	0.289	0.630		0.813	0.518
1820-24	0.577	0.494	0.627	0.566								
1825-29	0.605		0.634	0.548								
1830-34	0.627		0.623	0.538								
1835-39	0.576		0.641	0.507								
1840-44	0.686		0.669	0.409								
1845-49	0.619		0.669	0.452								
1615-49	0.42			0.57	0.16			0.24	0.42			0.44
1650-99	0.52	0.48	0.57	0.57	0.32	0.27	0.36	0.35	0.61	0.56	0.62	0.62
1700-49	0.53	0.52	0.61	0.59	0.33	0.31	0.42	0.37	0.61	0.59	0.68	0.64
1750-99	0.53	0.53	0.59	0.58	0.34	0.33	0.38	0.35	0.64	0.62	0.65	0.60
1800-19	0.53		0.60	0.54	0.34		0.45	0.33	0.64		0.75	0.61
1820-49	0.62		0.64	0.50								

A similar classification for the towns can be observed in the mortality-risk rate for the cohorts aged over 15, up to their 50th birthday. At 50, about one third of the members of the various cohorts born in Velletri, Cori and Norma after the mid-17th century were still alive. In this case also, the situation was better in Segni, where 40% of the contingents often survived up to the age of 50, due to higher survival probability between the ages of 15 and 50 (Table 2 and Figures 11 and 12).

As a result of the significant impact of this high mortality rate on the reproduction potential of the various cohorts, the values of R_0 - which express the maternity rate net of mortality (Net Reproduction Rate) - are considerably lower than the ones derived from the GRR. The female cohorts born in Velletri between 1615 and 1670 show, in fact, net reproduction rates consider-

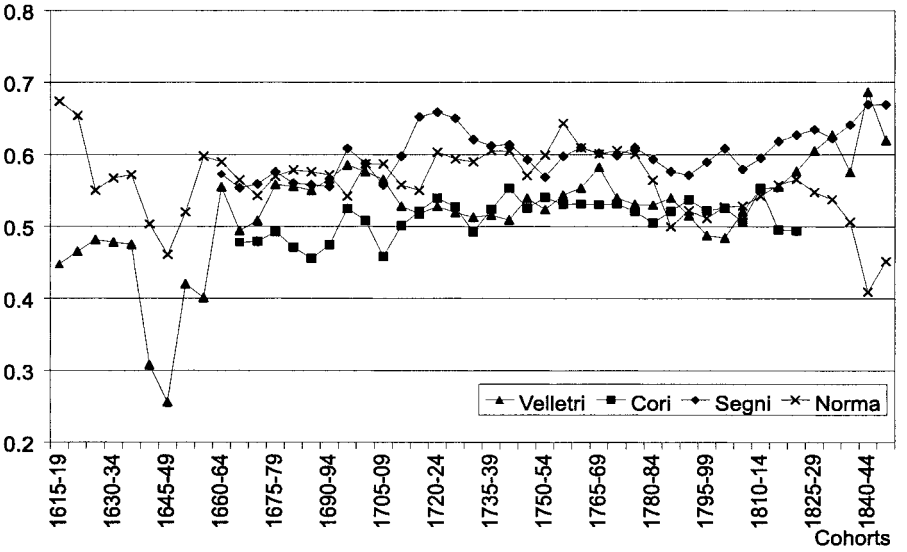

Figure 10. Surviving women at 15th birthday by cohort

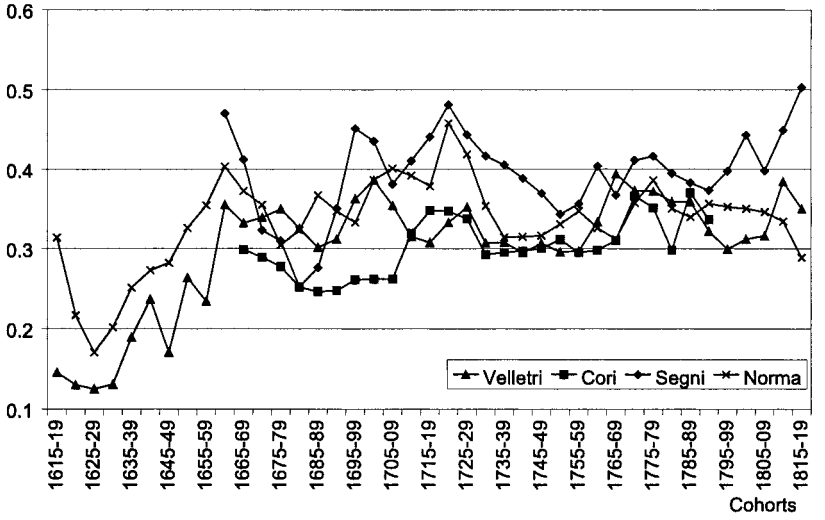

Figure 11. Surviving women at 50th birthday by cohort

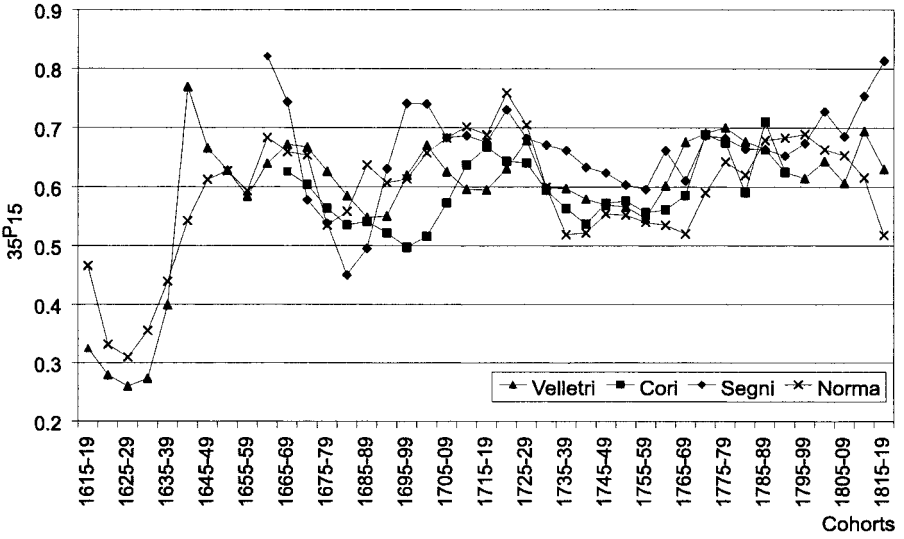

Figure 12. Probability of survival from age 15 to 50 by cohort

ably under 1. This means that these women, decimated by exceptionally high mortality rates in the first half of the century, gave birth to a number of daughters far lower than the rate at their own birth. On average, 100 women born between 1615 and 1649 managed to give birth to 65 daughters. A similar generational replacement incapacity also occurred in Norma regarding women born between 1625 and 1655, but in this case the deficit was lower, and the women's daughters totalled about 90% of the number of components of their mothers' generation (Table 3 and Figure 13). Subsequently, the improvement of the survival rate enabled the female cohorts to carry out for a longer time the reproductive function. This occurred in particular in Norma, where the very high fertility rate and the good survival conditions ensured average R_0 values of 1.3-1.4 daughters per woman after the mid-17th century - as well as in Segni (1.2-1.35 daughters per woman). In Cori, by contrast, the average R_0 values were just over the threshold of one daughter per woman, while for the cohorts born in Velletri a gradual improvement occurred in reproductive performances. The average rate rose from 1.01 daughters per woman for the 1650-1699 cohorts to 1.2 daughters on average for the female cohorts born in the early 19th century.

Table 3. Reproduction patterns of female cohorts, 1615-1819

Cohorts	Net Reproduction Rates at birth (R_0)				Net Reproduction Rates at age 15 (R_{15})				Intrinsic Rates of Increase (r‰)			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1615-19	0.94			1.57	0.54			1.07	-1.92			15.21
1620-24	0.82			1.24	0.74			0.98	-6.36			7.18
1625-29	0.66			0.86	0.55			0.93	-13.53			-5.16
1630-34	0.48			0.79	0.56			0.82	-23.75			-7.85
1635-39	0.52			0.94	0.54			0.93	-21.50			-2.14
1640-44	0.61			0.94	1.00			1.02	-16.28			-2.03
1645-49	0.50			0.89	1.08			1.09	-22.97			-4.09
1650-54	0.78			0.98	1.04			1.09	-8.03			-0.79
1655-59	0.75			1.26	1.03			1.22	-9.41			7.81
1660-64	1.03		1.24	1.37	1.06		1.20	1.33	1.12		7.02	10.59
1665-69	0.99	0.96	1.18	1.40	1.17	1.05	1.29	1.34	-0.45	-1.44	5.42	11.19
1670-74	1.02	0.95	1.27	1.34	1.15	1.01	1.33	1.45	0.53	-1.68	7.87	9.73
1675-79	1.16	1.01	1.28	1.41	1.17	0.94	1.24	1.46	4.89	0.26	8.15	11.59
1680-84	1.12	1.04	1.17	1.50	1.06	1.10	1.25	1.44	3.67	1.19	5.23	13.45
1685-89	1.02	1.03	1.19	1.48	0.95	1.17	1.39	1.41	0.51	0.83	5.79	13.00
1690-94	1.05	1.09	1.28	1.45	0.98	1.24	1.52	1.52	1.63	2.85	8.20	12.21
1695-99	1.15	1.13	1.41	1.31	1.02	1.13	1.51	1.44	4.70	3.90	11.39	8.98
1700-04	1.18	1.02	1.30	1.34	1.05	0.99	1.37	1.35	5.37	0.55	8.64	9.70
1705-09	1.14	0.89	1.09	1.43	1.04	1.01	1.19	1.48	4.26	-3.95	2.77	11.90
1710-14	1.00	1.11	1.20	1.43	0.97	1.22	1.23	1.55	0.05	3.39	6.10	11.74
1715-19	1.02	1.20	1.29	1.38	1.07	1.21	1.17	1.43	0.72	6.05	8.35	10.61
1720-24	1.06	1.16	1.30	1.38	1.05	1.16	1.12	1.37	1.88	4.84	8.69	10.55
1725-29	1.14	1.13	1.17	1.23	1.19	1.13	1.08	1.33	4.20	3.94	5.24	6.84
1730-34	1.09	0.97	1.09	1.14	1.18	1.05	1.07	1.18	2.86	-0.84	2.99	4.32
1735-39	1.14	0.97	1.04	1.03	1.29	0.99	1.02	1.02	4.43	-0.84	1.16	1.04
1740-44	1.15	1.00	1.11	1.14	1.22	0.96	1.08	1.14	4.79	0.04	3.32	4.31
1745-49	1.22	1.04	1.16	1.24	1.20	1.03	1.20	1.31	6.69	1.42	4.97	7.16
1750-54	1.13	1.04	1.18	1.38	1.15	0.97	1.23	1.30	4.17	1.36	5.32	10.57
1755-59	1.16	1.00	1.24	1.43	1.15	0.98	1.20	1.11	4.89	-0.15	7.21	11.82
1760-64	1.18	0.98	1.34	1.26	1.10	0.99	1.26	1.08	5.65	-0.60	9.74	7.67
1765-69	1.48	1.02	1.34	1.18	1.24	1.01	1.32	1.01	13.08	0.77	9.76	5.60
1770-74	1.29	1.10	1.33	1.34	1.15	1.09	1.35	1.17	8.40	3.32	9.45	9.87
1775-79	1.24	1.05	1.40	1.53	1.21	1.02	1.33	1.35	7.08	1.72	11.23	14.19
1780-84	1.13	1.03	1.30	1.47	1.17	1.13	1.31	1.41	3.92	0.98	8.88	12.81
1785-89	1.13	1.09	1.24	1.30	1.16	1.04	1.33	1.45	4.07	2.96	7.31	8.85
1790-94	1.04	1.17	1.19	1.36	1.16	1.07	1.30	1.47	1.18	5.17	5.70	10.26
1795-99	1.00		1.23	1.29	1.24		1.33	1.38	-0.14		7.00	8.44
1800-04	0.98		1.29	1.31	1.26		1.32	1.34	-0.75		8.57	8.98
1805-09	1.12		1.26	1.40	1.24		1.39	1.34	3.75		7.66	11.14
1810-14	1.33		1.37	1.44	1.65		1.54	1.09	9.58		10.65	12.23
1815-19	1.36		1.52	1.41	1.52		1.64	1.14	10.31		14.02	11.42

(continued on next page)

Table 3. *(continued)*

Cohorts	Net Reproduction Rates at birth (R_0)				Net Reproduction Rates at age 15 (R_{15})				Intrinsic Rates of Increase (r‰)			
	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma	Velletri	Cori	Segni	Norma
1615-49	0.65			1.03	0.72			0.98	-15.19			0.16
1650-99	1.01	1.03	1.25	1.35	1.06	1.09	1.34	1.37	-0.08	0.84	7.38	9.78
1700-49	1.11	1.05	1.17	1.27	1.13	1.08	1.15	1.31	3.52	1.46	5.22	7.82
1750-99	1.18	1.05	1.28	1.35	1.17	1.03	1.30	1.27	5.23	1.72	8.16	10.01
1800-19	1.20		1.36	1.39	1.42		1.48	1.22	5.72		10.22	10.94

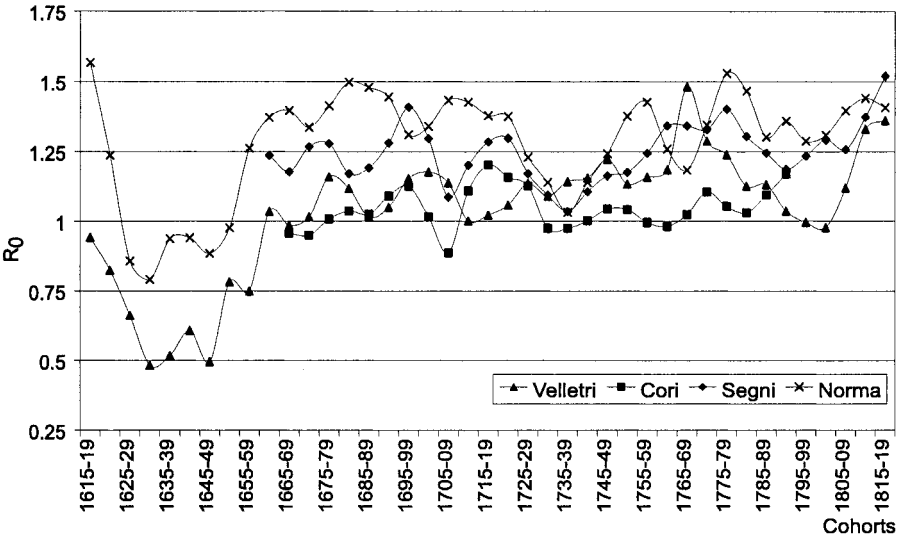

Figure 13. Net reproduction rates at birth (R_0), by cohort

Interestingly, the modest but increasing improvement of the survival rate has, over time, produced not only an increase of the size in the cohorts of the daughters with respect to those of their mothers (as shown by the increase of R_0 values) but also an expansion, from one generation to the next, of the number of potential reproductive women. This aspect is measured by the Net Reproduction Rate at the age of 15 (R_{15}), by which the number of surviving daughters aged 15 is compared to the women surviving at the same age as their mothers' generation. As we can see in Table 3 and Figure 14, the R_{15}

values were almost over the R_0 values, for the cohorts born in Velletri, Segni and Norma, and to a lesser extent also in Cori. However, it must be observed that in the case of Norma, the worsening of the survival conditions, occurring from the last quarter of the 18th century and even more so in the 19th century, reduced the effects of the good reproductive results; the R_{15} values, though exceeding 1, were lower than the R_0 rates for almost all the cohorts born between 1750 and 1819.

At this point, we can evaluate the populations' growth capacity due to the reproduction rate of the various cohorts in the history of the four towns. This evaluation can be conducted on the basis of the relationship $R_0 = e^{ra}$ - where R_0 is the number of daughters actually born on average to each woman of the cohort, e is the basis of the natural logarithms, a is the average age at giving birth, and r is the increase - from which we derive the values of $r = logR_0/a$ expressing the increase, occurring on average over a period of time equal to a, between the number of women of the cohort considered at birth and the number of daughters they produced. In other words, this is the increase between the mothers' generation and that of the daughters. The values of r, multiplied by 1,000, are shown in Table 3 and illustrated in Figure 15. They provide a useful indicator of the natural growth model occurring in the populations concerned.

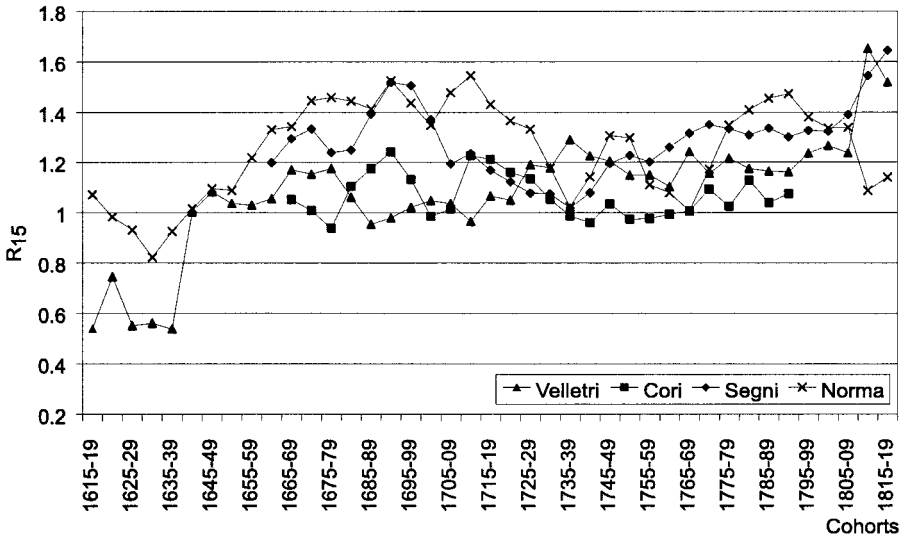

Figure 14. Net reproduction rates at 15 (R_{15}), by cohort

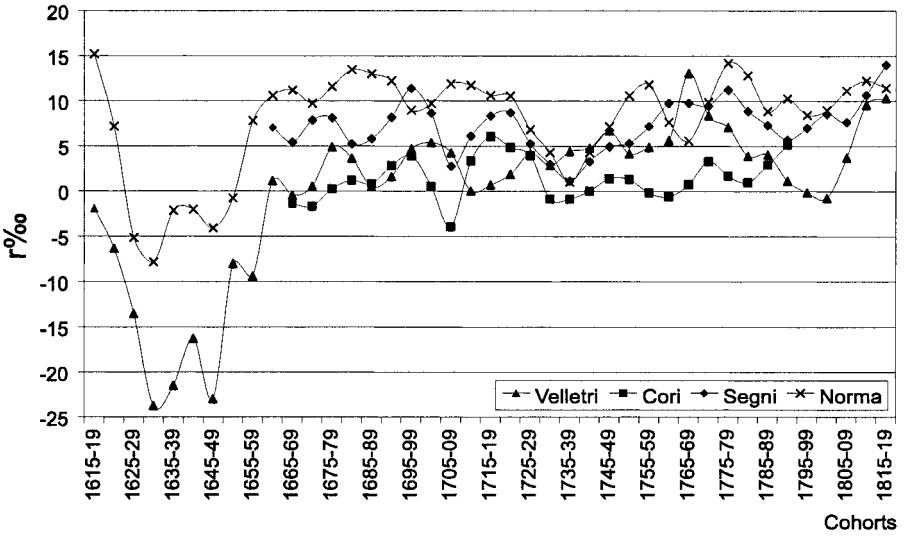

Figure 15. Intrinsic rate of increase (r‰), by cohort

What can we conclude from these data? They tell us that - given the elimination of the adverse survival conditions severely limiting the reproductive potential of the cohorts born up to the mid-17th century in Norma, or up to 1675 in Velletri and Cori, - these populations experienced a natural growth rate with positive increases in the cohorts. Nevertheless, it occurred with sharp differences between the towns. While in Velletri the average values of *r* for cohort groups do not exceed 5 per 1,000, in Cori, the rate was under 2 per 1,000, and in Segni and Norma increases of over 10 per 1,000 were recorded (see the values summarised at the bottom of Table 3). But actually, none of the towns was able to fully benefit from its reproductive capacity; the growth of the populations was much lower than it could have been if the net out-migration had not limited the potential. This is clearly evidenced by the data shown in Table 4, in which, for each of the towns, the average values of *r*, by cohort groups, are accompanied by the values of the average populations' growth (*i* per 1,000) calculated in a deferred time interval of thirty years, i.e. equivalent to the average distance between the birth of the mothers' generations and the birth of their daughters. We can, in fact, observe wide differences between the values of *r* and those of *i*: the former are always considerably higher than the latter, and the latter have negative average values in Cori, from the start of the 18th century, but also in Velletri and Segni. What we should stress, however, is that the populations of Segni and Norma (the latter more clearly) were able to contrast the migration deficit and to record consid-

erable increases as a result of their higher and more long-lasting reproductive capacity.

Table 4. Intrinsic rates of increase (r‰) by cohort, and rates of population growth (i‰) by year

Velletri				Cori			
Cohorts	r‰	Years	i‰	Cohorts	r‰	Years	i‰
1615-1669	-11.19	1645-1699	2.15	1665-1669	-1.44	1695-1699	1.04
1670-1719	2.63	1700-1749	-2.30	1670-1719	1.34	1700-1749	-1.85
1720-1769	5.26	1750-1799	2.05	1720-1769	0.99	1750-1799	-0.74
1770-1819	4.74	1800-1849	4.55	1770-1794	2.83	1800-1824	-1.76

Segni				Norma			
Cohorts	r‰	Years	i‰	Cohorts	r‰	Years	i‰
1660-1669	6.22	1690-1699	2.71	1615-1669	2.72	1645-1699	3.68
1670-1719	7.25	1700-1749	2.79	1670-1719	11.29	1700-1749	7.01
1720-1769	5.84	1750-1799	-0.36	1720-1769	6.99	1750-1799	3.36
1770-1819	9.05	1800-1849	5.84	1770-1819	10.82	1800-1849	5.38

5 Comments

The results of our analyses suggest some concluding remarks. First of all, we can observe how the technique of inverse projection adopted has enabled us to develop a more detailed analysis of the populations examined by cohort, thus providing some clarifications of the trend of these populations that are much more effective than those deriving from the study of the fertility and mortality indicators conducted in specific time periods.

In the second place, with specific regard to the demographic processes expressed by the populations, the results we have illustrated seem to provide, at least partially, a contribution to the study of the specific characteristics of the mountainous-area populations. Various studies conducted in the 1990s, concentrating particularly on the demographic trends of Alpine populations in modern times, have highlighted a natural growth of these populations, characterised by low birth-rates and mortality rates[6]. In the case of the towns examined, belonging to a mountainous and hilly area of the Latium Apennines, the higher reproductive capacity of the Segni population (altitude 650

[6] See in particular [7, 13, 6].

metres) is clearly evident; this was due to survival conditions of its female cohorts that were definitely better than the ones observed in the cohorts of Cori (altitude between 200 and 400 metres) and also of Velletri (a hill town) and Norma. Figure 16 shows the constant predominance of the cohort reproduction rates in Segni (and also in Norma - a very isolated town with an altitude of 430 meters - thanks to its high fertility rates), as compared to the other two towns.

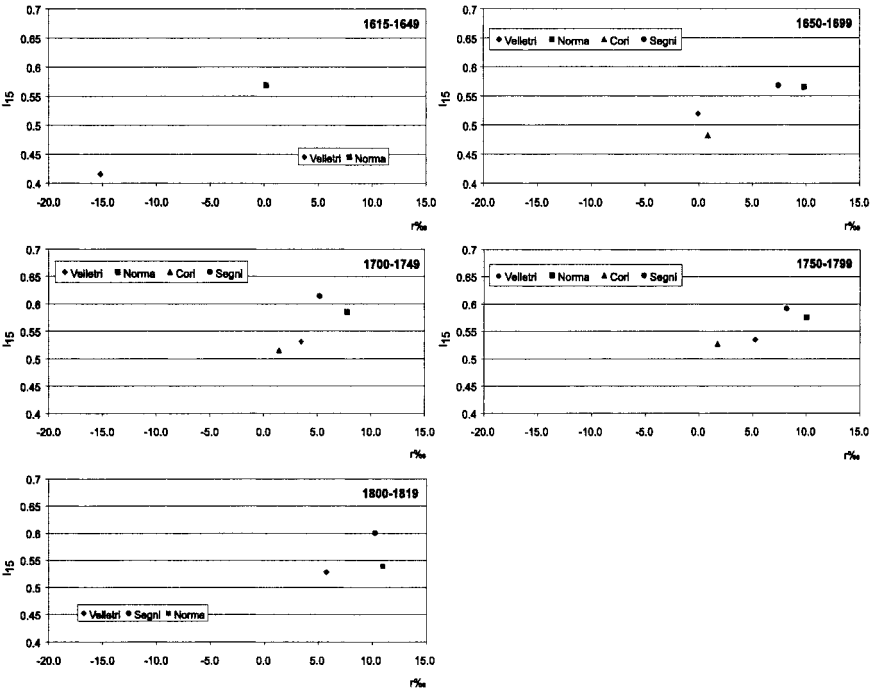

Figure 16. Survival and intrinsic rate of increase by cohort

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