European Journal of Population 10: 223–274, 1994.

A Reconstruction of the Population of North Italy from 1650 to 1881 using Annual Inverse Projection with Comparisons to England, France, and Sweden

Patrick R. Galloway
Department of Demography, University of California, Berkeley, California, U.S.A.

Received 18 August 1993; final version received 15 April 1994

Galloway, P. R., 1994. A reconstruction of the population of North Italy from 1650 to 1881 using annual inverse projection with comparisons to England, France and Sweden. European Journal of Population / Revue Européenne de Démographie 10: 223–274.

Abstract. North Italy annual population and vital rates are reconstructed from 1650 to 1881 using series of vital event indices from many rural parishes and cities. Inverse projection is applied to the reconstructed series of vital events and population to generate annual age distribution, gross reproduction rate, net reproduction rate, life expectancy at birth, and infant mortality rate. The results are compared with official sources and detailed demographic rates produced by annual inverse projection using data from England, France, and Sweden. Over the long term, North Italy is generally characterized by stagnant and relatively high mortality. Fertility and nuptiality are relatively high at the beginning and at the end of the period.

Galloway, P. R., 1994. Une reconstitution de la population d'Italie du Nord par projection inverse annuelle comparée avec l'Angleterre, la France et la Suède. European Journal of Population / Revue Européenne de Démographic 10: 223–274.

Résumé. La population et les taux d'accroissement naturels d'Italie du Nord sont reconstitués de 1650 à 1881 à l'aide de séries de faits d'état civil qui existent pour de nombreuses paroisses rurales et villes. La projection inverse est appliquée aux séries reconstituées d'événements et de populations pour engendrer des répartitions par âge calculées annuellement, un taux brut de reproduction, un taux net de reproduction, une espérance de vie à la naissance et un taux de mortalité infantile. Les résultats sont comparés à des sources statistiques officielles et à des taux détaillés fournis par projection inverse annuelle utilisant des données anglaises, françaises et suédoises. Sur le long terme, l'Italie du Nord est généralement marquée par une mortalité stable à un niveau relativement élevé. La fécondité et le nuptialité sont relativement élevées au début et à la fin de la période d'observation.

Correspondence to: P. R. Galloway, Department of Demography, University of California, 2232 Piedmont Avenue, Berkeley, California 94720, U.S.A.

1. Introduction

The derivation of useful information from limited material is one of the challenges faced by nearly every scientist. One of the mainstays of empirical historical demographic research has been family reconstitution from parish registration data, a time-consuming and tedious task. While providing the researcher with an age distribution and age-specific mortality and marital fertility rates for a given parish, generalization of the results is problematic due to unknown registration deficiencies and the inability to capture the characteristics of unspecified numbers of migrants. Subject to these constraints, long-term trends in regional demographic rates can be examined by combining reconstitution data from large numbers of parishes.

Annual inverse projection can generate in just a fraction of the time many of the measures produced by family reconstitution.[1] Given an initial population size, a series of annual births, deaths and net-migration, and making some reasonable assumptions about initial age distribution and mortality, fertility, and net-migration schedules, inverse projection will generate annual age distribution, total fertility rate, gross and net reproduction rates, and life expectancy (Lee, 1978, 1985a, 1993; McCaa, 1993). With more data, sex-specific mortality rates, marital fertility rates, and nuptiality rates can in principle be produced (Lee, 1993; McCaa, 1993). Short, medium and long term weather, Malthusian preventive, and Malthusian positive checks to population growth can be examined by including in the analysis real wage and weather data (Galloway, 1985, 1986a, 1986b, 1987, 1988, 1993a, 1994; Lee, 1977, 1981, 1985b, 1987, 1990.)[2]

One of the remarkable events in recent demographic history was the publication of the reconstructed population of England by Wrigley and Schofield (1981). Equally remarkable has been the limited number of similar population reconstructions for other countries or regions.[3] The dearth in this type of demographic research may be understandable given the enormous research effort involved in the reconstruction of the English population. However, certain other constraints present themselves when considering a similar analysis of other European countries. While France has been the locus of seemingly innumerable parish reconstitutions, population reconstruction is hampered by severe under-registration of infant and child deaths up to the end of the 17th century (Biraben and Blanchet, 1985). There are many series of vital events published for Spain, but under-registration of infant and child mortality (Livi Bacci and Reher, 1993), as in France, is a problem. Parish level research has been relatively sparse in the rest of Europe where only a few series of parish level vital events have appeared, with the notable exception of North Italy where series of parish vital events are plentiful.

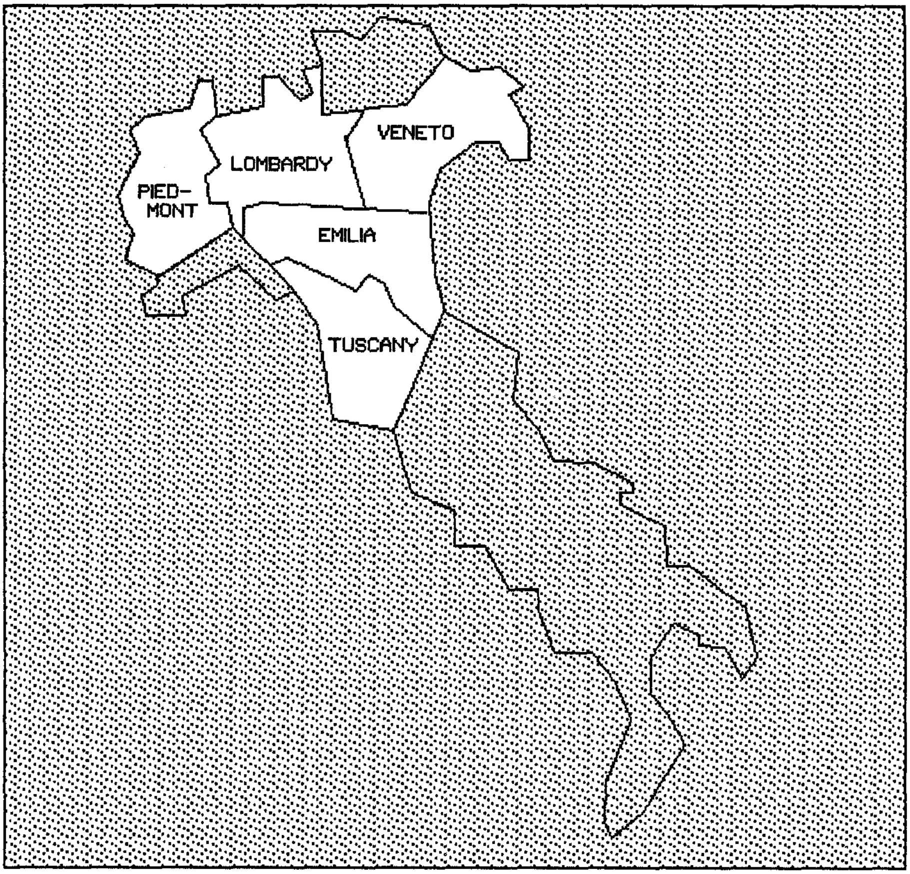
The purposes of this study are:

1. Construct an annual series of births, marriages, deaths, and population for North Italy from 1650 to 1881 using series of vital events from parishes and cities.
2. Generate annual population growth rates, and annual crude birth (CBR), marriage (CMR), and death (CDR) rates for North Italy 1650 to 1881.
3. Use annual inverse projection (Lee, 1985a; McCaa, 1993) to derive yearly estimates of age structure, gross reproduction rate (GRR), net reproduction (NRR), life expectancy at birth (e_0), and infant mortality rate for North Italy 1650 to 1881.
4. Apply annual inverse projection to the population and vital events of England, France, and Sweden.
5. Examine and compare levels and trends of age structure and detailed demographic measures in North Italy and the three countries.

2. North Italy demographic data

There exists no published population reconstruction for any large area in continental Europe before 1740. Nothing has been published which covers detailed measures of annual population movement at any aggregated level in Italy or in any other Mediterranean land before 1861, except for Tuscany and there only crude rates have been published from 1810 forward (Bandettini, 1961).[4]

The area chosen for analysis consists of the five provinces shown in Map 1, which will be called henceforth North Italy.[5] While located in the northern half of Italy, the provinces of Liguria and Trento are not included because of their relative lack of historical data. The population of North Italy in 1881 was 13.9 million (Direzione Generale di Statistica, 1881), or about half the population of all Italy. North Italy's population was more than twice the size of either Belgium or the Netherlands, larger than the combined population of the countries of Scandinavia, only slightly smaller than Spain, about half the size of England and Wales, and about a third the size of France and Germany (Mitchell, 1981, pp. 29–34).



Map. 1. North Italy. The map shows the five provinces of North Italy.

2.1. *Data*

Italy seems a promising area for population reconstruction for several reasons. A large number of articles have appeared over the past decade containing long continuous series of births, marriages, and deaths for both rural and urban parishes. These data series usually end around 1800. The northern half of Italy is particularly well represented. Romani (1982, pp. 374–376) has provided a useful outline of virtually all regional census and registration data from 1815 to 1860. The data found in these publications coupled with official census data beginning in 1861 provide the basic raw material for reconstructing the population of North Italy.

On the down side, Italy was a collection of various small states before unification in 1861. Published census and registration material for these small states is almost nonexistent before 1815 and that which is published between 1815 and 1860 has many gaps (Romani, 1982), a notable exception being the data for Tuscany from 1810 onwards (Bandettini, 1961). It would be useful to compare demographic rates estimated from reconstruction and inverse projection with those derived from family reconstitution. Unfortunately, few family reconstitution studies have been undertaken for parishes in North Italy (Livi Bacci and Breschi, 1990).

It is difficult to assess the quality of registration of vital events in the source material, but an examination of the series suggests that the dramatic underregistration of infant and child deaths found in Spain and France is not a problem in North Italy.[6] In this exercise, all published registration material is accepted as it stands. In later sections I will make some comparisons and conduct some tests that suggest that data quality is adequate after 1650.

2.2. *Period*

Very little demographic data have been published for places in North Italy covering the period before 1580. As a consequence this analysis will begin in 1580 and end in 1881, the date of the third national Italian census.[7]

2.3. *Net out-migration*

Little migration data for North Italy are available before the middle of the 19th century (Willcox, 1931, p. 440; Società Italiana di Demografia Storica, 1990). However, it has been suggested that net external migration (migration out of North Italy minus migration into North Italy) was not important in North Italy until the last half of the 19th century (Willcox, 1929, p. 811). During the 40-year period between 1820 and 1860, only 13,793 persons from all Italy are recorded to have emigrated to the United States (U.S. Bureau of the Census, 1975, p. 106). Furthermore, certain social and economic indicators suggest that net external migration was not significant in North Italy before the last half of the 19th century. Because North Italy was almost entirely Catholic, expulsion on religious grounds would seem unlikely. In-migration spawned by economic growth during the period under consideration also seems improbable given Italy's transformation into a virtual economic backwater after the end of the 16th century. Indeed the economic picture of Italy during the 17th, 18th, and most of the 19th centuries is one of stagnation (Cipolla, 1980, pp. 249, 253–263). Net external migration from North Italy was probably negligible or nonexistent before 1861, so for purposes of population reconstruction, no net external migration in North Italy is assumed before 1861.

3. Reconstructing annual vital events and population in North Italy

Only accurate series of annual births (*B*) and deaths (*D*) and a final population (*P*) size are needed, assuming no net external migration, to retroject annual population size using the balancing equation: $P_{t-1} = P_t - B_t + D_t$, where t is time. Once annual population size is known yearly vital rates can be mechanically generated.

The first population census for all five provinces combined occurred in 1861, the year of unification, followed by enumerations in 1871 and 1881. For purposes of retrojection, the census population in 1861 of 12,292,000 (Table 1) is used as the final population size. The census populations in 1871 and 1881, 13,204,000 and 13,902,000 respectively are held fixed allowing intercensal net migration to be calculated after 1861. Population for each year from 1580 to 1860 will be estimated using the balancing equation and assuming no net external migration.

The basic strategy is to compile provincial, urban, and rural indices of vital events using all available birth, marriage, and death series. Interpolation is not used in any of the birth, marriage, or death series. When constructing rural indices, each rural parish for which data are available in a given year is given equal weighting with each of the other rural parishes for which data are available in that year. Provincial and urban indices are treated similarly. Table 2 provides a detailed listing of the periods and places used in the construction of the indices. Figure 1 presents the number of provinces, rural parishes, and cities used. Just as there are no provincial data before 1810, there are relatively little rural parish or urban data after 1816.

3.1. *Indicators of demographic and economic homogeneity in North Italy*

Figures 2 and 3 show series of baptisms in various rural parishes and cities in North Italy. They reveal synchronous medium-term fluctuations in both rural and urban sectors (Bellettini, 1980b, 1987, pp. 78–82) throughout North

Table 1. Population of provinces in North Italy from published sources.

Province	1774	1816	1838	1861	1871	1881
Piedmont						
Direzione Generale di Statistica 1884, p. 48:				2764	2900	3070
Romani 1982, p. 374:		2285	2686			
Based on growth of 'Piedmont' 1774–1819 from Beloch 1961, p. 264:	2342					
Lombardy						
Direzione Generale di Statistica 1884, p. 48:				3261	3461	3681
Based on growth of 'Lombardy' 1774–1861, 1816–1861, and 1838–1861 from Direzione Generale di Statistica 1884, p. 46:	1913	2379	2729			
Veneto						
Direzione Generale di Statistica 1884, pp. 46, 48:		1954	2094	2340	2643	2814
Interpolation between 1770 and 1780 from Direzione Generale di Statistica 1884, pp. 46:	1724					
Emilia						
Direzione Generale di Statistica 1884, p. 48:				2006	2114	2183
Based on growth of Bologna Diocese 1774–1881, 1816–1881, and 1838–1881 from Bellettini 1978, p. 9:	1308	1448	1717			
Tuscany						
Bandettini 1961, p. 11:		1320	1681	1921	2086	2154
Based on growth of 'Tuscany' 1766–1816 and 1794–1816 from Direzione Generale di Statistica 1884, p. 46. 1774 is interpolated from the resulting 1766 and 1794 figures:	1110					
North Italy total	8397	9386	10907	12292	13204	13902

Note: Population figures are in thousands.

Italy. Given the synchronous movements found among most of the series, the indices of vital events that will be produced probably reflect the vital events of North Italy as a whole.

Based on medium term price movements in a number of cities scattered throughout North Italy[8] there also appears to be a certain amount of economic homogeneity over the medium term within North Italy (Fig. 4). It is not clear whether this homogeneity was caused by common weather patterns, economic integration, or other factors. For purposes of this analysis, I wish to show only that homogeneity appears to exist.[9]

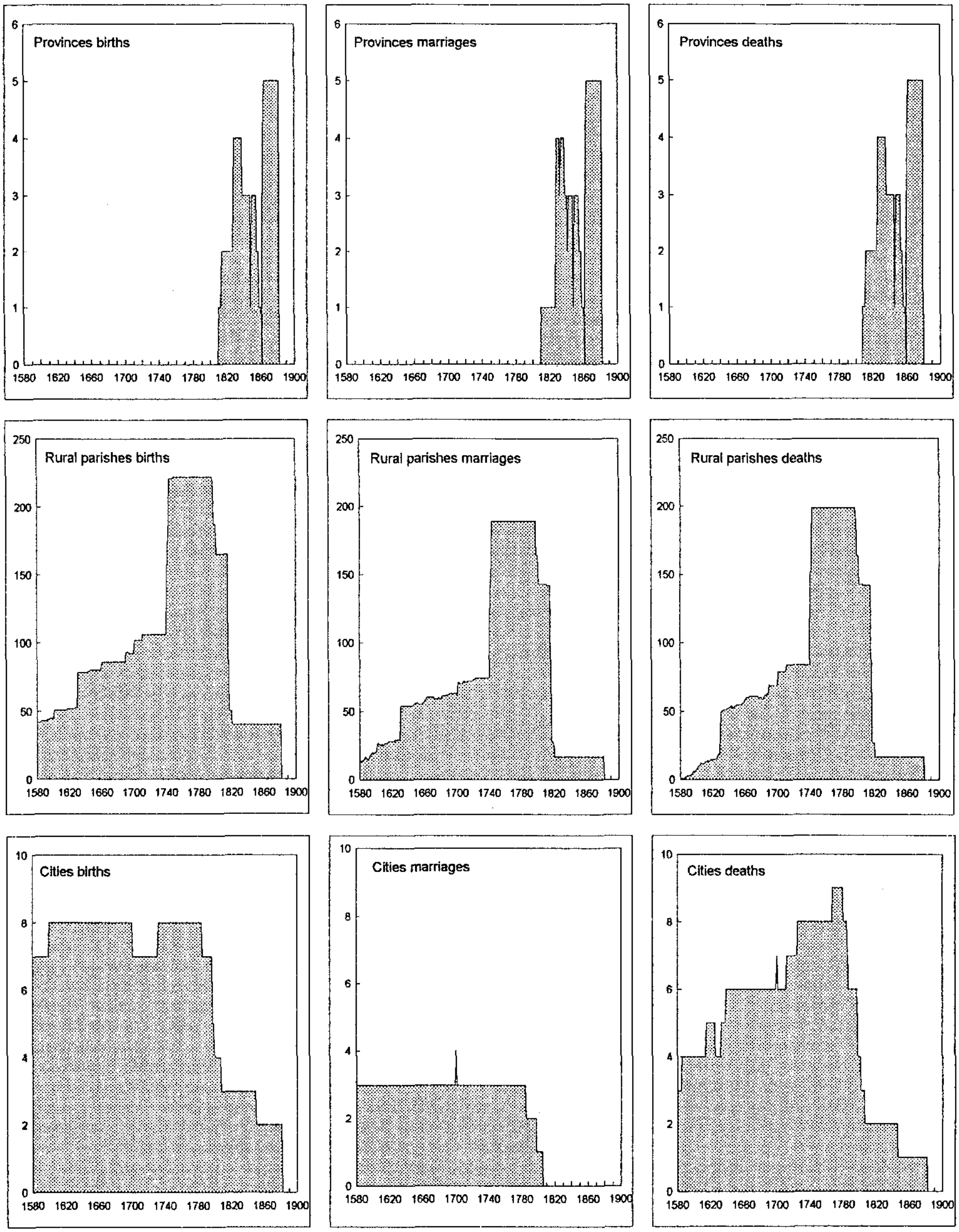
Table 2. Vital events in provinces, cities, and rural parishes of North Italy from published sources.

Provinces	Baptisms	Marriages	Burials	Source
Piedmont	1828–1837;	1828–1837;	1828–1837;	Romani 1982, p. 374.
	1862–1881	1862–1881	1862–1881;	Direzione Generale di Statistica 1884, pp. 65, 68, 70.
Lombardy	1814–1847;	1828–1831;	1814–1847;	Baptisms and burials, Romani 1955, pp. 415, 428.
	1849–1854;	1833–1840;	1849–1854;	Marriages, Romani 1982, p. 376.
		1842–1847		
		1842–1854		Marriages, Romani 1982, p. 376.
	1862–1881	1862–1881	1862–1881	Direzione Generale Di Statistica 1884, pp. 65, 68, 70.
Veneto	1828–1857;	1828–1857;	1828–1844;	Romani 1982, p. 376
	1849–1857;	1849–1857;	1849–1857;	Romani 1982, p. 376.
	1863–1881	1863–1881	1863–1881	Direzione Generale Di Statistica 1884, pp. 65, 68, 70.
Emilia	1862–1881	1862–1881	1862–1881	Direzione Generale Di Statistica 1884, pp. 65, 68, 70.
Tuscany	1810–1860;	1810–1860;	1810–1860;	Bandettini 1961, p. 11
	1862–1881	1862–1881	1862–1881	Bandettini 1961, p. 11
Total number of provinces	5	5	5	

Cities	Baptisms	Marriages	Burials	Source
Bologna	1580–1881			Bellettini and Tassinari 1977, pp. 74–77.
Bologna (8 parishes)		1580–1805	1585–1805	Bellettini 1961, pp. 244–367.
Faenza	1580–1807			Angeli 1980, pp. 663–665.
Florence	1580–1849			Zuccagni-Orlandini 1848, pp. 420–507.
Florence (1 parish)			1580–1625	Parenti 1943–1949, pp. 284–285.
Gorizia	1700–1784	1700–1784	1700–1784	Fanfani 1979, pp. 10–11.
Livorno			1767–1785	Del Panta 1977, p. 336.
Milan			1580–1845	Ferrario 1838–1850, pp. 375–383.
Padua			1725–1779	Ferrario 1838–1850, p. 200.
Parma	1580–1699			Romani 1970, pp. 267–269.
Pavia	1580–1700	1580–1700	1615–1700	Aleati 1957, pp. 44, 49, 54.
Ravenna	1600–1796			Bolognesi 1982, p. 257.
Ravenna (6 parishes)			1639–1796	Bolognesi 1982, p. 258.
Siena	1580–1799			Ottolenghi 1903, pp. 348–358.
Turin			1712–1800	Levi 1974, pp. 243–245.
Venice	1580–1797	1580–1797	1580–1797	Beltrami 1954, pp. 112–127.
Verona	1732–1881		1633–1881	Donazzolo and Saibante 1926, pp. 79–83.
Total number of cities	10	4	11	

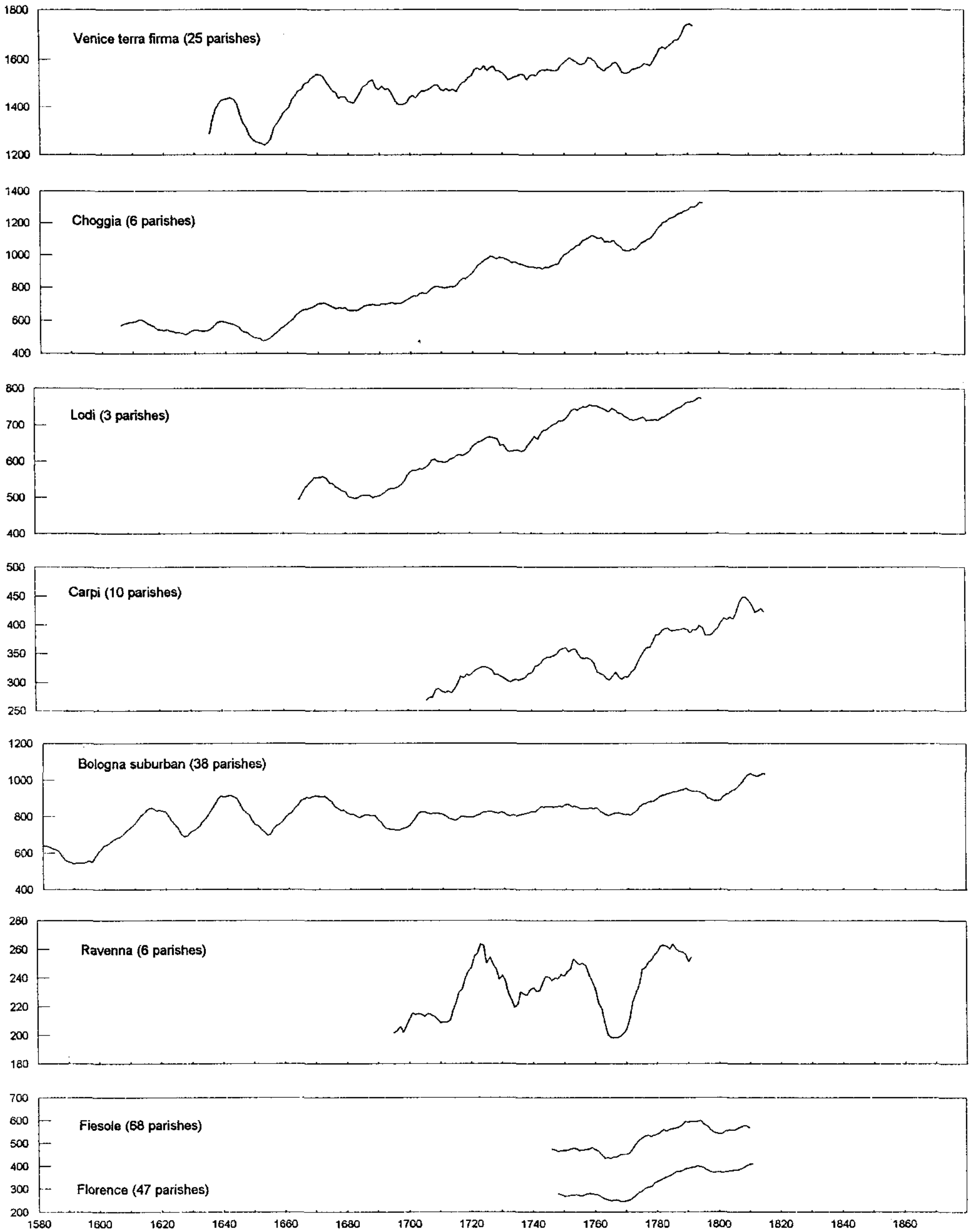
Table 2. (Continued).

Rural parishes	Baptisms	Marriages	Burials	Source
Adria (2 parishes)	1580–1881	1580–1881	1627–1881	Rossi 1970, pp. 102–105, 118–121, 143–146.
Bologna (38 parishes)	1580–1881			Bellettini and Tassinari 1977, pp. 74–77.
Bologna (16 parishes)		1580–1881	1580–1881	Bellettini and Tassinari 1977, pp. 99–619.
Carpi (10 parishes)	1701–1820	1701–1820	1701–1820	Bellettini 1980a, pp. 659–660.
Chioggia (6 parishes)	1601–1800	1601–1800	1630–1800	Etonti 1982, pp. 314–319.
Fiesole (68 parishes)	1741–1815	1741–1815	1741–1815	Del Panta and Livi-Bacci 1980, p. 671.
Florence (47 parishes)	1743–1816	1743–1816	1743–1816	Del Panta and Livi-Bacci 1980, p. 671.
Lodi (3 parishes)	1660–1800	1660–1800	1660–1800	Roveda 1980, pp. 653–658.
Piedmont Villanova Solaro parish	1646–1800	1646–1800	1646–1800	Dossetti 1977, pp. 156–158.
Piedmont Torre S. Giorgio parish	1691–1800	1691–1800	1687–1800	Dossetti 1977, pp. 158–161.
Piedmont Polonghera parish	1593–1800	1593–1800	1593–1800	Dossetti 1977, pp. 162–164.
Piedmont Strambino parish	1580–1800	1580–1800	1562–1800	Dossetti 1977, pp. 165–168.
Piedmont Romano parish	1627–1800	1580–1800	1632–1800	Dossetti 1977, pp. 172–175.
Piedmont Vische parish	1596–1800	1596–1701;	1596–1800	Dossetti 1977, pp. 177–179.
		1723–1800		Dossetti 1977, pp. 177–179.
Piedmont Mazze parish	1580–1800	1648–1800	1648–1800	Dossetti 1977, pp. 180–183.
Piedmont Pocapaglia parish	1659–1800	1720–1800	1605–1800	Dossetti 1977, pp. 183–186.
Piedmont La Morra parish	1660–1800	1677–1800	1678–1800	Dossetti 1977, pp. 186–188.
Piedmont Verduno parish	1585–1800	1662–1800		Dossetti 1977, pp. 191–193.
Piedmont San Front parish	1661–1800	1662–1800	1662–1800	Dossetti 1977, pp. 197–199.
Piedmont Cuneo parish	1643–1799		1711–1799	Dossetti 1977, pp. 204–207.
Piedmont Bra parish	1617–1693;	1602–1671;	1588–1800	Dossetti 1977, pp. 207–210.
	1748–1800	1681–1800		Dossetti 1977, pp. 207–210.
Ravenna (4 parishes)	1711–1796		1711–1796	Bolognesi 1980, pp. 666–670.
Ravenna (6 parishes)	1690–1796		1690–1796	Bolognesi 1980, pp. 666–670.
Venice terra firma (25 parishes)	1630–1797	1630–1797	1630–1797	Beltrami 1954, pp. 150–152.
Total number of parishes	222	189	199	



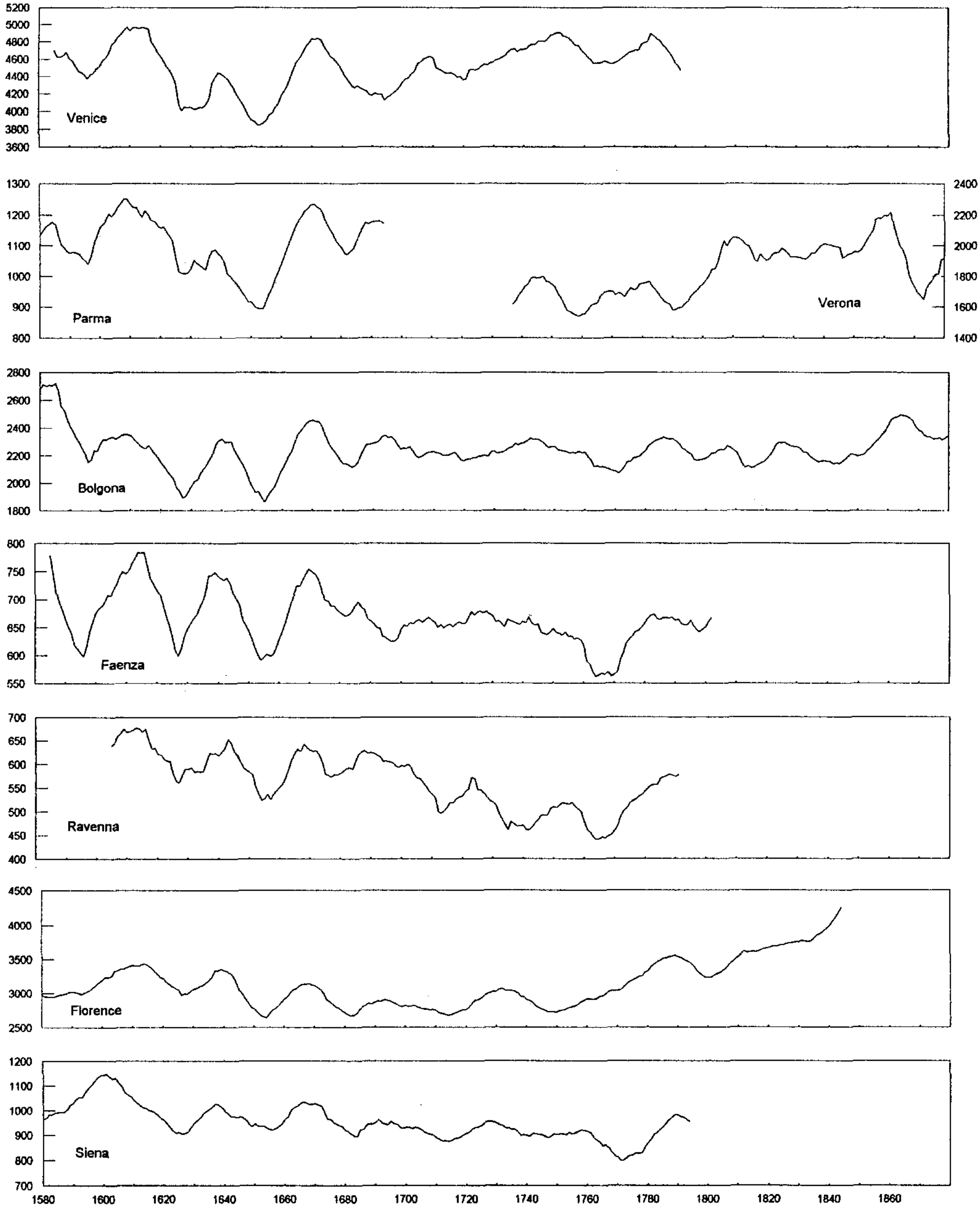
Source: Table 2.

Fig. 1. Number of provinces, rural parishes and cities used in the analysis.



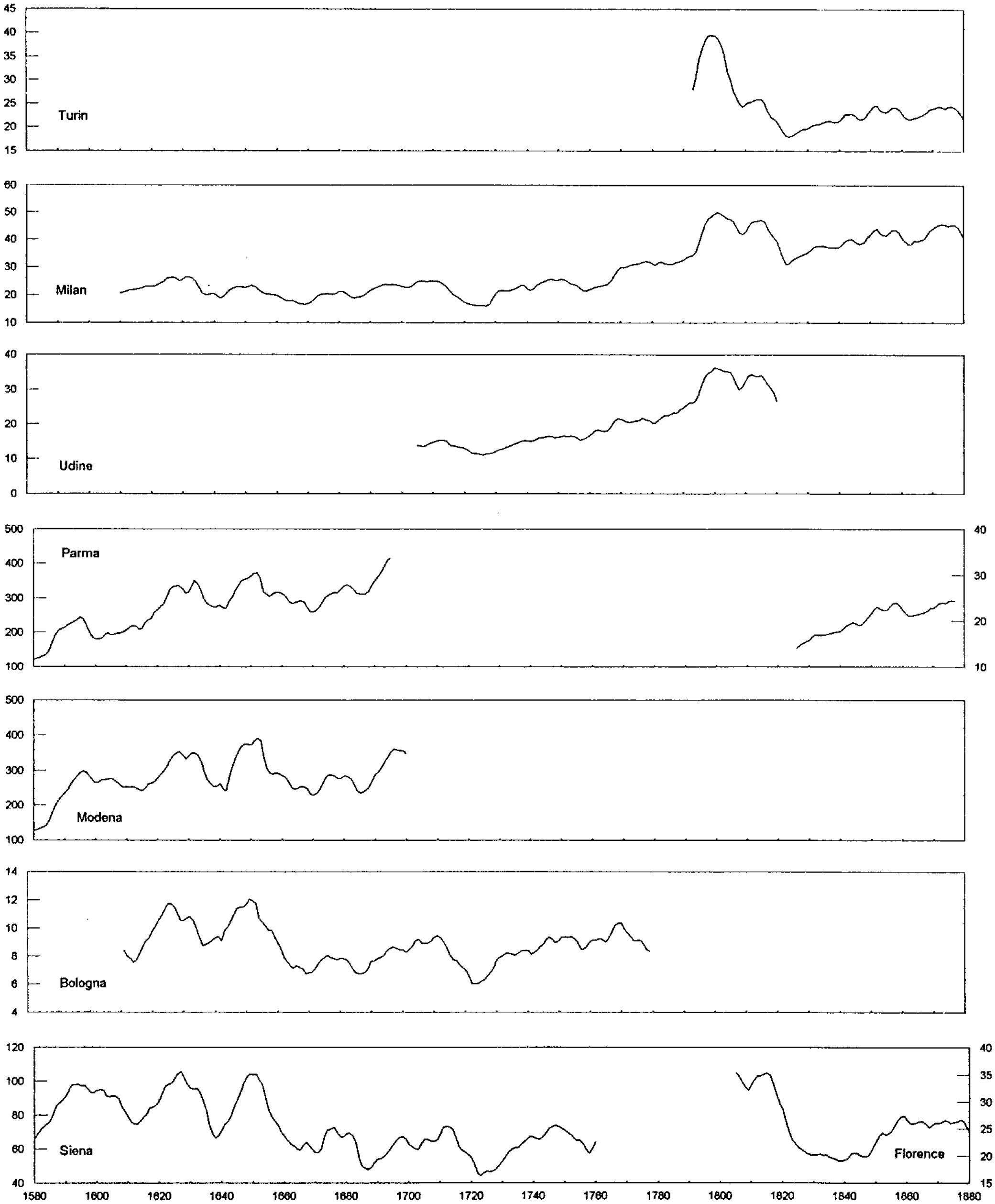
Source: Table 2.

Fig. 2. Baptisms in various rural parishes in North Italy (11 year moving average).



Source: Table 2.

Fig. 3. Baptisms in various cities in North Italy (11 year moving average).



Source: Note 8.

Fig. 4. Wheat prices in various cities in North Italy (11 year moving average).

3.2. *Reconstructing annual population and vital events in North Italy*

Figure 5 shows schematically how the annual birth indices and annual birth series are reconstructed. Total births for all five Provinces of North Italy were first published in 1863. Box A in Fig. 5 indicates total births for all five provinces of North Italy from 1863 to 1881. These data were published by the Italian government and are assumed to be accurate.

An index of births from 1814 to 1863 (1863 = 1.00) is constructed for each province. There are a number of gaps in some series; in fact there are no data for Emilia before 1862 (see Table 2). However, data exist for every year for at least one province, except for 1861 which was estimated using data from a large number of parishes in Bologna Diocese. An annual average is taken of the four provincial birth indices to yield a North Italy birth index. Each province is weighted equally regardless of population size. This birth index is applied to the 1863 birth data to generate an estimate of North Italy births for each year from 1814 to 1862, as shown in Boxes

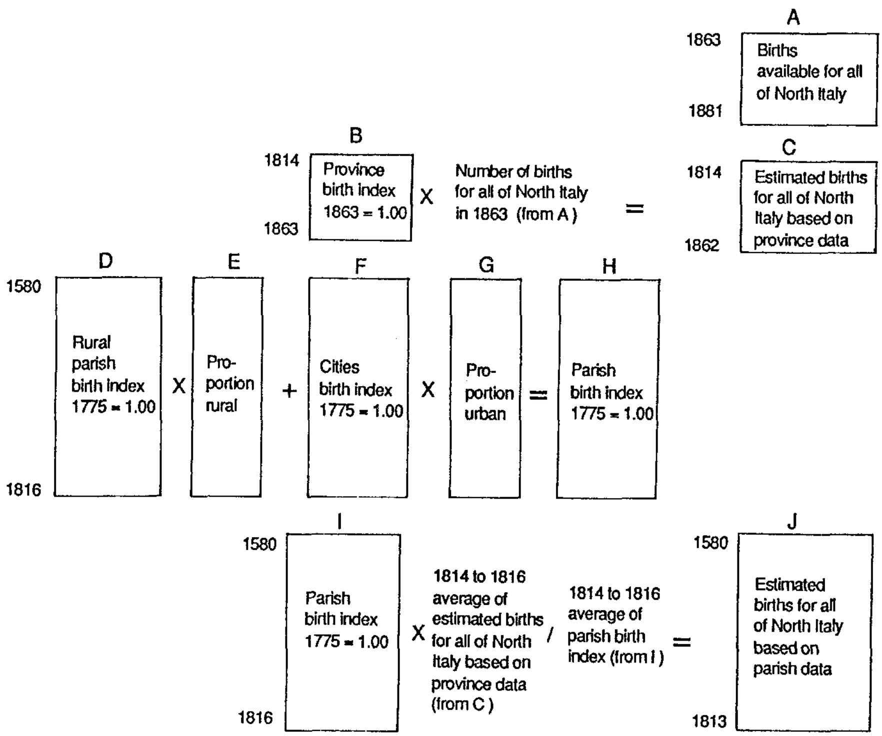


Fig. 5. Construction of North Italy birth series 1580 to 1863.

B and C in Fig. 5. The same procedure is used to construct North Italy marriage and death series from 1814 to 1862.

Indices of annual vital events (1775 = 1.00) for cities and indices of annual vital events (1775 = 1.00) for rural parishes are constructed in a similar manner covering the period 1580 to 1881. The sources and periods for the data used for the rural parishes and cities of North Italy are detailed in Table 2. Rural series of births, marriages, and deaths are based on 222, 189, and 199 parishes respectively. Urban series of births, marriages, and deaths are taken from 10, 4, and 11 cities respectively. The number of provinces, cities, and rural parishes for which birth, marriage, and death data available for each year from 1580 to 1881 is presented in Fig. 1. The urban marriage index ends in 1805 due to lack of data. After 1816, the number of parishes for which information is available drops off rapidly.

The proportion of the population living in cities with at least 10,000 inhabitants in northern Italy has been estimated by DeVries (1984, pp. 39, 45–46) for the years 1550, 1600, 1650, 1700, 1750, 1800, and 1850.[10] Intervening years have been interpolated to arrive at an annual measure of urbanization. Boxes D, E, F, G, and H in Fig. 5 show that the rural parish birth index is multiplied by the proportion rural, and the cities birth index is multiplied by the proportion urban. The sum of these two series is a birth index for all of North Italy 1580 to 1816. The death and marriage indices are constructed in a similar manner.

Finally, a series of births for North Italy is generated by multiplying the parish birth index in North Italy 1580 to 1816 (from Box I which is the same as Box H) by the estimated average number of births in North Italy 1814 to 1816 (from Box C) divided by the average parish birth index 1814 to 1816. The overlap period 1814 to 1816 is used because this is the period for which the volume of data for cities and rural parishes is at its maximum relative to that for provinces (Fig. 1). Series of deaths for North Italy are constructed in the same manner using the same overlap period of 1814 to 1816. The series of marriages uses the overlap period 1828 to 1831 in order to have more than one province as the base estimate for marriage.

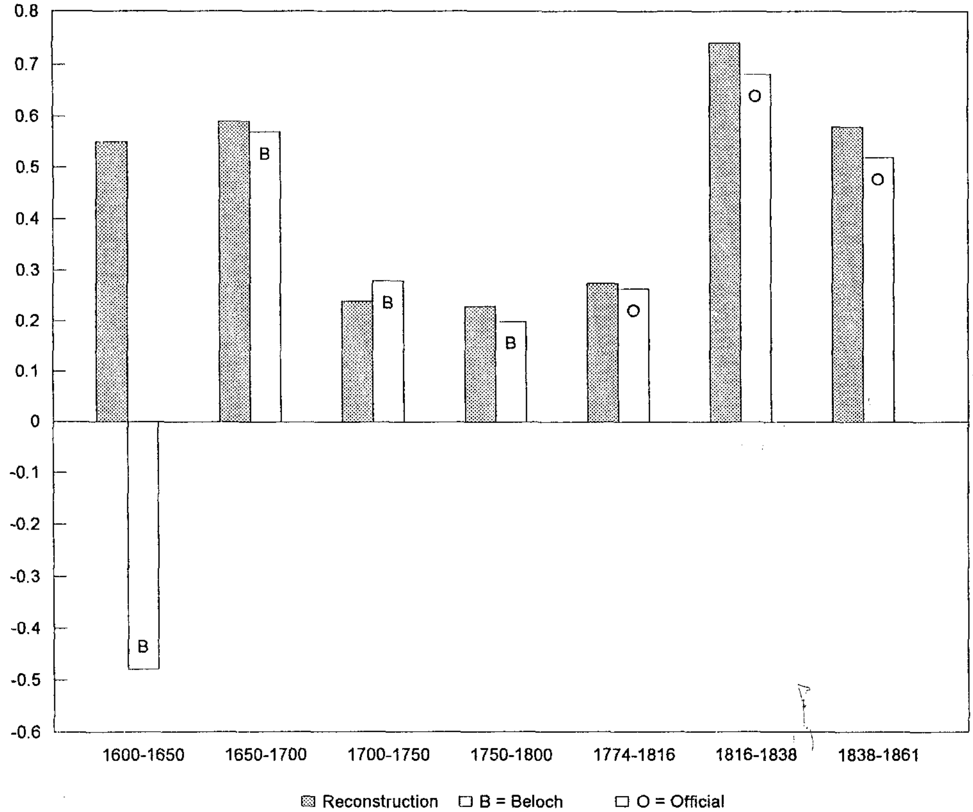
Combining Boxes A, C, and J in Fig. 5 results in annual series of births for North Italy from 1580 to 1881. The same procedure outlined in Fig. 5 is used to estimate marriages and deaths. The series of births and deaths are applied to the census population of 1861 to retroject the annual population size using the balancing equation $P_{t-1} = P_t - B_t + D_t$. Recall that it is assumed that the births and deaths series are not under-registered, that the rural parish, city, and province indices are representative, that the level of urbanization is about right, and that there is no (or virtually no) net external migration in North Italy before 1861.

The annual series of population, births, marriages, deaths, and population growth from 1650 to 1881 for North Italy can be found in Appendix Table 1.[11] Based on the amount of data used in the reconstruction (Fig. 1), the most reliably reconstructed period would be around 1740 to 1881, with some confidence in the period 1640 to 1739, and less confidence in the period 1580 to 1639. The earliest period is wracked by plagues in 1585, 1591, and 1630, the latter being the last great plague event in North Italy.[12] Such years of tremendous mortality crises may be particularly troublesome for reconstruction purposes. Along with general social and economic disruption one might expect a deterioration in the quality of registration of vital events.

3.3. *The reconstructed North Italy population compared to other estimates*

Beloch's (1937, 1961, 1965) monumental three volume study of Italian population to 1800 contains many population figures, but virtually no information on vital events or rates.[13] An examination of Beloch's (1961, pp. 351, 353) population data for North Italy provides a useful check of the reliability of the reconstructed population. It is important to note that Beloch's population estimates are derived solely from historical population censuses, while my population estimates are based on subtracting births and adding deaths to only one population count, the 1861 census. As a consequence the population estimates generated by Beloch are based on independent data. Beloch's area definition of North Italy is somewhat different from mine, but the population growth rates should be about the same. From 1600–1650 Beloch's population growth rate is –0.48 percent per annum, the reconstructed growth rate estimate is 0.55, a large difference (see Fig. 6). The corresponding figures for the period 1650–1700 are 0.57 and 0.59, 1700–1750 0.28 and 0.24, and 1750–1800 0.20 and 0.23. The match is remarkably close after 1650, and provides strong support for my estimates.

Population growth rates generated in my analysis can also be compared with estimates based on published population data for an area approximating North Italy for the years 1774, 1816, 1838, 1861, 1871 and 1881 (Table 1). Population counts for the earlier three years are based on population censuses for various areas and are independent of my data. Of course the population figures for 1861, 1871, and 1881 match exactly. Looking at



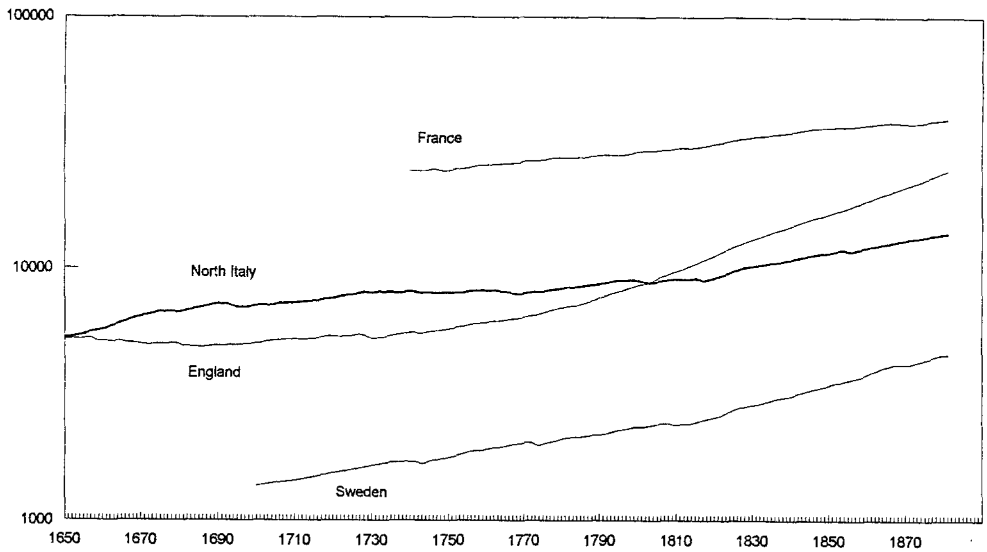
Notes: Population growth rate is percent per annum.
Sources: Table 1, Appendix Table 1, and Beloch (1961, pp. 351, 353).

Fig. 6. Average annual population growth rate estimates for North Italy from reconstructions, Beloch, and official sources.

growth rates in Fig. 6, there is a very good correspondence for the periods 1774 to 1816, 1861 to 1838, and 1838 to 1861.

Because of probable death registration problems resulting from plague events, the decreasing number of parishes with mortality data in the sample before 1650 (see Fig. 1), and the large difference in the reconstruction estimate of population growth rate compared to Beloch's estimate from 1600 to 1650, only the period 1650 to 1881 will be examined, leaving the problems of the period 1580 to 1649 to another study.

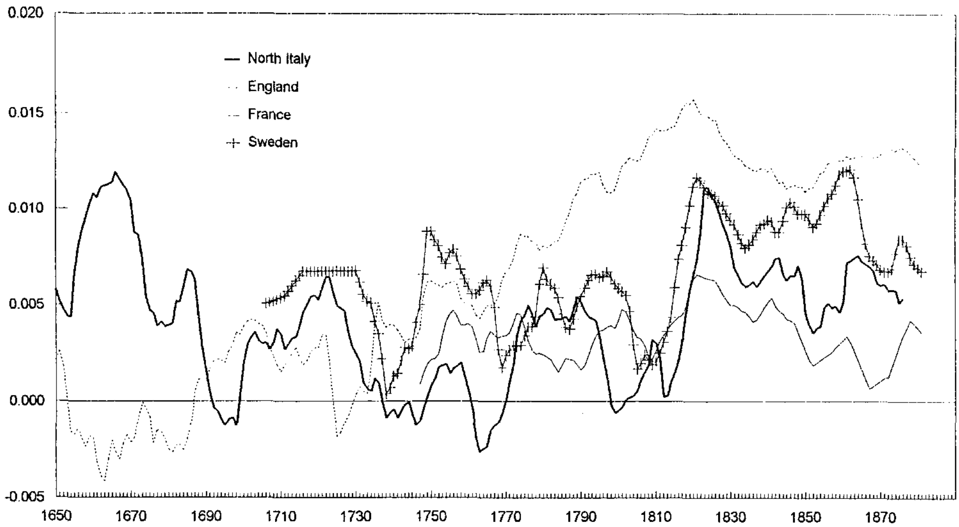
North Italy's reconstructed population size (Fig. 7) and population growth



Sources: Appendix Table 1 and Appendix Figs. 1 to 4. Sweden 1700–1735 (Hofsten and Lundström, 1976, p. 172).

Fig. 7. Population (in thousands, note logarithmic scale).

rate (Fig. 8) are compared to population size and population growth rate in England, France, and Sweden. Official census and registration data start in Sweden around 1750 and not until the beginning of the 19th century in England and France. Earlier data are based on reconstructions (see Appendix Figs. 2 to 4 for sources). Up to 1700, estimates are available only for North Italy and England where the population growth rates seem to move inversely. Between 1700 and 1770, there is a general synchrony among the countries with peak growth rates around 1725 and 1755 and troughs around 1740 and 1765. The main feature after 1770 is the incredible growth of England compared to the other three countries. North Italy, France and Sweden experience a trough in growth around 1810, probably due in part to the Napoleonic Wars, yet England is strangely unaffected. There is a tremendous upsurge in growth of comparable magnitudes in North Italy and Sweden after the war. All countries undergo rapid population growth in the 1820s, which falls off afterwards, only to increase again in the 1850s and 1860s. Medium term fluctuations in North Italy population growth tend to mirror Sweden most closely, but at a lower overall level.



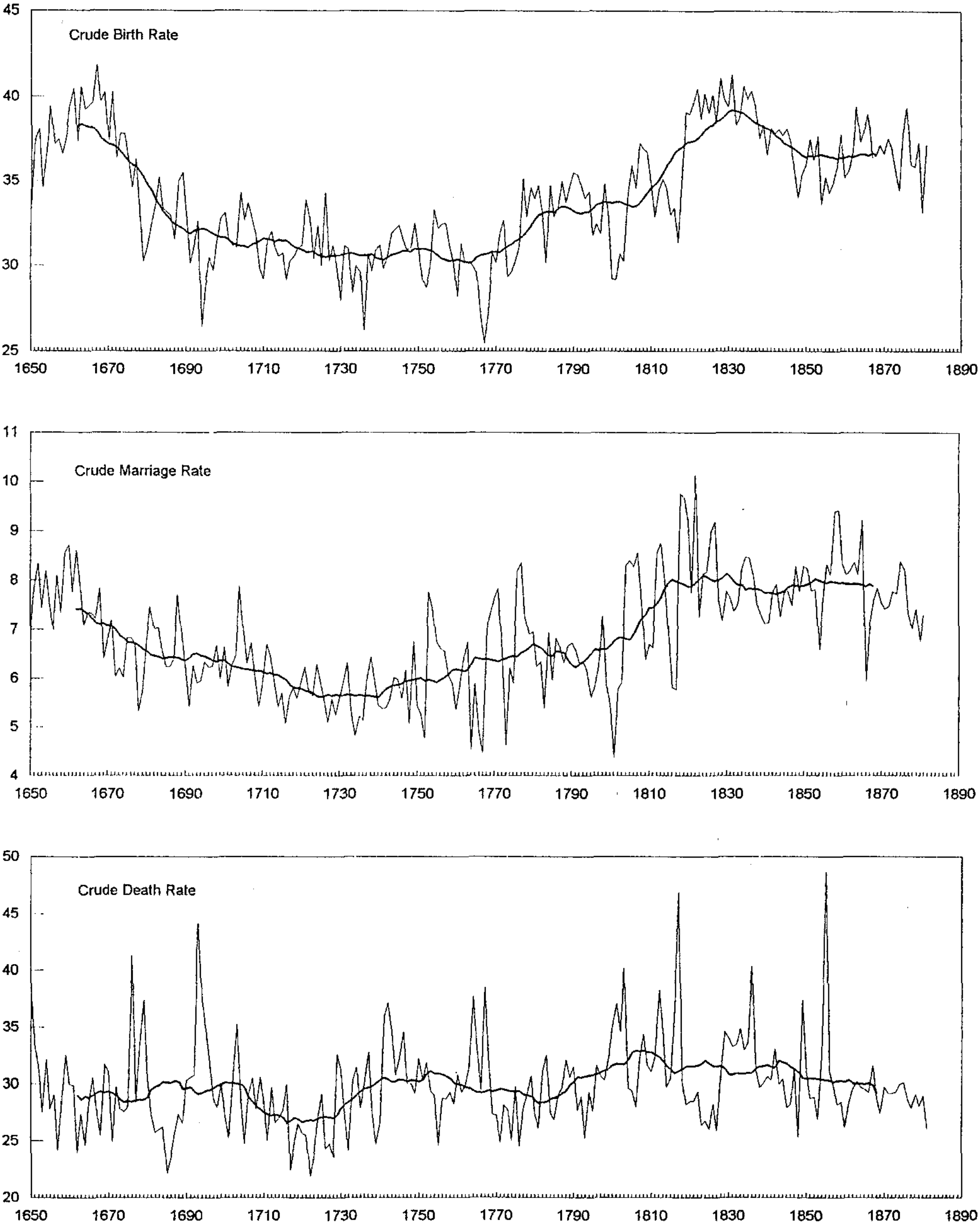
Sources: Appendix Table 1 and Appendix Figs. 1 to 4. Sweden rates 1700–1735 are based on quinquennial data (Hofsten and Lundström, 1976, p. 172).

Fig. 8. Average annual population growth rate (11 year moving average).

3.4. *The reconstructed North Italy vital rates compared with other estimates*

Having reconstructed annual population using vital events, it is a simple matter to calculate annual vital rates. Annual crude birth, marriage, and death rates from 1650 to 1881 for North Italy are presented in tabular form in Appendix Table 1. The annual rates and twenty-five year average are shown in Fig. 9. CBR and CMR are elevated at the beginning of the period, perhaps in response to the plague of 1630. CBR averages around 31 for the first half of the 18th century, after which it begins to rise to around 39 about 1830.[14] In terms of long term movement, CMR tends to mirror the CBR. The crude death rate, on the other hand, shows little secular trend, averaging about 30 throughout the entire period.

Breschi (1990, 1991) reconstructed CBR, CDR, and CMR for Tuscany from 1640 to 1940 using a method that is very different from mine.[15] Recall that Tuscany is one of the five provinces of North Italy. My estimates for North Italy and Breschi's (1991, p. 26) estimates for Tuscany of CBR, CMR, and CDR from 1650 to 1881 are similar in terms of magnitude and long-term trend.



Source: Appendix Table 1.

Fig. 9. Reconstructed crude birth rate, crude marriage rate, and crude death rate in North Italy. The thin line is North Italy annual data. The thick line is a 25 year moving average of North Italy data.

There are very little published data on vital rates before unification in 1861. Livi Bacci (1977, pp. 17–28) provides some early estimates of CBR in areas of North Italy,[16] and suggests these estimates be used with caution given the uncertain quality of the data. He finds an average CBR of 39.2 in the Regno d'Italia 1810–1812 (Livi Bacci, 1977, p. 18), which is higher than the North Italy reconstruction estimate of 34.0 (Appendix Table 1). He also shows a CBR for the Italian departments within the French Empire 1807–1812 of 36.3 (Livi Bacci, 1977, p. 19), which compares favourably with the North Italy reconstruction figure of 35.5. Finally, in four provinces of North Italy he shows a CBR of 39.8 (Livi Bacci, 1977, p. 28) between 1830 and 1840, which matches closely the North Italy reconstruction estimate of 39.1 for the same period.

Table 3 ranks the 25 years of highest CDR in North Italy between 1650 and 1881, along with a death index and the possible cause for high mortality using data derived from Del Panta and Livi Bacci (1977, pp. 414–415). Detrended wheat prices, which are known to be associated with annual variations in mortality (Galloway, 1985, 1988, 1994), are also shown.[17] Typhus, high prices,[18] and smallpox were the primary causes of high mortality between 1650 and 1830, with cholera becoming important after 1830. Correlating reconstructed CDR with the Del Panta-Livi Bacci Death Index (available for only 52 of the 231 years) yields a highly significant positive coefficient and an $r = 0.73$, suggesting some confidence in the reconstructed CDR estimate as a measure of annual mortality variation.

Annual volatility can be measured in the reconstructed series and compared to annual volatility in other countries and regions in order to further gauge the reliability of the reconstruction. Barring unusually severe mortality shocks (which are not observed in North Italy from 1650 to 1881), the annual volatility of the North Italy series should be about the same as in other countries. Divide each point, call it x, in a series by an eleven year average of data points centered around x. The mean of this series is about one, so that the standard deviation and coefficient of variation are the same. The coefficient of variation is the measure of annual volatility. This measure in North Italy from 1650 to 1881 was 0.046 for CBR, 0.110 for CMR, and 0.106 for CDR. The average volatility of series in 14 European countries and regions using a variety of time periods all before 1870 was: CBR mean of 0.047, CMR mean of 0.091, and CDR mean of 0.101 (Galloway, 1988, p. 281).[19] Annual volatility in the North Italy series of vital rates is normal when compared to that found in other European countries and regions.

Table 3. Years of highest mortality in North Italy 1650 to 1881.

CDR rank	CDR	Year	Wheat price detrended		Death index	Death cause
1	48.62	1855	1.224	high prices	97.13	Cholera
2	46.84	1817	1.264	high prices	80.23	Typhus
3	44.75	1693	1.055		31.04	Smallpox
4	41.28	1676	0.953		19.16	
5	40.33	1836	0.931		24.48	Cholera
6	40.17	1803	0.953		n.a.	Smallpox in 1802
7	38.47	1767	1.162	high prices	18.04	Famine, typhus
8	38.31	1650	1.105		21.23	Typhus in 1649
9	38.26	1812	1.050		n.a.	
10	37.66	1764	0.981		15.75	
11	37.36	1679	1.223	high prices	n.a.	
12	37.35	1849	0.980		37.25	Cholera
13	37.26	1694	1.221	high prices	n.a.	Smallpox in 1693
14	37.12	1742	0.979		n.a.	
15	37.09	1801	1.355	high prices	18.82	Smallpox, typhus
16	35.83	1741	0.974		n.a.	
17	35.82	1816	1.501	high prices	n.a.	
18	35.23	1703	0.895		n.a.	
19	35.15	1800	1.430	high prices	15.46	War, smallpox
20	34.82	1833	0.995		13.72	
21	34.74	1813	0.880		n.a.	
22	34.70	1695	1.200	high prices	n.a.	
23	34.59	1829	1.152	high prices	n.a.	
24	34.58	1802	1.125		17.68	Smallpox
25	34.55	1746	0.962		n.a.	

Notes: The wheat price series is detrended by dividing each point by an eleven year average centered around that point. The mean is one, the standard deviation is 0.148.
Death Index and Death Cause are from Del Panta and Livi Bacci (1977).
They list only the high mortality years according to their index.
Only the 11 North Italy locations which they provide are used. The index's mean is zero.
Sources: Appendix Table 1, Note 8, and Del Panta and Livi Bacci (1977, pp. 414–415).

4. Annual inverse projection

Annual inverse projection requires an initial population size, and series of annual births, deaths and net-migration. If we make some reasonable assumptions about initial age distribution and mortality, fertility, and net-migration schedules, inverse projection will generate annual age distribution, total fertility rate, gross and net reproduction rates, and various age-specific mortality rates including life expectancy at birth and infant mortality rate (Lee, 1978, 1985a, 1993).[20] With more detailed data, sex-specific mortality and fertility rates, marital fertility rates, and nuptiality rates could be produced (Lee, 1993; McCaa, 1993).

Inverse projection has long been available and has recently been implemented in a software package called 'Populate' (McCaa, 1989, 1993; McCaa and Perez Brignoli, 1898). However, application of inverse projection has been limited and some of the more detailed analyses are of areas which already have fairly reliable census and registration data. Inverse projection has been applied to Norway (Brunborg, 1977; McCaa, 1898), a village in the Philippines (Smith and Ng, 1982), England (Lee, 1985a), rural parishes in New Castile (Reher, 1991), Tuscany (Breschi, 1990, 1991), and Sweden (McCaa, 1993).

Using back-projection techniques Wrigley and Schofield (1981) examined English data and Van Dijk (1989) analyzed data from the small town of Eindhoven. Balthazar (1990) applied generalized inverse projection (Oeppen, 1993) to data from the town of Lucerne. Generalized inverse projection also has been applied to Amsterdam 1681 to 1920 (Van Leeuwen and Oeppen, 1993). For a discussion of problems, some serious, with these techniques see Lee (1985a, and especially 1993). Biraben and Bonneuil (1986) have made some estimates for the region of Caux using a kind of back-projection technique.

Annual inverse projection is applied to data from North Italy, England, France, and Sweden. The countries are chosen because they have the longest series of vital events and population counts in Europe. Annual population, births, marriages, and deaths counts are used for England, France, Sweden as indicated in Appendix Figs. 2 to 4. For North Italy, I use the reconstructed annual population and vital events data from Appendix Table 1.

The initial age distribution used for the North Italy, England, and Sweden is Sweden 1751–1760 (Sundbärg, 1909, pp. 200–206). The initial age distribution for France is from Henry and Blayo (1975, p. 92). Choice of the initial age distribution is not particularly important because subsequent age distributions are almost completely determined by other demographic parameters after the first 20 years or so.

A net migration age distribution is estimated using a schedule from Sweden 1861–1915 (Central Bureau of Statistics, 1969, p. 128). The Swedish schedule is used because such data do not appear to exist for other countries.

The model West mortality schedule is employed throughout (Coale and Demeny, 1966). A fertility schedule with mean age of childbearing of 31 (Coale and Demeney, 1966, p. 30) is used for North Italy and England. The mean age of childbearing of 29 is used in France because this produces fertility rate estimates that are closer to fertility rates from other sources. The fertility schedule used for Sweden is Sweden 1891–1900 (Sundbärg, 1907, p. 277) with a mean age of childbearing of 29.

Modest alterations in the initial age distribution, mean age of childbearing, schedules of net migration, mortality, and fertility do not substantively alter the results. Tabular results are presented only for North Italy because of space limitations (Appendix Table 1). Appendix Figs. 1 to 4 summarize the results for the four areas.

4.1. *Comparison of North Italy annual inverse projection results with other estimates*

Official life expectancy, infant mortality, and age distribution data for North Italy are only available for the very end of the period. The inverse projection estimates come very close to matching these official data (indicated by boxes in Appendix Fig. 1). The near absence of family reconstitution studies in Italy has already been mentioned. As a consequence it is not possible to compare the inverse projection fertility estimates with fertility estimates from other studies. Del Panta and Livi Bacci (1980, p. 103) found that the average infant mortality rate from 1691 to 1820 in ten areas (groups of rural parishes and cities) in North Italy was 252. The infant mortality rates in two of these ten places, Venice city and Venice countryside, were respectively 334 and 322, very much higher than any of the other eight. Excluding the two Venetian areas, the average infant mortality rate in North Italy was 233. Average annual ${}_1q_0$ in North Italy from the inverse projection data (Appendix Table 1) from 1691 to 1820 is 231, which is close to Del Panta and Livi Bacci's estimate.

4.1. *Comparison of England, France, and Sweden annual inverse projection results with other estimates*

Where available, independent estimates from other sources, usually official, are indicated in the graphs in Appendix Figs. 1 to 4 by small boxes as a means of checking the inverse projection estimates. As it turns out, the correspondence between inverse projection estimates and official data is very close in all countries. The results for Sweden 1737 to 1986 are especially encouraging because the period covers the evolution from a nearly total agrarian state to a modern industrialized nation (Appendix Fig. 4; see also McCaa, 1993).

5. Age structure, gross reproduction rate, life expectancy at birth, and demographic terrain

5.1. *Age structure*

The age structure of North Italy generated by inverse projection is compared to England, France, and Sweden in Fig. 10. Naturally, the proportion of the population age 0 to 14 closely mirrors the lagged GRR (Fig. 11). The proportions in the prime working ages (15 to 49) are similar in all four countries, averaging about 51 percent. This provides some support for the reliability of our North Italy estimates.

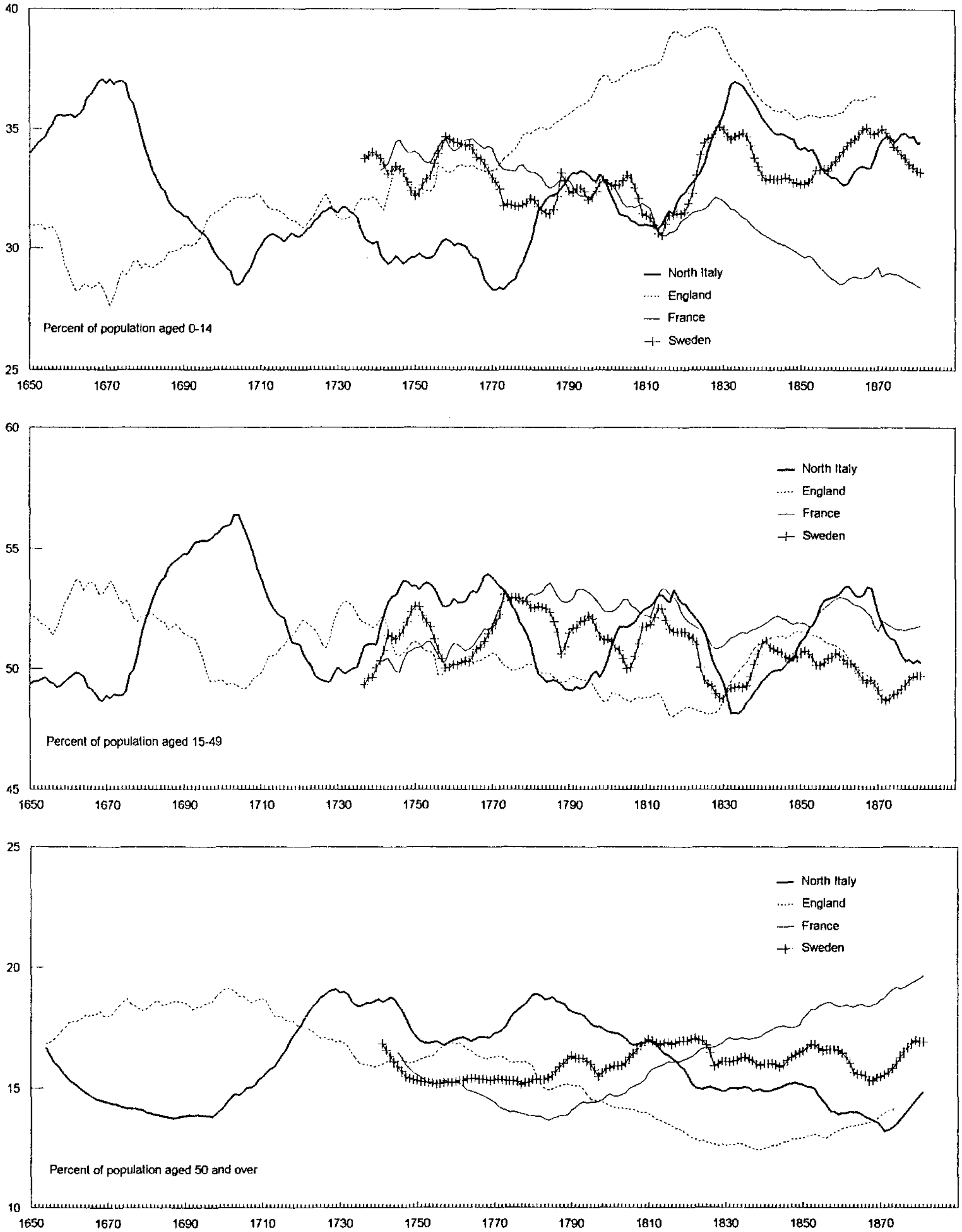
5.2. *Gross reproduction rate*

Annual fluctuations, medium-term movements, and the long-term trend in GRR can be found in Fig. 11 for the four areas. The vertical scale in Fig. 11 is the same for each of the four areas. The annual fluctuations in fertility in all the areas, after detrending, are probably a result of variations in annual prices (or annual real wage) and yearly adult mortality (Galloway, 1988, 1994). The medium-term variations, as reflected in a plot of eleven year moving averages, show some interesting similarities in North Italy and France. Troughs can be seen around 1770, 1805, and 1850, with peaks around 1790 and 1830 in both countries.[21] This synchrony will be explored in a later study.

Figure 11 reveals remarkable differences in long-term fertility trends. GRR in England increases almost monotonically from 1650 to around 1820, after which if falls off. Fertility seems to decline almost monotonically in France from 1740 to around 1850 when it reaches a level lower than that found in any other area. GRR remains about level in Sweden from 1740 to 1880. In North Italy, as discussed earlier, GRR is high from 1650 to 1670, perhaps in response to the devastating plague of 1630. It reaches a low around 1695, after which it increase gradually to peak around 1830. Fertility levels in the mid-19th century had become similar in North Italy, England, and Sweden with an average GRR of 2.51, 2.48, and 2.24 respectively from 1820 to 1881. GRR in France was 1.80.

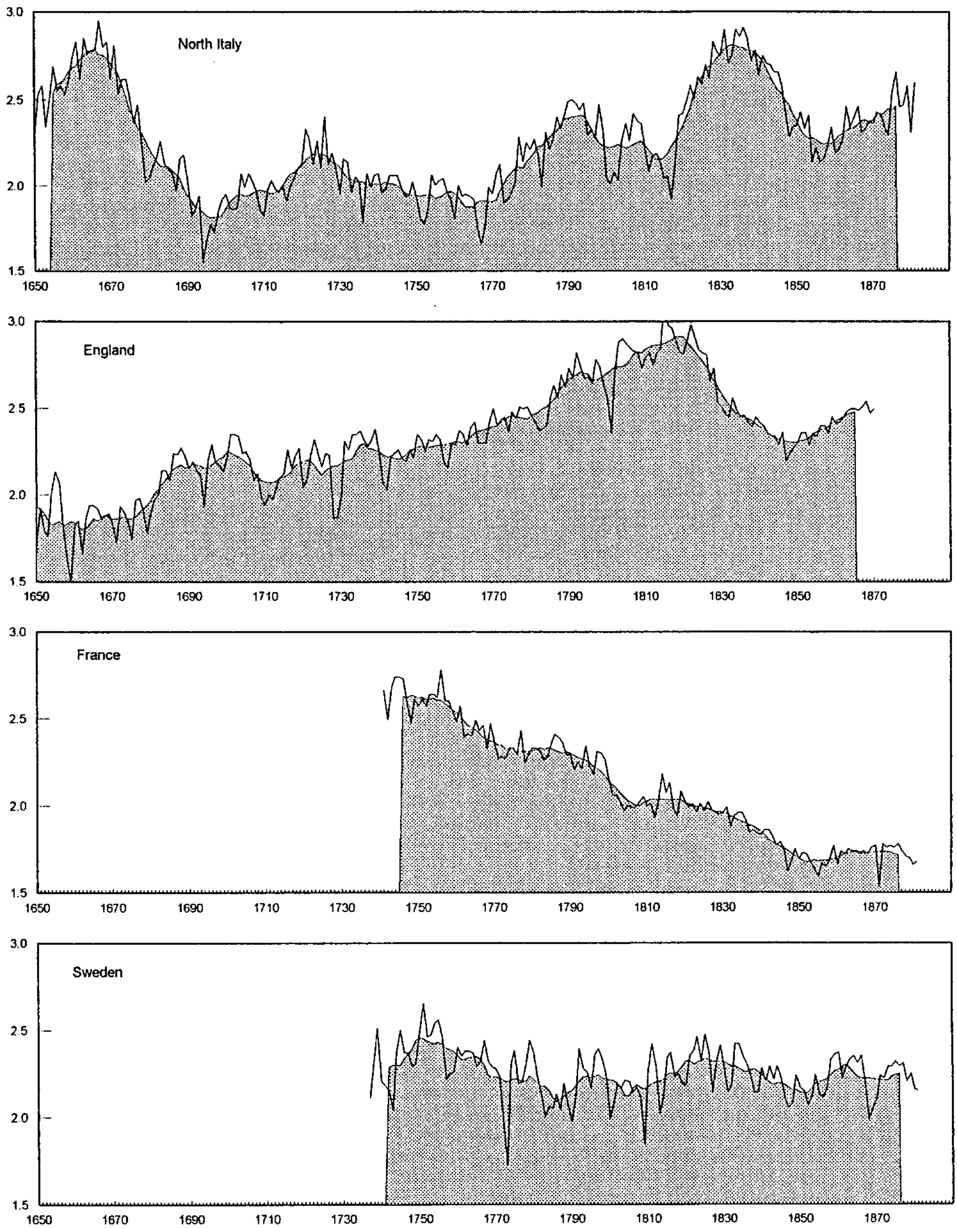
5.3. *Life expectancy at birth*

Annual variations in mortality (Fig. 12) are likely caused by high grain prices, epidemics, war, weather extremes, or any combination of these (Galloway



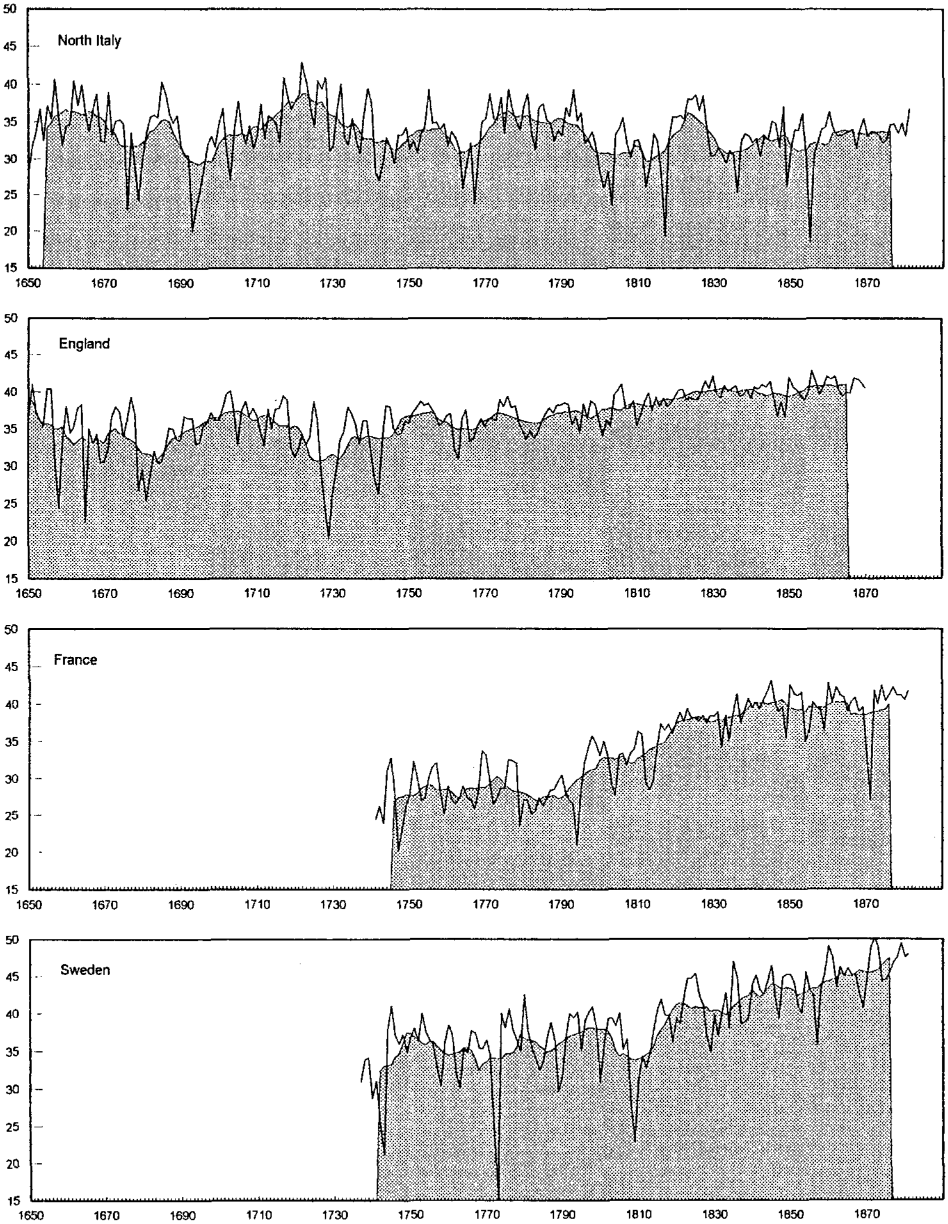
Source: Appendix Figs. 1 to 4.

Fig. 10. Age structure in North Italy, England, France, and Sweden.



Source: Appendix Figs. 1 to 4.

Fig. 11. Gross reproduction rate in North Italy, England, France, and Sweden. Annual and 11 year moving averages are shown.



Source: Appendix Figs. 1 to 4.

Fig. 12. Life expectancy at birth in North Italy, England, France, and Sweden. Annual and 11 year moving averages are shown.

1988, 1994). The three years of highest mortality in North Italy, 1855, 1817, and 1693 were caused by cholera, typhus, and smallpox respectively (Fig. 12 and Table 3). Among the four areas, the most devastating mortality crisis occurred in Sweden in 1773 where life expectancy at birth dropped to 15 as a result of a severely deficient harvest (Utterström, 1954, p. 137). Interestingly, mortality fluctuations are much less volatile in England after 1750 compared to the other areas.

There appears to be little synchrony in medium-term movements across the series. Over the long-term life expectancy at birth is stagnant in North Italy, increases slightly in England, is flat in France from 1750 to 1790, after which it increases appreciably until about 1840, where it levels off again. Life expectancy at birth has no trend in Sweden until around 1810, when it begins its secular increase.

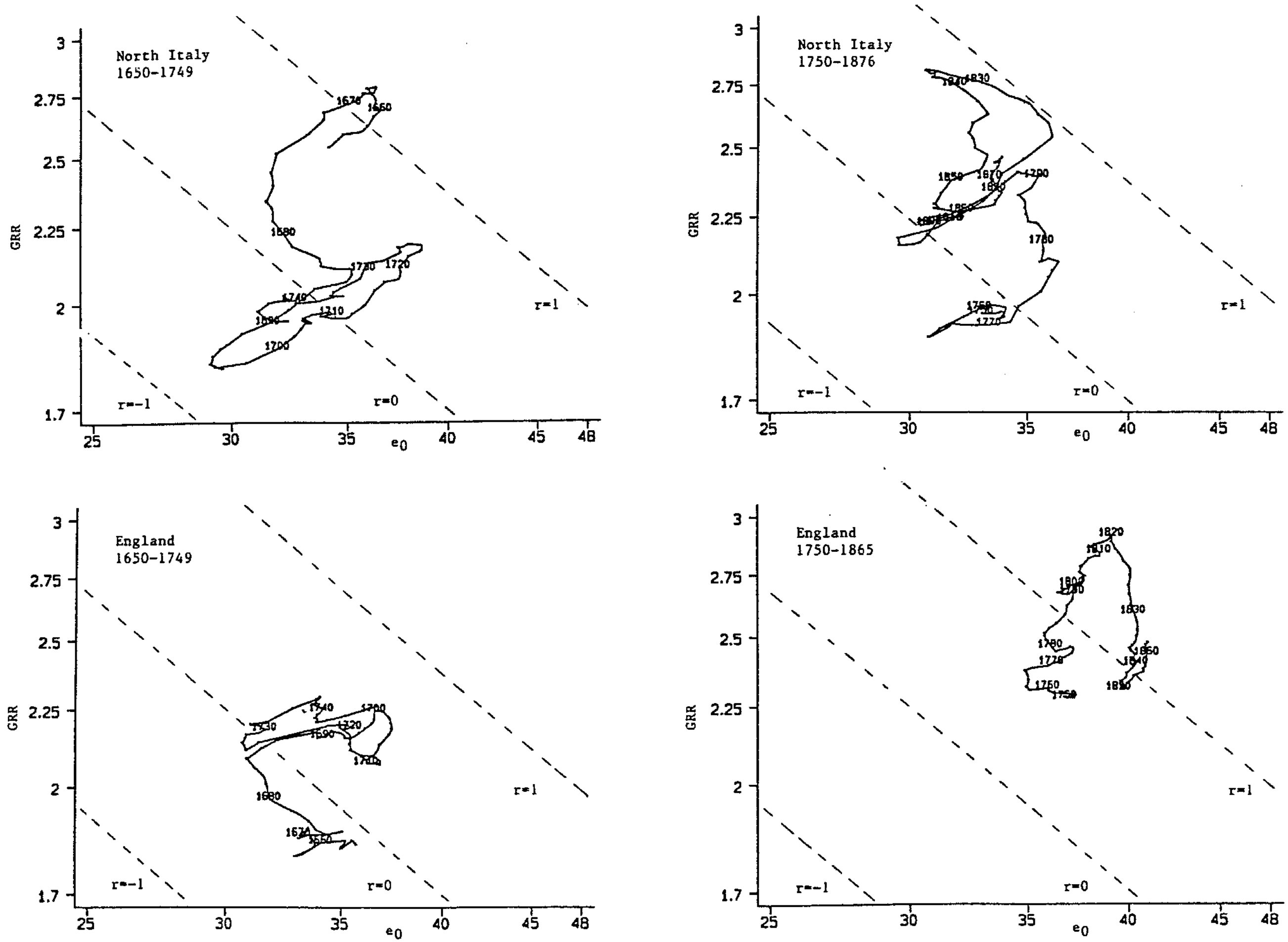
Life expectancy at birth in North Italy was relatively low compared to the other countries in the mid-19th century. Life expectancy at birth in England, France and Sweden was 40, 39, and 43 respectively from 1820 to 1881, and only 33 in North Italy. This may be related to Italy's relatively low productivity in the primary sector. Bairoch's (1973, p. 472) average index of level of agricultural development in Italy in 1840, 1860, and 1880 was 50. Corresponding figures for the other countries were England 203, France 133, and Sweden 98.[22]

5.4. *Demographic terrain*

We can examine the relative importance of GRR and life expectancy at birth and their relative contribution to the intrinsic population growth rate using a graphical presentation discussed in Wrigley and Schofield (1981, pp. 236–248).[23] The graphs are shown in Fig. 13 and 14. If the demographic terrain approximates a square, then fertility and mortality contribute equally to the intrinsic population growth rate. If the demographic map approximates a rectangle that is higher than wider, fertility dominates. If the rectangle is wider than higher, mortality tends to dominate.

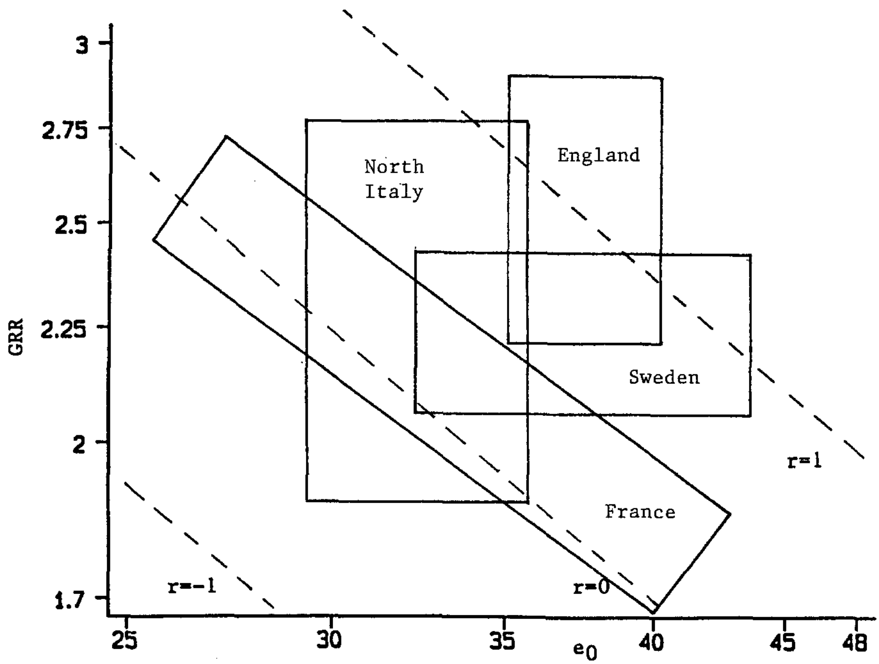
Figure 13 suggests little difference in the demographic terrain mapped by fertility and mortality in North Italy over the two periods 1650–1749 and 1750–1876, with little difference in the average intrinsic population growth rate. Both components in England, on the other hand, shift to the right and upwards, resulting in a marked increase in the intrinsic population growth rate.

However, when the North Italy maps are examined more closely, there



Note: The years refer to midpoints of eleven year averages. *Sources:* Appendix Table 1 and Appendix Figs. 1 and 2.

Fig. 13. Gross reproduction rate, life expectancy at birth, and intrinsic population growth rate in North Italy and England.



Note: Based on 11 year moving averages.
Sources: Appendix Table 1 and Appendix Figs. 1 to 4.

Fig. 14. Simplified representation of demographic terrain covered by North Italy, England, France, and Sweden 1750 to 1849.

is a substantial decline in fertility from 1660 to 1690. The high fertility in the middle of the 17th century may be a response to the plague in 1630. Mortality variations drive a low intrinsic population growth rate in the first half of the 18th century. The terrain mapped after the middle of the 18th century suggests an intrinsic population growth rate dominated by fertility variations.

If we restrict the period to 1750–1849, we can compare demographic terrains in the four countries. For clarity, rectangles are used to approximate the demographic maps. In Fig. 14 we see England's intrinsic growth rate dominated by fluctuations in fertility, while Sweden's is largely affected by mortality. Population growth in France is always around zero with fertility and mortality offsetting each other (Wrigley and Schofield, 1981, p. 248). North Italy's demographic terrain is similar to England's but enlarged and shifted to the left and downward. As in England, population growth in

North Italy is generally dominated by fertility swings. Fluctuations in mortality are smaller than fertility variations in North Italy, but they occur around a lower level of life expectancy than in England. As a consequence population growth in North Italy is much less than in England.

5.5. *Urban and rural differences*

Before concluding, it might be useful to compare the findings from these four areas to four large cities in an initial attempt to examine differences in urban and rural population structure and movement. I applied annual inverse projection techniques to data from four cities: Venice, Verona, Rome, and Stockholm.[24] North Italy, England, France, and Sweden are predominantly rural (except perhaps 19th century England), hence the demographic measures generated will reflect for the most part the rural sector. If these four areas and the four cities are, on average, typical, we can generalize in a preliminary way about the relative differences in the detailed demographic measures found in rural and urban sectors in preindustrial Europe.

The annual demographic measures are summarized by averaging the annual rates within each of the following periods: 1650–1699, 1700–1749, 1750–1819, 1820–1881, and for the entire period 1650–1881. This is done for each area and city where data are available. Population growth in the four countries was most rapid during the 19th century. Growth rates in the cities tended to vary from slightly positive to slightly negative until the 19th century when the growth rate increased dramatically in a manner similar to the countries. On average, annual population growth rate was about 3.7 per mille in the cities, and about 5.2 per mille in the countries. In marked contrast, the rate of natural increase was usually negative in the cities averaging about –5.0 per mille per annum, and usually positive in the countries averaging about 5.8 per mille per annum. CBR was about the same in both cities and countries (32.6 and 33.6), but CDR was much higher in the cities than in the countries (37.5 and 27.7). Migration into cities must have been considerable if the cities were to maintain positive population growth rates. In fact the crude net migration rate in the cities was substantial and positive with an average of 8.6 per mille.

Without inverse projection estimates, it might be assumed that fertility rates were about the same in both urban and rural sectors. While CBR was essentially the same in both sectors, GRR was about 2.23 in the rural sector, and 1.89 in the cities, some 15 percent lower. This can be explained by the distribution of population aged 15–49 which was higher in the cities, 57 percent, than in the country, 51 percent. Urban demand for labour in the peak productive years would account for this difference and indeed most studies show that the majority of in-migrants fell with this age group. The cities had proportionately fewer children (aged 0–14), 27 percent compared to 33 percent, while the proportion of elderly persons (aged 50 and over) was about the same in both sectors, 16 percent. CMR appears higher on average in the cities, but we have no age-specific estimates.

The common notion that cities were a mortality sump (Wrigley, 1967; DeVries, 1984, pp. 179–182) is supported by the results. Average life expectancy was 36 in the country and only 26 in the cities. This is reflected in infant mortality rates which are higher in the cities than in the countries. Urban infant mortality averaged 303, some forty percent greater than in the country.[25] Differences in NRR neatly summarize the consequences of somewhat lower fertility and considerably higher mortality in the cities. In each of the periods, NRR in the cities was always below one, averaging 0.76, while in the country it always exceeded one, averaging 1.20.

6. Summary

Only some of the analytic possibilities using the North Italy reconstruction data have been explored in this study. Comparative studies could be undertaken of rural and urban difference in weather, Malthusian preventive, and Malthusian positive checks to population growth over the short term (Lee, 1891, 1990; Galloway, 1985, 1986b, 1987, 1988, 1993a, 1994), medium term (Yule, 1906; Lee, 1977), and long term (Wrigley and Schofield, 1981; Lee, 1985b, 1987; DeVries, 1985; Galloway, 1986a). Applying population reconstruction and inverse projection to data from other large regions and cities would be useful, especially where population counts are numerous.

The population reconstruction of North Italy from 1650 to 1881 appears reliable when compared to the results of other independent researchers and official data. In North Italy, and in each of the three other countries examined, annual inverse projection estimates correspond well with nearly all official data.

Over the long term, North Italy was characterized by low and stagnant life expectancy with relatively low population growth. Fertility and nuptiality were higher at the beginning of the period and at the end of the period. Changes in the intrinsic population growth rate were generally dominated by fluctuations in fertility, much like England, but within a much higher mortality regime. Comparisons with fertility and mortality measures in England, France, and Sweden reveal a remarkable variety of demographic trends and regimes. Even greater differences are found when rural areas are compared with the mortality-driven regimes of large cities.

Acknowledgements

The research on which this paper is based has been funded by grants HD25841 and HD07275 from the U.S. National Institute of Child Health and Human Development. I thank Ronald Lee, Robert McCaa, David Reher, Paola Subacchi, Marco van Leeuwen, and anonymous reviewers for helpful comments.

Notes

[1] Of course both techniques should be used together whenever possible.

[2] The impact of variations in the weather and the real wage in North Italy on short, medium and long term fluctuations in demographic rates will be analyzed in another study.

[3] These are discussed later in Section 4. All of these analyses, except that of England, provide only quinquennial or decadal demographic measures, which are less useful than annual measures, especially for historians who may be interested in the demographic background of a particular year.

[4] Breschi (1990, 1991) published graphs of his reconstruction of Tuscany, one of the five provinces of North Italy, from 1640 to 1940 using quinquennial data. However Breschi did not publish the pre-1810 data from which the graphs were derived.

[5] These provinces were called Compartimenti after unification in 1861. Later they were called Regioni. Before unification, the political entities comprising North Italy had many names including Ducato, Granducato, Provinz, Regno, and Stato.

[6] An unusually low or a significant long-term increase in the infant mortality rate can be an indicator of under-registration of infant deaths. Del Panta and Livi Bacci's (1980, p. 103) review of decadal infant mortality rates from 1691 to 1820 in ten parishes and cities located in North Italy suggests that infant mortality had no long-term trend in some places, an upward trend in others, and a downward trend in still other places. The average infant mortality rate for all ten places over the whole period was 252. Bellettini and Samoggia (1983, p. 200) use earlier data and find a downward trend in infant mortality from 1641 to 1880 in three parishes near Bologna with an average of 284. A similar downward trend is found in three parishes near Ravenna from 1690 to 1796 (Bolognesi, 1980, p. 270) with an average of 302. In general, these data do not suggest under-registration of infant deaths.

[7] It will be shown later that the reconstruction estimates before 1650 may not be reliable. The first national census of Italy was taken in 1861, the second in 1871, and the third in 1881. Using official Italian registration and census material, the analysis could conceivably be carried forward to the present.

[8] Sources for annual wheat prices are: Turin 1788–1886 (Felloni, 1957, p. 15; Felloni, 1976, p. 383); Milan 1580–1886 (De Maddalena, 1957, p. 13 and 1974, p. 419,; Ferrario, 1838–1850, pp. 227–230; Romani, 1968, p. 235; Sella, 1968, pp. 138, 149–150); Udine 1700–1825 (House of Commons Parliamentary Papers, 1827, pp. 108–113); Parma 1580–1700 (Romani, 1975, p. 316); Parma 1821–

1886 (Romani 1968, pp. 218–219); Modena 1580–1705 (Basini, 1974, pp. 165–166); Bologna 1606–1784 (Bellettini and Tassinari, 1977, pp. 82–86); Siena 1580–1765 (Parenti, 1942, pp. 27–28); and Florence 1800–1886 (Bandettini, 1957, p. 13). Series are spliced based on overlapping data when necessary.

[9] Measures of economic homogeneity over the short-term can be found by correlating detrended wheat prices among the cities shown in Fig. 4. The wheat prices are detrended by dividing each data point, call it x, by an eleven year average of data points centered around x. I divided the period 1580–1881 into three periods: 1580–1649, 1650–1749, and 1750–1881. I then correlated each detrended wheat price series with all the others in each time period with the criterion being a sample size of at least 30 years after de-trending. This resulted in 32 bivariate correlation coefficients (r's). Each was positive and each was statistically significant within 1 percent using a t-test.

[10] The estimated proportion urban is the average of north and central Italy as defined by DeVries (1984, pp. 39, 45–46). These estimates are: 1550 13.25%, 1600 14.55%, 1650 14.25%, 1700 13.95%, 1750 14.35%, 1800 13.95%, and 1850 20.30%. Small changes in the estimates of proportion urban will not substantially effect the results of the reconstruction procedure.

[11] Appendix Table 1 also includes vital rates and inverse projection estimates of infant mortality rate, life expectancy, fertility measures, and age distribution, which will be discussed later. The data from 1580 to 1649 are not shown in Appendix Table 1 because there appear to be some problems (which will be discussed later) with the reliability of the reconstructed data during this period. The drop in CMR in 1866 is apparently a result of change in national registration policy. In 1866 only civil marriages are recognized (Kertzer and Hogan, 1989, pp. 118–124).

[12] I estimate that 7 percent of the population of North Italy perished in 1629, and another 18 percent died in 1630.

[13] Cipolla (1965, pp. 573), Del Panta (1980, p. 135), and Bellettini (1987, p. 13) made population estimates for Italy which are derived largely from Beloch's (1937, 1961, 1965) data. Little useful information can be found about vital rates before 1800 in any of these studies.

[14] CBR for Livorno Jews generally follows the long-term U-shape found in the reconstructed CBR. The CBR of Livorno Jews was 54.8 in the 1670s and 42.3 from 1675–1700. It dropped dramatically in the first quarter of the 18th century to 28.1, declined slowly over the middle of the 18th century to 21.6 during the last quarter of the 18th century, and then began to rise in the 19th century reaching 29.5 in the 1850s (Livi Bacci, 1977, p. 42).

[15] See footnote 4.

[16] None of these areas correspond exactly with my definition of North Italy.

[17] It is likely that a substantial number of deaths resulting from increased grain prices occurred one or two years after the price shock. Therefore the only way to assess the importance of say, wheat prices to mortality changes, it to use a statistical model which employs a lag structure. This has been done by many historians over the past decade with useful results (see Galloway, 1994, pp. 6–7 for a summary of findings). These short-run interactions will be examined in another paper where the impact of changes in seasonal temperature and rainfall as well as prices on vital rates will be assessed (Galloway, 1985, 1987, 1994). The possibility of secular trends in the estimated coefficients (Galloway, 1994) will also be explored, along with urban and rural differences (Galloway, 1985, 1986b, 1987, 1993a) and correlations with measures of economic welfare (Galloway, 1986b, 1987, 1988, 1993a). Nonlinear effects will also be examined (Lee, 1981; Galloway, 1987, 1994).

[18] Typhus epidemics are often spawned by high grain prices (for London see Galloway, 1985, p. 498; for Sweden see Galloway, 1987, p. 164).

[19] The volatility range (minimum and maximum) in the series of the 14 European countries and regions was: CBR 0.026 to 0.066, CMR 0.056 to 0.152, and CDR 0.049 to 0.156 (Galloway, 1988, p. 281).

[20] See Lee (1985a) for a detailed discussion of inverse projection.

[21] Peaks and troughs of an 11 year moving average of the North Italy birth series closely mirror the peaks and troughs of an 11 year moving average of the France birth index from 1580 to around 1720 (Dupâquier et al., 1988, p. 150). The synchronic movement in births could be driven by an integrated

grain market (the prime mover of the real wage) across France and North Italy which in turn may be driven by medium term climatic variations. Fertility fluctuations may be caused by movements in the real wage and may be independently influenced by climatic change (Galloway, 1994). A similar correspondence is not found in the mortality series of North Italy and France. As discussed earlier, the North Italy mortality series may be defective before 1650. The French mortality series is known to exclude child deaths before 1670 (Biraben and Blanchet, 1985).

22 The fertility and mortality figures may be more meaningful when compared to "less-developed-countries" today. Total fertility rate, TFR, 1820 to 1881 was 5.1 in North Italy, the same as England's 5.1, somewhat higher than Sweden's 4.6, and much higher than France's 3.7. In 1990 the average TFR of the world's 41 "low-income countries excluding India and China" was 5.2 (World Bank, 1992, p. 270), about the same as North Italy in the mid-19th century. Life expectancy at birth for the same group of 41 "low-income countries excluding India and China" was 55 (World Bank, 1992, p. 218), substantially higher than North Italy's 33. The lowest life expectancy at birth of the 125 countries surveyed by the World Bank was Sierra Leone at 42 (World Bank, 1992, pp. 218–219), still well above North Italy in the mid-19th century.

23 Wrigley and Schofield's assumptions (none too severe) are used (1981, p. 238).

24 Details can be found in Galloway (1993b). The data for Venice run from 1582 to 1797, Verona 1729 to 1925, Rome 1702 to 1870, and Stockholm 1721 to 1905. Stockholm was used to check the procedure because the Stockholm data are among the best available for cities. In general, annual inverse projection using city data appears to be a useful exercise, especially when applied to those cities which have many reliable population counts.

25 Elevated mortality in the cities is likely a result of relatively frequent outbreaks of infectious disease, exacerbated by the cities' high density and insanitary conditions. Such outbreaks are often spawned by the mixing of urban and rural populations when migrants moved from the countryside into the city during periods of dearth (Galloway, 1985, p. 500, 1986b).

References

Aleati, G., 1957. La Popolazione di Pavia durante il Domino Spagnolo, Giuffrè, Milano.

Angeli, A., 1980. 'Alcune linee di sviluppo della popolazione di Faenza nel secolo XVIII', in Società Italiana di Demografia Storica, La Popolazione Italiana nel Settecento, CLUEB, Bologna, pp. 249–262.

Bairoch, P., 1973. 'Agriculture and the industrial revolution 1700–1914' in C. Cipolla, The Fontana Economic History of Europe, The Industrial Revolution, Collins, Glasgow, pp. 452–506.

Balthazar, A., 1990. 'A case study concerning generalized inverse projection and urban history, some basic patterns in the long-term population development of Lucerne, Switzerland, 1700 to 1930', Historical Methods 23(3), 92–103.

Bandettini, P., 1957. 'I prezzi sul mercato di Firenze dal 1800 al 1890', Archivio Economico dell'Unificazione Italiana 5(1), 1–24.

Bandettini, P., 1961. La Popolazione della Toscana dal 1810 al 1959, Scuola di Statistica della Università Firenze, Firenze.

Basini, G.L., 1974. Sul Mercato di Modena tra Cinque e Seicento. Prezzi e salari, Milano.

Bellettini, A., 1961. La Popolazione di Bologna dal Secolo XV all'Unificazione Italiana, Zanichelli, Bologna.

Bellettini, A., 1978. 'La popolazione di Bologna nel corso dell'Ottocento', Storia Urbana 2(5), 2–32.

Bellettini, A., 1980a. 'L'evoluzione demografica dell'Italia nel quadro europea del settecento: analogie e particolarità', in Società Italiana di Demografia Storica, La Popolazione Italiana nel Settecento, CLUEB, Bologna, pp. 13–70.

Bellettini, A., 1980b. 'La démographie italienne au XVI^{e} siècle: sources et possibilities de recherche', Annales de Démographie Historique 1980, 19–38.

Bellettini, A., 1987. La Popolazione Italiana, un Profilo Storico, Einaudi, Torino.

Bellettini, A. and Samoggia, A., 1983. 'Evolution differentielle et mouvement saisonnier de la mortalité infantile et enfantine dans la banlieue de Bologne (XVII^{e}–XIX^{e} siècles)', Annales de Démographie Historique 1983, 195–207.

Bellettini, A. and Tassinari, F., 1977. Fonti per lo Studio della Popolazione del Suburbio di Bologna dal Secolo XVI all Fine dell'Ottocento. Volume 10. Fonti per la Storia di Bologna, Istituto per la Storia di Bologna, Bologna.

Beloch, K.J., 1937. Bevölkerungsgeschichte Italiens. I. Grundlagen. die Bevölkerung Siziliens und des Königreichs Neapal, De Gruyter, Berlin.

Beloch, K.J., 1961. Bevölkerungsgeschichte Italiens. III. Die Bevölkerung der Republik Venedig, des Herzogtums Mailand, Piemonts, Genuas, Corsicas und Sardiniens, die Gesamtbevölkerung Italiens, De Gruyter, Berlin.

Beloch, K.J., 1965. Bevölkerungsgeschichte Italiens. II. Die Bevölkerung des Kirchenstaates, Toscanas und der Herzogtümer am Po, De Gruyter, Berlin.

Beltrami, D., 1954. Storia della Popolazione di Venezia dalla Fine del Secolo XVI alla Caduta della Repubblica, Longo & Zoppelli, Treviso.

Biraben, J.N. and Blanchet, D., 1985. 'Premiers résultats de l'enquête, population urbaine du centre du bassin Parisien, population urbaine de l'ouest', Congres International de Démographie, Florence.

Biraben, J.N. and Bonneuil, N., 1986. 'Population et économie en pays de Caux aux XVI^{e} et XVII^{e} siècles', Population 41(6), 937–960.

Blayo, Y., 1975. 'Mouvement naturel de la population française de 1740 à 1829', Population 30, no. special, 15–64.

Bolognesi, D., 1980. 'Demografia ed economia del Revennate nel settecento', in Società Italiana di Demografia Storica, La Popolazione Italiana nel Settecento, CLUEB, Bologna, pp. 263–284.

Bolognesi, D., 1982. 'Demografia e rendita urbana a Ravenna fra sei e settecento, prime ricerche', in Società Italiana di Demografia Storica, La Demografia Storica delle Città Italiane, CLUEB, Bologna, pp. 247–262.

Breschi, M., 1990. 'La popolazione della Toscana dal 1640 al 1940, un'ipotesi di recostruzione', Dipartimento Statistico, Università degli Studi di Firenze, Serie Ricerche Empiriche 17.

Breschi, M., 1991. 'Aggregative methods for reconstructing historical populations: considerations on their use in Italy', International Union for the Scientific Study of Population seminar on Old and New Methods in Historical Demography. A Critical Appraisal. Mallorca, 1991.

Brunborg, H., 1977. 'The inverse projection method applied to Norway, 1735–1974', unpublished manuscript of the Norwegian Central Bureau of Statistic, Oslo.

Central Bureau of Statistics, 1969. Historisk Statistik för Sverige, Del 1. Befolkning Andra Upplagen 1720–1967, Beckman, Stockholm.

Cipolla, C.M. 1965. 'Four centuries of Italian demographic development', in Glass and Eversley, eds., Population in History, Essays in Historical Demography, Arnold, London, pp. 570–587.

Cipolla, C.M., 1980. Before the Industrial Revolution, European Society and Economy, 1000–1700, Norton, New York.

Coale, A.J. and Demeny, P., 1966. Regional Model Life Tables and Stable Populations, Princeton University Press, Princeton.

De Maddalena, A., 1957. 'I prezzi dei generi commestibili e dei prodotti agricoli sul mercato di Milano dal 1800 al 1890', Archivio Economico dell'Unificazione Italiana 5(1), 1–24.

Del Panta, L., 1977. 'Cronologia e diffusione delle crisi di mortalità in Toscana dalla fine del XIV agli inizi del XIX secolo', Ricerche Storiche 7(2), 293–343.

Del Panta, L., 1980. Le Epidemie nella Storia Demografica Italian (Secoli XIV–XIX), Loescher, Torino.

Del Panta, L. and Livi-Bacci, M., 1977. 'Chronologie, intensitè et diffusion des crises de mortalité en Italie: 1600–1850', Population 32, numéro spécial, 401–445.
Del Panta, L. and Livi-Bacci, M., 1980. 'Le componenti naturali dell'evoluzione demografica nell'Italia del settecento', in Società Italiana di Demografia Storica, La Popolazione Italiana nel Settecento, CLUEB, Bologna, pp. 71–140.
DeVries, J., 1984. European Urbanization 1500–1800, Harvard University Press, Cambridge.
DeVries, J., 1985. 'The population and economy of the preindustrial Netherlands', Journal of Interdisciplinary History 15(4), 661–682.
Direzione Generale di Statistica, 1861, 1871, 1881. Statistica d'Italia, Popolazione, Censimento Generale, Barbèra, Firenze.
Direzione Generale di Statistica, 1878–1884. Annuario Statistico Italiano, Elzeviriana, Rome.
Donazzolo P. and Sailbante, M., 1926. 'Lo sviluppo demografico di Verona e della sua provincia dalla fine del sec. XV ai giorni nostri', Metron VI(3–4), 56–180.
Dossetti, M. 1977. 'Aspetti demografici del Piemonte occidentale nei secoli XVII e XVIII', Bollettino Storico Bibliografico Subalpino 75, 127–237.
Dublin, L.I., 1949. Length of Life; a Study of the Life Table, Ronald, New York.
Dupâquier, J. et al., 1988. Histoire de la Population Française 2 – De la Renaissance à 1789, Presses Universitaires de France, Paris.
Etonti, M., 1982. 'Per una storia demografica di Chioggia nei secoli XVII e XVIII', in Società Italiana di Demografia Storica, La Demografia Storica delle Città Italiane, CLUEB, Bologna, pp. 305–320.
Fanfani, T., 1979. Economia e Società nei Domini Ereditari della Monarchia Absburgica ne Settecento (Le Conte di Gorizia e Gradisca), Mori Varese.
Felloni, G., 1957. 'I prezzi sul mercato di Torino dal 1815 al 1890', Archivio Economico dell'Unificazione Italiana 5(1), 1–24.
Felloni, G., 1976. 'Monetary changes and prices in Italy in the Napoleonic period', Journal of European Economic History 5(2), 379–390.
Ferrario, G., 1838–1850. Statistica Medica di Milano dal Secolo XV Fino ai Nostri Giorni. Volume II, Bernardoni, Guglielmini e Redaelli, Milano.
Galloway, P.R., 1985. 'Annual variations in deaths by age, deaths by cause, prices, and weather in London 1670 to 1830', Population Studies 39(3), 487–505.
Galloway, P.R., 1986a. 'Long-term fluctuations in climate and population in the preindustrial era', Population and Development Review 12(1), 1–24.
Galloway, P.R., 1986b. 'Differentials in demographic responses to annual price variations in pre-revolutionary France: a comparison of rich and poor areas in Rouen, 1681 to 1787', European Journal of Population 2(3/4), 269–305.
Galloway, P.R., 1987. Population, Prices, and Weather in Preindustrial Europe, Ph.D. dissertation, Graduate Group in Demography, University of California, Berkeley.
Galloway, P.R., 1988. 'Basic patterns in annual variations in fertility, nuptiality, mortality, and prices in preindustrial Europe', Population Studies 42(2), 275–303.
Galloway, P.R., 1993a. 'Short-run population dynamics among the rich and poor in European countries, rural Jutland, and urban Rouen', in D.S. Reher and R. Schofield (eds), Old and New Methods in Historical Demography, Clarendon, Oxford, pp. 84–108.
Galloway, P.R., 1993b. 'A population reconstruction of North Italy 1650 to 1881 using annual inverse projection with comparisons to England, France, Sweden, and the cities of Venice, Verona, Rome, and Stockholm,' Department of Demography, University of California, Berkeley.
Galloway, P.R., 1994. 'Secular changes in the short-term preventive, positive, and temperature checks to population growth in Europe, 1460–1909', Climatic Change 26, 3–63.
Henry, L. and Blayo, Y., 1975. 'La population de la France de 1740 a 1860', Population 30, 71–122.
Hofsten, E. and Lundström, H., 1976. Swedish Population History, Main Trends from 1750 to 1970, Norstedt, Stockholm.

Holmberg, I., 1970. 'A study of mortality among cohorts born in the 18th and 19th century', Statistical Reports 1970, 71–86.

House of Commons Parliamentary Papers, 1827. 'Consuls returns', 108–113.

INSEE (Institut National de la Statisque et des Études Économiques), 1966. Annuaire Statistique de la France 1966, Résumé Rétrospectif, Paris.

INED (Institut National d'Études Démographiques), 1977. 'Sixième rapport sur la situation démographique de la France', Population 32(2), 253–338.

Istituto Centrale di Statistica, 1958. Sommario di Statistiche Storiche Italiane 1861–1955, Rome.

Kertzer, D. and Hogan, D., 1989. Family, Political Economy, and Demographic Change, University of Wisconsin Press, Madison.

Lee, R.D., 1977. 'Methods and models for analyzing historical series of births, deaths, and marriages', in Lee (ed), Population Patterns in the Past, Academic Press, New York, pp. 337–370.

Lee, R.D., 1978. Econometric Studies of Topics in Demographic History, Arno, New York.

Lee, R.D., 1981. 'Short-term variation: vital rates, prices and weather', in E.A. Wrigley and R.S. Schofield, The Population History of England 1541–1871, A Reconstruction, Edward Arnold, London, pp. 356–401.

Lee, R.D., 1985a. 'Inverse projection and back projection: a critical appraisal, and comparative results for England, 1539 to 1871', Population Studies 39, 233–248.

Lee, R.D., 1985b. 'Population homeostasis and English demographic history', Journal of Interdisciplinary History 15(4), 635–660.

Lee, R.D., 1987. 'Population dynamics of humans and other animals', Demography 24(4), 443–465.

Lee, R.D., 1990. 'The demographic response to economic crisis in historical and contemporary population', Population Bulletin of the United Nations 29, 1–15.

Lee, R.D., 1993. 'Inverse projection and demographic fluctuations, a critical assessment of new methods', in D.S. Reher and R. Schofield (eds), Old and New Methods in Historical Demography, Clarendon, Oxford, pp. 7–28.

Levi, G., 1974. 'Gli aritmetici politici e la demografia piemontese negli ultimi anni del settecento', Rivista Storica Italiana 86, fascicolo II, 201–265.

Livi Bacci, M., 1977. A History of Italian Fertility during the Last Two Centuries, Princeton University Press, Princeton.

Livi Bacci, M. and Breschi, M., 1990. 'Italian fertility: an historical account', Journal of Family History 15(4), 385–408.

Livi Bacci, M. and Reher, D.S., 1993. 'Other paths to the past: from vital series to population patterns', in D.S. Reher and R. Schofield (eds), Old and New Methods in Historical Demography, Clarendon, Oxford, pp. 66–83.

McCaa, R., 1989. 'Populate, a microcomputer projection package for aggregative data applied to Norway, 1736–1970', Annales de Démographie Historique 1989, 287–298.

McCaa, R., 1993. 'Benchmarks for a new inverse population projection program: England, Sweden, and a standard demographic transition', in D.S. Reher and R. Schofield (eds), Old and New Methods in Historical Demography, Clarendon, Oxford, pp. 40–56.

McCaa, R. and Pérez Brignoli, H., 1989. 'Populate: from births and deaths to the demography of the past, present, and future', Working Paper 89-06-1, Center for Population Analysis and Policy, University of Minnesota.

Mitchell, B.R., 1981. European Historical Statistics 1750–1975, Facts on File, New York.

Oeppen, J., 1993. 'Back projection and inverse projection; members of a wider class of constrained projection models', Population Studies 47(2), 245–267.

Ottolenghi, D., 1903. 'Studi demografici sulla popolazione di Siena dal secolo XIV al XIX', Bollettino Senese di Storia Patria, 297–358.

Parenti, G., 1942. Prezzi e Mercato del Grano a Siena (1546–1765), Casa Editrice del Dott. Carlo Cya, Firenze.

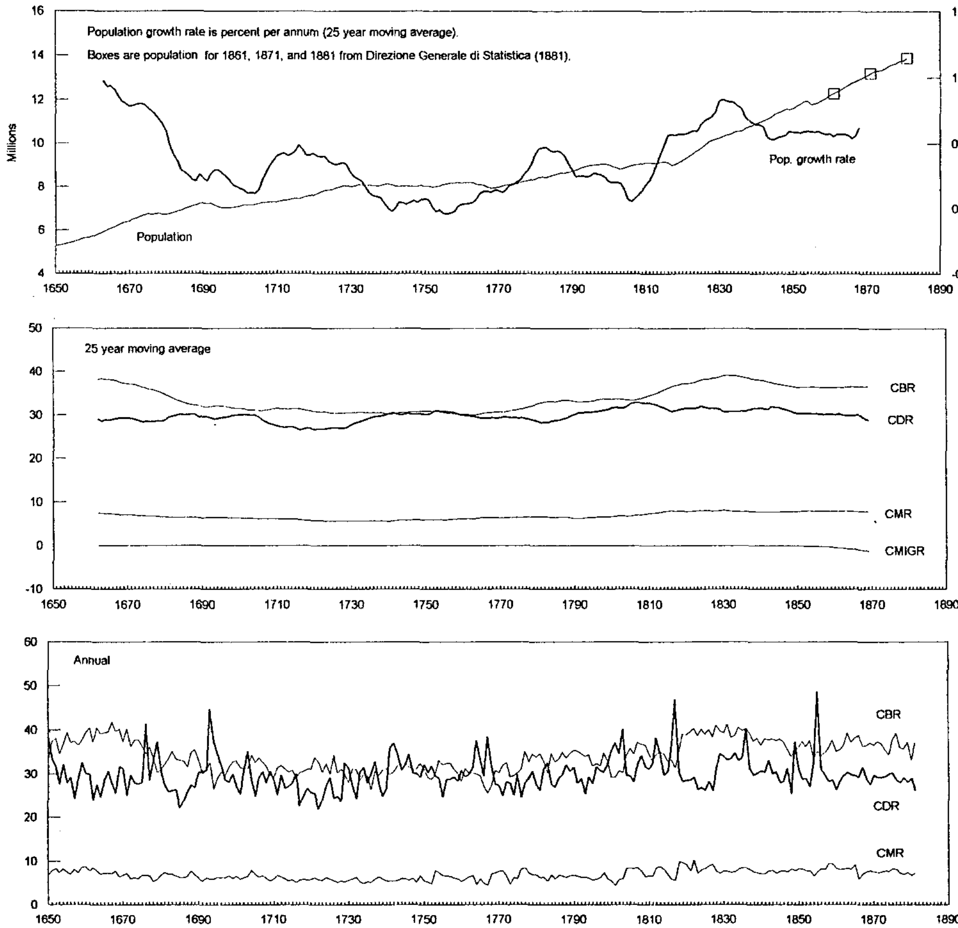
Parenti, G., 1943–1949. 'Fonti per lo studio della demografia Fiorentina: i libri dei morti', Genus 6, 281–301.
Reher, D.S., 1991. 'Dinámicas demográficas en Castilla la Nueva 1550–1900: un ensayo de reconstrucción', in J. Nadal-Oller (ed), La Evolución Demográfica Bajo los Austrias (Actas del II Congreso del la ADEH, April 1990, vol. 3), Instituto de Cultura Juan Gil Albert, Alicante, pp. 17–75.
Romani, M., 1955. Il movimento demografico in Lombardia dal 1750 al 1850', Economia e Storia, Rivista Italiana di Storia Economica e Sociale 4, 412–452.
Romani, M., 1968. Storia Economica d'Italia nel Secolo XIX (1815–1915), Giuffrè, Milano.
Romani, M., 1982. Storia Economica d'Italia nel Secolo XIX (1815–1882), Società editrice il Mulino, Bologna.
Romani, M.A., 1970. 'Aspetti dell'evoluzione demografica Parmense nei secoli XVI e XVII', Studi e Ricerche della Facolta' di Economia e Commercio 7, 215–276.
Romani, M.A., 1975. Nella Spirale di una Crisi, Popolazione, Mercato e Prezzi a Parma tra Cinque e Seicento, Giuffrè, Milano.
Rossi, F., 1970. 'Storia della popolazione di Adria dal XVI al XIX secolo', Genus XXVI (1–2), 73–167.
Roveda, E., 1980. 'L'andamento demografico del Logigiano nel corso del settecento', in Società Italiana di Demografia Storica, La Popolazione Italiana nel Settecento, CLUEB, Bologna, pp. 227–248.
Sella, D., 1968. Salari e Lavoro nell'Edilizia Lombarda durante il Secolo XVII, Editrice Succ. Fusi, Pavia.
Smith, P.C. and Ng, S., 1982. 'The components of population change in nineteenth-century south-east Asia: village data from the Philippines', Population Studies 36(2), 237–255.
Società Italiana di Demografia Storica, 1990. 'Le migrazioni internazionali dal medioevo all'età contemporanea: il caso italiano', Bollettino di Demografia Storica 12, 1–294.
Sundbärg, G., 1907. 'Forsatta bidrag til en Svensk befolkningsstatistik för åren 1750–1900, V och VI, giftermålsfrekvensen, födelsefrekvensen', Statistisk Tidskrift 143, 181–282.
Sundbärg, G., 1909. 'Forsatta bidrag til en Svensk befolkningsstatistik för åren 1750–1900, VIII, medelfolkmängden efter ålder och kön, för beräkning af dödstalen', Statistisk Tidskrift 146, 186–230.
Sweden Statistical Yearbook (Various).
U.S. Bureau of the Census, 1975. Historical Statistics of the United States, Colonial Times to 1970, Bicentennial Edition, Part 2, Washington D.C.
Utterström, G., 1954. 'Some population problems in pre-industrial Sweden', Scandinavian Economic History Review 2(2), 103–165.
Van Dijk, H., 1989. 'Demographic aspects of urbanization during the nineteenth century', in R. Lawton and R. Lee, (eds), Urban Population Development in Western Europe from the Late-Eighteenth to the Early-Twentieth Century, Liverpool University Press, Liverpool, pp. 27–50.
Van Leeuwen, M.H.D. and Oeppen, J.E., 1993. 'Reconstructing the demographic regime of Amsterdam 1681–1920' in Lucassen, J. et al. (eds), Economic and Social History in the Netherlands V pp. 61–102.
Willcox, W.F., (ed), 1929. International Migrations, Volume 1, Gordon and Breach, New York.
Willcox, W. F., (ed), 1931. International Migrations, Volume 2, National Bureau of Economic Research, New York.
World Bank, 1992. World Development Report 1992, Oxford University Press.
Wrigley, E.A., 1967. 'A simple model of London's importance in changing English society and economy, 1650–1750', Past and Present 37, 44–70.
Wrigley, E.A. and Schofield, R.S., 1981. The Population History of England 1541–1871, A Reconstruction, Edward Arnold, London.
Yule, G.U., 1906. 'On the changes in the marriage and birth rates in England and Wales during the past half century; with an inquiry as to their probable causes', Journal of the Royal Statistical Society 69, 88-132.
Zuccagni-Orlandini, A., 1848. Ricerche Statistiche sul Granducato di Toscana, Volume 1, Il Ministero delle Finanze, Florence.

Appendix

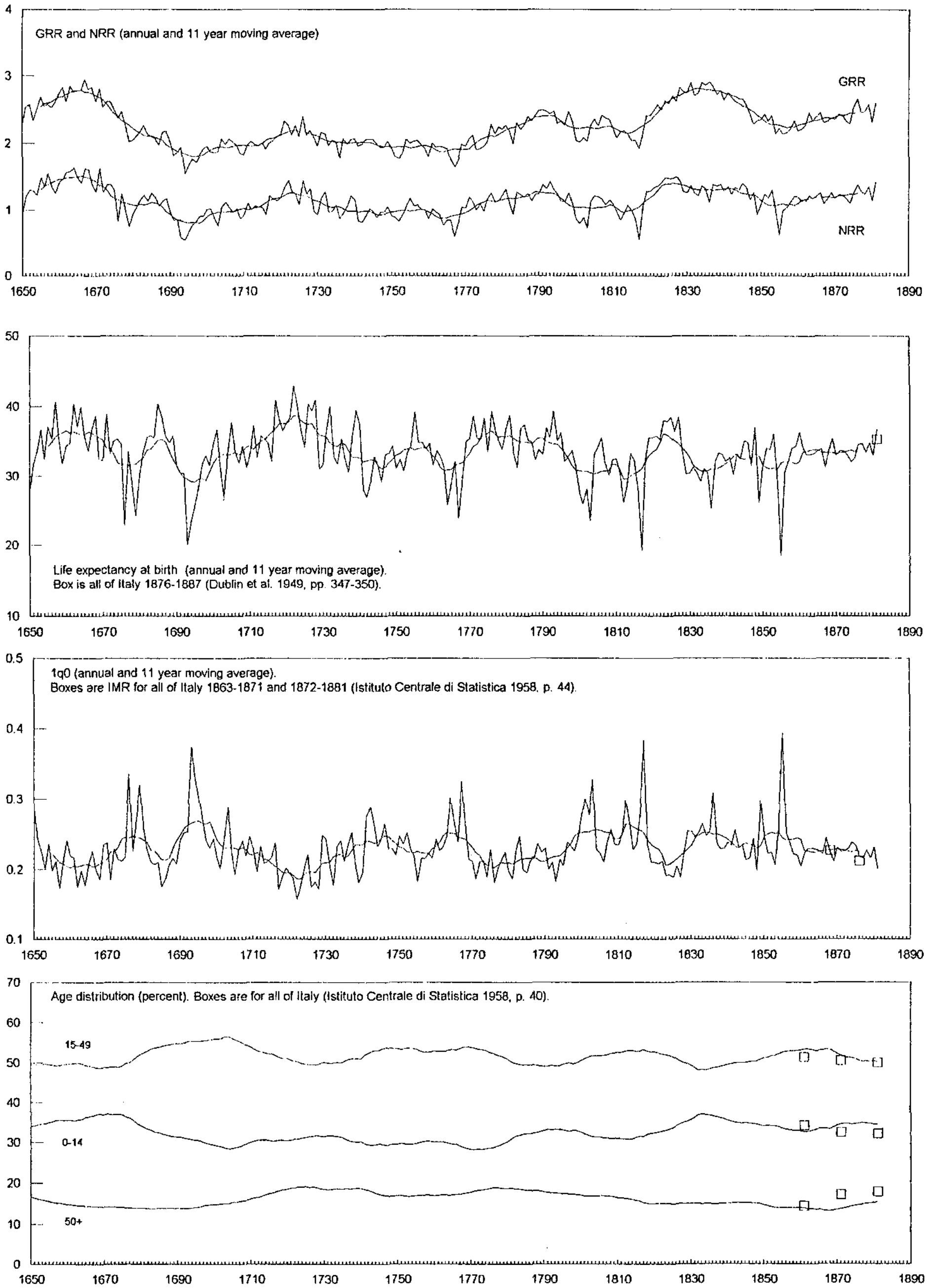
Appendix Fig. 1. North Italy annual inverse projection estimates 1650 to 1881 with comparisons with other sources.

Inverse projection inputs:
Initial population is Italy 1649 (Appendix Table 1).
Initial age distribution is Sweden 1751–1760 (Sundbärg 1909, pp. 200–206).
Annual births, deaths, and population 1650–1881 (Appendix Table 1).
Annual net migration rates are calculated from annual births, deaths, and year-end population.
The values of q_x for life expectancy at birth of 27 and for life expectancy at birth of 67 are from the West model life tables.
Net migration age distribution is for Sweden 1861–1915 (Central Bureau of Statistics 1969, p. 128).
Fertility schedule with mean age of childbearing 31 is from Coale and Demeny (1966, p. 30).

Note that CMIGR is the crude net migration rate which is $[\{P(t) - P(t{-}1) - B(t) + D(t)\} \times 2 \times 1000]/[P(t) + P(t{-}1)]$ where P is year-end population, B is births, D is deaths, and t is year.



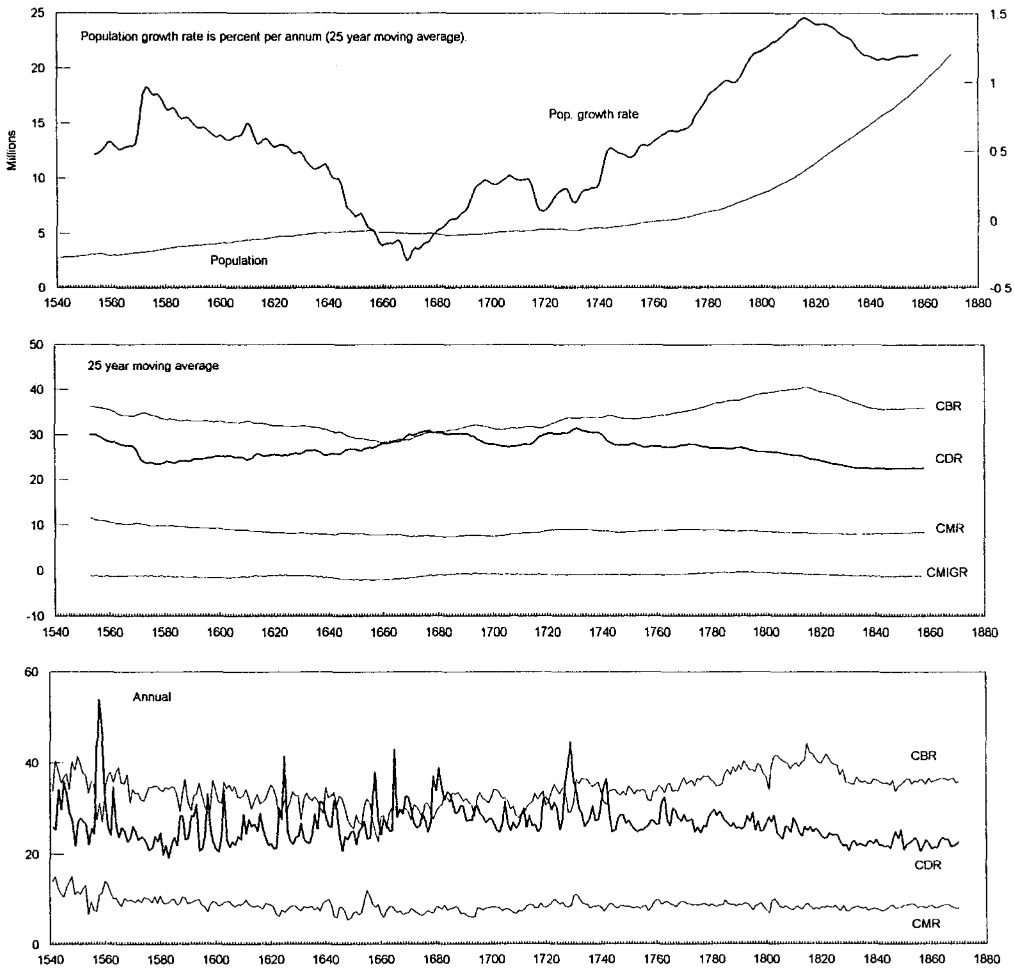
Appendix Fig. 1. (Continued).



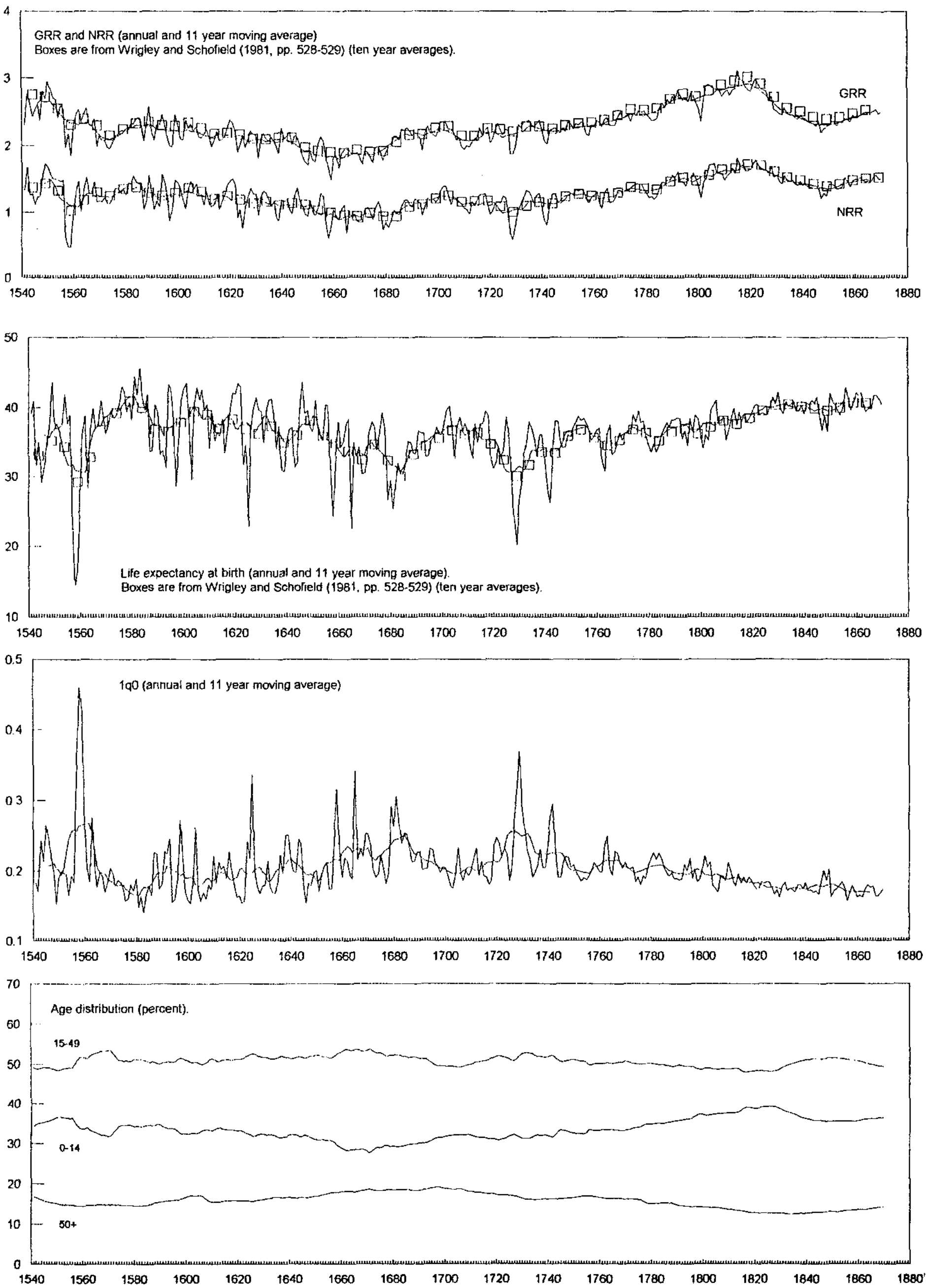
Appendix Fig. 2. England annual inverse projection estimates 1541 to 1870 with comparisons with other sources.

Inverse projection inputs:
Initial population is England 1540 (Wrigley and Schofield 1981, pp. 496, 531).
Initial age distribution is Sweden 1751–1760 (Sundbärg 1909, pp. 200–206).
Annual births, deaths, and population 1541–1870 (Wrigley and Schofield 1981, pp. 496–502, 531–535).
Annual net migration rates are calculated from annual births, deaths, and year-end population.
The values of q_x for life expectancy at birth of 27 and for life expectancy at birth of 67 are from the West model life tables.
Net migration age distribution is for Sweden 1861–1915 (Central Bureau of Statistics 1969, p. 128).
Fertility schedule with mean age of childbearing 31 is from Coale and Demeny (1966, p. 30).

Note that CMIGR is the crude net migration rate which is $[\{P(t) - P(t-1) - B(t) + D(t)\} \times 2 \times 1000]/[P(t) + P(t-1)]$ where P is year-end population, B is births, D is deaths, and t is year.



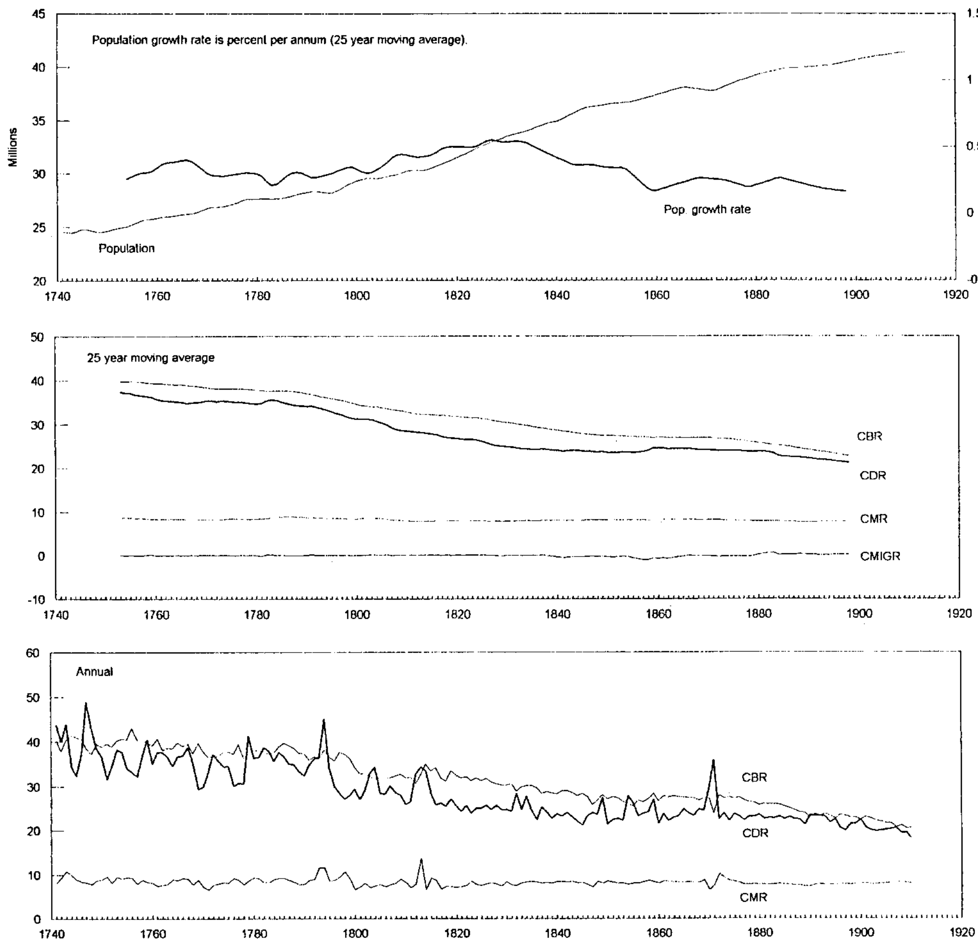
Appendix Fig. 2. (Continued).



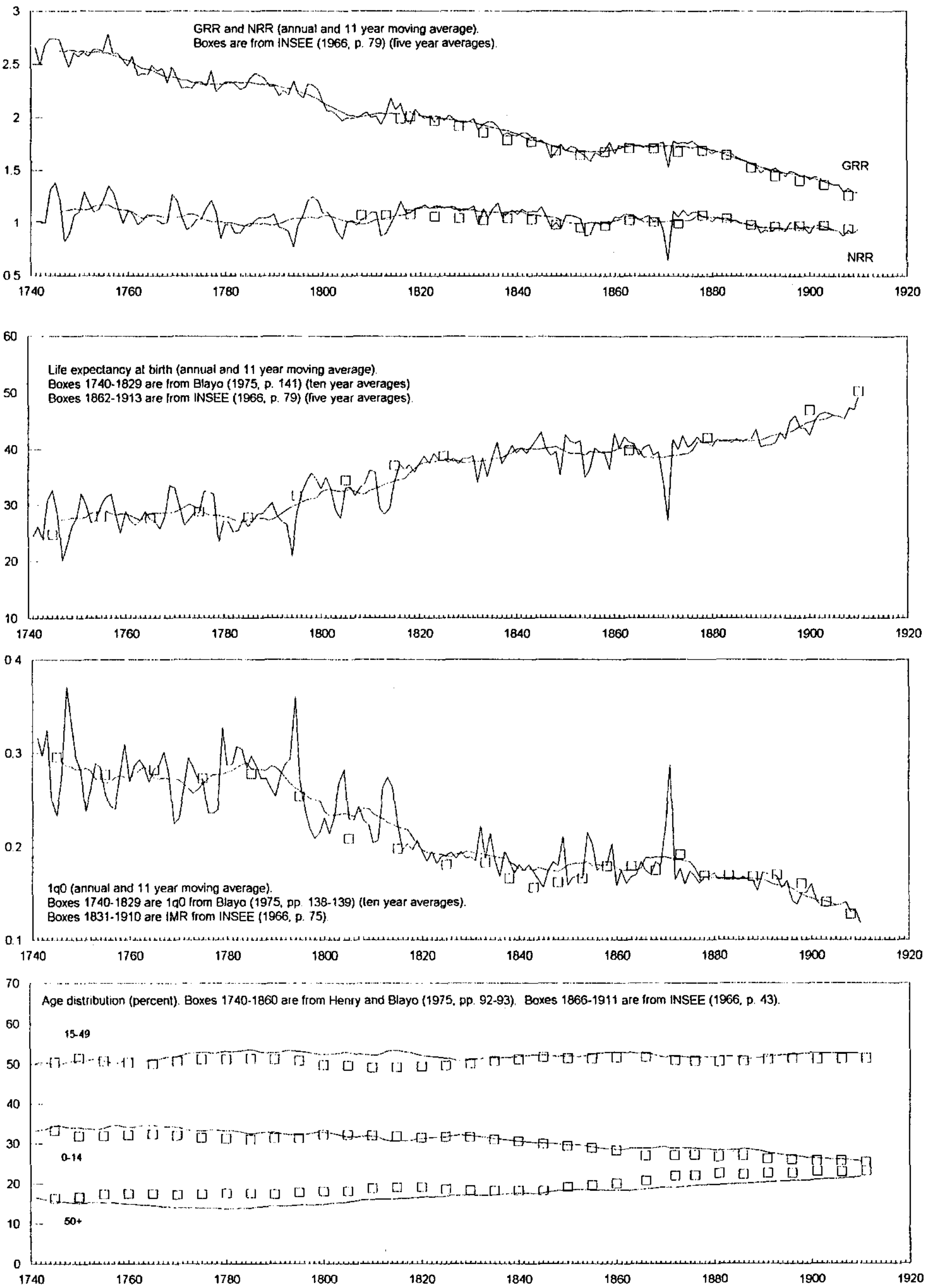
Appendix Fig. 3. France annual inverse projection estimates 1741 to 1881 with comparisons with other sources.

Inverse projection inputs:
Initial population is France 1740 (INED 1977, p. 332).
Initial age distribution is France 1740 (Henry and Blayo 1975, p. 92).
Annual births, deaths, and population 1741–1839 (INED 1977, pp. 332–333) and 1840–1910 (Mitchell 1981, pp. 192–112).
Annual net migration rates are calculated from annual births, deaths, and year-end population.
The values of q_x for life expectancy at birth of 27 and for life expectancy at birth of 67 are from the West model life tables.
Net migration age distribution is for Sweden 1861–1915 (Central Bureau of Statistics 1969, p. 128).
Fertility schedule with mean age of childbearing 29 is from Coale and Demeny (1966, p. 30).

Note that CMIGR is the crude net migration rate which is $[\{P(t) - P(t{-}1) - B(t) + D(t)\} \times 2 \times 1000]/[P(t) + P(t{-}1)]$ where P is year-end population, B is births, D is deaths, and t is year.



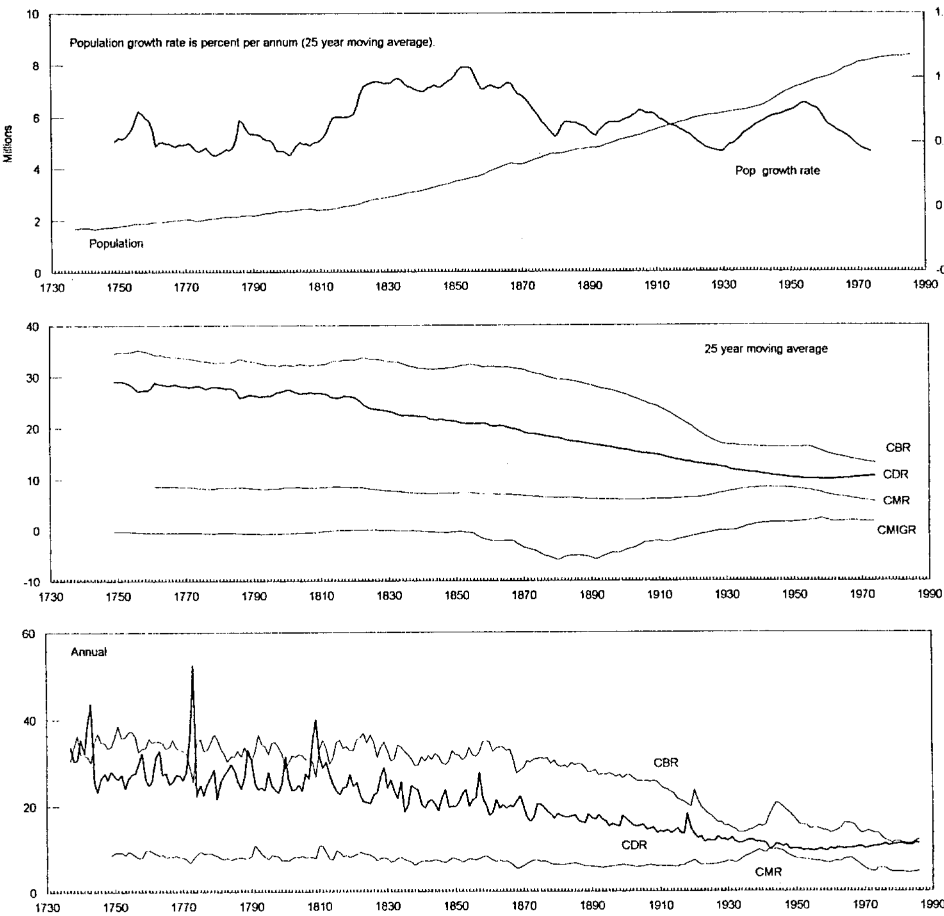
Appendix Fig. 3. (Continued).



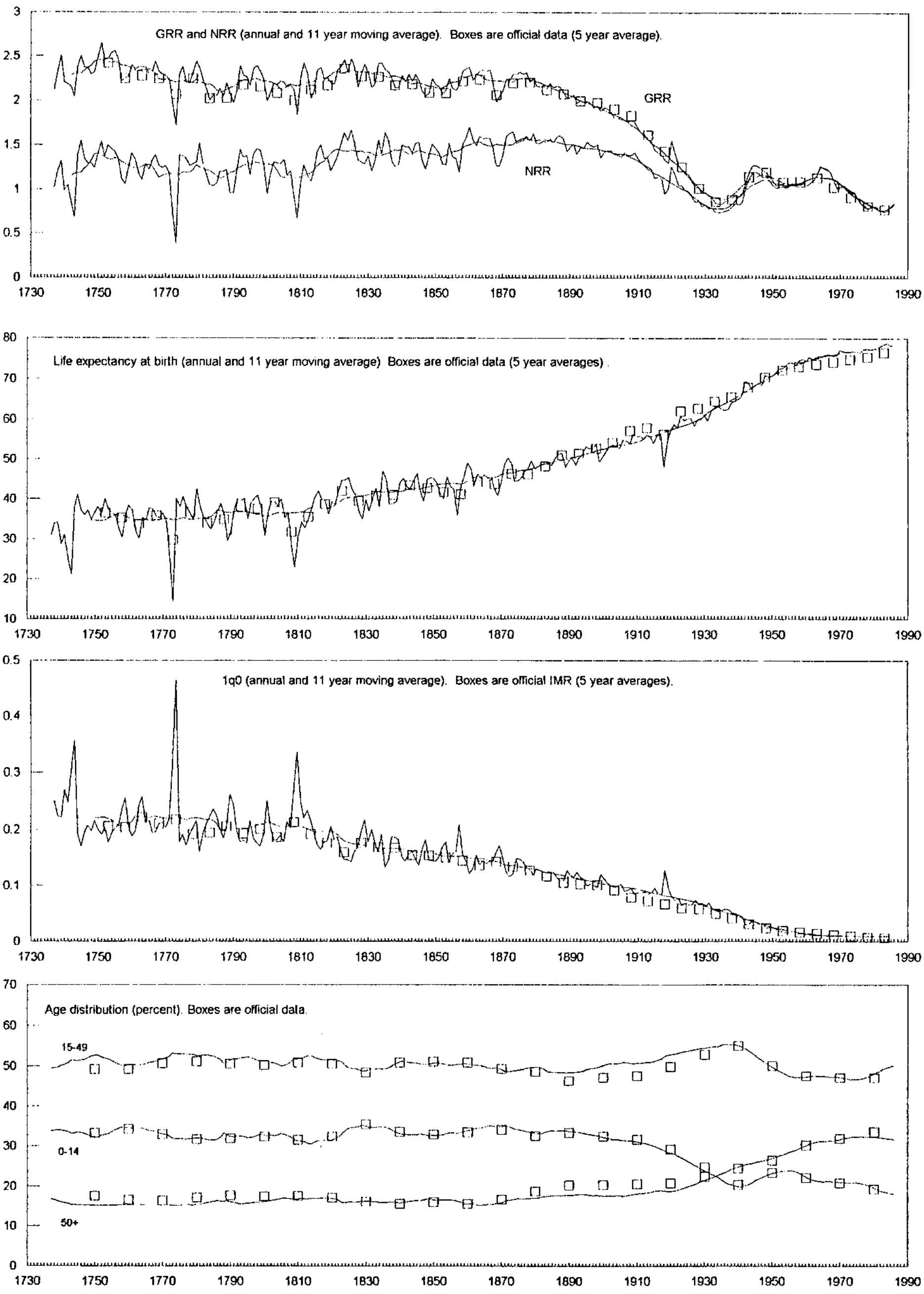
Appendix Fig. 4. Sweden annual inverse projection estimates 1737 to 1986 with comparisons with other sources.

Inverse projection inputs:
Initial population is Sweden 1736 (Central Bureau of Statistics 1969, p. 86).
Initial age distribution is Sweden 1751–1760 (Sundbärg 1909, pp. 200–206).
Annual births, deaths, and population 1737–1986 (Central Bureau of Statistics 1969, pp. 44–99; Sweden Statistical Yearbooks).
Annual net migration rates are calculated from annual births, deaths, and year-end population.
The values of q_x for life expectancy at birth of 27 and for life expectancy at birth of 67 are from the West model life tables.
Net migration age distribution is for Sweden 1861–1915 (Central Bureau of Statistics 1969, p. 128).
Fertility schedule with mean age of childbearing 29 is for Sweden 1891–1900 (Sundbärg 1907, p. 277).

Note that CMIGR is the crude net migration rate which is $[\{P(t) - P(t{-}1) - B(t) + D(t)\} \times 2 \times 1000]/[P(t) + P(t{-}1)]$ where P is year-end population, B is births, D is deaths, and t is year.
Official data are from Central Bureau of Statistics (1969), Sweden Statistical Yearbooks, and Holmberg (1970).



Appendix Fig. 4. (Continued).



Appendix Table 1. North Italy population reconstruction with annual inverse projection estimates 1650 to 1881.

Year	Births	Deaths	Marriages	Population yearend	Population growth %	CBR	CDR	CMR	CMIGR	$_1q_0$	e_0	GRR	NRR	Age % 0-14	Age % 15-49	Age % 50+
1650	177129	203403	36457	5296420	-0.49	33.36	38.31	6.87	0.0	0.284	27.4	2.26	0.93	33.97	49.36	16.67
1651	198619	177785	41543	5317253	0.39	37.43	33.50	7.83	0.0	0.243	31.6	2.53	1.20	34.17	49.46	16.34
1652	203034	167479	44458	5352808	0.67	38.06	31.39	8.33	0.0	0.226	33.6	2.58	1.30	34.39	49.49	16.07
1653	185726	147778	39980	5390756	0.71	34.57	27.51	7.44	0.0	0.201	36.7	2.34	1.29	34.53	49.55	15.94
1654	198922	173674	44276	5416004	0.47	36.81	32.14	8.19	0.0	0.236	32.4	2.50	1.22	34.64	49.64	15.71
1655	214667	151377	41052	5479294	1.17	39.41	27.79	7.54	0.0	0.198	37.1	2.69	1.49	35.01	49.47	15.50
1656	204656	159935	38462	5524015	0.82	37.20	29.07	6.99	0.0	0.211	35.4	2.55	1.35	35.19	49.41	15.35
1657	208259	134483	45047	5597792	1.34	37.45	24.18	8.10	0.0	0.173	40.6	2.58	1.55	35.52	49.23	15.23
1658	205666	161688	41295	5641770	0.79	36.60	28.77	7.35	0.0	0.211	35.4	2.53	1.34	35.59	49.28	15.13
1659	212629	184079	48430	5670321	0.51	37.59	32.55	8.56	0.0	0.242	31.8	2.61	1.25	35.52	49.45	14.98
1660	224870	170580	49662	5724611	0.96	39.47	29.94	8.72	0.0	0.219	34.4	2.75	1.42	35.57	49.59	14.87
1661	232762	171917	44687	5785456	1.06	40.44	29.87	7.76	0.0	0.217	34.7	2.83	1.47	35.58	49.71	14.75
1662	217450	139295	50098	5863610	1.35	37.33	23.92	8.60	0.0	0.174	40.4	2.62	1.57	35.48	49.84	14.66
1663	239270	161577	46271	5941303	1.33	40.54	27.37	7.84	0.0	0.198	37.1	2.85	1.58	35.61	49.82	14.54
1664	234807	147048	42407	6029063	1.48	39.23	24.57	7.09	0.0	0.177	39.9	2.76	1.64	35.79	49.69	14.50
1665	239124	171858	44536	6096329	1.12	39.44	28.35	7.35	0.0	0.208	35.8	2.78	1.49	36.29	49.25	14.45
1666	242590	187043	44925	6151877	0.91	39.61	30.54	7.34	0.0	0.226	33.6	2.79	1.41	36.41	49.18	14.41
1667	259133	171070	44736	6239940	1.43	41.82	27.61	7.22	0.0	0.200	36.8	2.95	1.62	36.66	48.98	14.36
1668	249451	160082	49203	6329309	1.43	39.69	25.47	7.83	0.0	0.186	38.7	2.80	1.61	36.95	48.74	14.34
1669	255864	201411	40765	6383762	0.86	40.25	31.69	6.41	0.0	0.235	32.5	2.83	1.38	37.08	48.66	14.29
1670	239417	199321	43560	6423858	0.63	37.39	31.13	6.80	0.0	0.238	32.2	2.62	1.27	36.87	48.90	14.21
1671	260670	161369	46476	6523158	1.55	40.27	24.93	7.18	0.0	0.185	38.9	2.81	1.63	37.07	48.78	14.17
1672	237828	194548	39458	6566438	0.66	36.34	29.73	6.03	0.0	0.229	33.2	2.53	1.26	36.86	48.94	14.17
1673	249521	183845	40987	6632114	1.00	37.81	27.86	6.21	0.0	0.214	35.1	2.62	1.38	36.94	48.91	14.16
1674	251992	183892	40150	6700214	1.03	37.80	27.59	6.02	0.0	0.212	35.3	2.62	1.38	37.01	48.87	14.12
1675	244740	188112	45948	6756842	0.85	36.37	27.96	6.83	0.0	0.217	34.6	2.51	1.30	36.87	49.06	14.10
1676	233021	277988	45987	6711875	-0.67	34.60	41.28	6.83	0.0	0.335	22.9	2.37	0.82	36.26	49.75	13.99
1677	244468	191342	45228	6765001	0.79	36.28	28.40	6.71	0.0	0.226	33.5	2.47	1.24	36.06	49.96	13.96
1678	225878	224572	36028	6766307	0.02	33.39	33.19	5.33	0.0	0.272	28.5	2.26	0.97	35.48	50.59	13.90
1679	203894	251901	38994	6718300	-0.71	30.24	37.36	5.78	0.0	0.320	24.2	2.02	0.74	34.69	51.43	13.88
1680	208426	204047	45541	6722679	0.07	31.01	30.36	6.78	0.0	0.258	29.9	2.04	0.92	34.15	52.02	13.85
1681	217548	184389	50212	6755838	0.49	32.28	27.36	7.45	0.0	0.228	33.3	2.11	1.05	33.72	52.43	13.82
1682	227276	174640	47564	6808474	0.78	33.51	25.75	7.01	0.0	0.210	35.6	2.17	1.15	33.20	52.96	13.80
1683	240842	177801	48148	6871515	0.93	35.21	25.99	7.04	0.0	0.207	35.9	2.26	1.22	32.89	53.36	13.76
1684	230194	180684	45488	6921024	0.72	33.38	26.20	6.60	0.0	0.210	35.5	2.13	1.13	32.54	53.70	13.79
1685	230679	153986	43415	6997717	1.11	33.15	22.13	6.24	0.0	0.175	40.3	2.10	1.25	32.41	53.77	13.84
1686	231604	165661	43889	7063660	0.94	32.94	23.56	6.24	0.0	0.187	38.6	2.07	1.19	31.99	54.19	13.85
1687	223350	182128	45426	7104882	0.58	31.53	25.71	6.41	0.0	0.207	35.9	1.97	1.06	31.75	54.39	13.89
1688	249509	194954	54905	7159437	0.77	34.98	27.33	7.70	0.0	0.216	34.8	2.16	1.13	31.59	54.51	13.87
1689	255073	191283	49567	7223228	0.89	35.47	26.60	6.89	0.0	0.208	35.8	2.18	1.17	31.51	54.64	13.88
1690	239099	219216	44672	7243111	0.28	33.06	30.31	6.18	0.0	0.243	31.6	2.02	0.96	31.34	54.81	13.87
1691	218199	221480	39267	7239831	-0.05	30.13	30.58	5.42	0.0	0.253	30.5	1.82	0.84	31.33	54.78	13.87
1692	225231	222600	45358	7242462	0.04	31.10	30.74	6.26	0.0	0.254	30.4	1.86	0.85	31.09	55.05	13.86
1693	234843	322119	42499	7155185	-1.21	32.62	44.75	5.90	0.0	0.374	20.0	1.94	0.58	30.90	55.30	13.82
1694	188209	265162	42366	7078232	-1.08	26.45	37.26	5.95	0.0	0.330	23.3	1.55	0.54	30.73	55.31	13.95
1695	203717	244912	44802	7037038	-0.58	28.86	34.70	6.35	0.0	0.303	25.6	1.68	0.65	30.62	55.36	14.07
1696	214123	224648	43721	7026513	-0.15	30.45	31.95	6.22	0.0	0.273	28.5	1.77	0.76	30.43	55.33	14.24
1697	208466	200796	43947	7034183	0.11	29.65	28.56	6.25	0.0	0.242	31.8	1.72	0.82	30.10	55.41	14.47
1698	222317	197146	47043	7059354	0.36	31.55	27.98	6.68	0.0	0.231	33.0	1.84	0.91	29.78	55.57	14.64
1699	231837	211959	42347	7079232	0.28	32.79	29.98	5.99	0.0	0.244	31.5	1.92	0.91	29.57	55.67	14.76
1700	234891	192386	47147	7121737	0.60	33.08	27.09	6.64	0.0	0.217	34.7	1.95	1.01	29.40	55.89	14.70
1701	224949	179915	41608	7166771	0.63	31.49	25.18	5.82	0.0	0.201	36.7	1.87	1.02	29.21	55.94	14.83
1702	223360	219687	44964	7170444	0.05	31.16	30.65	6.27	0.0	0.248	31.0	1.86	0.87	29.05	55.99	15.01
1703	222185	252101	46384	7140528	-0.42	31.05	35.23	6.48	0.0	0.289	26.9	1.87	0.76	28.59	56.40	15.04
1704	245504	203829	56325	7182203	0.58	34.28	28.46	7.87	0.0	0.225	33.7	2.07	1.05	28.47	56.41	15.10
1705	235303	178304	50484	7239202	0.79	32.63	24.73	7.00	0.0	0.193	37.7	1.99	1.12	28.58	56.04	15.36
1706	244429	210764	45757	7272867	0.47	33.69	29.05	6.31	0.0	0.227	33.5	2.07	1.04	28.90	55.64	15.46
1707	238190	222142	48935	7288915	0.22	32.71	30.51	6.72	0.0	0.241	31.9	2.02	0.97	29.09	55.24	15.63
1708	232076	203133	44247	7317858	0.40	31.78	27.81	6.06	0.0	0.219	34.4	1.97	1.02	29.47	54.75	15.79
1709	217857	223435	39609	7312280	-0.08	29.78	30.54	5.41	0.0	0.247	31.2	1.85	0.87	29.88	54.22	15.87
1710	213383	207689	43039	7317975	0.08	29.17	28.39	5.88	0.0	0.230	33.1	1.82	0.91	30.09	53.78	16.12
1711	230512	183673	49155	7364815	0.64	31.40	25.02	6.70	0.0	0.196	37.3	1.97	1.10	30.36	53.26	16.38
1712	235961	218917	47647	7381859	0.23	32.00	29.69	6.46	0.0	0.233	32.7	2.03	1.00	30.54	52.84	16.56

Appendix Table 1. (Continued).

Year	Births	Deaths	Marriages	Population yearend	Population growth %	CBR	CDR	CMR	CMIGR	$_1q_0$	e_0	GRR	NRR	Age % 0-14	Age % 15-49	Age % 50+
1713	229603	196594	44158	7414868	0.45	31.03	26.57	5.97	0.0	0.208	35.8	1.98	1.06	30.60	52.55	16.88
1714	226503	200422	40177	7440949	0.35	30.49	26.98	5.41	0.0	0.211	35.4	1.96	1.04	30.54	52.33	17.16
1715	228962	206623	42476	7463288	0.30	30.72	27.73	5.70	0.0	0.217	34.7	2.00	1.04	30.43	52.20	17.40
1716	217133	223256	37844	7457166	-0.08	29.11	29.93	5.07	0.0	0.238	32.1	1.91	0.92	30.25	52.14	17.62
1717	226597	168015	42182	7515749	0.79	30.27	22.44	5.63	0.0	0.171	40.8	2.00	1.21	30.45	51.61	17.93
1718	230021	187098	43766	7558672	0.57	30.52	24.82	5.81	0.0	0.190	38.2	2.04	1.16	30.64	51.11	18.19
1719	235014	200811	42353	7592876	0.45	31.02	26.51	5.59	0.0	0.202	36.5	2.10	1.14	30.51	51.07	18.39
1720	237429	195269	45119	7635035	0.56	31.18	25.65	5.93	0.0	0.194	37.6	2.13	1.19	30.48	51.02	18.53
1721	259526	195341	47746	7699221	0.84	33.85	25.48	6.23	0.0	0.187	38.5	2.33	1.34	30.60	50.64	18.76
1722	253052	169302	44294	7782971	1.09	32.69	21.87	5.72	0.0	0.157	42.9	2.27	1.44	30.80	50.35	18.86
1723	237375	185593	44018	7834754	0.67	30.40	23.77	5.64	0.0	0.175	40.2	2.12	1.27	30.86	50.13	18.99
1724	253912	213005	49357	7875661	0.52	32.32	27.12	6.28	0.0	0.200	36.8	2.26	1.24	31.15	49.73	19.08
1725	236256	229506	46641	7882412	0.09	29.99	29.13	5.92	0.0	0.221	34.2	2.10	1.08	31.25	49.59	19.10
1726	271617	192270	44000	7961759	1.01	34.29	24.27	5.55	0.0	0.174	40.4	2.40	1.44	31.51	49.52	18.96
1727	241221	197258	40725	8005721	0.55	30.21	24.71	5.10	0.0	0.182	39.3	2.12	1.24	31.54	49.46	19.02
1728	250691	189175	44834	8067236	0.77	31.19	23.54	5.58	0.0	0.171	40.9	2.19	1.32	31.69	49.45	18.91
1729	241074	262519	42248	8045791	-0.27	29.92	32.58	5.24	0.0	0.249	31.0	2.09	0.98	31.63	49.79	18.61
1730	224575	251122	44965	8019245	-0.33	27.96	31.26	5.60	0.0	0.243	31.6	1.95	0.92	31.48	50.07	18.47
1731	250297	217480	47748	8052063	0.41	31.15	27.06	5.94	0.0	0.203	36.5	2.16	1.18	31.69	49.89	18.40
1732	250341	194964	51016	8107440	0.69	30.98	24.13	6.31	0.0	0.177	40.0	2.14	1.27	31.73	49.81	18.46
1733	230014	245718	42531	8091736	-0.19	28.40	30.34	5.25	0.0	0.233	32.8	1.96	0.96	31.57	49.92	18.54
1734	242329	254370	38981	8079695	-0.15	29.97	31.46	4.82	0.0	0.241	31.8	2.05	0.98	31.45	50.02	18.54
1735	239208	225215	42130	8093688	0.17	29.58	27.85	5.21	0.0	0.211	35.4	2.02	1.07	31.29	50.07	18.64
1736	211929	242787	41464	8062830	-0.38	26.23	30.05	5.13	0.0	0.236	32.4	1.78	0.87	30.73	50.58	18.70
1737	247080	264209	47939	8045702	-0.21	30.68	32.80	5.95	0.0	0.253	30.6	2.07	0.95	30.38	50.98	18.60
1738	238554	221471	51774	8062785	0.21	29.62	27.50	6.43	0.0	0.208	35.7	1.99	1.06	30.27	51.02	18.66
1739	250023	199239	48180	8113569	0.63	30.91	24.63	5.96	0.0	0.181	39.4	2.06	1.21	30.18	51.04	18.77
1740	253463	216090	44307	8150942	0.46	31.17	26.57	5.45	0.0	0.196	37.4	2.07	1.15	30.28	51.00	18.71
1741	242153	291198	43786	8101898	-0.60	29.80	35.83	5.39	0.0	0.276	28.1	1.96	0.83	29.72	51.79	18.45
1742	245722	299748	43552	8047873	-0.67	30.43	37.12	5.39	0.0	0.289	26.9	1.98	0.81	29.51	52.29	18.24
1743	256218	277046	44703	8027045	-0.26	31.88	34.47	5.56	0.0	0.265	29.3	2.06	0.91	29.34	52.77	17.91
1744	258186	247279	48382	8037952	0.14	32.14	30.78	6.02	0.0	0.233	32.8	2.06	1.02	29.47	53.03	17.52
1745	260057	258374	48049	8039635	0.02	32.35	32.14	5.98	0.0	0.243	31.6	2.06	0.98	29.69	53.07	17.23
1746	252955	277364	44844	8015226	-0.30	31.51	34.55	5.59	0.0	0.265	29.2	1.99	0.88	29.52	53.45	17.07
1747	248000	240792	49426	8022434	0.09	30.93	30.03	6.16	0.0	0.229	33.2	1.94	0.97	29.35	53.70	16.94
1748	249044	241018	40726	8030460	0.10	31.03	30.03	5.07	0.0	0.229	33.2	1.94	0.97	29.49	53.61	16.89
1749	261313	234644	54297	8057129	0.33	32.49	29.17	6.75	0.0	0.220	34.3	2.02	1.04	29.64	53.45	16.86
1750	249830	259239	43811	8047720	-0.12	31.03	32.19	5.44	0.0	0.247	31.1	1.93	0.90	29.64	53.46	16.91
1751	234370	243678	42215	8038412	-0.12	29.14	30.30	5.25	0.0	0.236	32.4	1.80	0.88	29.78	53.30	16.94
1752	230055	255505	38209	8012963	-0.32	28.66	31.84	4.76	0.0	0.252	30.7	1.77	0.82	29.66	53.49	16.86
1753	240207	235317	62224	8017854	0.06	29.97	29.36	7.76	0.0	0.229	33.3	1.85	0.92	29.59	53.60	16.78
1754	267376	233365	59771	8051866	0.42	33.28	29.04	7.44	0.0	0.219	34.4	2.06	1.06	29.61	53.52	16.88
1755	260205	198659	54484	8113412	0.76	32.19	24.58	6.74	0.0	0.182	39.2	2.00	1.17	29.70	53.31	16.97
1756	263677	233489	53859	8143600	0.37	32.44	28.72	6.63	0.0	0.216	34.8	2.03	1.06	30.03	52.95	17.04
1757	264974	233886	53519	8174688	0.38	32.48	28.67	6.56	0.0	0.215	34.9	2.04	1.07	30.29	52.60	17.08
1758	254413	239564	49699	8189537	0.18	31.09	29.28	6.07	0.0	0.223	33.9	1.97	1.00	30.36	52.59	17.11
1759	247712	231219	48395	8206030	0.20	30.22	28.21	5.90	0.0	0.216	34.7	1.92	1.00	30.29	52.65	17.03
1760	230989	252126	43905	8184893	-0.26	28.19	30.76	5.36	0.0	0.243	31.6	1.80	0.86	30.11	52.91	16.96
1761	256133	240047	47868	8200979	0.20	31.26	29.30	5.84	0.0	0.226	33.6	2.00	1.01	30.18	52.76	17.04
1762	247253	245198	52541	8203034	0.03	30.15	29.89	6.41	0.0	0.233	32.8	1.94	0.96	30.14	52.78	17.12
1763	247397	258087	55209	8192345	-0.13	30.18	31.48	6.73	0.0	0.247	31.2	1.95	0.92	30.08	52.81	17.13
1764	244794	307302	36991	8129837	-0.76	30.00	37.65	4.53	0.0	0.301	25.8	1.94	0.76	29.79	53.14	17.10
1765	239905	268907	47780	8100835	-0.36	29.56	33.14	5.89	0.0	0.265	29.2	1.92	0.84	29.64	53.26	17.11
1766	218379	238717	39472	8080497	-0.25	26.99	29.51	4.88	0.0	0.239	32.1	1.75	0.84	29.60	53.17	17.28
1767	204672	308884	35893	7976286	-1.29	25.49	38.47	4.47	0.0	0.324	23.8	1.65	0.59	29.18	53.51	17.32
1768	217685	251814	55815	7942157	-0.43	27.35	31.64	7.01	0.0	0.260	29.8	1.76	0.79	28.70	53.88	17.45
1769	244591	217805	58179	7968943	0.34	30.74	27.38	7.31	0.0	0.214	35.0	1.99	1.04	28.49	53.95	17.57
1770	240656	217490	61001	7992108	0.29	30.16	27.25	7.64	0.0	0.211	35.4	1.95	1.03	28.31	53.82	17.86
1771	256377	199006	62770	8049479	0.72	31.96	24.81	7.83	0.0	0.186	38.7	2.07	1.19	28.31	53.59	18.11
1772	263414	226814	52780	8086080	0.45	32.65	28.11	6.54	0.0	0.211	35.4	2.12	1.12	28.38	53.42	18.23
1773	237106	224089	37421	8099096	0.16	29.30	27.69	4.62	0.0	0.212	35.3	1.90	1.00	28.30	53.30	18.38
1774	239990	202858	50386	8136229	0.46	29.56	24.99	6.21	0.0	0.189	38.3	1.92	1.09	28.49	53.03	18.49
1775	245265	242088	47970	8139406	0.04	30.14	29.75	5.89	0.0	0.228	33.4	1.95	0.98	28.64	52.61	18.71

Appendix Table 1. (Continued).

Year	Births	Deaths	Marriages	Population yearend	Population growth %	CBR	CDR	CMR	CMIGR	$_1q_0$	e_0	GRR	NRR	Age % 0-14	Age % 15-49	Age % 50+
1776	253616	200047	66801	8192975	0.66	31.06	24.50	8.18	0.0	0.181	39.3	2.01	1.17	28.73	52.39	18.88
1777	288665	228745	68678	8252895	0.73	35.10	27.82	8.35	0.0	0.201	36.6	2.28	1.25	29.12	51.98	18.90
1778	271510	240047	60088	8284358	0.38	32.84	29.03	7.27	0.0	0.213	35.1	2.14	1.12	29.41	51.75	18.85
1779	287054	254625	57260	8316787	0.39	34.58	30.68	6.90	0.0	0.224	33.8	2.25	1.14	29.86	51.43	18.68
1780	283038	228830	57991	8370995	0.65	33.92	27.42	6.95	0.0	0.198	37.0	2.21	1.22	30.28	50.99	18.73
1781	291768	219448	52452	8443315	0.86	34.70	26.10	6.24	0.0	0.186	38.7	2.27	1.31	30.92	50.30	18.80
1782	279295	262681	53621	8459929	0.20	33.05	31.08	6.34	0.0	0.228	33.3	2.18	1.09	31.56	49.81	18.63
1783	254668	274666	45587	8439932	-0.24	30.14	32.51	5.39	0.0	0.247	31.2	1.99	0.93	31.77	49.67	18.57
1784	294128	232808	58770	8501252	0.73	34.72	27.48	6.94	0.0	0.199	36.9	2.31	1.27	32.04	49.46	18.52
1785	280214	229026	50881	8552440	0.60	32.86	26.86	5.97	0.0	0.195	37.4	2.21	1.23	32.20	49.49	18.31
1786	286141	249267	58430	8589315	0.43	33.39	29.08	6.82	0.0	0.213	35.2	2.27	1.19	32.24	49.54	18.22
1787	301182	255738	57262	8634760	0.53	34.97	29.70	6.65	0.0	0.215	34.9	2.40	1.25	32.35	49.49	18.14
1788	291426	277450	54663	8648735	0.16	33.72	32.11	6.33	0.0	0.237	32.3	2.33	1.13	32.52	49.34	18.12
1789	300729	265144	57755	8684320	0.41	34.70	30.59	6.66	0.0	0.224	33.8	2.41	1.23	32.75	49.15	18.05
1790	308980	274220	58576	8719080	0.40	35.51	31.51	6.73	0.0	0.230	33.1	2.49	1.24	33.03	49.11	17.87
1791	309387	242263	57688	8786204	0.77	35.35	27.68	6.59	0.0	0.199	36.9	2.50	1.38	33.19	49.10	17.68
1792	305604	254368	55819	8837440	0.58	34.68	28.87	6.33	0.0	0.210	35.6	2.48	1.32	33.15	49.26	17.60
1793	301492	224213	56350	8914719	0.87	33.97	25.26	6.35	0.0	0.182	39.3	2.44	1.43	33.26	49.17	17.58
1794	307153	261683	54911	8960189	0.51	34.37	29.28	6.14	0.0	0.214	35.1	2.48	1.30	33.22	49.23	17.51
1795	285153	247800	50426	8997542	0.42	31.76	27.60	5.62	0.0	0.205	36.2	2.29	1.24	33.10	49.48	17.39
1796	292141	284968	52511	9004715	0.08	32.46	31.66	5.83	0.0	0.239	32.1	2.33	1.13	32.87	49.78	17.33
1797	287089	276213	56301	9015591	0.12	31.86	30.66	6.25	0.0	0.233	32.8	2.27	1.12	32.81	49.91	17.29
1798	314415	274159	65559	9055847	0.45	34.80	30.34	7.26	0.0	0.226	33.6	2.47	1.25	33.11	49.62	17.26
1799	297711	292483	53137	9061075	0.06	32.87	32.29	5.87	0.0	0.245	31.4	2.32	1.09	32.88	49.94	17.17
1800	263801	317543	49407	9007333	-0.59	29.20	35.15	5.47	0.0	0.279	27.9	2.04	0.86	32.53	50.40	17.06
1801	261769	332787	39281	8936315	-0.79	29.18	37.09	4.38	0.0	0.300	25.9	2.01	0.79	32.14	50.98	16.89
1802	273443	308419	51695	8901340	-0.39	30.66	34.58	5.80	0.0	0.277	28.1	2.08	0.88	31.81	51.38	16.80
1803	267829	355836	52349	8813333	-0.99	30.24	40.17	5.91	0.0	0.327	23.5	2.03	0.72	31.45	51.75	16.83
1804	302368	261943	73301	8853759	0.46	34.23	29.65	8.30	0.0	0.229	33.2	2.27	1.13	31.38	51.76	16.89
1805	318700	261677	74665	8910781	0.64	35.88	29.46	8.41	0.0	0.222	34.1	2.36	1.21	31.36	51.74	16.89
1806	308926	250299	73963	8969408	0.66	34.56	28.00	8.27	0.0	0.210	35.5	2.26	1.20	31.16	51.85	16.98
1807	334729	290380	76934	9013758	0.49	37.23	32.29	8.56	0.0	0.240	31.9	2.42	1.16	31.11	51.97	16.90
1808	332838	309715	69260	9036881	0.26	36.88	34.32	7.67	0.0	0.257	30.1	2.38	1.08	30.98	52.22	16.79
1809	332626	287062	57800	9082444	0.50	36.71	31.69	6.38	0.0	0.236	32.4	2.36	1.15	30.98	52.43	16.61
1810	316262	282589	61054	9116117	0.37	34.76	31.06	6.71	0.0	0.235	32.5	2.22	1.09	31.00	52.54	16.44
1811	299653	295588	60496	9120182	0.04	32.86	32.42	6.63	0.0	0.251	30.8	2.08	0.97	30.95	52.61	16.39
1812	314105	348240	77891	9086047	-0.37	34.51	38.26	8.56	0.0	0.298	26.1	2.17	0.85	30.93	52.81	16.27
1813	319024	315723	79569	9089348	0.04	35.10	34.74	8.76	0.0	0.269	28.9	2.19	0.95	30.82	53.08	16.14
1814	314962	270766	73725	9133543	0.49	34.57	29.72	8.09	0.0	0.228	33.3	2.14	1.07	30.97	53.08	15.94
1815	301629	279184	63264	9155988	0.25	32.98	30.53	6.92	0.0	0.237	32.3	2.04	0.99	31.31	52.88	15.83
1816	305230	327528	53257	9133690	-0.24	33.38	35.82	5.82	0.0	0.282	27.6	2.05	0.86	31.59	52.78	15.58
1817	284048	424519	52280	8993220	-1.54	31.34	46.84	5.77	0.0	0.383	19.3	1.92	0.55	31.46	53.29	15.23
1818	318089	271933	87920	9039375	0.51	35.28	30.16	9.75	0.0	0.236	32.4	2.15	1.05	31.97	52.96	15.05
1819	355422	256033	87753	9138765	1.10	39.10	28.17	9.65	0.0	0.210	35.6	2.41	1.28	32.23	52.73	15.00
1820	357791	261740	84349	9234815	1.05	38.95	28.49	9.18	0.0	0.210	35.6	2.42	1.29	32.33	52.69	14.97
1821	367808	264718	71860	9337905	1.12	39.61	28.51	7.74	0.0	0.208	35.8	2.49	1.34	32.59	52.44	15.03
1822	379968	275432	95043	9442441	1.12	40.46	29.33	10.12	0.0	0.212	35.3	2.58	1.36	32.76	52.20	15.07
1823	367712	250544	68886	9559609	1.24	38.70	26.37	7.25	0.0	0.191	38.0	2.50	1.42	32.98	52.02	15.00
1824	386666	257634	78200	9688642	1.35	40.18	26.77	8.13	0.0	0.192	37.9	2.63	1.49	33.22	51.83	14.96
1825	380496	254164	79660	9814974	1.30	39.02	26.06	8.17	0.0	0.188	38.5	2.59	1.48	33.57	51.53	14.88
1826	396302	279005	88849	9932272	1.20	40.14	28.26	9.00	0.0	0.204	36.4	2.70	1.47	34.13	51.03	14.88
1827	384289	259337	91796	10057220	1.26	38.45	25.95	9.18	0.0	0.188	38.4	2.62	1.50	34.59	50.39	14.99
1828	415056	313110	76438	10159170	1.01	41.06	30.98	7.56	0.0	0.224	33.8	2.83	1.44	35.02	50.01	15.01
1829	406008	352349	73101	10212830	0.53	39.86	34.59	7.18	0.0	0.255	30.3	2.77	1.27	35.26	49.75	15.00
1830	403374	348256	79554	10267950	0.54	39.39	34.01	7.77	0.0	0.254	30.4	2.75	1.26	35.62	49.35	15.01
1831	425605	342831	78712	10350720	0.81	41.28	33.25	7.64	0.0	0.246	31.3	2.90	1.37	36.21	48.74	15.07
1832	397524	346900	76424	10401340	0.49	38.31	33.43	7.37	0.0	0.253	30.5	2.71	1.25	36.84	48.14	15.04
1833	403961	362839	78494	10442460	0.40	38.76	34.82	7.53	0.0	0.265	29.2	2.75	1.21	36.96	48.17	14.89
1834	425876	345914	86281	10522420	0.77	40.63	33.00	8.23	0.0	0.248	31.1	2.90	1.36	36.91	48.13	14.95
1835	420697	355185	89430	10587930	0.62	39.86	33.65	8.47	0.0	0.255	30.4	2.86	1.31	36.81	48.29	14.96
1836	427254	427052	89586	10588130	0.00	40.35	40.33	8.46	0.0	0.308	25.2	2.91	1.11	36.54	48.59	14.88
1837	419283	332129	86046	10675280	0.82	39.44	31.24	8.09	0.0	0.238	32.1	2.85	1.38	36.31	48.76	14.89
1838	401951	318108	80432	10759120	0.79	37.51	29.68	7.50	0.0	0.229	33.3	2.72	1.36	36.10	49.01	14.92

Appendix Table 1. (Continued).

Year	Births	Deaths	Marriages	Population yearend	Population growth %	CBR	CDR	CMR	CMIGR	$_1q_0$	e_0	GRR	NRR	Age % 0-14	Age % 15-49	Age % 50+
1839	413753	324685	78737	10848190	0.83	38.30	30.05	7.29	0.0	0.230	33.1	2.78	1.38	35.81	49.21	14.99
1840	397584	333655	77377	10912120	0.59	36.54	30.67	7.11	0.0	0.239	32.1	2.64	1.28	35.50	49.48	15.04
1841	417487	332525	78204	10997080	0.78	38.11	30.35	7.14	0.0	0.234	32.7	2.75	1.35	35.26	49.62	15.11
1842	417004	364689	85549	11049400	0.48	37.83	33.08	7.76	0.0	0.256	30.2	2.71	1.23	35.04	49.82	15.19
1843	422169	332555	87812	11139010	0.81	38.05	29.98	7.92	0.0	0.231	33.0	2.70	1.34	34.86	49.92	15.20
1844	421409	340423	81072	11220000	0.73	37.69	30.45	7.25	0.0	0.235	32.5	2.66	1.30	34.79	49.96	15.24
1845	429461	314998	87370	11334460	1.02	38.08	27.93	7.75	0.0	0.213	35.1	2.66	1.40	34.83	49.96	15.18
1846	426073	321259	88663	11439270	0.92	37.42	28.21	7.79	0.0	0.216	34.8	2.58	1.35	34.73	50.16	15.16
1847	409418	358128	85834	11490560	0.45	35.71	31.24	7.49	0.0	0.244	31.5	2.43	1.15	34.64	50.34	15.06
1848	392104	292182	95478	11590480	0.87	33.98	25.32	8.27	0.0	0.198	37.0	2.28	1.26	34.59	50.32	15.06
1849	409690	432438	90033	11567730	-0.20	35.38	37.35	7.78	0.0	0.298	26.1	2.34	0.92	34.24	50.82	14.98
1850	416990	361476	96051	11623240	0.48	35.96	31.17	8.28	0.0	0.246	31.2	2.35	1.10	34.14	51.14	14.67
1851	437594	335369	96129	11725460	0.88	37.48	28.73	8.23	0.0	0.222	34.0	2.43	1.24	34.23	51.30	14.45
1852	425998	339699	91618	11811760	0.74	36.20	28.86	7.78	0.0	0.224	33.8	2.33	1.18	34.09	51.67	14.25
1853	447194	319820	92888	11939130	1.08	37.66	26.93	7.82	0.0	0.206	36.1	2.41	1.30	34.16	51.81	14.03
1854	401481	387495	78906	11953120	0.12	33.61	32.44	6.61	0.0	0.258	30.0	2.14	0.97	33.87	52.11	14.04
1855	418458	577332	90642	11794250	-1.33	35.24	48.62	7.63	0.0	0.394	18.6	2.22	0.62	33.45	52.61	13.93
1856	405022	366791	98302	11832480	0.32	34.29	31.05	8.32	0.0	0.252	30.6	2.14	0.99	33.22	52.86	13.97
1857	413439	353915	96169	11892000	0.50	34.85	29.84	8.11	0.0	0.239	32.1	2.16	1.04	33.09	52.92	13.98
1858	427548	336483	112176	11983070	0.77	35.82	28.19	9.40	0.0	0.222	34.0	2.22	1.13	32.98	52.98	14.03
1859	454394	342876	113411	12094590	0.93	37.74	28.48	9.42	0.0	0.220	34.3	2.34	1.21	32.98	53.02	14.02
1860	427818	318168	101384	12204240	0.91	35.21	26.19	8.34	0.0	0.204	36.3	2.19	1.19	32.80	53.13	14.02
1861	435889	348177	99446	12291950	0.72	35.59	28.43	8.12	0.0	0.222	34.1	2.21	1.13	32.68	53.38	13.94
1862	450180	364808	101118	12367577	0.62	36.51	29.59	8.20	-0.7	0.230	33.1	2.27	1.13	32.71	53.46	13.81
1863	489197	375322	103897	12471708	0.84	39.39	30.22	8.37	-0.7	0.230	33.1	2.46	1.22	32.99	53.28	13.76
1864	466990	372216	101637	12556738	0.68	37.32	29.74	8.12	-0.7	0.229	33.3	2.34	1.17	33.26	53.05	13.69
1865	480643	372749	116188	12654888	0.78	38.13	29.57	9.22	-0.7	0.226	33.6	2.40	1.21	33.42	53.00	13.60
1866	495302	372335	75590	12768110	0.89	38.96	29.29	5.95	-0.7	0.222	34.0	2.46	1.26	33.46	53.09	13.44
1867	465245	404069	90395	12819542	0.40	36.36	31.58	7.07	-0.7	0.245	31.3	2.31	1.09	33.41	53.40	13.20
1868	469182	370521	97850	12908459	0.69	36.47	28.80	7.61	-0.7	0.224	33.8	2.33	1.18	33.39	53.39	13.24
1869	481457	355901	101641	13024271	0.90	37.13	27.45	7.84	-0.7	0.211	35.4	2.38	1.26	33.76	52.83	13.36
1870	478117	388397	98718	13104246	0.61	36.60	29.73	7.56	-0.6	0.231	33.0	2.36	1.17	34.25	52.24	13.51
1871	493475	383977	97549	13204000	0.76	37.51	29.19	7.42	-0.6	0.225	33.7	2.43	1.23	34.54	51.82	13.70
1872	490023	386704	98946	13273941	0.53	37.01	29.21	7.47	-2.4	0.226	33.6	2.42	1.22	34.69	51.44	13.88
1873	472444	390100	103332	13322907	0.37	35.53	29.33	7.77	-2.4	0.230	33.1	2.34	1.17	34.67	51.26	14.09
1874	459072	400418	103128	13348183	0.19	34.42	30.03	7.73	-2.4	0.239	32.1	2.29	1.10	34.46	51.21	14.31
1875	507215	403402	112200	13418618	0.53	37.90	30.14	8.38	-2.4	0.234	32.6	2.54	1.25	34.57	50.94	14.52
1876	530188	385526	110612	13529903	0.83	39.35	28.61	8.21	-2.4	0.218	34.6	2.66	1.38	34.81	50.54	14.67
1877	488010	378328	99307	13606207	0.56	35.97	27.88	7.32	-2.4	0.216	34.7	2.46	1.28	34.83	50.32	14.86
1878	488476	396606	95748	13664699	0.43	35.82	29.09	7.02	-2.4	0.227	33.4	2.47	1.24	34.66	50.37	14.99
1879	510854	384592	101626	13757583	0.68	37.26	28.05	7.41	-2.3	0.216	34.8	2.58	1.35	34.71	50.22	15.09
1880	456335	399231	93118	13781309	0.17	33.14	28.99	6.76	-2.3	0.231	33.0	2.31	1.14	34.43	50.36	15.19
1881	514537	360468	101316	13902000	0.88	37.17	26.04	7.32	-2.3	0.200	36.8	2.60	1.43	34.45	50.24	15.34

Notes: See text for sources of births, deaths, marriages, population, and net crude migration rates (CMIGR).
Details regarding the annual inverse projection inputs are discussed in the text.
The following is a summary of the annual inverse projection inputs:
Initial population is Italy 1649.
Initial age distribution is Sweden 1751-1760 (Sundbärg 1909, pp. 200-206).
Annual births, deaths, and population 1650-1881.
Annual net migration rates are calculated from annual births, deaths, and yearend population.
q_x for e_0 27 and q_x for e_0 67 are from the West model life tables.
Net migration age distribution is for Sweden 1861-1915 (Central Bureau of Statistics 1969, p. 128).
Fertility schedule with mean age of childbearing 31 is from Coale and Demeny (1966, p. 30).