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DIFFERENTIALS IN DEMOGRAPHIC RESPONSES TO ANNUAL PRICE VARIATIONS IN PRE-REVOLUTIONARY FRANCE
A Comparison of Rich and Poor Areas in Rouen, 1681 to 1787

Patrick R. GALLOWAY *
University of California, Berkeley, USA

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Abstract. An examination of the annual responses of vital events to variations in wheat prices among groups of parishes in the city of Rouen from 1681 to 1787 reveals significant differences between rich and poor parishes in the strength of the preventive check. The urban poor respond to a price increase by dramatically decreasing fertility, while the fertility of the urban wealthy is virtually unaffected. An increase in prices is associated with relatively large increases in mortality, suggesting a strong positive check. However, little difference can be found between the rich and poor areas in the magnitude or timing of mortality responses to price variations.

Résumé. ***La réponse démographique différentielle aux variations annuelles des prix en France d'avant la Révolution: Une comparaison entre quartiers riches et pauvres à Rouen, 1681–1787.***
Un examen des réponses annuelles des événements démographiques aux variations du prix du blé dans des groupes de paroisses de la ville de Rouen de 1681 à 1787 révèle des différences significatives entre paroisses riches et paroisses pauvres dans l'intensité du contrôle préventif. Les citadins pauvres répondent à une hausse de prix par une baisse considérable de fécondité, tandis que la fécondité des riches est pratiquement inchangée. Une hausse des prix est associée à des augmentations relativement sensibles de la mortalité, suggérant un important contrôle positif. Toutefois, on ne trouve que peu de différences entre les riches et les pauvres dans l'ampleur ou le calendrier des réponses de la mortalité aux variations de prix.

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Author's address: Graduate Group in Demography, Program in Population Research, University of California, 2234 Piedmont Avenue, Berkeley, California 94720, USA.

1. Introduction

It has often been suggested, but rarely demonstrated in any rigorous manner, that the urban poor in pre-industrial Europe suffered more from high food prices, usually caused by bad harvests, than did the urban rich. The present inquiry focuses on the impact of annual fluctuations in wheat prices on annual variations in fertility, nuptiality, and mortality in Rouen, differentiating the responses by socioeconomic strata. The aim is to examine the differential impact, if any, of fluctuations in wheat prices on variations in vital events among the rich and poor using a methodology that adds a dynamic dimension to the usual cross-sectional analyses. The direction, magnitude, and temporal structure of these demographic responses are estimated and differences and similarities discussed. This type of analysis allows inferences to be made about the relative strengths of the short-term Malthusian preventive and positive checks and about the role welfare levels may play in the determination of the timing and magnitude of these checks within an urban context.

There is an extensive literature concerning the impact of annual harvest variations on vital rates in pre-industrial Europe. [1] Most of these investigations attempted to show some relationship between harvest variations, usually measured by grain prices, and mortality levels. Fertility and nuptiality responses were occasionally discussed. From his classic analysis of the Beauvaisis, Goubert concluded 'Le prix du blé constitue presque toujours un véritable baromètre démographique. L'ampleur et la fréquence des pointes cycliques du prix des

[1] See for example the work of Farr (1846), Appleby (1975) and Mirowski (1976) on London, Edwards on Norwich (1969), Yule (1906), Wrigley and Schofield (1981), and Schofield (1985) on England, and Wrigley (1969) and Appleby (1979) on England and France. Investigations focusing on areas in France include Goubert (1952, 1960) on Beauvais, Lefebvre-Teillard (1969) on Dole, Lebrun (1971) on Anjou, Perrot (1975) on Caen, and Beaudry (1976) on Périgord. For studies of France in general see Meuvret (1946, 1965), Goubert (1973) and Lebrun (1980). Similar analyses for places in Germany include Schreiber (1940) and Paas (1981) on Augsburg, François (1975) on Koblenz, Dreyfus (1956) on Mainz and Trier, and Hohorst (1977) on Prussia. Scandinavian studies include analyses by Heckscher (1935, 1954), Thomas (1941), Gille (1949), Jutikkala (1955), Utterström (1954, 1955, 1965), Imhof (1976), Turpeinen (1979, 1980), Kaukiainen (1984), and Johansen (1986). Studies covering other places include Flinn (1977) on Scotland, Piuz (1974) and Perrenoud (1979) on Geneva, Mendels (1970) on Flanders, Bruneel (1977) on Brabant, and Del Panta and Livi Bacci (1977) on Italy. A larger perspective is taken by Flinn (1981) in his analysis of various European parishes from 1500 to 1820. Post (1985) restricts his study of vital rates and price variations in Europe to the early 1740s.

grains provoquent l'ampleur et la fréquence des crises démographiques. Et celles-ci déterminent en grande partie les mouvements et même le niveau de la population' [Goubert (1952, p. 468)]. Although there was general agreement with Goubert that price variations affected vital rates, more precise estimates of the magnitude and timing of these effects awaited more rigorous statistical techniques. Lee (1981) set the stage for further analysis in his work on short-term variations in vital rates, prices and the weather in England. This was followed closely by similar investigations, each employing a distributed-lag model, but using methodologies and variables different enough to render direct comparisons difficult. [2] Moreover, virtually all previous research along these lines has been restricted to country, regional, or city-wide units of analysis with no attempts to differentiate varying responses by socio-economic strata. [3] A very promising source for investigating possible differentials is provided by a recently compiled data set for Rouen, however.

2. Data

Rouen in the eighteenth century was one of the largest cities in France with a population of some 80,000. It was a major administrative, ecclesiastical, and industrial center. Its primary industry was the production of cloth. Bardet (1983) has published an extraordinary work chronicling in fine detail the demographic and economic development of Rouen from the seventeenth through the nineteenth centuries. I restrict my examination of the data to the period 1681 to 1787 for three reasons. The last outbreak of plague occurred in Rouen in 1669 [Bardet

[2] See Eckstein et al. (1982, 1985), Bengtsson (1984), and Bengtsson and Ohlsson (1985) on Sweden, Richards (1983) and Weir (1984) on France, Schultz (1986) on England and Sweden, Bengtsson (1986) on England, France and Sweden, Hammel (1985) on Croatia, Galloway (1985) on London, and Galloway and Lee (1985) on pre-industrial Japan, Taiwan, and the Bombay Presidency.

[3] Mendels (1970) analyzed the differential impact of variations in prices on fluctuations in marriages in urban, proto-industrial, and agricultural areas in Flanders. Derouet (1980) examined the relative volatility of demographic measures over time among labourers and journaliers in rural Thimerais. I analyzed the impact of variations in prices on fluctuations in vital rates in nine European countries before 1870 and discussed the magnitude and the timing of these responses in relation to measures of industrialization, income, and urbanization. See Galloway (1987).

Table 1
Socioeconomic and demographic characteristics by social standing in Rouen.

Characteristic	Notables	Boutiquiers	Artisans	Labourers	Unknown	Rouen	Source: Bardet (1983)
Households							
% distribution of family heads							
1700–1729	21		26	27	26	100	v.1, p. 184
1730–1759	18		31	41	10	100	
1760–1792	16		32	46	6	100	
% distribution of family heads [a]							
Centre	39		53 [b]	8		100	v.2, pp. 121–124
West	28		59 [b]	13		100	
North	45		39 [b]	16		100	
East	2		58 [b]	41		100	
Faubourgs	1		64 [b]	35		100	
Indices of relative wealth							
Average taxes (livres tournois)							
1728	26.8	12.1	9.4	1.2			v.1, p. 230
Average rent (livres tournois)							
1773	488	266	202	77			
Demographic characteristics							
Age at first marriage 1640–1792							
Males	30.8	28.5	27.2	26.1			v.1, p. 255
Females	24.8	26.0	24.9	25.6			
Total marital fertility rate							
1670–1699	7.22	7.13	6.76	NA			v.1, p. 279
1700–1729	4.97	5.70	6.58	6.28			
1730–1759	4.98	5.00	5.83	5.94			
1760–1789	4.06	3.65	4.91	4.90			
Average age at last birth of women married before age 30							
1670–1699	37.1	38.1	40.3	39.0			v.1, p. 282
1700–1729	35.8	37.0	39.0	39.5			
1730–1759	36.3	36.1	37.9	37.7			
1760–1789	33.5	33.9	36.6	37.4			
Pre-nuptial conceptions per 100 first births							
1640–1792	6	11	12	22			v.1, p. 326
Life expectancy during the second half of the 18th century							
At birth	32.5		29.5 [b]	24.5		28.2	v.1, p. 373
At age 15	43.5		43.0 [b]	40.2		42.9	
Infant mortality rate [c]	242		269 [b]	322		282	

[a] The data are derived from plots on maps and are thus subject to some small error. The estimated distributions are calculated using a base which is the sum of officers, wholesale merchants, tavern keepers, wood artisans, cotton artisans, and labourers in 1773.
[b] Includes boutiquiers.
[c] Based on life expectancy at birth (cfr. supra) and Coale-Demeny model-west life tables.

(1983, Vol. 1, p. 347)]: prior to that time sporadic plague epidemics tended to dominate mortality fluctuations and would probably overwhelm any effects of the harvest on mortality. The period ends in 1787, two years before the revolution, which was a major structural change replete with chaotic price movements and questionable registration procedures. Finally, the exact limits of the period we can examine are determined by the fact that the demographic data needed are available only for the years 1681 to 1787.

Table 1 presents data on socioeconomic and demographic characteristics by social standing, more specifically for four occupational groups: notables, boutiquiers, artisans, and labourers. Both average taxes and rents reflect considerable differences between these groups in terms of wealth: the rich, i.e. the notables, were taxed at a rate twenty-two times that of the labourers and their house rents were six times greater. [4] Age at first marriage for women was about the same across all professions, although wealthy males tended to marry later than their poorer counterparts. Marital fertility and pre-nuptial conceptions were higher among the poor, suggesting that fertility levels were unimpaired by socioeconomic standing. Life expectancy at birth, a common measure of physical welfare, was 32.5 years for the notables, 29.5 for the boutiquiers and artisans, and 24.5 for the labourers. However, life expectancy at age fifteen (43.5, 43.0, and 40.2 years respectively) was about the same for all. This implies that the brunt of mortality differentials across socioeconomic strata was borne by infants and children. [5]

The methodology employed in the present analysis uses long series of annual births, marriages, and deaths. Bardet has published these data by geographic zone only (unfortunately not by parish or social standing). He divided Rouen into five zones: East, North, West, and Centre (all within the walls) and the Faubourgs (see fig. 1). My analysis will be concerned only with the area of Rouen within the walls since this area is fixed in size over time. Table 2 shows in some detail socioeconomic characteristics by zone. The poor are seen to be concentrated in the East, with the Centre being the locus of the affluent.

[4] It is of importance to note that nearly all residences within the walls of Rouen were rented (see tables 2 to 4 below).

[5] Direct calculation of urban infant mortality rates is problematic. A substantial number of infants born in the city were sent to the countryside to be breastfed, a practice which often led to the infant's death. See Blum (1985, pp. 536–540) for a detailed discussion.

Table 2
Socioeconomic characteristics by zone in Rouen.

Characteristic	Zone				Fau-bourgs	Rouen	Source
	East	North	West	Centre			
Households							
Number of hearths 1696	4889	2367	1954	3189	1058	13457	Bardet (1983, v.2, p. 9)
Number of hearths 1728	3830	2075	1417	2687	1438	11447	
Number of houses 1773	3425	2089	1167	2507	1735	10923	
Infrastructure							
Area of private buildings (ha) at end of 18th C.	27	16	11	26			Bardet (1983, v.1, p.97)
Houses per ha	127	131	106	96			
Fountains at end of 18th C.	10	6	8	18			Bardet (1983, v.1, p. 120)
Houses per fountain	343	348	146	139			
Wells 1826	115	100	42	72			Bardet (1983, v.1, p. 120)
Houses per well	30	21	28	35			
Lamps per km of street 1775	19	38	36	46			Bardet (1983, v.1, p. 127)
Indices of relative wealth							
Family assistance index 1720–89	101	33	36	8	49	57	Bardet (1983, v.2, p. 83)
Percent of all houses rented:							
1713	86	85	88	88			Bardet (1983, v.2, p. 95)
1773	87	82	83	82	76	83	
Average rent (livres tournois):							
1713	59	125	140	176			Bardet (1983, v.2, p. 95)
1773	175	265	334	421	201	268	

Cohabited houses as % of all houses 1773	24	8	12	5	16	14	Bardet (1983, v.1, p. 172)
Literacy							
Percentage of marriages with signatures 1670–1792							
Male	65	81	82	88	64	74	Bardet (983, v.2, p. 125)
Female	43	63	65	77	37	55	
Illegitimacy							
Illegitimate births per 100 total births 1681–1787	4.8	5.6	3.4	1.2	3.9	4.9	Bardet (1983, v.2, pp. 18–22)
Occupation (%distribution) [a]							
Officers 1597	9	51	13	28	0	100	Benedict (1981, p. 29)
Officers 1728	3	47	24	25	0	100	Bardet (1983, v.2, p. 121)
Officers 1773	9	55	18	16	1	100	Bardet (1983, v.2, p. 121)
Lawyers 1597	4	64	16	16	0	100	Benedict (1981, p. 29)
Well-to-do merchants 1565	12	9	13	65	0	100	Benedict (1981, p. 28)
Wholesale merchants 1773	2	2	16	79	1	100	Bardet (1983, v.2, p. 122)
Tavern keepers 1773	38	9	12	29	12	100	Bardet (1983, v.2, p. 124)
Wood artisans 1773	29	8	21	35	7	100	Bardet (1983, v.2, p. 122)
Cotton artisans 1773	61	3	3	4	29	100	Bardet (1983, v.2, p. 123)
Poor 1586	59	13	13	4	12	100	Benedict (1981, p. 30)
Labourers 1773	66	5	4	5	22	100	Bardet (1983, v.2, p. 123)
Percentage distribution within each Zone in 1773 [a,b]							
Notables	2	45	28	39	1	14	Bardet (1983, v.2, pp. 121–124)
Artisans	58	39	59	53	64	57	
Labourers	41	16	13	8	35	30	
Total	100	100	100	100	100	100	

[a] The data are derived from plots on maps and are thus subject to some small error.
[b] The estimated distributions are calculated using a base which is the sum of officers, wholesale merchants, tavern keepers, wood artisans, cotton artisans, and labourers in 1773.

Three measures of welfare by zone are available from Bardet: average rent in 1713, average rent in 1773, and a family assistance index covering the period 1720 to 1789. The last of these is calculated by dividing the total number of persons receiving family assistance by the total number of marriages (no population data are available) between 1720 and 1789, and then multiplying by 1000 [Bardet (1983, Vol. 1, p. 133)]. All three measures are highly correlated.

The average number of total births, legitimate births, marriages, [6] non-infant deaths, and total deaths, along with the welfare measures are shown for each zone in table 3. The coefficient of variation is presented for each detrended series. The series were detrended by dividing each data point in the series by an eleven-year average of data points centered around it. This eliminates any long-term movements from the series, since I am interested only in annual responses.

While ecological analysis utilizing four zones is helpful, investigation of smaller geographical units is likely to be more revealing. To this end I obtained Bardet's series of births, marriages, and deaths for each parish in Rouen in machine-readable form from Biraben and Blanchet (1985), to whom I am very grateful. These series, after detrending, cover a slightly shorter period – 1681 to 1744 instead of 1681 to 1787. While the zones might be characterized as too large as units of analysis, some of the parishes were actually too small. Spencer (1976, p. 40) has shown that a minimum average of twenty to twenty-two marriages per year is needed to avoid statistical problems related to increasing variance when using small numbers. I have, therefore, ranked the parishes by 1713 rent and grouped them using the criterion that each group must have an average of about fifty marriages per year, twice Spencer's minimum, between 1681 and 1744. This procedure resulted in eight groups (see appendix table A.1 and fig. 1). The relevant socioeconomic and demographic data for each group of parishes are shown in table 4. As with the data by zone, the family assistance index, 1713 rent, and 1773 rent are highly inter-correlated.

Annual variations in grain prices are used as a proxy for annual variations in the standard of living [Lee (1981, p. 357), Richards (1983, pp. 199–200), Weir (1984, p. 36), and Galloway (1985, p. 488)]. Over the short term, fluctuations in the price of grain were the primary determinants of variations in the real wage: we can observe empirically

[6] Series of first marriages and series of remarriages are unavailable.

Table 3
Socioeconomic characteristics and vital events by zone in Rouen.

Characteristic	Zone					Rouen [a]
	East	North	West	Centre	Total	
Socioeconomic						
Infant mortality rate [b]	290	265	268	263	282	282
Family assistance index 1720–1789	101	33	36	8	59	57
Rental houses as % of all houses						
1713	86	85	88	88	87	
1773	87	82	83	82	84	83
Average rent (livres tournois)						
1713	59	125	140	176	112	
1773	175	265	334	421	281	268
Vital events						
Average events per year, raw series, 1681–1787						
Total births	939	357	262	427	1986	2743
Legitimate births	894	337	253	422	1906	2608
Marriages	239	110	76	125	550	632
Non-infant deaths [c]	546	198	132	195	1060	1749
Total deaths	819	292	202	307	1621	2523
Coefficient of variation, detrended [d] series, 1681–1787						
Total births	0.081	0.057	0.072	0.059	0.056	0.053
Legitimate births	0.083	0.055	0.072	0.060	0.056	0.054
Marriages	0.149	0.121	0.127	0.108	0.100	0.101
Non-infant deaths [c]	0.324	0.311	0.303	0.316	0.303	0.331
Total deaths	0.212	0.206	0.199	0.195	0.195	0.230

[a] Rouen is the sum of zone East, zone North, zone West, zone Centre, Hôtel-Dieu, Hôpital Général, and the Faubourgs.
[b] The infant mortality rate is estimated based on the proportion of notables, artisans, and labourers in each zone using data shown in table 1.
[c] Non-infant deaths = Total deaths − (Total births * infant mortality rate).
[d] The detrended series are calculated by dividing each data point, call it x, in the series by an eleven-year average of data points centered around x.
Sources: Bardet (1983, Vol. 2). Family assistance index, p. 83; % houses rented, p. 95; average rent, p. 95; births, pp. 18–22; marriages, pp. 18–26; total deaths, pp. 18–24.

that from year to year nominal wages rarely fluctuated, while prices, which were dominated by grain, tended to vary substantially.

Data on grain prices in Rouen itself are not available for the entire period 1681 to 1787. A relatively short wheat price series does exist for

Table 4
Socioeconomic characteristics and vital events by group of parishes in Rouen.

Characteristic	Group of parishes [a]								
	1	2	3	4	5	6	7	8	Total
Socioeconomic									
Infant mortality rate [b]	295	292	281	277	258	261	254	244	274
Family assistance index									
1720–1789	105	98	41	29	17	32	18	7	59
Rental houses as % of all houses									
1713	85	86	86	86	86	88	87	89	87
1773	88	87	84	82	78	81	80	87	84
Average rent (livres tournois)									
1713	56	62	105	120	137	152	164	212	112
1773	165	184	242	264	370	353	389	448	281
Vital events									
Average events per year, raw series, 1681–1744									

Marriages	107	116	51	49	53	48	56	50	530
Non-infant deaths [c]	259	296	97	88	99	88	104	86	1121
Total deaths	384	450	146	141	145	133	161	135	1695
Coefficient of variation, detrended [d] series, 1681–1744									
Total births	0.109	0.087	0.078	0.066	0.074	0.077	0.069	0.069	0.059
Marriages	0.192	0.148	0.178	0.146	0.130	0.130	0.143	0.134	0.103
Non-infant deaths [c]	0.419	0.351	0.371	0.421	0.389	0.380	0.365	0.386	0.359
Total deaths	0.277	0.228	0.241	0.262	0.260	0.241	0.234	0.243	0.233

[a] Groups displayed in order of increasing average rent in 1713.
[b] The infant mortality rate is estimated from the following equation: Infant mortality rate = −0.183 ∗ (rent in 1773) + 325.443, where $r = -0.94$. This equation is based on the following data [Bardet (1983, v. 1, pp. 230, 373; v. 2, p. 116) and Coale and Demeny (1966, pp. 4–8)]:

	Rent 1773	Life exp.	Corresponding ${}_1q_0$ in West Model Life Tables
Ouvriers	77	24.5	321.8
Artisans and boutiquiers	220	29.5	269.3
Notables	488	32.5	241.9

[c] Non-infant deaths = Total deaths − (Total births ∗ Infant mortality rate).
[d] The detrended series are calculated by dividing each data point, call it x, in the series by an eleven-year average of data points centered around x.
Source: Appendix, table A.1.

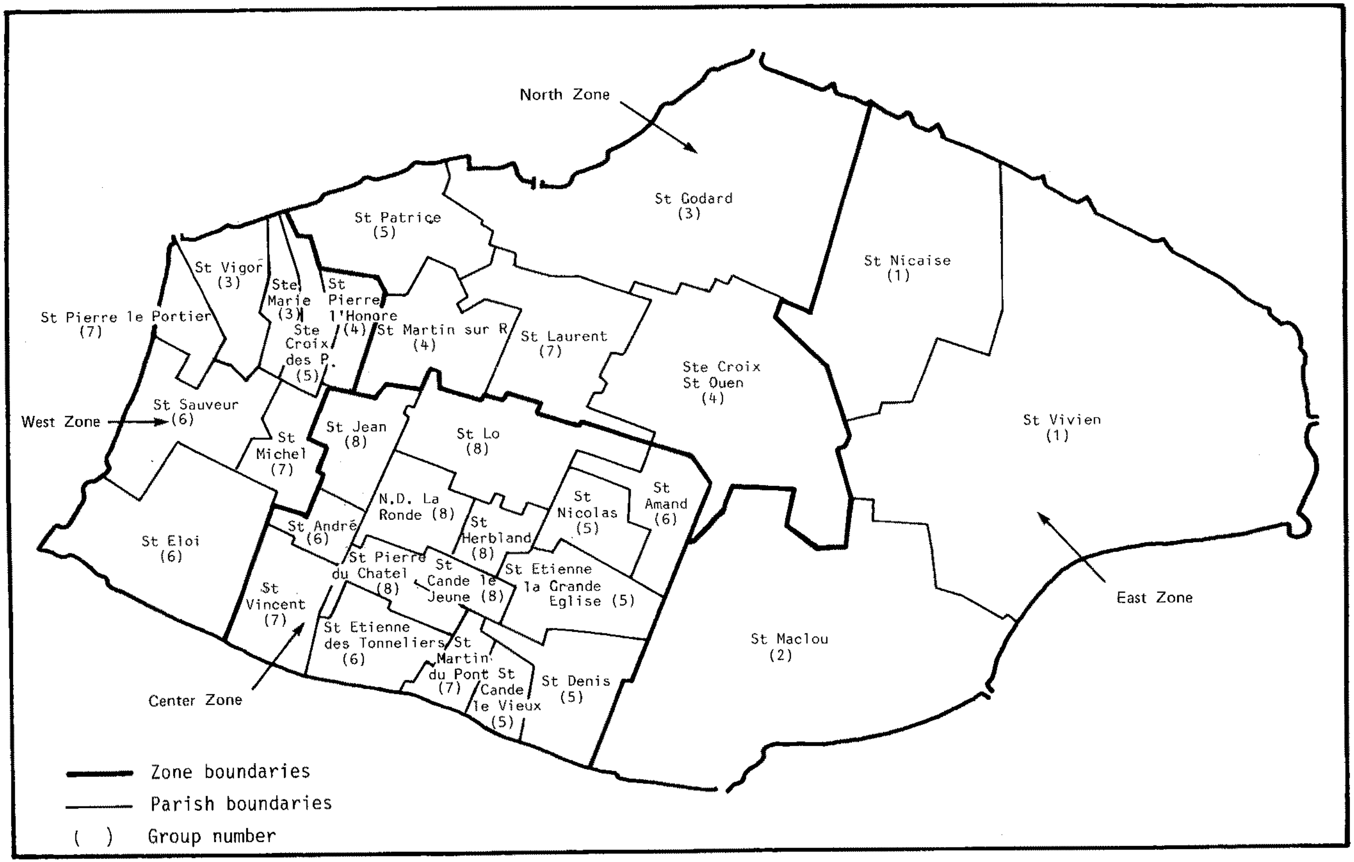

Fig. 1. Rouen–parishes within the walls.

Source: Base map is from Bardet (1983, v. 2, p. 57).

Rouen Généralité [Labrousse (1933, Vol. 1, p. 113)], but after detrending covers only the period 1761 to 1785. Pontoise calendar-year wheat prices [Dupâquier et al. (1968, pp. 31–101)] are, therefore, used instead. Pontoise is a small town some 90 kilometers southeast of Rouen; it is located in the same climatic zone so one would expect year-to-year variations in the size of the harvest, and in wheat prices, to be about the same. Where the detrended Pontoise and Rouen Généralité wheat-price series overlap, they are highly correlated ($r = 0.92$) and have virtually the same coefficients of variation (0.143 and 0.140 respectively). For statistical purposes the two series are virtually indistinguishable. Bardet states 'Pour le XVIIIème siècle, les estimations du bailliage de Rouen permettent de constater que les prix du Vexin sont très voisins de ceux de la Haute-Normandie' (1983, Vol. 1, p. 354). Vexin is the district surrounding Pontoise. In fact, Bardet uses the Pontoise wheat price series in his analysis of mortality crises in Rouen between 1650 and 1790 [Bardet (1983, Vol. 2, pp. 185–187)]. It is fairly certain that the Pontoise series accurately reflects annual wheat price movements in Rouen as far back as 1681.

3. Methodology

One useful statistical property exploited in short-term analysis of vital rates is the fact that most of the variation from one year to the next takes place in the numerator, i.e., the births, marriages or deaths themselves, while variations in the denominator, i.e., population size, tend to be relatively small, given of course a sufficiently large population [Spencer (1976) and Lee (1977)]. As a consequence, annual variations in say, births, represent an effective substitute for annual variations in the crude birth rate. This is important for the historical investigator since population counts are both more scarce and less reliable than the series of births, marriages, and deaths compiled by pre-industrial Europeans. In fact there exist no reliable population data for Rouen until 1797.

The methodology utilized in this study is similar to that used by Lee (1981). In order to assess the impact of annual variations of one variable on another over time it is essential to remove the long-term trend. Recall that this is accomplished here by dividing each point in a series, call it x, by an eleven-year average of points centered around x

[Lee (1981, p. 358)]. The resulting detrended series has some interesting properties. Its mean is nearly unity, hence its coefficient of variation is virtually the same as the standard deviation of the series. This method of detrending also removes the 15 to 20-year fluctuation cycles caused by changes in population size or age structure [Lee (1981, p. 358)]. All series used in our distributed-lag regressions are detrended using this procedure.

The basic idea is to estimate the magnitude and lag structure of the response of the dependent variable (births, marriages, or deaths) to annual changes in the independent variable (prices). It is likely that the dependent variable is affected not only by the impact of the contemporary explanatory variable, but also by previous values of the explanatory variable. A distributed-lag model is used to allow for effects on the dependent variable some years after the initial price shock. For example, an equation in which births are a function of prices distributively lagged five years where B is births, P is prices, a is a constant, b is a coefficient, e is the error term, and t is time would be:

$$B_t = a + \sum_{k=0}^{4} b_k P_{t-k} + e_t.$$

Correction for second-order autoregressive disturbances is accomplished using the Cochrane–Orcutt iterative procedure where the error process is defined as $e_t = \rho_1 e_{t-1} + \rho_2 e_{t-2} + u_t$ where t is time, e is the error term, u is an independently distributed random variable, and ρ is a coefficient. In a series with a moderate to large number of observations this correction should have little effect on the value of the regression coefficients, but it should provide a better estimate of their significance [Harvey (1981, pp. 189–198)]. Because of the nature of the detrending procedure the estimated coefficients are elasticities.

The number of annual lags utilized in the estimation process is set at five years for the independent variables. Lengthening the lags beyond these points generally provided no significant information while decreasing degrees of freedom. Terminating the lags at these levels is consistent with previous research. For the independent variables Lee (1981, p. 375), Richards (1983, p. 205), Eckstein et al. (1985, p. 306), Bengtsson (1986, pp. 15, 20), and Schultz (1986, pp. 38–39) used five years, Weir (1984, p. 47) four years, and Hammel (1985, p. 281) three years.

For analysis of the fertility and nuptiality responses, it is desirable to allow for the simultaneous impact of adult mortality fluctuations on fertility and nuptiality. We have, therefore, included an additional independent variable for this. Since we do not have direct data on adult deaths we have taken instead an estimate of non-infant deaths, which serves as a proxy for both adult mortality and morbidity.

Non-linear effects of prices and non-infant deaths on vital rates will be examined by including squared terms in the equations. Finally, to explore the possible impact of consecutive years of high prices on vital rates, a variable that represents the number of consecutive years in which prices are one standard deviation above normal will also be included in the equations. Details of the equations used in this analysis will be discussed in the appropriate sections.

4. Demographic response differentials among the rich and poor

To the extent that price changes reflect movement in per capita food supply, those members of society having access to adequate food storage facilities or possessing sufficient capital to purchase grain during periods of shortage will be less affected by variations in the harvest. Consequently one would expect the elasticities of response of fertility, nuptiality, and mortality to a price increase among the urban well-to-do to be close to nil, while among the urban poor fertility and nuptiality should decline and mortality should increase. Indeed among those who control the means of distribution of stored and recently harvested grain, one might expect an increase in profitability during a poor harvest, perhaps leading to increased fertility and nuptiality. The causal factors and temporal structure of the fertility, nuptiality, and mortality responses will be discussed separately in the following sections.

4.1. Fertility response to price change among the rich and poor

Fluctuations in fertility resulting from variations in grain prices may be caused by a number of factors which can be grouped according to biological or behavioural criteria. Biological responses resulting from a decline in nutrition as a result of high food prices may be an increase in age at menarche, a reduction in the age of menopause, higher frequency of secondary sterility, an increase in spontaneous abortion, an increase in famine amenorrhoea, or an increase in fertility-reducing diseases [Hillman and Goodhart (1973), Le Roy Ladurie (1975), Frisch (1978a, b), Bongaarts (1980), Gibbs and Seitchik (1980), Underwood (1981), Menken et al. (1981), Bongaarts and Potter (1983), and Gray (1983)]. Fertility responses that might be categorized as behavioural would be induced abortion, voluntary control through increased conscious contraception, an increase in amenorrhoea as a result of psychological stress, an increase in abstinence, decreased libido, or a decrease in coital frequency caused by spousal separation as one or both partners search for means to obtain food, usually through employment, charity, or theft.

Direct evidence to measure the extent and magnitude of these factors is generally lacking for historical populations. In fact, there are practically no historical data, that can come to terms with questions about annual variations in abortion, age at menarche, or secondary sterility. Attempts to measure the extent of voluntary contraception are usually complicated by the difficulties involved in measuring the confounding influence of secondary sterility. Fluctuations in short-term migration resulting from fluctuations in the harvest and consequent inferred variations in coital frequency can be estimated by measuring short-term internal and external peasant migration. However, within the urban context spousal separation as a result of short-term migration would not significantly affect fertility. During a poor harvest migration is observed to occur from the countryside into the city, primarily because the city is the centre of charitable food distribution, storage facilities, and possible employment. Little movement is seen from the city into the countryside. Most births registered in the city are to residents, and any migration of residents within the city could only marginally affect fertility.

There is little research on the differential impact of variations in food supply on fluctuations in fertility among the rich and poor. Frisch (1978b, p. 199) presents some evidence that fertility among working-class women in 19th-century Britain was impaired by poor nutrition, hard physical work, and poor living conditions. More relevant to the present analysis, Stein and Susser found that during the 1944–45 Holland famine, fertility decline was greater among the working classes than the higher social classes (1978, p. 131). They suggest that this was a consequence of the higher social classes' greater access to food, an explanation which ‘emphasizes the influence of current nutritional state on fecundity’ [Stein and Susser (1978, p. 140)].

Although the Rouen data are unable to address many of the direct causal determinants of fertility decline resulting from high prices, we can still measure the magnitude and timing of the fertility response across socioeconomic strata and speculate on the reasons behind the resulting consistency or inconsistency of patterns in the hope of shedding some light on the strength of the preventive check. To that end we have run regressions utilizing annual detrended births as the dependent variable. Note that most of the annual variations in the fertility variable result from variations in *marital* fertility since annual variations in births resulting from newlyweds or unmarried couples will have only a marginal impact on annual variations in overall fertility [Lee (1981, pp. 366–369) and Weir (1984, p. 39)]. Annual detrended grain prices and annual detrended non-infant deaths each distributively lagged five years are the independent variables.

Regressions of eq. 1 were run for each of the eight groups of parishes, each of the four zones, the total of the parish groups, and the total of the four zones:

$$B_t = a + \sum_{k=0}^{4} b_k P_{t-k} + \sum_{k=0}^{4} c_k N_{t-k} + e_t, \tag{1}$$

where B is births, P is prices, N is non-infant deaths, e is the error term, and t is time.

Regressions using legitimate births were also run for each zone but not for groups of parishes (data on legitimacy at the parish level are not available to the author). Additionally, squared price terms are included in each regression in an effort to determine the extent of non-linear effects. Finally a ‘price runs’ dummy variable is included. This assigns the value one to the second year of two consecutive years in which each year was at least one standard deviation above the mean.

Fig. 2 presents the estimates of the *b*-coefficients, i.e., responses of fertility to an increase in prices, independent of non-infant mortality effects, for each group of parishes, each zone, group total, and zone total. The groups of parishes are displayed in the left-hand panels in order from left to right by 1713 average rent. The four zones are shown in a similar manner in the central panels.

The regression results may be interpreted as follows using Parish Group 1 (shown on the extreme left-hand side of the left-hand panels in fig. 2 and in the top line of appendix table A.2) as an example. Recall that the regression coefficients are elasticities. Say there is a 100% increase in prices at lag 0. This would result in a negligible (0.1%) increase in births at lag 0 (top panel), followed by a considerable (12.6%) decrease in births a year later (lag 1 panel), a small (3.8%) increase in births two years after the shock (lag 2 panel), a small (2.7%) increase in births three years after, and a very small (0.9%) decrease in births four years after. The greatest effect is one year after the shock. This is what one might expect since gestation is about nine months. The effect is negative and highly significant as predicted. The lag sum (shown in the bottom panel), which is the net effect of a price shock cumulated over all five years, shows a 6.9% decline in births.

The most striking finding is the large and significant decline in fertility one year after the price shock (lag 1) among the poor, in contrast to the relatively muted impact found among the rich. This is most clearly observed among the eight parish groups. While there is some rebound in births two and three years after the price increase, the cumulative effect (lag sum) over five years still reflects the differential response observed at lag 1 within the parish groups and zones. There is a tendency for the rich actually to increase fertility as a result of high prices. It is noteworthy that the lag sum of the group total and the zone total is practically nil, disguising the different effects found using smaller units of analysis. Substituting legitimate births, available only for the four zones, for total births in the regressions yields virtually the same results.

Since these fertility responses to price changes are independent of mortality effects, are the same for total births and legitimate births, and are unlikely to be affected by migration or spousal separation, it appears likely that voluntary marital fertility control is being practised among the urban poor of Rouen in response to high grain prices (although stress, loss of libido, and famine amenorrhoea effects cannot be completely ruled out). As mentioned above it has been shown that annual variations in nuptiality can have little effect on annual fluctuations in overall fertility. This control is probably accomplished through abstinence, coitus interruptus, abortion, or contraceptive use. Finally, fertility control in response to higher prices is clearly not practised among the urban affluent.

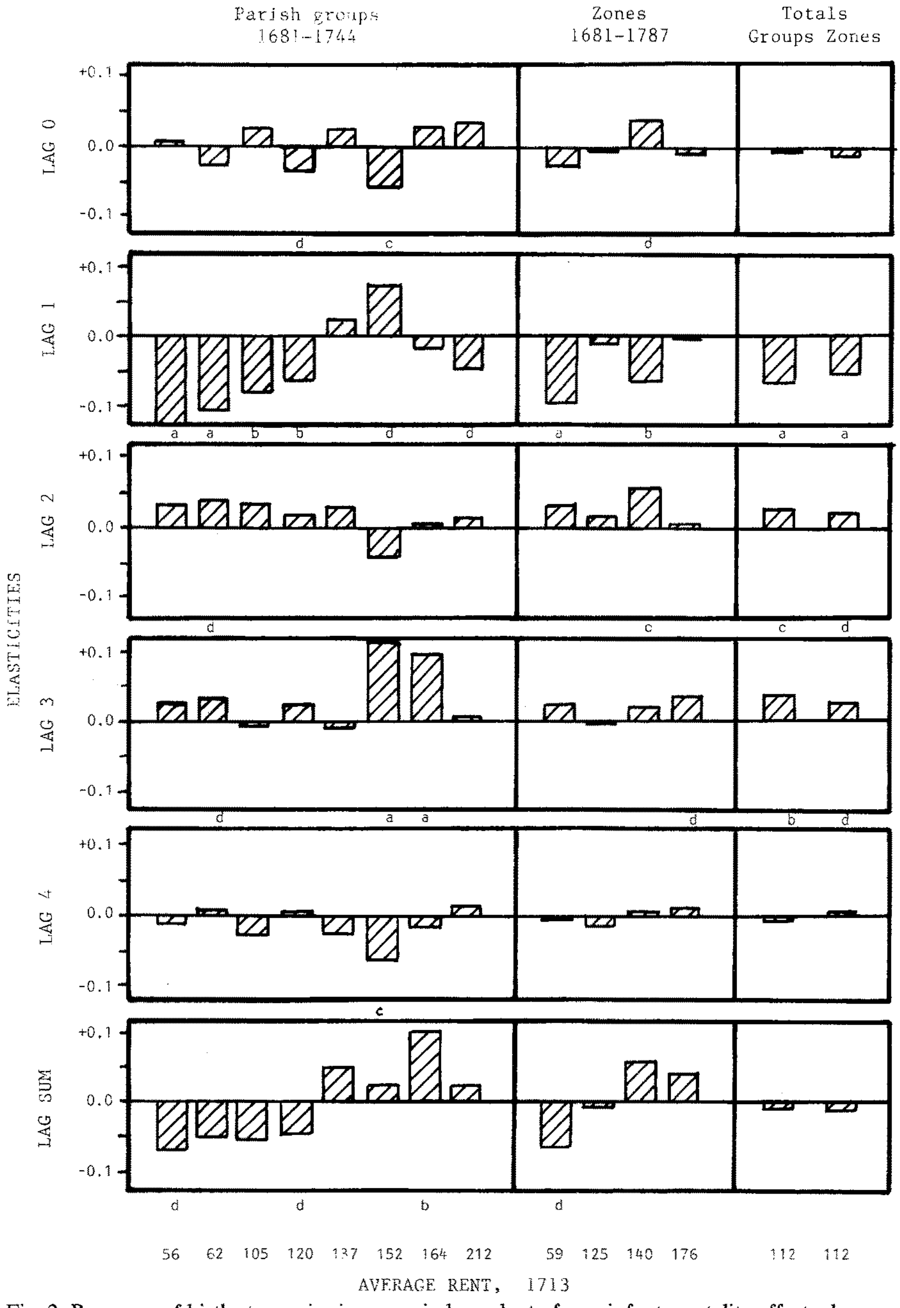

Fig. 2. Response of births to a price increase, independent of non-infant mortality effects: by area within Rouen.

[a,b,c,d] The *t*-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (1).

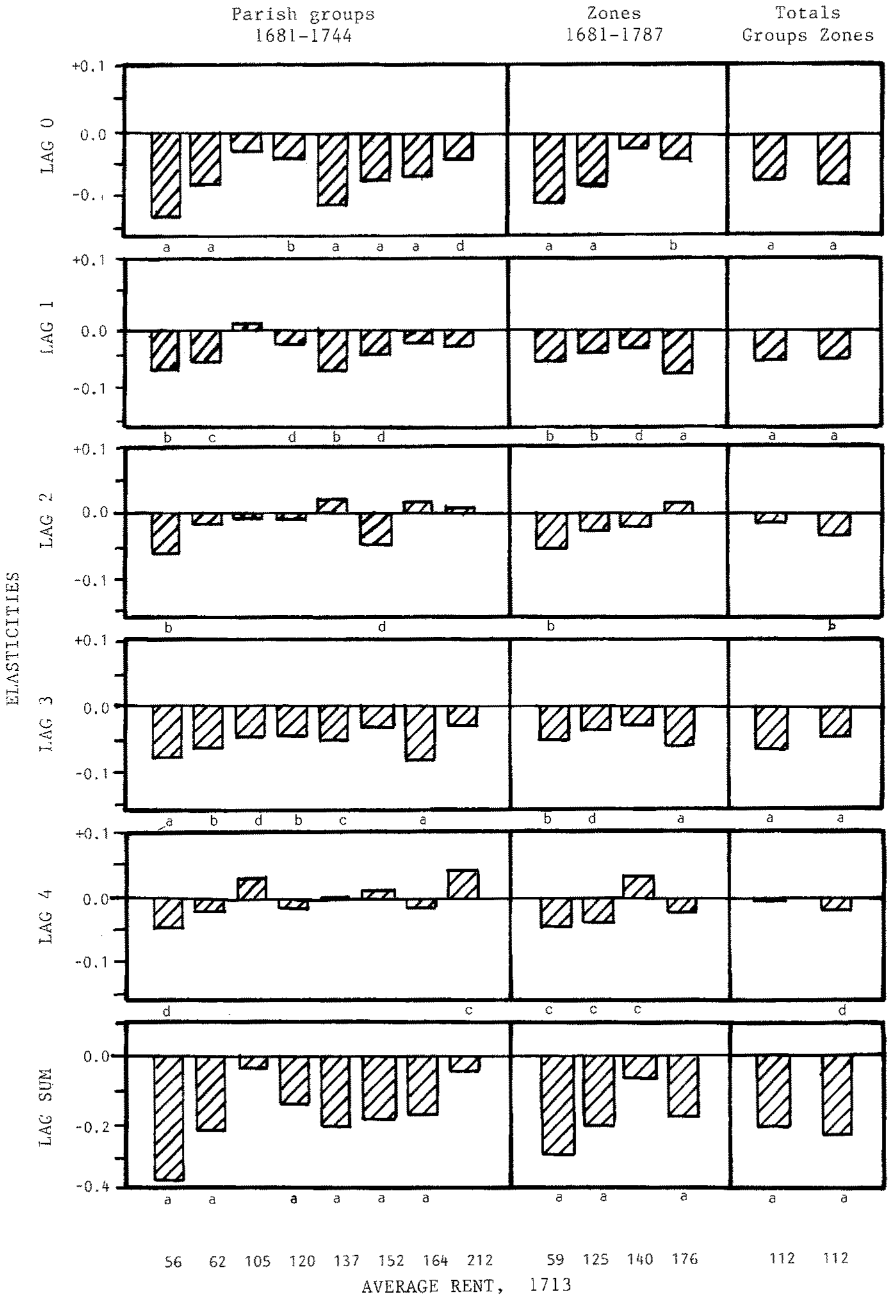

Fig. 3. Response of births to a non-infant mortality increase, independent of price effects: by area within Rouen.

[a,b,c,d] The t-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (1).

Fig. 3 displays the estimates of the c-coefficients in eq. 1, i.e., the response of births to an increase in non-infant deaths (our proxy for adult mortality and morbidity) independent of price effects. An increase in deaths is associated with a contemporary (lag 0) decrease in births across all groups and zones. The reason is fairly straightforward. As the number of female deaths increases, births decrease since some of those deaths are of pregnant women. The effect is compounded by male deaths and female morbidity, the latter leading to miscarriages and spontaneous abortions. Across socioeconomic strata it appears that the cumulative effect (lag sum) of mortality on births is strongest among the very poor. This may reflect a relatively greater likelihood of the poor to contract fertility-inhibiting diseases.

The amount of variance explained in the fertility regressions runs from 16 to 74% with the greatest amount found among the poorest groups and zones. Adding squared price terms and price-run terms generally does not increase the amount of variance explained.

4.2. *Nuptiality response to price change among the rich and poor*

Periods of dearth should decrease or postpone marriages as the prospects for setting up a successful household are diminished. A surge in adult mortality would increase the stock of widows and widowers, leading to an increase in remarriages. An increase in adult mortality would also open up economic opportunities for those not yet married, allowing them to marry. On the negative side, heightened mortality would be accompanied by an increase in mourning which would tend to delay some marriages. The perception of increased mortality and morbidity might dampen the atmosphere of nuptial expectations, leading to postponement of marriage for some and perhaps permanently discouraging marriage for others.

The regressions of nuptiality on prices and non-infant deaths, a proxy for adult mortality and morbidity, are similar to those for fertility with marriages, M, being the dependent variable:

$$M_t = a + \sum_{k=0}^{4} b_k P_{t-k} + \sum_{k=0}^{4} c_k N_{t-k} + e_t. \quad (2)$$

The response of marriages to a price increase independent of mortality effects is shown graphically in fig. 4. Looking at lag 0, only the very

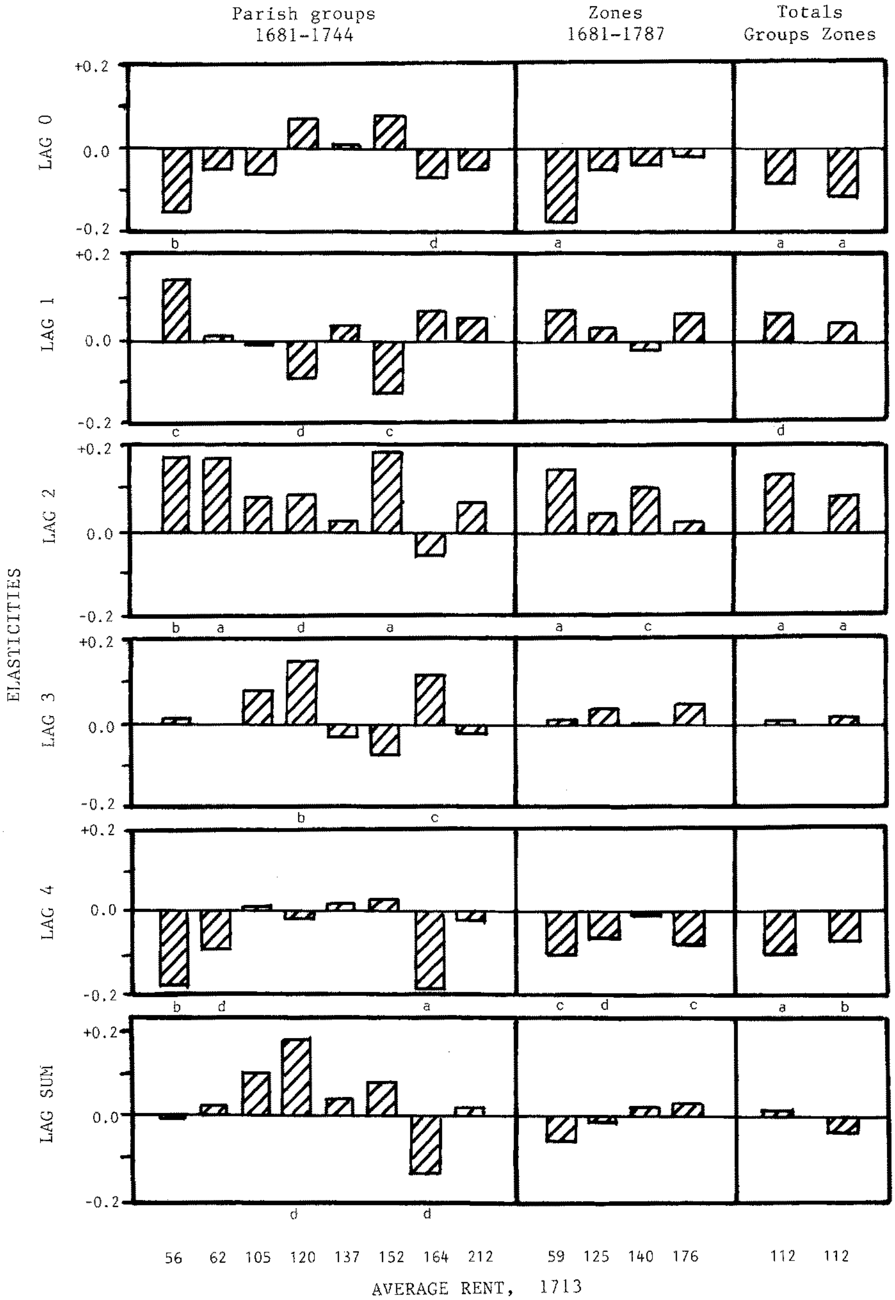

Fig. 4. Response of marriages to a price increase, independent of non-infant mortality effects: by area within Rouen.

[a,b,c,d] The *t*-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (2).

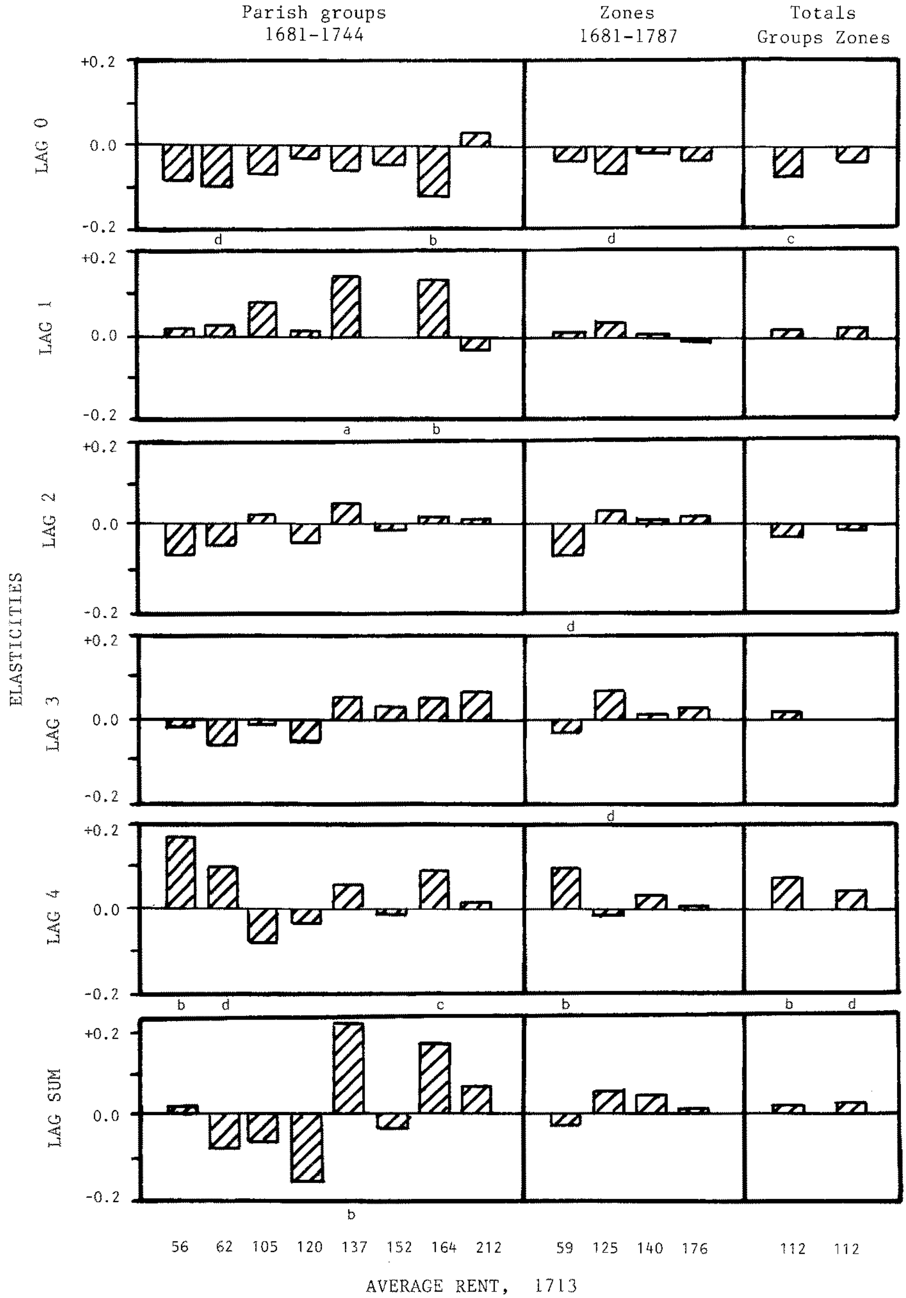

Fig. 5. Response of marriages to a non-infant mortality increase, independent of price effects: by area within Rouen.

[a,b,c,d] The t-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (2).

poor seem to exhibit a significant negative response to an increase in prices. However they also experience a significant positive rebound one and two years after the price shock. The very poor do delay marriage to a greater extent than the average or wealthy, but over the long term the differences are minor: the cumulative effect (lag sum) over five years shows a virtual nil response across all socioeconomic levels among the four zones. The pattern of the lag sum response across the parish groups is difficult to interpret, but in no case is the cumulative elasticity highly significant.

The response of nuptiality to non-infant mortality net of price effects is displayed in fig. 5, which shows that an increase in deaths reduces marriages in all groups and zones at lag 0 except among the very rich, but most of the elasticities are statistically insignificant. It is difficult to distinguish any regular pattern of response across the various groups and zones. Finally, we can note that the amount of variance in nuptiality explained by prices and non-infant deaths together ranges from only 10 to 41%.

4.3. Mortality response to price change among the rich and poor

Among the fertility, nuptiality, and mortality responses to price fluctuations one might at first expect that the mortality response would manifest itself most convincingly in accord with socioeconomic level. After all, food consumption among the wealthy is unlikely to be significantly diminished as a result of high prices. It would seem that an increase in deaths resulting from malnutrition and famine-induced diseases would be most evident among the poor.

Regressions were run using eq. 3 where non-infant deaths, N, is a function of prices distributively lagged five years. In eq. 4, total deaths, D, is the dependent variable.

$$N_t = a + \sum_{k=0}^{4} b_k P_{t-k} + e_t, \tag{3}$$

$$D_t = a + \sum_{k=0}^{4} b_k P_{t-k} + e_t. \tag{4}$$

The regression results are shown in fig. 6, which displays the non-in-

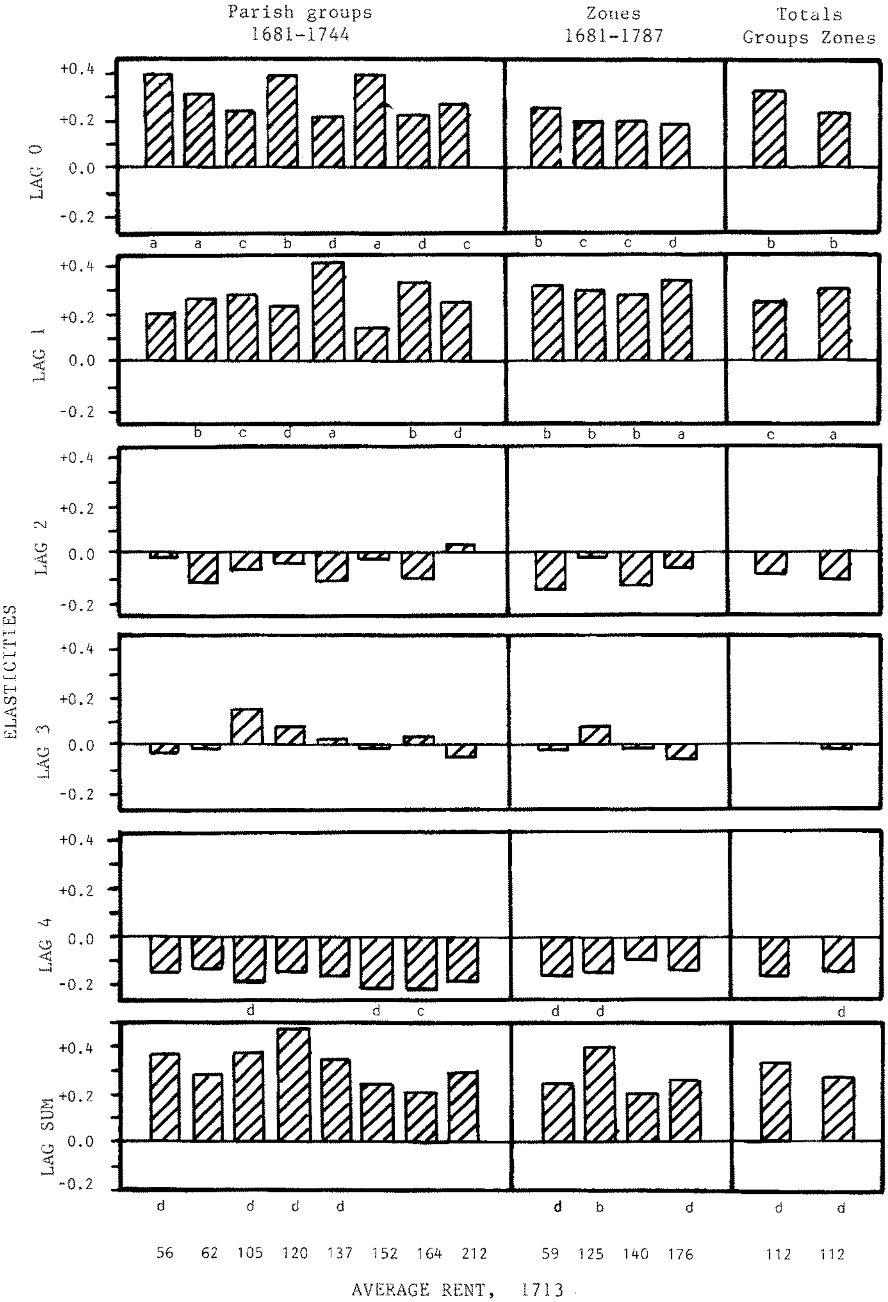

Fig. 6. Response of non-infant deaths to a price increase: by area within Rouen.

[a,b,c,d] The t-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (3).

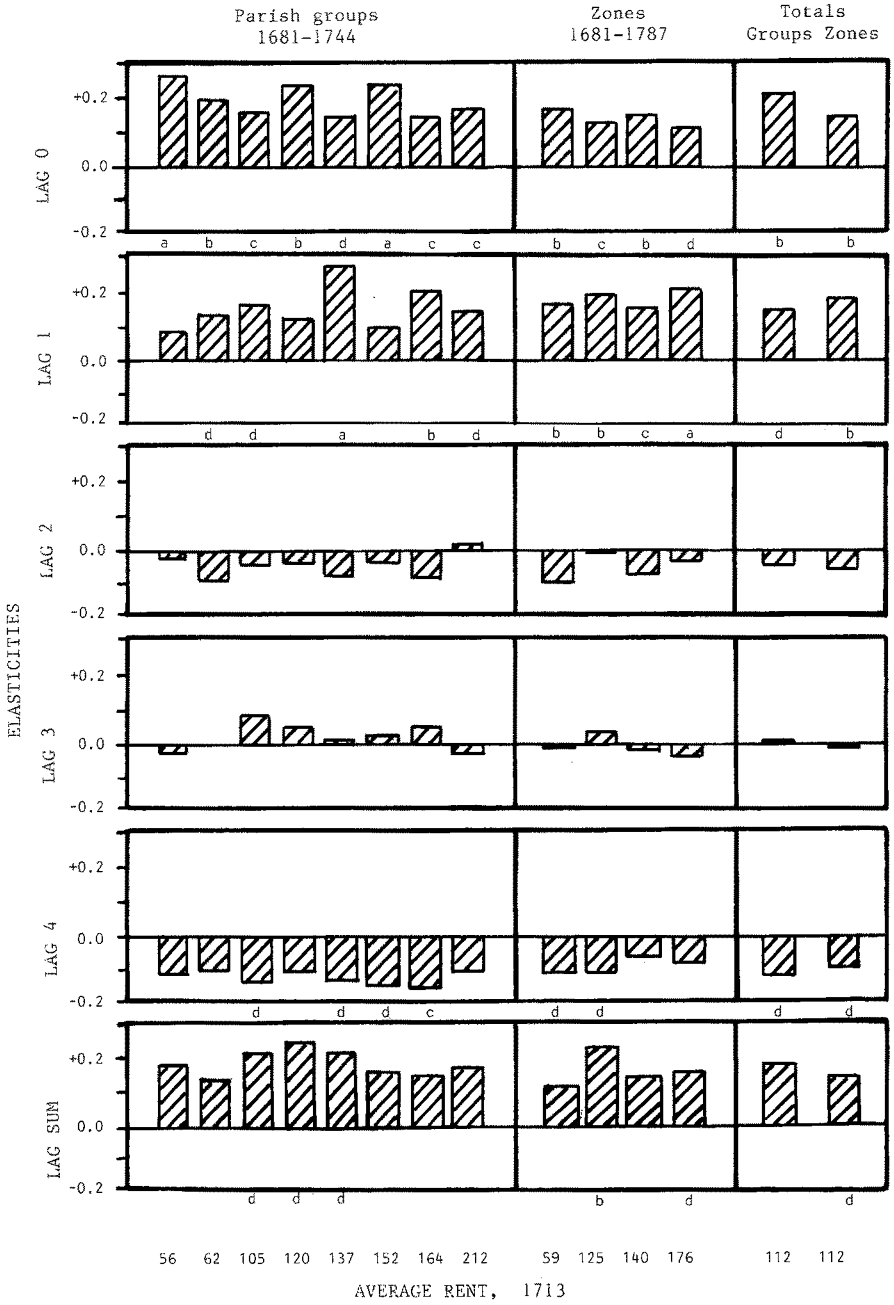

Fig. 7. Response of deaths to a price increase: by area within Rouen.

[a,b,c,d] The *t*-statistic is significant at the following levels: a = 1%, b = 5%, c = 10%, d = 20%.

Source: Appendix, table A.2, eq. (3).

fant response to a price increase, and fig. 7, which shows the response of total deaths to a price increase. The figures show a profound and significant increase in deaths at lags 0 and 1 as a result of an increase in prices. Although an almost imperceptibly greater increase in the response of the poor relative to the wealthy can be discerned at lag 0 and in the lag sum, in general one is forced to conclude that mortality responses among the rich and poor to higher grain prices are virtually the same in terms of both magnitude and timing. This rather surprising finding merits some explanation.

It is difficult using historical data to separate the direct effects on mortality of a decrease in food supply, mainly starvation and malnutrition, from other effects which involve interactions of malnutrition, impaired immuno-competence, increased migration, and an increase in infectious disease [Scrimshaw et al. (1968), Axelrod (1980), Snyderman (1980), Martorell and Ho (1984), Carmichael (1985), Livi Bacci (1985), McKeown (1985), Taylor (1985), Tilly (1985), and Watkins and van de Walle (1985)]. It has been argued by many, including Graunt (1662, p. 20) in reference to London, that few persons actually died of starvation during poor harvest years. The increase in mortality is rather a function of the increased susceptibility of the body to various diseases as a result of malnourishment. May and Anderson note 'Of special importance are the effects that can arise from the now widely recognized fact that the impact of an infection is often related to the nutritional state of the host. Broadly speaking, malnourished hosts have lowered immunological competence, and are less able to withstand the onslaught of infection. The effective pathogenicity of a parasite therefore tends to increase as host density rises to a level where competition for available food resources is severe' [May and Anderson (1979, p. 460)]. However the urban rich were unlikely to suffer reduced grain consumption as a result of high prices. Nonetheless the empirical findings indicate that the magnitude of mortality increase as a result of an increase in prices is about the same among the wealthy as the poor. It is possible that food consumed by the wealthy, while normal in quantity, may be contaminated or of poor nutritional quality during periods of dearth.

It is also possible that nutritional state has little impact on increasing survival among the rich relative to the poor during a bad harvest. I have shown elsewhere that deaths from epidemic diseases, i.e. smallpox, typhus, and fevers, increased when grain prices increased in London during the period 1675 to 1825 [Galloway (1985, pp. 498–500)]. I suggested that an increase in the frequency of interaction among different members of the urban and rural populace as a result of short-term migration into the city caused by a poor harvest would probably lead to an increase in the probability of contracting infectious diseases in the city. This is consistent with Meuvret's suggestion that '...the connexion between disease and dearth seems to be mainly due to the spread of infection consequent upon movements undertaken to escape regions experiencing food-shortage' [Meuvret (1965, p. 511)]. The rich were as ignorant as the poor in matters of personal hygiene and, based upon my findings, the presumably greater access to food supplies among the wealthy provided no protection from increased mortality. Infectious diseases during periods of dearth appear to have spread with ease to all classes in densely populated Rouen.

What were the mechanisms by which infectious disease spread to the more affluent members of Rouen society? Casual day-to-day interaction of the wealthy with the poor is one possibility. Another lies in the institution of domestic service. Nearly all wealthy households employed domestics who, during a poor harvest, may have contracted illnesses from poorer relatives and then spread the diseases among their employer's household. Hufton explains that 'in Montpellier and Agde, when the harvests of the Rouergue or the Gévaudan were deficient, or even when the grape-harvest did not demand as much seasonal labour as usual, these cities were flooded by pauvres montagnards, beggars who were all of a kind, farmers whose resources had temporarily failed them, and with them came their wives and children. Such people, hoping for enough to tide them over a few difficult months, appealed to their relatives established in wealthy households for simple help, slops, bones, and bits of bread from the master's table' [Hufton (1974, p. 101)]. Empirical evidence lends some support to this notion. Looking at the cumulative effect over five years (lag sum) of a price increase on mortality in fig. 6, the zone with the greatest increase in deaths is the North zone, designated by an average rent of 125 livres tournois. Bardet shows that of the four zones, the greatest number of domestics per household in Rouen is found in the North zone [Bardet (1983, Vol. 2, p. 120)].

Finally, the amount of variance in mortality explained by changes in prices ranges from 19 to 36%. An examination of non-linear effects reveals that consecutive years of high prices seem to increase mortality significantly among the poor, probably as a result of infectious diseases contracted as a consequence of prolonged malnourishment.

5. Conclusions

From a demographic perspective, high prices had the greatest impact on mortality in Rouen; however, little difference between rich and poor areas can be found in either the magnitude or the timing of mortality response. The positive check appears to be equally effective across all socioeconomic strata, although the poor seem to suffer more as a result of consecutive years of high prices.

The primary difference between the responses of the rich and the poor urban areas to an increase in grain prices is found in the preventive check, i.e., fertility. The poor areas experience a large and significant fall in fertility as a result of high prices, while the fertility of the more affluent areas is hardly affected. It is suggested that the poor's response probably takes the form of voluntary fertility control operating through increased abstinence, coitus interruptus, abortion, or contraception. Cross-sectional statistics show that the poor actually maintained higher fertility levels than the rich (see table 1). Thus the vulnerability of the urban poor in terms of the preventive check is reflected only in the dynamic analysis.

Appendix

Table A.1
Socioeconomic characteristics and vital events by parish and group of parishes: Rouen 1681–1789.

Parish	Houses		Average rent		% rented		1720–1789		Births 1681–1744		Marriages 1681–1744		Deaths 1681–1744	
	1713	1773	1713	1773	1713	1773	Mar-riages	Assis-tance	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
Nicaise	499	463	52	161	85	88	2176	102	88	17.5	25	7.5	84	27.5
Vivien	1219	1158	58	166	85	87	6170	106	333	40.7	82	18.0	299	105.8
Group 1	1718	1621	56	165	85	88	8346	105	421	49.4	107	22.5	384	128.0
Maclou	1936	1806	62	184	86	87	9558	98	528	62.5	116	18.8	450	124.0
Group 2	1936	1806	62	184	86	87	9558	98	528	62.5	116	18.8	450	124.0
Vigor	166	122	99	282	92	85	606	36	35	6.6	9	3.4	27	9.9
Godard	741	793	106	230	85	83	2832	44	118	25.2	36	7.7	103	34.8
Marie la Petite	105	93	107	288	86	89	376	29	21	4.9	5	2.6	16	6.1
Group 3	1012	1008	105	242	86	84	3814	41	173	30.6	51	9.9	146	46.4
Pierre l'Honoré	150	159	116	259	87	79	725	28	39	7.7	10	3.0	30	12.9
Croix et Ouen	456	426	121	260	84	82	1710	29	92	13.7	24	6.4	68	20.7
Martin sur Renelle	251	252	121	273	89	85	1192	29	63	8.5	16	4.2	44	15.1
Group 4	857	837	120	264	86	82	3627	29	194	21.8	49	9.3	141	44.6
Nicolas	136	110	129	322	87	90	444	5	22	4.4	7	2.8	17	6.2
Croix des Pelletiers	117	115	131	266	84	85	579	35	24	5.7	8	3.4	21	7.6
Patrice	256	236	132	314	83	75	1007	32	38	7.0	13	3.6	39	16.4

Cande le Vieux	173	168	145	387	92	73	655	14	38	6.9	9	3.4	28	11.3
Denis	190	205	145	464	87	73	724	4	34	7.9	10	3.4	24	9.8
Group 5	1007	991	137	370	86	78	3934	17	181	22.5	53	9.3	145	46.6
André de la Ville	64	69	147	346	86	80	313	16	15	3.9	4	2.0	10	3.6
Eloi	323	333	151	375	86	80	1500	44	79	11.3	20	4.1	63	17.8
Sauveur	166	118	153	343	91	86	568	51	35	6.3	11	3.8	25	8.7
Amand	78	66	153	329	91	83	298	7	11	5.2	4	2.3	10	4.6
Etienne des Tonnel.	163	190	154	333	87	79	609	5	31	5.7	8	3.3	24	7.9
Group 6	794	776	152	353	88	81	3288	32	172	21.3	48	6.9	133	34.6
Vincent	253	233	159	450	85	76	945	12	55	9.6	12	3.8	37	10.5
Martin du Pont	155	148	159	473	89	79	777	14	49	10.6	11	4.0	34	11.5
Laurent	406	374	162	310	85	81	1294	17	69	12.2	18	4.0	52	15.2
Pierre le Portier	62	46	175	434	89	93	324	59	15	3.5	4	2.5	12	5.4
Michel	181	184	178	392	91	82	679	12	37	7.5	9	3.3	27	11.6
Group 7	1057	985	164	389	87	80	4019	18	225	31.1	56	8.6	161	45.6
Pierre du Chatel	85	83	190	450	82	82	333	9	15	4.0	5	2.3	12	4.5
Jean	275	297	195	450	90	88	958	7	60	10.1	14	3.8	39	13.1
Lô	292	323	198	363	90	93	899	12	53	12.0	14	4.0	38	13.5
Cande le Jeune	98	93	204	537	79	77	366	5	19	5.6	5	2.0	13	5.0
Notre-Dame la Ronde	186	163	234	472	94	85	587	5	36	7.6	8	2.7	23	8.6
Herbland	86	103	303	587	84	85	305	0	17	4.2	4	2.5	10	5.5
Group 8	1022	1062	212	448	89	87	3448	8	200	30.0	50	7.2	135	42.7
Total	9403	9086	112	281	87	84	40034	59	2095	205.7	530	66.8	1695	490.8

Sources: Bardet (1983, Vol. 2, pp. 83 and 95), Biraben and Blanchet (1985).

Table A.2
Regressions of fertility, nuptiality and mortality on grain prices, by area within Rouen. [e]

	R-sq.	Corr. R-sq	Durbin Watson	F	Con-stant	Grain prices Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag sum	Non-infant deaths Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag sum
Births [eq. (1)]																	
Parish groups, 1681–1744 ($N = 64$)																	
1	0.640	0.579	2.046	8.501 [a]	1.441 [a]	0.001	−0.126 [a]	0.038	0.027	−0.009	−0.069 [d]	−0.132 [a]	−0.058 [b]	−0.059 [b]	−0.078 [a]	−0.043 [d]	−0.369 [a]
2	0.643	0.583	2.010	8.497 [a]	1.273 [a]	−0.029	−0.107 [a]	0.039 [d]	0.035 [d]	0.011	−0.050	−0.081 [a]	−0.046 [c]	−0.015	−0.063 [b]	−0.017	−0.221 [a]
3	0.160	0.020	1.996	0.839	1.092 [a]	0.025	−0.083 [b]	0.038	−0.008	−0.025	−0.052	−0.031	0.007	−0.006	−0.046 [d]	0.035	−0.040
4	0.501	0.418	2.007	4.727 [a]	1.188 [a]	−0.034 [d]	−0.064 [b]	0.021	0.024	0.007	−0.047 [d]	−0.044 [b]	−0.026 [d]	−0.011	−0.047 [b]	−0.012	−0.142 [a]
5	0.353	0.245	1.956	2.591 [b]	1.159 [a]	0.025	0.023	0.032	−0.010	−0.022	0.048	−0.115 [a]	−0.066 [b]	0.021	−0.051 [c]	0.002	−0.209 [a]
6	0.266	0.144	1.928	2.898 [a]	1.165 [a]	−0.058 [c]	0.069 [d]	−0.041	0.112 [a]	−0.059 [c]	0.024	−0.078 [a]	−0.042 [d]	−0.050 [d]	−0.030	0.012	−0.188 [a]
7	0.413	0.315	1.947	3.073 [a]	1.075 [a]	0.028	−0.019	0.008	0.093 [a]	−0.013	0.098 [b]	−0.072 [a]	−0.024	0.015	−0.082 [a]	−0.011	−0.174 [a]
8	0.300	0.184	2.021	1.997 [b]	1.028 [a]	0.033	−0.046 [d]	0.016	0.004	0.018	0.025	−0.044 [d]	−0.028	0.003	−0.028	0.044 [c]	−0.052
Total	0.740	0.696	1.996	12.587 [a]	1.219 [a]	−0.004	−0.065 [a]	0.029 [c]	0.037 [b]	−0.004	−0.007	−0.076 [a]	−0.050 [a]	−0.017	−0.065 [a]	−0.002	−0.211 [a]
Zones, 1681–1787 ($N = 107$)																	
East	0.532	0.489	1.983	9.542 [a]	1.362 [a]	−0.025	−0.095 [a]	0.033	0.025	−0.002	−0.064 [d]	−0.111 [a]	−0.049 [b]	−0.052 [b]	−0.047 [b]	−0.037 [c]	−0.297 [a]
North	0.272	0.205	1.977	3.005 [a]	1.216 [a]	−0.002	−0.011	0.019	−0.002	−0.011	−0.008	−0.085 [a]	−0.039 [b]	−0.022	−0.031 [d]	−0.032 [c]	−0.209 [a]
West	0.193	0.118	1.886	2.056 [c]	1.010 [a]	0.039 [d]	−0.065 [b]	0.058 [c]	0.022	0.004	0.059	−0.029	−0.034 [d]	−0.020	−0.026	0.042 [c]	−0.066
Centre	0.291	0.225	1.998	3.425 [a]	1.138 [a]	−0.008	−0.003	0.002	0.035 [d]	0.014	0.040	−0.046 [b]	−0.074 [a]	0.016	−0.059 [a]	−0.016	−0.179 [a]
Total	0.517	0.472	1.942	8.860 [a]	1.244 [a]	−0.011	−0.054 [a]	0.026 [d]	0.027 [d]	0.002	−0.009	−0.081 [a]	−0.051 [a]	−0.034 [b]	−0.046 [a]	−0.022 [d]	−0.234 [a]
Marriages [eq. (2)]																	
Parish groups, 1681–1744 ($N = 64$)																	
1	0.213	0.082	2.139	2.624 [a]	0.995 [a]	−0.155 [b]	0.146 [c]	0.179 [b]	0.004	−0.179 [b]	−0.005	−0.084	0.012	−0.064	−0.022	0.170 [b]	0.011
2	0.241	0.114	2.122	2.759 [a]	1.048 [a]	−0.056	0.004	0.177 [a]	−0.000	−0.094 [d]	0.030	−0.094 [d]	0.020	−0.043	−0.062	0.099 [d]	−0.079
3	0.311	0.196	1.996	2.223 [b]	0.970 [a]	−0.062	−0.008	0.091	0.080	0.005	0.106	−0.069	0.077	0.023	−0.021	−0.084	−0.073
4	0.215	0.084	2.020	1.695 [d]	0.984 [a]	0.067	−0.097 [d]	0.093 [d]	0.147 [b]	−0.023	0.186 [d]	−0.034	0.009	−0.042	−0.059	−0.040	−0.165
5	0.310	0.195	1.993	2.026 [b]	0.719 [a]	0.002	0.028	0.034	−0.030	0.012	0.045	−0.054	0.141 [a]	0.051	0.046	0.052	0.236 [b]
6	0.186	0.050	2.020	1.249	0.963 [a]	0.073	−0.134 [c]	0.193 [a]	−0.071	0.022	0.084	−0.047	−0.000	−0.010	0.024	−0.008	−0.042
7	0.407	0.308	1.939	2.947 [a]	0.977 [a]	−0.076 [d]	0.063	−0.051	0.113 [c]	−0.186 [a]	−0.137 [d]	−0.125 [b]	0.131 [b]	0.022	0.045	0.088 [c]	0.162
8	0.118	−0.029	2.003	0.992	0.918 [a]	−0.059	0.047	0.079	−0.022	−0.025	0.020	0.027	−0.036	0.007	0.057	0.006	0.061
Total	0.302	0.186	2.092	5.890 [a]	0.974 [a]	−0.092 [a]	0.053 [d]	0.144 [a]	0.012	−0.103 [a]	0.015	−0.065 [c]	0.018	−0.038	0.017	0.080 [b]	0.012
Zones, 1681–1787 ($N = 107$)																	
East	0.207	0.133	2.031	3.459 [a]	1.091 [a]	−0.182 [a]	0.065	0.153 [a]	0.008	−0.102 [c]	−0.058	−0.030	0.013	−0.078 [d]	−0.033	0.096 [b]	−0.031
North	0.163	0.085	2.016	2.234 [b]	0.965 [a]	−0.055	0.021	0.048	0.037	−0.063 [d]	−0.012	−0.061 [d]	0.035	0.021	0.064 [d]	−0.012	0.046
West	0.114	0.032	1.917	1.124	0.936 [a]	−0.048	−0.033	0.110 [c]	0.002	−0.005	0.026	−0.014	0.006	0.005	0.010	0.032	0.040
Centre	0.102	0.019	2.016	2.248 [b]	0.962 [a]	−0.024	0.052	0.032	0.052	−0.078 [c]	0.034	−0.029	−0.008	0.011	0.026	0.007	0.007
Total	0.222	0.150	2.016	4.607 [a]	1.022 [a]	−0.121 [a]	0.036	0.096 [a]	0.022	−0.069 [b]	−0.036	−0.030	0.023	−0.023	−0.002	0.048 [d]	0.016

Non-Infant deaths [eq. (3)]										
Parish groups, 1681–1744 ($N = 64$)										
1	0.313	0.266	2.005	4.349 [a]	0.646 [b]	0.398 [a]	0.187	−0.030	−0.040	−0.151	0.364 [d]
2	0.359	0.316	2.010	5.183 [a]	0.717 [a]	0.312 [a]	0.254 [b]	−0.138	−0.010	−0.137	0.281
3	0.248	0.197	2.013	2.931 [b]	0.639 [b]	0.234 [c]	0.267 [c]	−0.082	0.137	−0.188 [d]	0.368 [d]
4	0.266	0.216	1.988	3.209 [b]	0.541 [c]	0.387 [b]	0.220 [d]	−0.061	0.069	−0.149	0.466 [d]
5	0.324	0.278	1.999	3.914 [a]	0.675 [a]	0.203 [d]	0.405 [a]	−0.123	0.014	−0.169	0.330 [d]
6	0.325	0.279	2.005	4.076 [a]	0.781 [a]	0.375 [a]	0.120	−0.039	−0.011	−0.213 [d]	0.232
7	0.313	0.266	2.039	3.798 [a]	0.809 [a]	0.204 [d]	0.307 [b]	−0.120	0.027	−0.221 [c]	0.196
8	0.275	0.226	2.011	3.293 [a]	0.733 [a]	0.251 [c]	0.227 [d]	0.022	−0.047	−0.177	0.275
Total	0.344	0.300	2.014	4.768 [a]	0.678 [a]	0.315 [b]	0.241 [c]	−0.077	0.002	−0.153	0.328 [d]
Zones, 1681–1687 ($N = 107$)											
East	0.274	0.246	2.015	5.453 [a]	0.768 [a]	0.250 [b]	0.295 [b]	−0.144	−0.015	−0.146 [d]	0.239 [d]
North	0.231	0.201	2.033	5.012	0.611 [a]	0.192 [c]	0.275 [b]	−0.007	0.071	−0.139 [d]	0.392 [b]
West	0.200	0.169	2.020	3.984 [a]	0.804 [a]	0.190 [c]	0.256 [b]	−0.129	−0.029	−0.088	0.200
Centre	0.273	0.244	1.993	5.953 [a]	0.746 [a]	0.176 [d]	0.323 [a]	−0.051	−0.071	−0.120	0.256 [d]
Total	0.277	0.249	2.021	5.950 [a]	0.736 [a]	0.219 [b]	0.292 [a]	−0.098	−0.011	−0.132 [d]	0.269 [d]
Deaths [eq. (4)]											
Parish groups, 1681–1744 ($N = 64$)											
1	0.287	0.239	2.003	4.188 [a]	0.814 [a]	0.270 [a]	0.078	−0.019	−0.032	−0.106	0.191
2	0.309	0.262	2.012	4.415 [a]	0.852 [a]	0.200 [b]	0.129 [d]	−0.085	−0.000	−0.097	0.147
3	0.248	0.197	2.021	2.925 [b]	0.781 [a]	0.159 [c]	0.155 [d]	−0.040	0.079	−0.130 [d]	0.223 [d]
4	0.244	0.193	1.986	3.046 [b]	0.747 [a]	0.241 [b]	0.111	−0.037	0.044	−0.103	0.256 [d]
5	0.349	0.305	1.998	4.314 [a]	0.781 [a]	0.145 [d]	0.269 [a]	−0.072	0.007	−0.127 [d]	0.222 [d]
6	0.318	0.272	2.007	3.870 [a]	0.842 [a]	0.240 [a]	0.083	−0.034	0.021	−0.144 [d]	0.167
7	0.315	0.269	2.050	3.872 [a]	0.844 [a]	0.143 [c]	0.193 [b]	−0.076	0.047	−0.149 [c]	0.159
8	0.262	0.212	2.022	3.236 [a]	0.827 [a]	0.164 [c]	0.133 [d]	0.016	−0.039	−0.098	0.177
Total	0.325	0.279	2.018	4.509 [a]	0.810 [a]	0.208 [b]	0.133 [d]	−0.047	0.005	−0.106 [d]	0.193
Zones, 1681–1787 ($N = 107$)											
East	0.243	0.213	2.021	4.825 [a]	0.883 [a]	0.165 [b]	0.157 [b]	−0.091	−0.009	−0.100 [d]	0.121
North	0.240	0.210	2.039	5.296	0.758 [a]	0.125 [c]	0.182 [b]	−0.003	0.040	−0.101 [d]	0.244 [b]
West	0.194	0.162	2.020	3.801 [a]	0.850 [a]	0.147 [b]	0.142 [c]	−0.069	−0.015	−0.052	0.153
Centre	0.257	0.228	1.994	5.595 [a]	0.834 [a]	0.107 [d]	0.198 [a]	−0.033	−0.033	−0.072	0.167 [d]
Total	0.259	0.230	2.026	5.576 [a]	0.848 [a]	0.143 [b]	0.167 [b]	−0.061	−0.006	−0.089 [d]	0.155 [d]

[a,b,c,d] The significance level of the test statistics is: a = 1%, b = 5%, c = 10%, d = 20%.

[e] The secular trend has been removed from each series by dividing each data point, all it x, in a series by an eleven-year average of data points centered around x. The regressions are corrected for second-order autoregressive disturbances using the iterative Cochrane–Orcutt procedure. R-squared and corrected R-squared are calculated for the untransformed variables.

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