6 Short-Run Population Dynamics among the Rich and Poor in European Countries, Rural Jutland, and Urban Rouen

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Introduction

The study of the impact of annual changes in living standards on annual changes in demographic events provides the historian with one of the few opportunities to explore analytically the historical actor's response to important events in his or her life. The methods that have evolved during the past decade enable the historian effectively and easily to use the only long series of records available throughout most of historical Europe: namely, births, marriages, deaths, and prices.[1]

Research on short-run demographic fluctuations has expanded considerably during the past decade.[2] Some fundamental response patterns have emerged which may function as templates with which future research may compare the results of similar analyses in other places and other times. The pattern of the short-term preventive check, defined as the fertility response to price changes, is very similar in different European countries, with a typically strong decrease in

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[1] R. D. Lee, '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* (London, 1981), pp. 356–401; see also his Ch. 1 above. P. R. Galloway, 'Annual Variations in Deaths by Age, Deaths by Cause, Prices, and Weather in London 1670–1830', *Population Studies*, 39(3) (1985), pp. 487–505; P. R. Galloway, 'Population, Prices and Weather in Preindustrial Europe', Ph.D. dissertation, University of California at Berkeley, 1987; P. R. Galloway, 'Changements séculaires des freins du court terme, la croissance démographique en Europe de 1640 à 1909: frein préventif, frein positif et frein de température', in D. Blanchet, A. Blum, and N. Bonneuil (eds.), *Modèles de la démographie historique* (Paris, 1992), pp. 193–240; Z. Eckstein, T. P. Schultz, and K. L. Wolpin, 'Short-Run Fluctuations in Fertility and Mortality in Pre-industrial Sweden', *European Economic Review*, 26 (1985), pp. 295–317; T. Bengtsson and G. Broström, 'A Comparison of Different Methods of Analyzing Cycles in Population and Economy', paper presented to the Ninth International Economic History Congress, Berne, 1986; T. P. Schultz, 'Short-Term Changes in Economic and Demographic Variables: Comparisons of Pre-industrial English and Swedish Time Series Using Alternative Statistical Frameworks', paper presented to the Ninth International Economic History Congress, Berne, 1986.

[2] For an overview see Galloway (1992) op. cit. in fn. 1, table 1.

births one year after a price shock, and a persistent cumulatively significant decrease in overall births four years later. Furthermore, the magnitude of the decrease (usually measured in elasticities relative to grain prices) is generally found to have been about the same. Recent research on populations in Tokugawa Japan and eighteenth-century Mexico reveals a striking similarity in the pattern and scale of the short-term preventive check when compared with European countries.[3] The short-term positive check, defined as the response of mortality to price changes, varies more in different countries. This response is usually, as the name suggests, positive. I found in 1988 that the magnitude of the short-term positive check varied inversely with measures of economic development in different European countries.[4]

The present analysis examines how demographic responses to price increases varied between rich and poor European countries, rich and poor districts in a rural portion of Jutland (Arhus diocese) in Denmark, and rich and poor parishes in the city of Rouen in France. The choice of these areas is governed by the desire to examine short-term preventive and positive checks in countries, in a rural setting, and in a major urban centre. Earlier efforts to estimate short-term preventive and positive checks according to some measure of economic development revolved around running regressions for populations classified by socio-economic welfare, and then eyeballing the results by presenting tables or graphs of the estimated coefficients according to the measure of socio-economic welfare which characterized the population.[5] Occasionally, the relationship between the magnitude and timing of the responses and the measure of welfare was obvious. However, in this earlier research the statistical significance of the differences in responses by welfare was never calculated. I shall use a method that allows us to test the statistical significance of the differing responses among the rich and poor areas. Pooling the data in each data set, I will allow the parameters themselves to be functionally related to the measure of socio-economic welfare. The primary advantage of the regression of pooled data over that used in earlier research is that it generates significance levels for the slope of the regression line estimated

[3] P. R. Galloway, 'Basic Patterns in Annual Variations in Fertility, Nuptiality, Mortality and Prices in Pre-industrial Europe', *Population Studies*, 42(2) (1988), pp. 275–303; D. S. Reher, 'Population and Economy in Eighteenth-Century Mexico: An Analysis of Short-Term Fluctuations', paper presented to the IUSSP Conference on the Population History of Latin America, 1989; G. Feeney and H. Kyoshi, 'Rice Price Fluctuations and Fertility in Late Tokugawa Japan', *Journal of Japanese Studies*, 16(1) (1990), pp. 1–30; Lee, Ch. 1 above.

[4] Galloway, op. cit. in fn. 3.

[5] T. Bengtsson, 'Comparisons of Population Cycles and Trends in England, France and Sweden 1751–1860', paper presented to the Ninth International Economic History Congress, Berne, 1986; T. Bengtsson, 'Migration, Wages and Urbanization in Sweden in the Nineteenth Century', unpublished paper, Department of Economic History, University of Lund, 1986; P. R. Galloway, 'Differentials in Demographic Responses to Annual Price Variations in Pre-revolutionary France: A Comparison of Rich and Poor Areas in Rouen, 1681–1787', *European Journal of Population*, 2(3/4) (1986), pp. 269–305; Galloway, op. cit. in fn. 3; F. F. Mendels, 'Industry and Marriages in Flanders Before the Industrial Revolution', in P. Deprez (ed.), *Population and Economics*, Proceedings of Section V of the Fourth Congress of the International History Association (Winnipeg, 1970); Reher, op. cit. in fn. 3; D. S. Reher, *Town and Country in Pre-Industrial Spain: Cuenca, 1550–1870* (Cambridge, 1990).

TABLE 6.1 *Means of the raw series and coefficients of variation of the detrended series in five countries, 1756–1870*

(a) Mean of raw series

Place	Period	% of Population in Agriculture, 1870	Income per head	Percentage urban	Crude birth rate (CBR)	Crude marriage rate (CMR)	Non-infant death rate (NIDR)	Crude death rate (CDR)
England	1756–1870	22.7[a]	\$526[b]	30.2[b]	37.0	8.4	18.8	24.9
France	1756–1870	49.2	\$411	11.8	32.8	8.2	21.8	29.1
Prussia	1756–1870	49.5[c]	\$346[c]	8.8[c]	40.0	9.1	22.6	30.2
Denmark	1756–1870	51.7	\$394	10.7	31.0	8.3	18.5	24.3
Sweden	1756–1870	53.9	\$320	4.2	32.6	8.0	19.1	24.9

(b) Coefficient of variation of detrended series

Place	Period	CBR	CMR	NIDR	CDR	Grain prices
England	1756–1870	0.028	0.056	0.064	0.049	0.199
France	1756–1870	0.026	0.102	0.111	0.084	0.179
Prussia	1756–1870	0.044	0.088	0.132	0.101	0.229
Denmark	1756–1870	0.036	0.073	0.133	0.101	0.238
Sweden	1756–1870	0.052	0.076	0.165	0.134	0.172

[a]UK [b]England and Wales [c]Germany

Notes:
NIDR = (total deaths – deaths under age 1) × 1000/population.
The Denmark CMR series goes from 1782 to 1870.
A series is detrended by dividing each data point (x) in the series by an 11-year moving average of data points centred around x.

Source: Galloway, op. cit. in fn. 3, p. 281.

for each lag. This slope represents the difference between rich and poor responses. The test of the statistical significance of the slope is often the primary hypothesis under examination. Thus, it is important to use this type of pooled regression technique, rather than simply eyeballing tables or graphs.

Data and Periods

For comparative purposes, we will be examining three data sets. The responses of changes in vital events to changes in grain prices according to a measure of welfare will be estimated for five European countries (England, France, Denmark, Prussia, and Sweden, 1756–1870) using income per head, 19 rural *herreds* (rural administrative districts) in Arhus diocese (1726–96) using land value, and eight parish groups in the city of Rouen (1681–1744) using rent.[6] We will use vital rates in the countries, simply because they are available, and vital events in rural Arhus diocese and the city of Rouen. Since population size changes little from one year to the next, rates and events are virtually interchangeable in the analysis of annual fluctuations. Summary statistics for all places and periods used are shown in Tables 6.1, 6.2, and 6.3.

I shall describe Arhus diocese in Jutland, Denmark, in some detail. This diocese contains a remarkably representative cross-section of Denmark. The dominant soil type is clay loam, which is the most fertile. To the west the soil becomes sandy loam, and in the extreme west, heath soil. There is an obvious soil-fertility gradient running from east to west, although there are some areas of poor soil in the northeastern peninsula of the diocese. The quality of the soil is accurately reflected in the tax assessment of the land:

> In considering soils and their value for agriculture it is interesting to see how nearly a map representing the old 'Hartkorn' valuation of the soils of Denmark agrees with the soil map. The Hartkorn valuation was made for tax purposes. The assessment was first carried out in 1664, revised in 1688, and again in 1844. The value of the soils for production of the crops then common, that is, the productivity of the soils without regard to location, was the basis used for the assessment.[7]

To a certain extent, the soil quality reflected the economic well-being of its farmers. Fertile soil produced higher yields with less labour and fertilizer than poorer soils. Holding farm size constant, output and profit were higher on good land than on poor land. Expanding the area of poor soil to match the output of a smaller farm with good soil involved increased labour costs and less efficient use of fertilizer, since more land must be covered. Hornby and Oxenboll noted that in the less fertile districts of Denmark 'farming on the whole was conducted more

[6] Details regarding the compilation and sources of the data and the measures of welfare used for the five countries can be found in Galloway, op. cit. in fn. 3, and, for the eight parish groups in Rouen, in Galloway (1986), op. cit. in fn. 5.

[7] E. Jensen, *Danish Agriculture: Its Economic Development* (Copenhagen, 1937), p. 76.

TABLE 6.2 *Means of the raw series and coefficients of variation of the detrended series in 19 rural* herreds *of Arhus diocese in Denmark, 1726–1796*

Place	Land value, 1844	Population, 1801	Population density, 1801	Mean of raw series			Coefficent of variation of detrended series		
				Births, 1726–96	Non-infant deaths, 1726–96	Deaths, 1726–96	Births, 1726–96	Non-infant deaths, 1726–96	Deaths, 1726–96
Ning	84	4,679	1510	170	114	152	0.115	0.348	0.264
Bjerre	77	7,550	1603	217	121	170	0.083	0.430	0.298
Rovso	74	2,234	1185	71	49	65	0.119	0.482	0.365
Galten	71	4,666	1288	118	76	103	0.098	0.373	0.270
Gjerlev	68	3,642	1043	89	53	73	0.127	0.414	0.297
Hatting	66	4,274	1336	107	65	89	0.121	0.402	0.297
O. Lisbjerg	65	4,991	1283	158	111	146	0.113	0.342	0.263
Hads	64	7,128	1654	180	113	153	0.105	0.408	0.300
Sabro-V. Lisbjerg	64	4,642	1294	134	93	123	0.103	0.342	0.259
Norrehald	58	2,785	925	72	46	62	0.106	0.421	0.311
Framlev	57	2,920	1441	91	56	77	0.122	0.466	0.336
Sonderhald	57	7,302	959	216	150	199	0.074	0.374	0.277
Voer	57	7,058	1348	182	118	159	0.092	0.340	0.245
Sonder	53	4,598	856	148	101	135	0.082	0.341	0.257
Houlbjerg	48	3,847	969	102	65	88	0.140	0.481	0.355
Gjen	30	4,708	870	123	70	97	0.130	0.460	0.330
Lysgard	24	4,730	687	144	88	121	0.138	0.378	0.271
Hids	17	2,420	533	59	33	46	0.158	0.466	0.317
Vrads-Thyrsting	16	6,459	464	210	123	170	0.109	0.429	0.307
Rural total	49	90,633	1009	2,592	1,645	2,228	0.053	0.310	0.224
Arhus diocese	50	125,997	1132	3,609	2,310	3,122	0.049	0.315	0.229
Denmark[a]	54	925,680	1355	25,863	17,200	23,019	0.038	0.161	0.118

[a] 1746–96.

Notes

For definitions of terms and sources see App.

The mean of the raw Copenhagen rye price series is 225, the standard deviation is 85, and the coefficient of variation is 0.333. The coefficient of variation of the detrended series is 0.253. A series is detrended by dividing each data point (x) in the series by an 11-year moving average of data points centred around x.

extensively and with a smaller return than in other parts of the country'.[8] In order to remain self-sufficient, farmers on poor lands often turned to other income-generating activities. The wool-knitting districts of Denmark are areas with the poorest soil quality. Some of these districts can be found in the extreme western portion of Arhus diocese.

We wish to examine only rural responses to price variations. Because data are not disaggregated by urban and rural sectors within each *herred*, any *herred* that contains one or more market towns is excluded from the analysis. This leaves the 19 *herreds* listed in Table 6.2. The land value of these rural administrative districts in Arhus diocese is highly correlated with the quality of the soil.

Long series of vital events published for contiguous small districts in pre-industrial Europe are not easily found. A. Lassen published such a series of births and deaths for each *herred* in eighteenth-century Arhus diocese.[9] Unfortunately, marriage data are not available for this period. The series that run from around 1720 to 1801 have remarkably few gaps. Table 6.2 provides summary statistics of births, non-infant deaths, and total deaths along with land value, population, and density. Details regarding the definitions and sources of the data can be found in the Appendix to this chapter.

The period under consideration, 1726–96, was an era characterized by 'a system of bondage (*Stavnsbaand*) which was introduced in 1733 and required peasants between 14 and 35 years of age to remain on the estate where they were born. This type of organization persisted until 1788 when bondage was abolished and peasants could move where they pleased'.[10] As a consequence, the population of each *herred* was thought to be relatively closed throughout the period under consideration. However, recent research suggests that there may have been parish-to-parish migration, despite the system of bondage.[11]

Differences between Rich and Poor

Because grain was the major component of the pre-industrial household budget, annual fluctuations in grain prices are useful proxies for annual variations in living standards.[12] Rising grain prices have been shown to affect, to varying degrees, all measures of demographic events.[13] The mechanisms involved will be discussed later.

Generally, the poor are expected to have suffered more from increased grain prices than the rich,[14] the basic notion being that the rich had ample provisions

[8] O. Hornby and E. Oxenboll, 'Proto-Industrialisation Before Industrialisation? The Danish Case', *Scandinavian Economic History Review*, 30(1) (1982), p. 31.

[9] A. Lassen, *Fald og Fremgang: Traek af Befolkningsudviklingen i Danmark 1645–1960* (Arhus, 1965).

[10] Jensen, op. cit. in fn. 7, p. 48. See also J. Danstrup, *A History of Denmark* (Copenhagen, 1948), pp. 79–89.

[11] H. C. Johansen, personal communication, 1987.

[12] Galloway, op. cit. in fn. 3, pp. 276–78.

[13] Ibid., pp. 286–87.

[14] W. Abel, *Agricultural Fluctuations in Europe from the Thirteenth to the Twentieth Centuries*

TABLE 6.3 *Means of the raw series and coefficients of variation of the detrended series in eight parish groups in Rouen, 1681–1744*

Description	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group total
Infant mortality rate	295	292	281	277	258	261	254	244	274
Family assistance index, 1720–89	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
Mean of raw series, 1681–1744									
Total births	421	528	173	194	181	172	225	200	2095
Marriages	107	116	51	49	53	48	56	50	530
Non-infant deaths	259	296	97	88	99	88	104	86	1121
Total deaths	384	450	146	141	145	133	161	135	1695

TABLE 6.3 (*Contd.*)

Description	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group total
Coefficient of variation of detrended 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	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

Notes:
The infant mortality rate is estimated based on the following equation:
Infant mortality rate = − 0.183 (rent in 1773) + 325.443, where $r = -0.914$.
This equation is based on the following data from J. P. Bardet, *Rouen aux XVII*[e] *et XVIII*[e] *siècles: les mutations d'un espace social* (Paris, 1983), vol. 1, pp. 230 and 373; vol. 2, p. 116; and A. J. Coale and P. Demeny, *Regional Model Life Tables and Stable Populations* (Princeton, NJ, 1966), pp. 4–8:

	Rent 1773	Life exp.	${}_1q_0$ (IMR) from West Model life tables
Ouvriers	77	24.5	321.8
Artisans and boutiquiers	220	29.5	269.3
Notables	488	32.5	241.9

Non-infant deaths = total deaths − (Total births × Infant mortality rate).
A series is detrended by dividing each data point, x, in the series by an 11-year moving average of data points centred around x.

Source: Galloway, op. cit. in fn. 5, pp. 278–79.

or funds to insulate themselves effectively from the vagaries of the harvest. In general, a poor harvest generated high cereal prices which may have benefited the large grain producers and distributors, who were relatively few in number. Most of the population of pre-industrial Europe—the landless labourers, the small farmers, and most urban dwellers—suffered. It is essentially their demographic responses to variations in grain prices that will dominate any analysis at the national level.[15]

During periods of dearth and high grain prices, large farms (in terms of output) increased profits, average-sized farms were variously affected, and small farmers suffered dramatically.[16] The standard of living of the rural poor was reduced in a number of ways. First, the amount of food the rural poor produced (at or below subsistence during normal harvests) declined. Secondly, high grain prices made purchasing additional food less likely. Thirdly, the high price of grain caused a shift in demand in the cities towards food and away from industrial products, which, of course, lowered earnings in rural domestic industry.[17] The poorer agricultural region of western Arhus diocese, the location of most of the domestic knitting industry in the diocese, was typical. During a year of high grain prices, domestic industrial output increased just as the demand for this output decreased, which led to markedly lower prices and earnings.

> The knitting region of Central Jutland falls into that classic European category in which domestic industry evolves energetically in a region that is agriculturally backward, and unsatisfactory. Production remained at a considerable level throughout the period. Nevertheless fluctuations did occur in accordance with a traditional causal pattern. In years when corn prices were high, knitting would typically accelerate, with the result that prices and earnings fell.[18]

In cities such as Rouen, the well-to-do would be sufficiently insulated from harvest failures. The profits of businessmen in control of the distribution of stored grain probably increased, while the urban poor suffered along with their rural counterparts as the price of provisions rose, just as the demand for their services and products fell off.[19]

(London, 1980), pp. 9–13; P. J. Bowden, 'Agricultural Prices, Wages, Farm Profits, and Rents', in J. Thirsk (ed.), *The Agrarian History of England and Wales*, v, *1640–1750, II: Agrarian Change* (Cambridge, 1985), pp. 61, 93; R. W. Fogel, 'Nutrition and the Decline of Mortality since 1700: Some Additional Preliminary Findings' National Bureau of Economic Research Working Paper Series 1802 (New York, 1986), p. 85; Galloway, op. cit. in fn. 3, p. 277.

[15] Galloway, op. cit. in fn. 3.

[16] Abel, op. cit. in fn. 14, pp. 9–13; Mendels, op. cit. in fn. 5. p. 88.

[17] E. A. Wrigley, *Population and History* (New York, 1969), p. 68; P. Goubert, *The Ancien Regime: French Society 1600–1750* (New York, 1973), pp. 109–10; H. Medick, 'The Structures and Function of Population Development under the Proto-Industrial System', in P. Kriedte, H. Medick, and J. Schlumbohm, *Industrialization Before Industrialization* (Cambridge, 1981), p. 90.

[18] Hornby and Oxenboll, op. cit. in fn. 8, p. 29.

[19] Abel, op. cit. in fn. 14, p. 9, referring to C. E. Labrousse, *Esquisse du mouvement des prix et des revenus en France au XVIII^e siècle* (Paris, 1933), and *La Crise de l'économie française à la fin de l'Ancien Régime et au début de la Révolution* (Paris, 1944).

Method

The method can best be described by example. All variables are detrended by dividing each data point, (x) by an 11-year moving average of data points centred around x. I use a distributed-lag model with lags of 0, 1, 2, 3, and 4 years.[20]

Suppose that we are interested in observing the pooled response of fertility (F) changes to price (P) changes in five European countries (N) from 1756 to 1870, where t is time, k is a lag, b is the regression coefficient, C is a constant, and e is an error term. The equation would be

$$F_{i,t} = C + \sum_{k=0}^{4} b_k P_{i,\,t-k} + e_{i,\,t} \qquad \text{for } i = 1, 2, \ldots, N; \quad t = 1, 2, \ldots, T. \tag{1}$$

In this case N, the number of cross-section units, is 5, and T, the time period (1756–1870) is 115. The total number of observations is NT or 575. It should be noted that in each series (N) the calculations actually include data for four years before the stated period, because of the number of lags used. We expect that the estimated fertility response, b, may vary in accord with some level of socio-economic welfare (W). Furthermore, based on previous analyses, we expect this relationship to be linear.[21] We write the following equations, recalling that k represents a lag:

$$b_k = a_k + c_k W_i \qquad \text{for } k = 0, 1, 2, 3, 4; \quad i = 1, 2, \ldots, N. \tag{2}$$

Substituting (2) into (1), we obtain

$$F_{i,t} = C + \sum_{k=0}^{4} (a_k + c_k W_i) P_{i,\,t-k} + e_{i,\,t} \qquad \text{for } i = 1, 2, \ldots, N; \quad t = 1, 2, \ldots, T. \tag{3}$$

The preceding equation may be rewritten as

$$F_{i,t} = C + \sum_{k=0}^{4} a_k P_{i,\,t-k} + \sum_{k=0}^{4} c_k W_i P_{i,\,t-k} + e_{i,\,t}$$

$$\text{for } i = 1, 2, \ldots, N; \quad t = 1, 2, \ldots, T \tag{4}$$

Dummy variables are introduced to allow the intercept term to vary over cross-section units.[22] We introduce dummy variables (D) into the preceding equation as follows:

[20] Galloway (1992), op. cit. in fn. 1, app. table 5.

[21] Galloway, op. cit. in fn. 5; Galloway (1987), op. cit. in fn. 1; Galloway, op. cit. in fn. 3.

[22] R. S. Pindyck and D. L. Rubinfeld, *Econometric Models and Economic Forecasts* (New York, 1981), p. 254.

TABLE 6.4 *Pooled regressions of vital rates on grain prices and non-infant death rates, five European countries (England, France, Denmark, Prussia, and Sweden), 1756–1870*

	Equation					
	(A)	(B)	(C)	(D)	(E)	(F)
Dependent variable	CBR	CBR	CMR	CMR	NIDR	CDR
Observations	575	575	551	551	575	575
Prices 0	0.047387	0.078737[b]	0.088210	0.138909	0.279455[d]	0.277494[c]
Prices − 1	−0.285706[a]	−0.181646[a]	−0.119683	−0.091536	0.705948[a]	0.489375[a]
Prices − 2	0.052023	0.055219	0.085371	−0.014326	−0.105463	−0.078368
Prices − 3	0.098061[c]	0.064000	0.102317	0.007214	0.004193	−0.001638
Prices − 4	0.017885	0.010361	0.072492	−0.012759	−0.066623	−0.070653
Prices × Inc 0	−0.000210[c]	−0.000273[b]	−0.000531[c]	−0.000635[b]	−0.000462	−0.000513[d]
Prices × Inc − 1	0.000510[a]	0.000285[b]	0.000288	0.000209	−0.001602[a]	−0.001145[a]
Prices × Inc − 2	−0.000053	−0.000058	−0.000160	0.000070	0.000426	0.000338
Prices × Inc − 3	−0.000227[c]	−0.000163[d]	−0.000244	−0.000084	−0.000167	−0.000118
Prices × Inc − 4	−0.000026	−0.000015	−0.000163	0.000039	0.000086	0.000111
NIDR 0		−0.309862[a]		−0.219938		
NIDR − 1		−0.098825		−0.143175		
NIDR − 2		0.007347		0.259411[d]		
NIDR − 3		−0.046609		0.332183[c]		
NIDR − 4		−0.049571		−0.094203		
NIDR × Inc 0		0.000579[a]		0.000448		
NIDR × Inc − 1		0.000228		0.000780[d]		
NIDR × Inc − 2		0.000067		−0.000456		
NIDR × Inc − 3		0.000133		−0.000742[d]		
NIDR × Inc − 4		0.000113		0.000324		

TABLE 6.4 (*Contd.*)

	Equation					
	(A)	(B)	(C)	(D)	(E)	(F)
Dummy 1	1.072376[a]	1.118109[a]	1.089360[a]	0.854896[a]	0.860860[a]	0.907474[a]
Dummy 2	1.073125[a]	1.000041[a]	1.196903[a]	0.862832[a]	1.087159[a]	1.082157[a]
Dummy 3	1.073062[a]	1.103597[a]	1.100779[a]	0.855172[a]	0.888658[a]	0.928771[a]
Dummy 4	1.071347[a]	1.160238[a]	1.047429[a]	0.851176[a]	0.777915[a]	0.843626[a]
Dummy 5	1.071082[a]	1.183704[a]	1.028039[a]	0.850734[a]	0.734470[a]	0.809923[a]
R^2 Untr.	0.343920	0.461750	0.109690	0.209150	0.145990	0.129240
Corr. R^2	0.327520	0.438270	0.086440	0.173070	0.124640	0.107470
DW	2.013392	2.011657	1.930693	1.969333	2.075567	2.073303
F-stat.	22.664810[a]	20.449130[a]	7.682370[a]	7.146373[a]	10.269590[a]	8.650193[a]
Lag sum						
Prices	−0.070350	0.026671	0.228706	0.027502	0.817510[b]	0.616210[b]
Prices × Inc	−0.000006	−0.000225	−0.000810	−0.000401	−0.001719[c]	−0.001327[c]
NIDR		−0.497520[b]		0.134278		
NIDR × Inc		0.001119[b]		0.000354		
Joint significance (F-statistic)						
Prices	9.86[a]	3.67[a]	0.69	0.39	5.63[a]	5.60[a]
Prices × Inc	5.32[a]	2.15[c]	0.79	1.17	3.90[a]	4.01[a]
NIDR		3.41[a]		1.57[d]		
NIDR × Inc		1.71[d]		1.30		
Dummies	45.99[a]	46.03[a]	83.25[a]	28.05[a]	36.63[a]	54.32[a]

Notes: NIDR is the non-infant death rate. 'Inc' is income per head in 1970 $US.
Sample size is reduced in marriage regressions because the Denmark marriage series begins in 1780.
The secular trend has been removed from each series by dividing each data point (x) in a series by an 11-year moving average of data points centred around x.
The regressions are corrected for second-order autoregressive disturbances using the iterative Cochrane–Oroutt procedure. R^2 and Corr. R^2 are calculated for the untransformed variables.
The subsets for Lag Sum and Joint Significance are lags 0–4 for each independent variable.
The significance level of the test statistics is: [a], 1%; [b], 5%; [c], 10%; [d], 20%.

TABLE 6.5 *Pooled regressions of vital statistics on rye prices and non-infant deaths, Arhus diocese 19 rural* herreds, *1726–1796*

Equation Dependent variable	(A) Births	(B) Births	(E) Non-Infant deaths	(F) Deaths
Observations	1,349	1,349	1,349	1,349
Prices 0	0.004570	0.014450	0.435260[a]	0.331790[a]
Prices − 1	− 0.273610[a]	− 0.237620[a]	0.137090	0.001670
Prices − 2	0.042590	0.011020	− 0.053710	0.002990
Prices − 3	− 0.062210	− 0.032730	− 0.307400[d]	− 0.299030[b]
Prices − 4	0.078150[c]	0.085560[c]	0.194540	0.166800[d]
Prices × LV 0	0.000152	− 0.000024	− 0.004110[d]	− 0.003460[c]
Prices × LV − 1	0.002280[b]	0.001720[c]	0.001600	0.002500
Prices × LV − 2	− 0.000342	− 0.000091	0.001150	− 0.000030
Prices × LV − 3	0.000770[d]	0.000252	− 0.000517	0.001360
Prices × LV − 4	− 0.001160[d]	− 0.001140[d]	− 0.001380	− 0.001480
NI Dths 0		− 0.060700[b]		
NI Dths − 1		0.020970		
NI Dths − 2		− 0.014410		
NI Dths − 3		− 0.060720[b]		
NI Dths − 4		0.017120		
NI Dths × LV 0		0.000884[b]		
NI Dths × LV − 1		0.000194		
NI Dths × LV − 2		0.000476		
NI Dths × LV − 3		0.000929[b]		
NI Dths × LV − 4		− 0.000168		
Dummy 1	1.062900[a]	0.996980[a]	0.873170[a]	0.891410[a]
Dummy 2	1.076280[a]	1.019290[a]	0.857890[a]	0.887560[a]
Dummy 3	1.073810[a]	1.022150[a]	0.834180[a]	0.879990[a]
Dummy 4	1.088030[a]	1.039480[a]	0.841270[a]	0.885450[a]
Dummy 5	1.090330[a]	1.045860[a]	0.825320[a]	0.875650[a]
Dummy 6	1.098570[a]	1.056860[a]	0.816560[a]	0.874080[a]
Dummy 7	1.097940[a]	1.057620[a]	0.808580[a]	0.869310[a]
Dummy 8	1.096550[a]	1.057590[a]	0.805830[a]	0.866530[a]
Dummy 9	1.101990[a]	1.063220[a]	0.819000[a]	0.879030[a]
Dummy 10	1.108880[a]	1.078150[a]	0.796710[a]	0.867580[a]
Dummy 11	1.109230[a]	1.079560[a]	0.798730[a]	0.868790[a]
Dummy 12	1.120510[a]	1.090930[a]	0.789750[a]	0.867730[a]
Dummy 13	1.115540[a]	1.085910[a]	0.788010[a]	0.864680[a]
Dummy 14	1.115720[a]	1.091380[a]	0.775780[a]	0.859210[a]
Dummy 15	1.126490[a]	1.108990[a]	0.765350[a]	0.857360[a]
Dummy 16	1.154590[a]	1.161420[a]	0.694450[a]	0.827320[a]
Dummy 17	1.166790[a]	1.182040[a]	0.688050[a]	0.831660[a]
Dummy 18	1.180290[a]	1.205770[a]	0.679880[a]	0.863159[a]
Dummy 19	1.182900[a]	1.209090[a]	0.664210[a]	0.823640[a]

TABLE 6.5 *(contd.)*

Equation	(A)	(B)	(E)	(F)
R^2 untr	0.101220	0.123730	0.088740	0.074260
Corr R^2	0.082160	0.098320	0.069410	0.054630
DW	2.030000	2.020000	2.070000	2.080000
F-stat	5.852000[a]	5.221000[a]	4.425000[a]	3.654000[a]
Lag sum				
Prices	−0.210510[a]	−0.159320[b]	0.405780[d]	0.204220
Prices × LV	0.001699[d]	0.000717	−0.003257	−0.001110
NI Dths		−0.097740[d]		
NI Dths × LV		0.002316[b]		
Joint significance (F-statistic)				
Prices	13.63[a]	10.53[a]	3.79[a]	3.88[a]
Prices × LV	4.62[a]	2.87[b]	0.56	0.88
NI Dths		2.09[c]		
NI Dths × LV		1.99[c]		
Dummies	45.37[a]	43.45[a]	3.90[a]	8.62[a]

Notes: 'NI Dths' are non-infant deaths; 'LV' is land value. Marriage data are not available.

The secular trend has been removed from each series by dividing each data point (x) in a series by an 11-year moving average of data points centred around x.

The regressions are corrected for second order autoregressive disturbances using the iterative Cochrane Orcutt procedure. R^2 and Corr R^2 are calculated for the untransformed variables.

The subsets for Lag Sum and Joint Significance are lags 0–4 for each independent variable.

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

$$F_{i,t} = \sum_{k=0}^{4} a_k P_{i,\,t-k} + \sum_{k=0}^{4} c_k W_i P_{i,\,t-k} + \sum_{j=1}^{N} g_i D_{i,\,j} + e_{i,\,t}$$

$$\text{for } i = 1, 2, \ldots, N \quad t = 1, 2, \ldots, T \qquad (5)$$

where $D_{i,\,j} = 1$ if $i = j$ and 0 otherwise. The values of a, c, and g are estimated using ordinary least squares (OLS). Corrections are made for second-order autoregressive disturbances by using Cochrane and Orcutt's iterative procedure. This procedure should result in a better estimate of the significance of the regression coefficients than simple OLS, provided T is moderately large.

The pooled regression results for the five European countries where fertility is a function of prices are shown in equation (A) in Table 4. Similar pooled regressions were run for fertility as a function of prices and non-infant mortality (equation (B)), nuptiality as a function of prices (equation (C)); nuptiality as a function of prices and non-infant mortality (equation (D)); non-infant mortality as a function of prices (equation (E)); and mortality, including non-infant mortality, as a function of prices (equation (F)). Table 6.5 shows the regression results

TABLE 6.6 *Pooled regressions of vital statistics on wheat prices and non-infant death rates, Rouen eight parish groups, 1681–1744*

Equation Dependent variable Observations	(A) Births 512	(B) Births 512	(C) Marriages 512	(D) Marriages 512	(E) Non-infant deaths 512	(F) Deaths 512
Prices 0	−0.038495[d]	−0.025565	−0.093881[c]	−0.039173	0.366511[a]	0.241765[a]
Prices −1	−0.188729[a]	−0.145809[a]	0.009400	−0.013504	0.244857[c]	0.112115
Prices −2	0.051747[d]	0.057518[c]	0.182558[a]	0.180945[a]	−0.121303	−0.070070
Prices −3	−0.022919	0.019539	−0.010443	0.056727	0.042413	0.023051
Prices −4	−0.019525	−0.011195	−0.013320	−0.054859	−0.160327	−0.125617[d]
Prices × Rent 0	0.000197	0.000221	0.000358	0.000089	−0.000552	−0.000365
Prices × Rent −1	0.000916[a]	0.000751[a]	−0.000086	0.000089	0.000030	0.000250
Prices × Rent −2	−0.000286	−0.000257	−0.000602	−0.000676[d]	0.000409	0.000229
Prices × Rent −3	0.000268	0.000116	0.000255	−0.000220	−0.000197	−0.000060
Prices × Rent −4	0.000131	0.000023	−0.000064	0.000119	−0.000115	0.000059
NI Dths 0		−0.101540[a]		−0.153988[a]		
NI Dths −1		−0.061337[b]		0.093959[c]		
NI Dths −2		−0.049296[c]		−0.051807		
NI Dths −3		−0.074544[a]		−0.109061[c]		
NI Dths −4		−0.038529[d]		0.060695		
NI Dths × Rent 0		0.000259[d]		0.000779[c]		
NI Dths × Rent −1		0.000177		−0.000389		
NI Dths × Rent −2		0.000286[d]		0.000363		
NI Dths × Rent −3		0.000164		0.000886[b]		
NI Dths × Rent −4		0.000339[c]		−0.000323		
Dummy 1	1.149494[a]	1.317015[a]	0.936695[a]	0.993916[a]	0.661323[a]	0.816698[a]
Dummy 2	1.143330[a]	1.303789[a]	0.933565[a]	0.984630[a]	0.652127[a]	0.810768[a]
Dummy 3	1.087601[a]	1.211826[a]	0.946173[a]	0.960711[a]	0.682194[a]	0.812477[a]
Dummy 4	1.068883[a]	1.180718[a]	0.947184[a]	0.948901[a]	0.686268[a]	0.809037[a]

TABLE 6.6 (*Contd.*)

Equation	(A)	(B)	(C)	(D)	(E)	(F)
Dummy 5	1.046684[a]	1.143395[a]	0.945149[a]	0.932453[a]	0.691213[a]	0.806653[a]
Dummy 6	1.031413[a]	1.116027[a]	0.949880[a]	0.924241[a]	0.705705[a]	0.809749[a]
Dummy 7	1.016273[a]	1.089752[a]	0.951323[a]	0.915024[a]	0.703071[a]	0.803560[a]
Dummy 8	0.957872[a]	0.990465[a]	0.954289[a]	0.876766[a]	0.725545[a]	0.798187[a]
R^2 untr	0.186170	0.356810	0.124850	0.162240	0.292030	0.281590
Corr R^2 untr	0.158170	0.320930	0.094740	0.115510	0.267660	0.266870
DW	1.983903	1.996138	2.030721	2.040757	2.009669	2.014507
F-stat	6.309660[a]	9.225024[a]	4.016314[a]	3.512677[a]	11.479080[a]	11.077090[a]
Lag sum						
Prices	−0.217921[a]	−0.105511[b]	0.074314	0.130135[d]	0.372152[d]	0.181245
Prices × rent	0.001226[a]	0.000854[b]	−0.000138	−0.000600	−0.000424	0.000113
NI Dths		−0.325246[a]		−0.160201		
NI Dths × rent		0.001226[a]		0.001316[d]		
Joint significance (F-statistic)						
Prices	12.22[a]	6.82[a]	4.05[a]	2.84[b]	5.16[a]	4.75[a]
Prices × rent	5.17[a]	3.58[a]	0.71	0.72	0.13	0.16
NI Dths		6.81[a]		3.01[b]		
NI Dths × rent		1.46[d]		1.99[c]		
Dummies	24.54[a]	29.49[a]	37.52[a]	37.06 [a]	6.12[a]	17.07[a]

Notes: 'NI Dths' are non-infant deaths. 'Rent' is average rent in 1713.

The secular trend has been removed from each series by dividing each data point (x) in a series by an 11-year moving average of data points centred around x.

The regressions are corrected for second-order autoregressive disturbances using the iterative Cochrane–Orcutt procedure. R^2 and Corr R^2 are calculated for the untransformed variables.

The sub-sets for Lag sum and joint significance are lags 0–4 for each independent variable.

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

for the 19 rural *herreds* of Arhus diocese. Note that no marriage data are available for Arhus diocese. Finally, Table 6.6 shows the results for Rouen parish groups.

The significance of the interacted terms in Tables 6.4–6.6 is particularly important, because it indicates whether the rich and poor responded differently. The data on lag sums are simply the summation of the sub-set of lags (0–4) of each independent variable. We test whether the resulting elasticity is different from 0.[23] If the interacted term is significantly different from 0, then the differences between rich and poor persist four years after the shock.

We also test the joint significance of sub-sets of independent variables.[24] This test simply indicates whether or not the sub-set of independent variables makes any contribution to the explanation of the dependent variable. If not, the sub-set of variables might just as well be dropped from the equation. For our purposes, a sub-set is defined as lags 0–4 of each independent variable. Note that it is possible for a sub-set of variables to have a lag sum that is not significant, yet to be jointly significant. This would suggest that there are significant differences between the estimated magnitudes of some of the individual coefficients.

The Short-Term Preventive Check

Fluctuations in fertility that result from variations in grain prices may be caused by a number of factors which can be grouped by biological or behavioural criteria. Biological responses caused by a decline in nutrition as a result of high food prices include: an increase in age at menarche; a reduction in the age at menopause; higher frequency of secondary sterility; an increase in spontaneous abortion; an increase in famine amenorrhoea; or an increase in fertility-reducing diseases. Fertility responses that might be categorized as behavioural would include induced abortion; voluntary control through increased conscious contraception; an increase in amenorrhoea as a result of psychological stress; an increase in the frequency of 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.

There is little research on the direct impact of variations in food supply on fluctuations in fertility among the rich and poor. R. E. Frisch has presented some evidence that fertility among working-class women in nineteenth-century Britain was impaired by poor nutrition, hard physical work, and poor living conditions.[25] More relevant to the present analysis, Z. Stein and M. Susser found that, during the 1944–45 famine in the Netherlands, fertility declined more among the working classes than among the higher social groups.[26] They suggest that this was a

[23] Pindyck and Rubinfeld, op. cit. in fn. 22, pp. 121–22 [24] Ibid., pp. 117–18.

[25] R. E. Frisch, 'Population, Food Intake, and Fertility', *Science*, no. 199 (1978), p. 22.

[26] Z. Stein and M. Susser, 'Famine and Fertility', in W. H. Mosley (ed.), *Nutrition and Human Reproduction* (New York, 1978), p. 131.

consequence of the higher social classes' greater access to food, an explanation 'which emphasizes the influence of current nutritional state on fecundity'.[27]

Although our data cannot throw light on many of the direct causal determinants of fertility decline that result from high prices, we can still measure the magnitude and timing of the fertility response in different socio-economic 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 (equations (A) and (B) in Tables 6.4, 6.5, and 6.6) in which annual detrended births or crude birth rates in countries are used as the dependent variable. Note that most of the annual variations in the fertility variable are due to variations in marital fertility, since annual variations in births resulting from newly-weds or unmarried couples will have only a marginal impact on annual variations in overall fertility.[28] Annual detrended grain prices and non-infant deaths, each distributively lagged five years, are the independent variables. The 'non-infant deaths' variable serves as a proxy for both adult mortality and morbidity.

Figure 6.1 displays the pooled regression results for the European countries, the rural *herreds* of Arhus diocese, and parish groups in Rouen. The vertical axes are elasticities, and are shown on the same scale in all three graphs. The dashed line is the zero-point on the vertical axis. The horizontal axes are measures of socio-economic welfare. Each solid line is labelled by its lag and represents the response of fertility to a price increase by socio-economic level. The very thick solid line, labelled *S*, represents the lag-sum response. Next to each lag label is a lower-case letter which indicates the significance of the slope. The absence of a letter indicates that the slope is probably not significant; i.e., there is no statistical difference between the responses of the rich and poor. Finally, with each graph there is a note which refers readers to a corresponding figure in other research which displays the responses to a price increase plotted against socio-economic measures where regressions are run for each individual country, *herred*, or parish group.

It is clear from all three graphs that the strongest responses to a price increase are found among the poor areas at lag 1, that this response is always significant, and that it is always negative. The lag-1 line slopes towards zero as one moves from poorer to richer areas in all three data sets, as we expected. The slope of the lag sum is not significant in the European countries and Arhus, but is significant in Rouen. In Arhus, the lines form a roughly fan-shaped pattern, which indicates that the range of the preventive check among the rural poor is much greater than the range among the rich.

While spousal separation as a result of temporary migration might explain the national and rural responses, it is unlikely to be the cause of the urban response

[27] Ibid. p. 140.
[28] Lee (1981), op. cit. in fn. 1., pp. 366–69; D. R. Weir, 'Life under Pressure: France and England 1670–1870', *Journal of Economic History*, 44(1) (1984), p. 39.

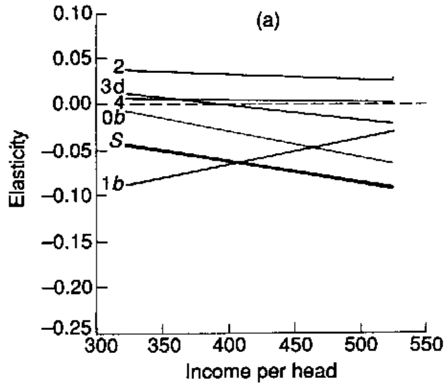
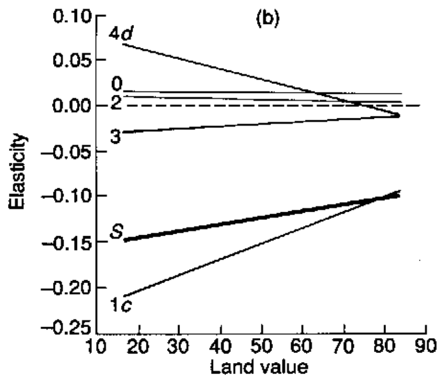


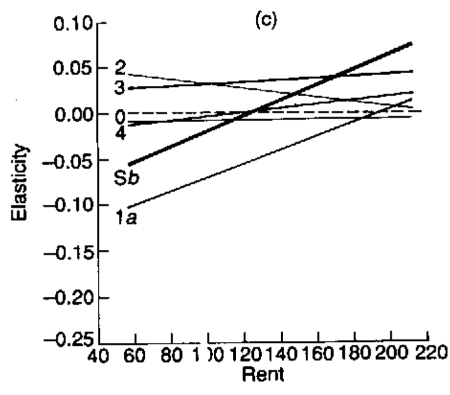
Fig. 6.1 Fertility responses to an increase in prices independent of non-infant mortality effects
(*a*) Five European countries according to income per head, 1756–1870.

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum. Significance is: *a*, 1%; *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 2.5 and eqn B in Galloway (1987), op. cit. in fn. 1, pp. 44, 304–21. See also eqn 2 in Galloway, op. cit. in fn. 3, foldout.
Sources: Table 6.1 and eqn (B) in Table 6.4.



(*b*) Nineteen rural *herreds* in Arhus diocese according to land value, 1726–1796

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum. Significance is: *a*, 1%; *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 8.2 and eqn B in Galloway (1987), op. cit. in fn. 1, pp. 215, 398–419.
Sources: Table 6.2 and eqn (B) in Table 6.5.



(*c*) Eight Rouen parish groups according to rent, 1681–1744

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum. Significance is: *a*, 1%: *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 2 and eqn 1 in Galloway, op. cit. in fn. 5, pp. 287, 300–01.
Sources: Table 6.3 and eqn (B) in Table 6.6.

in Rouen. During periods of high grain prices, migration was usually from rural to urban areas, where grain was stored and distributed. Thus, we have reasonably convincing evidence that, barring significant decreases in births due to biological factors discussed above, some form of conscious fertility control was probably in operation in the poorer parishes of Rouen.

Periods of dearth should reduce 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 and lead to an increase in remarriages. High adult mortality would also open up economic opportunities for those not yet married, thereby allowing them to marry. On the other hand, higher mortality would be accompanied by an increase in mourning, which might delay some marriages. The perception of increased mortality and morbidity might dampen the atmosphere of nuptial expectations and lead to postponement of marriage for some, and perhaps permanently discourage others from marrying.

Equations (D) in Tables 6.4 and 6.6 reveal the impact of a price increase on marriages in European countries and parish groups of Rouen. No marriage data are available for Arhus *herreds*. In general, the slopes of the responses are statistically insignificant in all cases, except at lag 0 in the European countries. However, comparison with earlier research[29] reveals that this slope is a result of the large negative response of marriages in France, and that the relative sizes of the response in other countries vary little at different income levels.

The responses of marriages to increases in non-infant mortality are shown in equations (D) in Tables 6.4 and 6.6. This response is mainly a result of remarriages.[30] We see in both data sets an initial decrease in marriages in poorer areas, with a corresponding increase in marriages one year later. The richer areas are virtually unaffected at lags 0 and 1. Looking at the overall effect (lag sum) within the European countries, there is a strong tendency for marriages to respond positively to higher non-infant mortality, and this response is about the same in the poor as in the rich countries. As cautioned earlier, it is important to look at the unpooled regression results as well. Indeed, marriages in England, the country with the highest incomes, showed no net response to increased non-infant mortality over the five-year interval.[31] In Rouen, there is a tendency for the poor not to remarry as a result of increased non-infant mortality.

The Short-Term Positive Check

High grain prices can increase mortality as a result of outright starvation, an increase in the susceptibility of the body to disease as a result of malnourishment, and an increase in migration which leads to an increase in the frequency of interaction among different members of the population, and in turn to an increase

[29] Galloway, op. cit. in fn. 3, foldout.
[30] Galloway (1987), op. cit. in fn. 1, pp. 106–11.
[31] Galloway, op. cit. in fn. 3. p. 287, fig. 2.

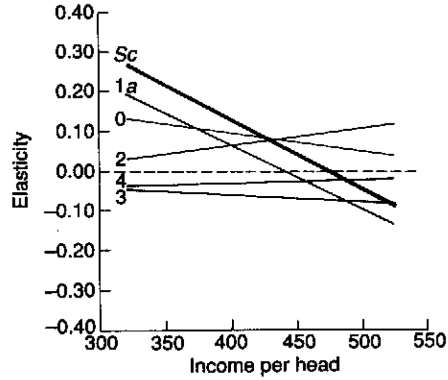
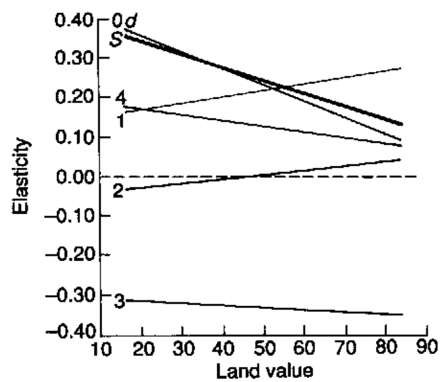


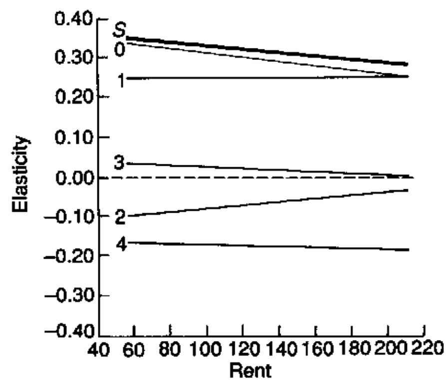
Fig. 6.2 Non-infant mortality responses to an increase in prices
(*a*) Five European countries according to income per head, 1756–1870

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum. Significance is: *a*, 1%; *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 2.12 and eqn K in Galloway (1987), op. cit. in fn. 1, pp. 51, 304–21. See also eqn 4 in Galloway, op. cit. in fn. 3, foldout.
Sources: Table 6.1 and eqn (E) in Table 6.4.



(*b*) Nineteen rural *herreds* in Arhus diocese according to land value, 1726–1796

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum. Significance is: *a*, 1%; *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 8.4 and eqn F in Galloway (1987), op. cit. in fn. 1, pp. 217, 398–419.
Sources: Table 6.2 and eqn (E) in Table 6.5.



(*c*) Eight Rouen parish groups according to rent, 1681–1744

Each line is labelled according to its lag and the significance of its slope. *S* means lag sum
Significance is: *a*, 1%; *b*, 5%; *c*, 10%; *d*, 20%.
Note: The lines correspond to fig. 6 and eqn 3 in Galloway, op. cit. in fn. 5, pp. 293, 300–01.
Sources: Table 6.3 and eqn (E) in Table 6.6.

in the frequency of outbreaks of infectious disease. It is difficult to use 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.

Figure 6.2 shows the various responses of non-infant mortality to variations in prices. The largest positive responses in all three data sets are seen among the poor at lags 0 and 1. These immediate positive responses, combined with the large negative elasticities at lag 3 in Arhus and lag 4 in Rouen, and the somewhat smaller negative elasticities at lags 3 and 4 in the five countries, suggest a kind of selectivity or timing effect where those who were about to die during the next four years, whether prices rose or not, were killed off more quickly as a result of the price increase. As a consequence, it is useful to calculate the lag sum and its significance to see whether there exists any more-or-less permanent effect of a price increase.

Looking at the lag sum responses, there is a significant tendency for mortality to be higher among the poor than among the rich in response to a price increase in the European countries. This is probably a result of overall economic development and associated improvements in harvest quantity, harvest quality, international trade, distribution, and storage capacity. While yearly changes in these factors determine annual grain price fluctuations, improvements in the overall level of any of them over time would tend to reduce the impact of grain-price variations on mortality and eventually the volatility of grain prices themselves.

No significant difference can be found in Arhus diocese or Rouen between the rich and poor responses. In fact, the joint significance test on the sub-set of interacted terms suggests that they contribute nothing, and may just as well be dropped from the equation. In Rouen we may attribute this to an influx of poor, perhaps diseased, rural migrants into the city in search of food or employment, thus increasing the frequency of interaction among the urban and rural poor populations, possibly leading in turn to an increased likelihood of outbreaks of infectious disease, sometimes epidemic.[32] The urban rich, whether through contact with servants or general interaction with the urban populace, were likely to be affected by these outbreaks. In rural Arhus diocese we may see a movement of the rural poor out of their districts and into wealthier districts in search of sustenance or employment where they themselves may die or generate outbreaks of deadly infectious disease which would tend to kill even the rich.

Conclusions

We have observed the operation of both short-term preventive and positive checks in countries, in rural Arhus diocese, and in the city of Rouen. As expected,

[32] Galloway (1985), op. cit. in fn. 1, p. 500; J. Walters and R. S. Schofield, *Famine, Disease and the Social Order in Early Modern Society.* (Cambridge, 1989)

the poor experience a significantly stronger preventive check than the rich at lag 1 in all areas. However, looking at the lag sum, this rich–poor difference is simply a matter of timing in the countries and Arhus, while it is more or less permanent in Rouen.

The positive check, as measured by the lag sum, is strong in all areas except the more developed countries. There is no difference in the positive check between the rich and poor in rural Arhus diocese and Rouen. The differentiation in the positive check between countries may result from different levels of overall economic development. In rural Arhus diocese and the city of Rouen we may attribute this constancy in the positive check to an influx of poor, and often sickly, rural migrants into the wealthier districts during years of high grain prices where they may make a significant contribution to the death rolls. This increased interaction among the populations may also spawn outbreaks of infectious disease, sometimes epidemic in proportion, from which the rich are unlikely to be immune.

Appendix **Sources of Data for Rural *Herreds* in Arhus Diocese**

Vital Events by Rural *Herred* in Arhus Diocese, 1721–1801

Births (baptisms) and total deaths for 1721–1801 for each rural *herred* in Arhus diocese are taken from Lassen (op. cit. in fn. 9, pp. 449–84). The series for the 19 rural *herreds* consist of 3,078 data points, of which only 38 were missing, and 5 were clearly in error. I have corrected these deficiencies on the basis of the change in births (or deaths) during the appropriate years in Arhus diocese. It should be noted that the printed series of births and deaths for Norrehald and Norre after 1769 are reversed, as a result of a typesetting error in Lassen's book (p. 456). The printed series were checked against 14 photographs of the original registration tables from 1787 to 1800 (Lassen, op. cit. in fn. 9, pp. 463–77), and found to be accurate.

The series for the *herreds* of Sabro and V. Lisbjerg are combined in the primary source material. The same is true for the *herreds* of Vrads and Thyrsting. The island *herred* of Samsoe, while technically in Arhus diocese, was excluded from all analyses because of a lack of data.

The series of total deaths probably includes stillbirths (A. E. Imhof, *Aspekte der Bevölkerungsentwicklung in den nordischen Ländern 1720–1750* (Berne 1976, p. 119)). Stillbirths were removed from total deaths in any given year by multiplying the births by 0.044 and subtracting the result from the total of deaths. This multiplier is the number of stillbirths per birth (baptism) in Arhus diocese between 1765 and 1800, taken from Lassen (op. cit. in fn. 9, p. 487).

Non-infant deaths were calculated by multiplying the numbers of births by 0.225 and subtracting this result from the total number of deaths (less stillbirths). No data on infant mortality are available for any of the *herreds*. The multiplier of 0.225 is for 26 rural parishes throughout Denmark between 1741 and 1801 and taken from H. C. Johansen, 'The position of the old in the rural household in a traditional society', *Scandinavian Economic History Review*, 24 (2) (1976), p. 133

Vital Events in Arhus Diocese, 1721–1801

Births (baptisms) and total deaths are taken from Lassen (op. cit. in fn. 9, pp. 21, 296, 446–48). Deaths less stillbirths and non-infant deaths have been calculated as described above.

Vital Events in Denmark, 1721–1801

Births and deaths during 1735–99 are taken from H. Gille, 'The Demographic History of the Northern European Countries in the Eighteenth Century', *Population Studies*, 3(1) (1949), pp. 60, 61. The data for 1800 and 1801 are from Denmark Statistike Department, *Bevolkningsudvikling od Sundhedsforhold, 1901–1960* (Copenhagen, 1966, p. 16). Non-infant deaths are $D - 0.225B$, where D and B are total numbers of deaths and births respectively. The infant mortality rate of 0.225 is discussed above.

Land Value of *Herreds* in Arhus Diocese and Denmark, 1801

Land value is tax assessment in *tonder hartkorn* per 0.1 Danish square miles. The data by *herred* come from A. F. Bergsoe, *Den Danske Stats Statistik*, Vol. 1 (Copenhagen, 1844, pp. 31–102)

Population and Density in *Herreds* in Arhus Diocese and Denmark, 1801

Density is population per Danish square mile in 1801 A. F. Bergsoe, *Den Danske Stats Statistik*, Vol. 1 (Copenhagen, 1844, pp. 31–102, 365–94).

Copenhagen Prices, 1715–1801

Prices between 1722 and 1800 are rye prices, based on the monthly prices of Danish rye in Copenhagen (some 80 miles east of Arhus). The average of the available monthly prices has been calculated for each year. The data come from A. Friis and K. Glamann, *A History of Prices and Wages in Denmark 1600–1800* (London, 1958, pp. 153–54, 207–24). The prices are in skillings per *tonde*.

Prices for the period 1715–21 and for 1801 are based on the growth rate of Rendsburg rye prices and taken from E. Waschinski, *Währung, Preisentwicklung und Kaufkraft des Geldes in Schleswig-Holstein von 1226 bis 1864* (Neumünster, 1959, pp. 177, 253), applied to the Copenhagen Danish rye prices. The prices are in skillings per *tonde*.

The annual fluctuations in Copenhagen rye prices almost certainly mirror annual variations in Arhus rye prices. Johansen has shown that between 1735 and 1849 the correlations of annual *kapitelstakster* rye price changes in six dioceses in Denmark ranged from 0.80 to 0.97, and concluded that the Danish rye grain market was already fairly well integrated into one common national market (H. C. Johansen, 'Regional mortality fluctuations in Denmark 1735–1849', paper presented to the Ninth International Economic

History Congress, Berne, 1986, p. 5. He used *kapitelstakster* prices and notes that 'the *kapitelstakster* were fixed late in the year and they are . . . used as an expression for the situation during the next year, since the new harvest did not influence prices until very late in the year' (ibid.). This kind of problem does not arise in my analysis, because I have been using calendar year prices.

Old and New Methods in Historical Demography

Editors

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