The reversal of the relation between economic growth and health progress: Sweden in the 19th and 20th centuries

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BACKGROUND

• Health progress, as measured by the decline in mortality rates and the increase in life expectancy, is usually conceived as related to economic growth, especially in the long run.

•Recent studies have shown that in the short term, death rates fluctuate up in expansions and down in recessions, with the death rate even reversing its declining long-term trend during periods of accelerated economic growth.

Overall Research Question

- What was the evolution of the relation between health progress and economic growth in Sweden during the 19th and 20th centuries, during the transformation of Sweden from an agricultural to an industrial market economy?

Major Sources of Data

- Historical economic statistics of Sweden (GDP, GDPpc, GDP deflator, unemployment) from O. Krantz

- Mortality data from the Human Mortality Database

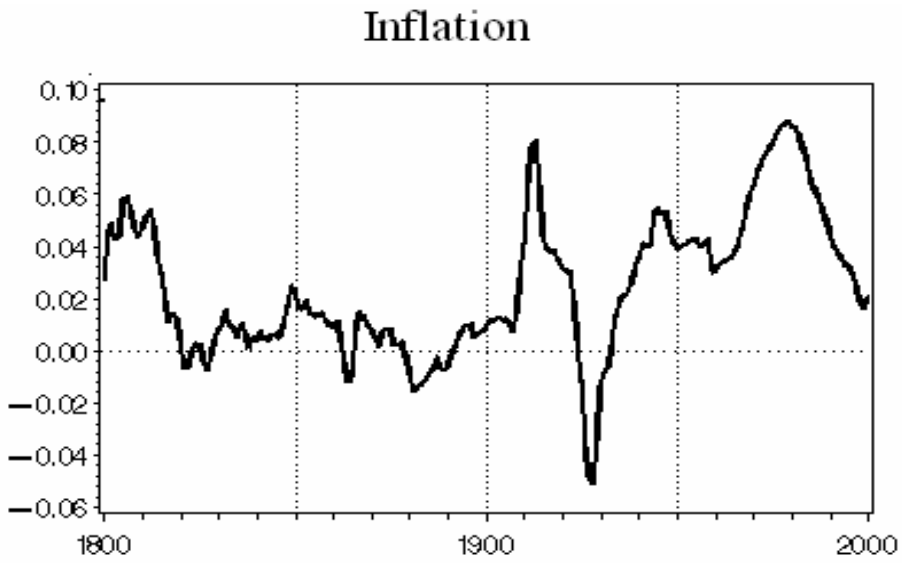
Explanatory Variables: Economic indicators

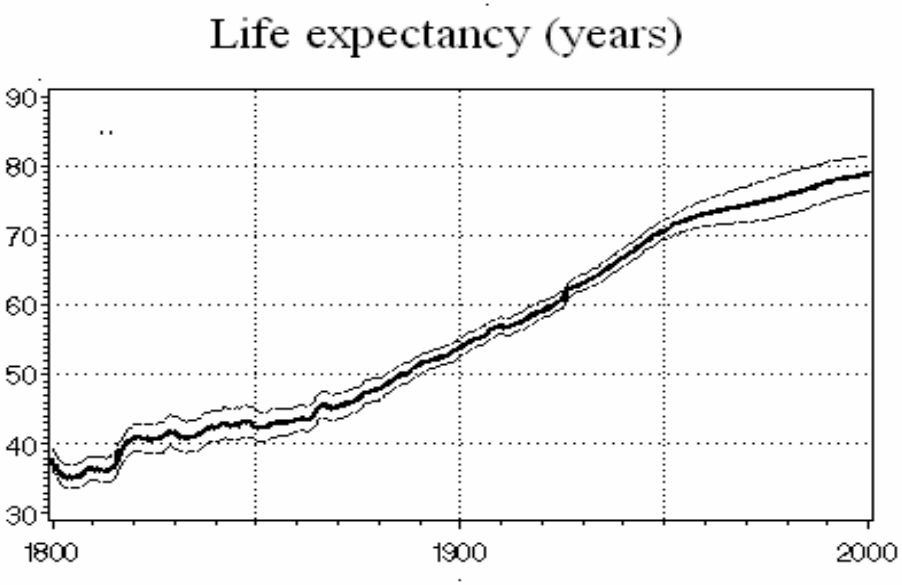
- GDP growth (annual rate of change in real GDP)
- Inflation (rate of change of GDP deflator)
- Harvest quality
- Unemployment

Outcome Variables: Health progress

- Longevity shortfall (90 - e0, A. Sen)
- Age-specific mortality rates

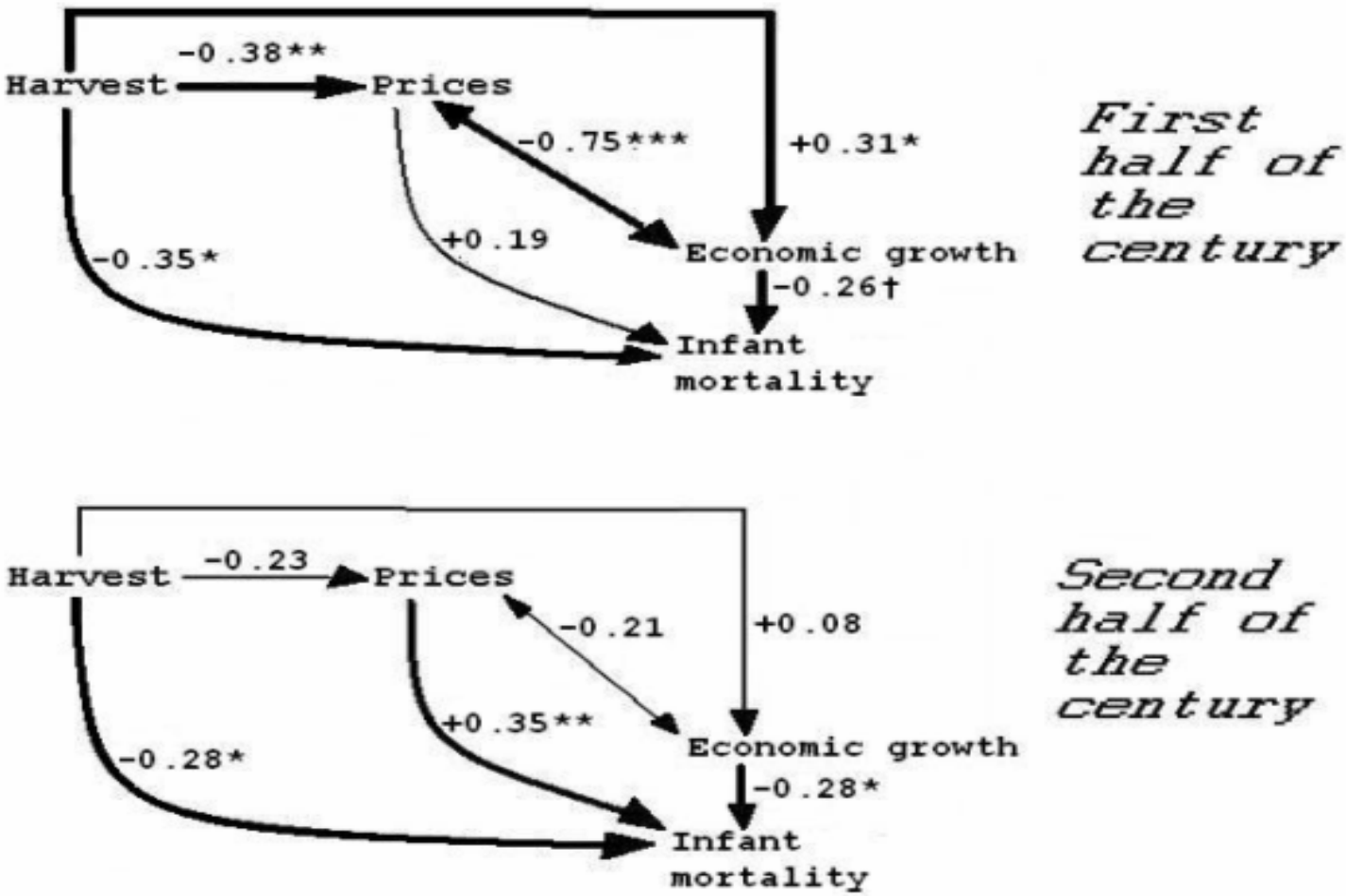
Only GDP growth models will be presented here





Except for the unemployment rate, all plots are 15-year centered moving averages.

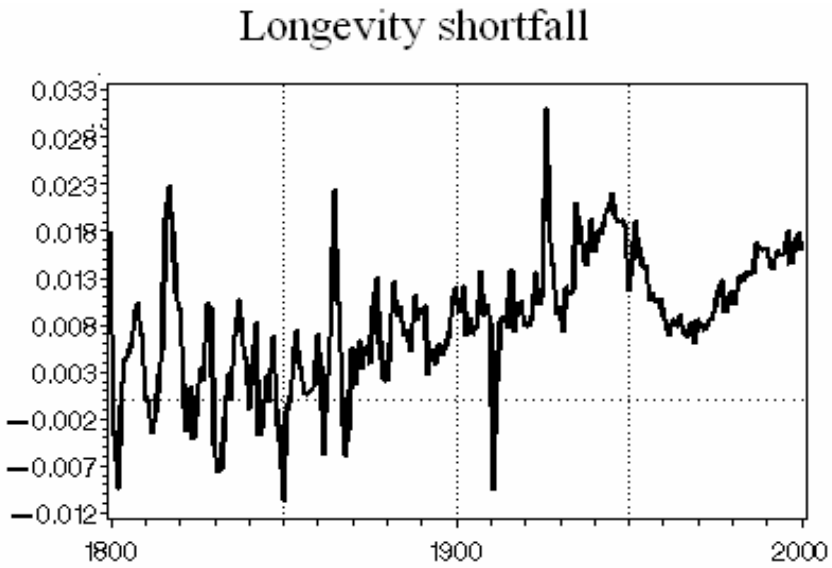
Figure A1. Pathways between harvests, price levels, economic growth, and infant mortality in Sweden during the 19th century. Correlations are computed between annual series of a general crop index in levels (harvest) and the annual rate of change of the GDP deflator (prices), volume GDP (economic growth), and infant mortality. Thick lines indicate statistically significant correlations.

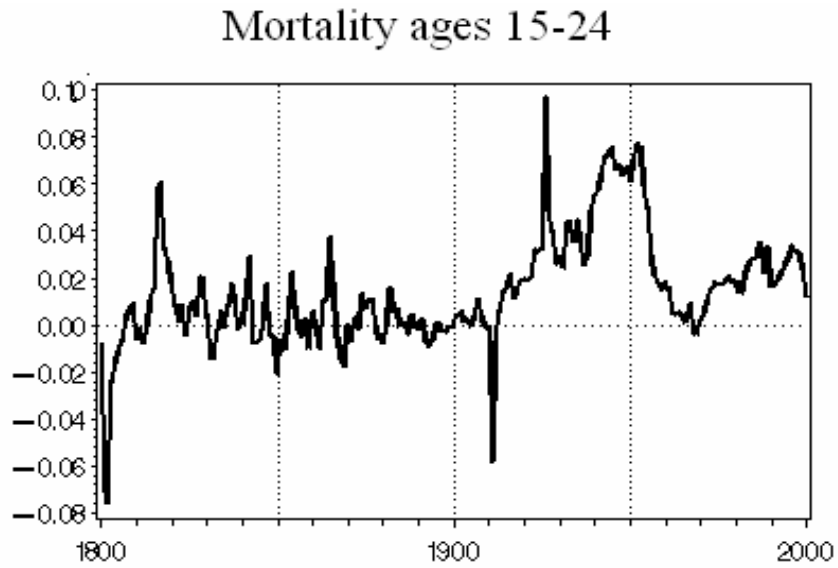


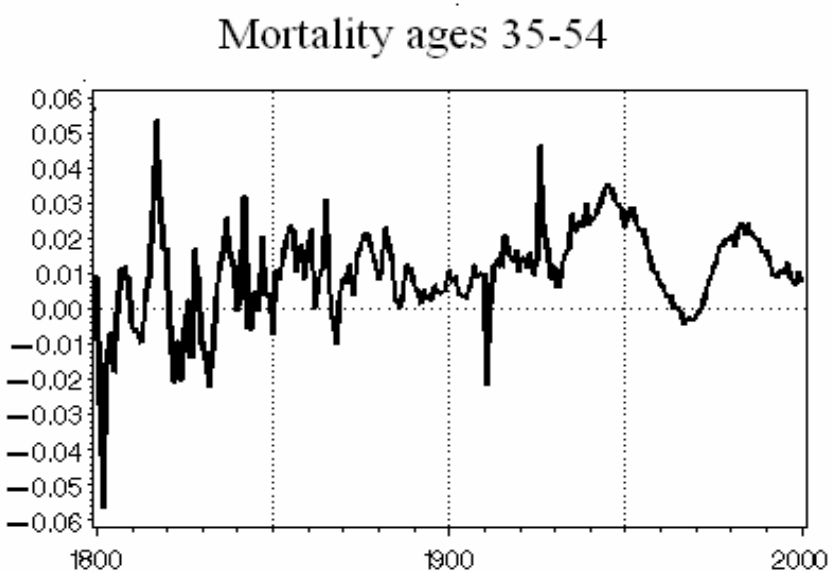
The rate of health progress is measured by either

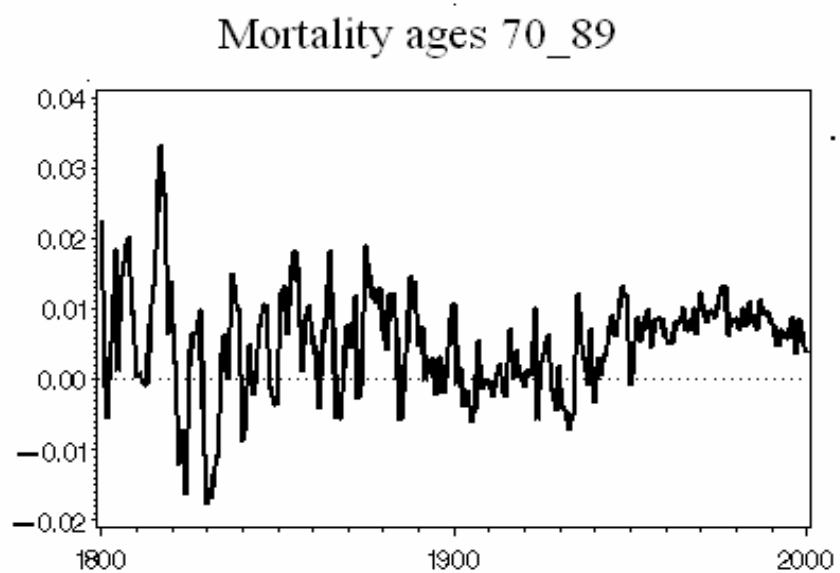
- the relative decline in longevity shortfall, that is $-\Delta \ln (90 - e_{0,t})$; or
- the relative decline in age-specific mortality, that is $-\Delta \ln m_{a,t}$

Rate of health progress as measured by $-(\ln h_t - \ln h_{t-1})$









Methods for analysis

- Regressions with interactions
- Cross-correlations
- Distributed lag regressions
- Relationships between smoothed series
- Spectral analysis
- Granger causality tests

Results

- Research Question 1: Does the effect of economic growth on health progress vary over time?
- Model: Health progress modeled as a function of economic growth g_t, time t, and the interaction between them, $g_t \bullet t$

$$-\Delta \ln h_t = b_0 + b_1 \cdot t + b_2 \cdot g_t + b_3 \cdot t \cdot g_t + \varepsilon_t$$

Sample	Health indicator, *h*	Economic growth, *g*	Interaction *g* · *t*	Tipping point
19th & 20th cent.	Longevity shortfall	0.76*** (0.20)	– 0.004* (0.002)	1990
19th century	Longevity shortfall	0.73* (0.32)	– 0.003 (0.006)	
20th century	Longevity shortfall	1.55* (0.66)	– 0.009* (0.005)	1972

Sample	Health indicator, *h*	Economic growth, *g*	Interaction $g \cdot t$	Tipping point
19th & 20th centuries	Longevity shortfall males	0.75*** (0.20)	– 0.004* (0.002)	1988
	Mortality 15-24 males	2.54*** (0.56)	– 0.012* (0.005)	2012
	Mortality 35-54 males	1.49*** (0.41)	– 0.009* (0.003)	1966
	Mortality 70-89 males	0.82** (0.27)	– 0.007* (0.003)	1917
20th century	Longevity shortfall males	1.67* (0.63)	– 0.010* (0.004)	1967
	Mortality 15-24 males	6.22** (2.22)	– 0.036* (0.016)	1973
	Mortality 35-54 males	3.56** (1.12)	– 0.023** (0.008)	1955
	Mortality 70-89 males	0.17* (0.73)	– 0.002 (0.005)	1885
19th & 20th centuries	Longevity shortfall females	0.77*** (0.21)	– 0.004* (0.002)	1993
	Mortality 15-24 females	1.81** (0.57)	– 0.007* (0.005)	2059
	Mortality 35-54 females	1.73*** (0.41)	– 0.011* (0.004)	1957
	Mortality 70-89 females	0.80* (0.31)	– 0.006* (0.003)	1933
20th century	Longevity shortfall females	1.38* (0.70)	– 0.008* (0.005)	1973
	Mortality 15-24 females	4.36 (2.54)	– 0.025 (0.018)	1971
	Mortality 35-54 females	2.46* (1.08)	– 0.016* (0.008)	1954
	Mortality 70-89 females	– 0.05* (0.87)	– 0.000 (0.006)	

- Research Question 2: Does the effect of economic growth on health progress vary with the level of GDP per capita?
- Model: Health progress modeled as a function of economic growth g_t, GDP per capita y_t,, and the interaction between them, y_t, • g_t

$$-\Delta \ln h_t = b_0 + b_1 \cdot \ln y_t + b_2 \cdot g_t + b_3 \cdot \ln y_t \cdot g_t + \varepsilon_t$$

Table 3. Parameter estimates of models in which annual health progress, measured as $-\Delta \ln h_t$, is regressed on a constant, GDP per capita y_t, economic growth g_t, and the interaction $g \cdot y_t$. Standard errors are in parenthesis following parameter estimates. For the explanation of the tipping point, see text.

Sample	Health indicator, h_t	Economic growth, g_t	Interaction $g_t \cdot y_t$	Tipping point
19th & 20th centuries	Longevity shortfall	1.44** (0.45)	– 0.26* (0.11)	1963
	Infant mortality	1.68* (0.68)	– 0.31 (0.19)	1961
	Mortality 35-54	2.95** (0.89)	– 0.57** (0.30	1953
19th century	Longevity shortfall	2.57 (2.05)	– 0.62 (0.63)	1909
	Infant mortality	2.26 (3.64)	– 0.45 (1.13)	1948
	Mortality 35-54	8.66* (4.31)	– 2.39 (1.34)	1883
20th century	Longevity shortfall	2.17* (0.90)	– 0.40* (0.18)	1961
	Infant mortality	– 0.16 (1.40)	0.06 (0.29)	<1800
	Mortality 35-54	4.33** (1.42)	– 0.83** (0.30)	1954

*$P < 0.05$ **$P < 0.01$

Regression models with interactions: conclusions

Economic growth has positive effects on health progress, but the effects diminish with time and then become negative

Economic growth has positive effects on health progress, but the effects diminish with the level of GDP per capita and then become negative

Research Question 3: Does economic growth affect health progress with a lag?

- Cross-correlation models
- Distributed lag regressions

Table 4. Correlations between health progress and economic growth at lag 0 and other lags, during overlapping half-centuries in Sweden

Years	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
A —Health progress as measured by the relative decline in longevity shortfall ($90 - e_0$)							
1801-1849	0.33*	0.10	0.01	− 0.27	− 0.04	0.08	− 0.17
1825-1874	0.32*	0.26	− 0.16	− 0.31*	− 0.05	0.02	0.09
1850-1899	0.34*	0.16	− 0.21	− 0.14	− 0.23	0.07	0.18
1875-1924	0.32*	− 0.03	− 0.43**	0.15	− 0.06	− 0.15	0.06
1900-1949	0.27	− 0.06	− 0.37**	0.17	0.09	− 0.25	0.10
1925-1975	− 0.05	− 0.28*	− 0.05	0.17	0.25	− 0.17	0.08
1950-*ca.*1998	− 0.10	− 0.24	− 0.02	− 0.21	− 0.10	0.00	− 0.10
B — Health progress as measured by the relative decline in mortality at ages 35-54							
1801-1849	0.36*	0.13	− 0.07	− 0.20	− 0.01	0.01	− 0.10
1825-1874	0.20	0.18	0.02	− 0.35*	− 0.03	− 0.02	− 0.02
1850-1899	0.15	0.11	− 0.04	− 0.17	− 0.16	0.03	0.28
1875-1924	0.32*	− 0.07	− 0.36*	0.13	0.01	− 0.17	0.18
1900-1949	0.27	− 0.09	− 0.30	0.10	0.13	− 0.24	0.09
1925-1975	− 0.16	− 0.42**	0.10	− 0.02	0.31*	− 0.21	0.13
1950-*ca.*1998	− 0.26	− 0.21	0.00	− 0.23	− 0.20	− 0.15	− 0.08

Crosscorrelations: conclusions

Economic growth reveals **positive** correlations with health progress at lag 0 in 1800-1850, but this correlation diminishes and then disappears with time.

Economic growth reveals **negative** correlations with health progress at lags 1 or 2 in the 20th century, particularly in its second half

Distributed lag regressions

- $\Delta \ln (h_t) = a + b_0 g_t + b_1 g_{t-1} + b_2 g_{t-2} + \ldots + b_k g_{t-k} + \varepsilon_t$

where

– $\Delta \ln (h_t)$ is health progress measured by the relative decline in year t of the health indicator h_t, and

g_{t-k} is economic growth at time *t-k,* that is, lagged *k* years with respect to the year in which health progress is measured

	Effects on the decline of longevity shortfall							Effects on the decline of mortality 35-54						
	Number of lags included in the regression							Number of lags included in the regression						
	0	1	2	3	4	5	15	0	1	2	3	4	5	15
	Sample 19th century													
β_0	0.56***	0.64***	0.62***	0.58**	0.58**	0.59**	0.43**	0.98***	1.12***	1.11***	1.02**	1.01**	1.03**	0.49
β_1		0.23	0.27	0.24	0.19	0.19	0.26		0.45	0.50	0.45	0.37	0.40	0.44
β_2			–0.08	–0.09	–0.13	–0.14	–0.26			– 0.04	– 0.09	– 0.11	– 0.15	– 0.01
β_3				–0.21	–0.24	–0.25	-0.45*				– 0.40	– 0.48	– 0.53	–1.08*
β_4					–0.26	–0.26	–0.15					– 0.27	– 0.26	– 0.03
β_5						–0.06	–0.16						– 0.26	– 0.20
β_6							–0.12							–0.08
	Sample 20th century													
β_0	0.25*	0.26*	0.20†	0.19	0.20	0.17	0.08	0.37	0.40*	0.33	0.32	0.32	0.27	0.15
β_1		–0.12	-0.08	-0.05	–0.05	–0.05	0.05		–0.24	–0.18	– 0.17	–0.18	–0.17	–0.03
β_2			–0.33*	-0.34**	-0.35**	–0.33*	-0.35*			–0.41†	–0.42*	-0.40*	–0.36	–0.43†
β_3				0.13	0.13	0.11	0.03				0.05	0.04	– 0.01	– 0.10
β_4					–0.02	0.00	0.14					0.07	0.12	0.29
β_5						–0.15	-0.22						– 0.31	– 0.40
β_6							0.06							0.11

Distributed lag regressions: conclusions

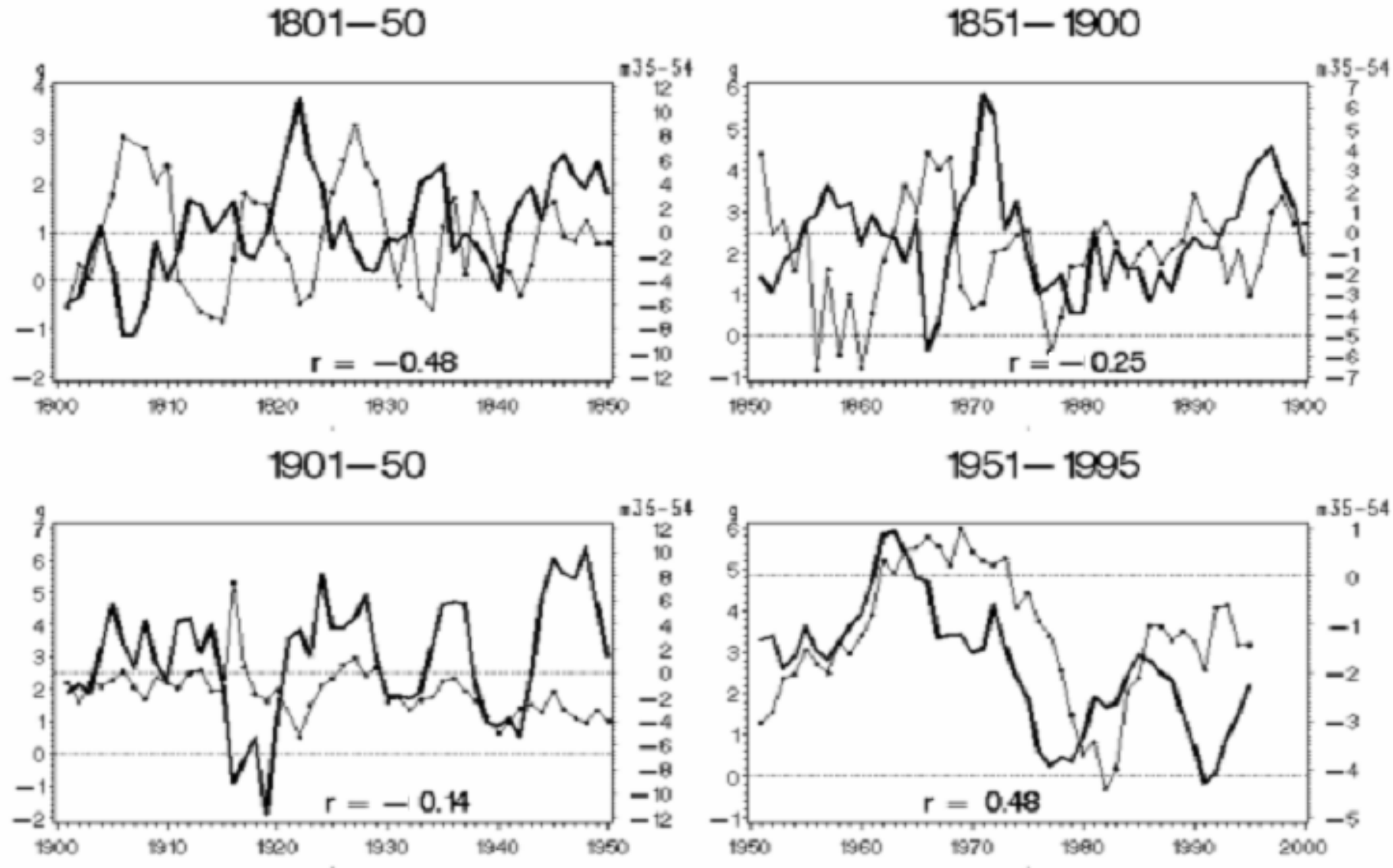
Economic growth reveals strong **positive** effects on health progress at lag 0 in the 19th century.

Economic growth reveals weaker **negative** effects on health progress at lags 1 or 2 in the 20th century

Research Question 4: Does average economic growth during several years affect average health progress?

- Models with economic growth and health progress averaged with 5-year, 11-year, and 15-year moving averages

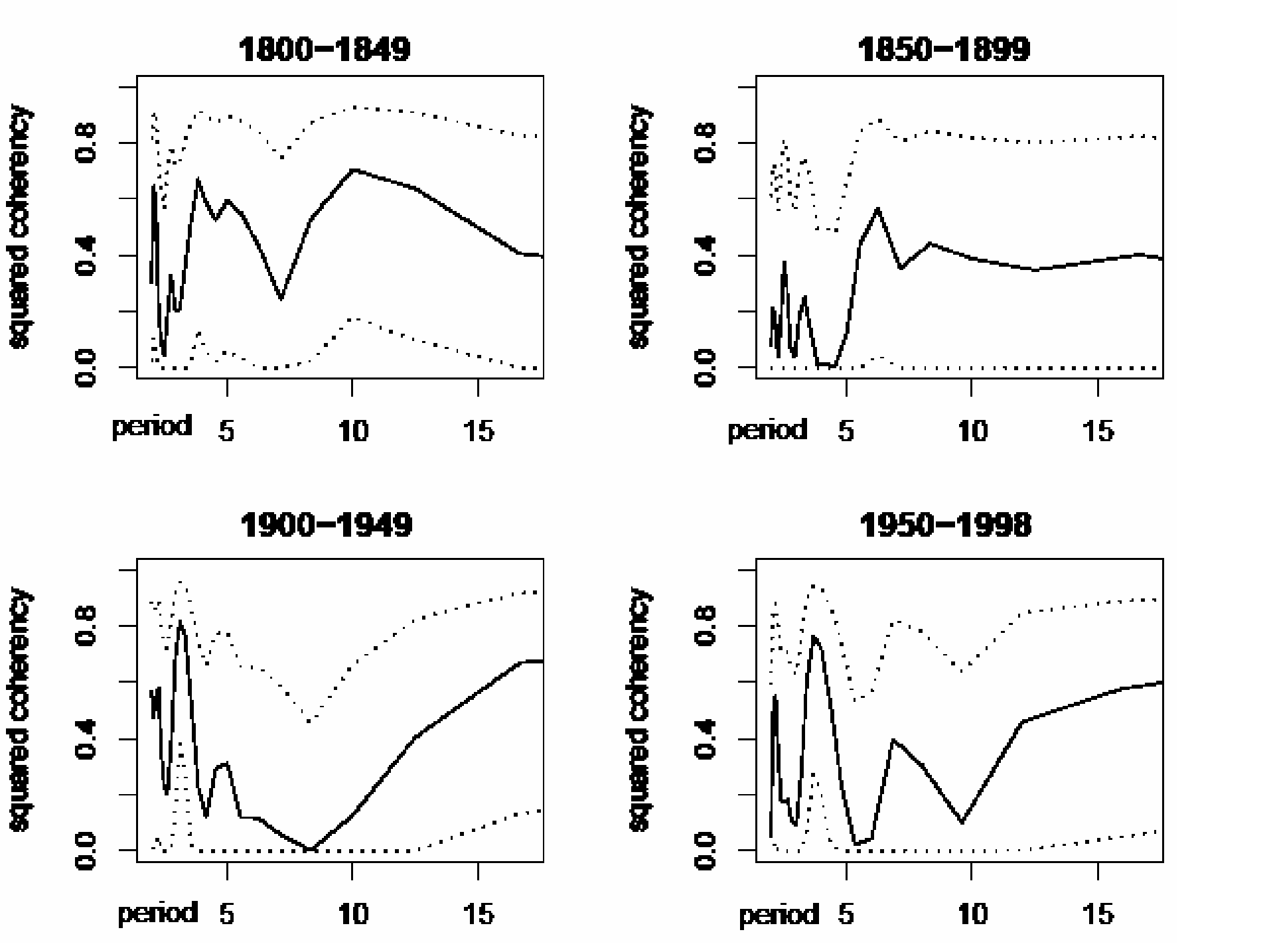
Figure 4. Economic growth (g, thick line) and rate of change of mortality at ages 35-54 in 19th and 20th century Sweden. Both variables are transformed into 5-year centered moving means. Scales in percentages.



Correlations of smoothed variables: conclusions

With the variables averaged in 5-year, 11-year, or 15-year moving averages, economic growth reveals **positive** correlations with health progress in 1800-1850, but the correlation becomes weaker in 1851-1900, almost zero in 1900-1950, and **negative** after 1950

- Similar results with spectral analysis
- The Granger causality test provides evidence consistent with that of regression and correlation models and spectral analysis.
- All statistical models suggest the same conclusions


1800–1849
1850–1899
1900–1949
1950–1998
squared coherency
0.0
0.4
0.8
period
5
10
15

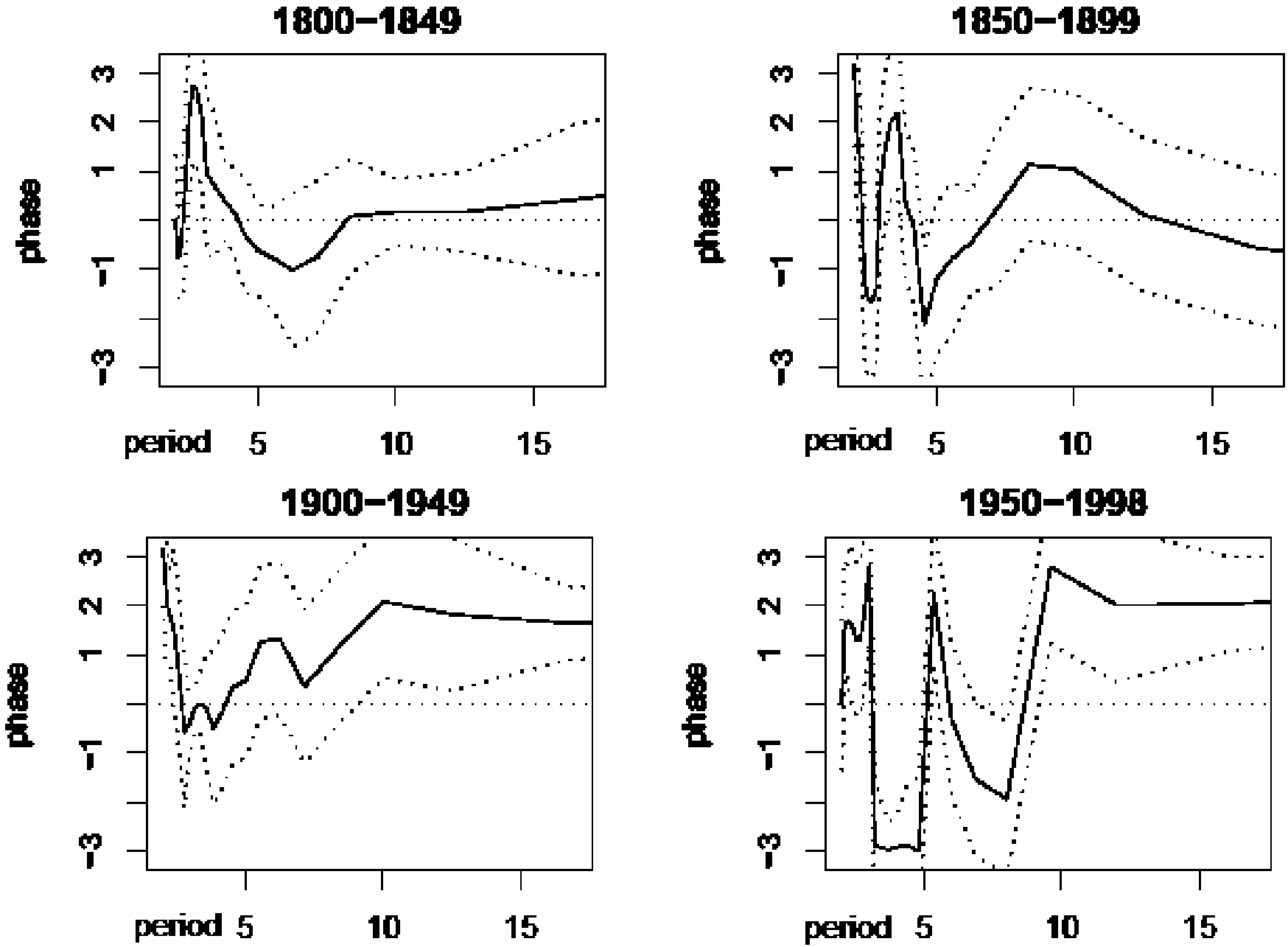

1800–1849
1850–1899
1900–1949
1950–1998
phase
period
-3
-1
1
2
3
5
10
15

Table C1. *F*-tests for Granger-causality

					Schwartz Bayesian Criterion	
Null hypothesis	Sample	Lag	*F*	*P*	Expanded model	Restricted model
Economic growth does not Granger-cause health progress (as measured by the relative decline in longevity shortfall)	19th century	1	3.26	0.07	– 269	–271
		2	2.94	0.06	– 263	–266
		3	2.06	0.11	– 255	–262
		4	1.42	0.23	– 248	–260
		5	1.15	0.34	– 236	–253
		10	0.52	0.87	– 200	–239
	20th century	1	0.01	0.93	– 347	–352
		2 (*)	6.02	0.00	– 350	–348
		3	3.79	0.01	– 337	–339
		4	2.78	0.03	– 323	–330
		5	2.30	0.05	– 314	–326
		10	1.91	0.06	– 259	–285
	20th century, 2nd half	1 (*)	5.16	0.03	– 266	– 265
		2	2.86	0.07	– 255	– 257
		3	3.39	0.03	– 248	– 250
		4	3.06	0.03	– 237	– 241
		5 (*)	2.54	0.04	– 255	– 232
Health progress (decline in longevity shortfall) does not Granger-cause economic growth	19th century	1	0.12	0.73	– 376	– 380
		2	1.31	0.27	– 367	– 373
		3	0.67	0.57	– 357	– 368
		4	1.04	0.39	– 346	– 360
		5	0.67	0.65	– 333	– 353
		10	1.18	0.31	– 290	–322

Table 5. Regression estimates of the effect of economic growth on health progress (as measured by the decline in longevity shortfall or in mortality at ages 35-54) in lag models

	Effects on the decline of longevity shortfall							Effects on the decline of mortality 35-54						
	Sample centuries 19 & 20													
	Number of lags included in the regression							Number of lags included in the regression						
	0	1	2	3	4	5	15	0	1	2	3	4	5	15
β_0	0.41***	0.45***	0.42***	0.42***	0.42***	0.42***	0.30**	0.68***	0.73***	0.70***	0.70***	0.70***	0.69***	0.42***
β_1		0.05	0.09	0.08	0.08	0.08	0.11		0.09	0.12	0.10	0.09	0.11	0.10
β_2			–0.19†	–0.19†	–0.20†	–0.20†	0.25†			–0.23	–0.23	–0.23	–0.21	–0.16
β_3				–0.06	–0.05	–0.05	–0.13				–0.22	–0.24	–0.26	–0.49*
β_4					–0.10	–0.10	–0.02					–0.08	–0.05	0.09
β_5						–0.03	–0.06						–0.16	–0.17
β_6							0.06							0.11

Major conclusions

- In the first half of the 19th century economic growth is strongly associated with health progress in Sweden, with years of greater economic growth being years of greater mortality decline.

- This relation becomes weaker as time passes and is eventually reversed: in the second half of the 20th century, the faster the economic growth, the slower the mortality decline.

Major Conclusions (cont.)

- **The effect of the economy on mortality occurs mostly at lag zero in the 19th century and lagged up to two years in the 20th. There is no evidence that economic growth affects mortality at greater lags.**
- **The usual view that faster economic growth leads to faster health progress is correct for the 19th century. However, the opposite is true for the last half of the 20th century**


0 50 100 km
0 50 100 mi
Kiruna
Norwegian Sea
Tärnaby
Luleå
Umeå
Gulf of Bothnia
FINLAND
Sundsvall
Hudiksvall
NORWAY
Gävle
Åland Is.
Uppsala
Karlstad
Örebro
STOCKHOLM
ESTONIA
Norrköping
Linköping
Jönköping
Göteborg
Gotland
LATVIA
Kalmar
Halmstad
Karlshamn
Oland
Helsingborg
Karlskrona
Baltic Sea
Sölvesborg
LITH.
Malmö
Bornholm
DENMARK
RUSSIA
GERMANY
POLAND

The End

Table 1. Statistics of the variables in the study period and its half centuries. All numbers are percentages

Variable	Years	Mean	Standard deviation	Minimum	Maximum
Economic growth	1801–ca. 1998	2.3	3.5	−8.9	11.7
	1801–1850	1.1	3.4	−7.0	7.0
	1851–1900	2.3	3.4	−8.8	11.7
	1901–1950	3.0	4.2	−8.9	10.9
	1951–ca. 1998	2.6	2.4	−2.4	8.6
Inflation	1801–ca. 1998	2.4	6.5	−25.0	36.9
	1801–1850	1.6	5.9	−10.1	21.3
	1851–1900	0.7	4.9	−13.2	12.1
	1901–1950	2.1	9.3	−25.0	36.9
	1951–ca. 1998	5.4	3.9	−1.9	19.4

Variable	Years	Mean	Standard deviation	Minimum	Maximum
Rate of decline in longevity shortfall	1801–*ca.* 1998	0.9	5.1	– 25.5	18.3
	1801–1850	0.5	6.4	– 15.3	18.3
	1851–1900	0.4	5.5	– 14.6	14.3
	1901–1950	1.4	5.5	– 25.5	18.2
	1951–*ca.* 1998	1.2	1.5	– 1.9	5.2
Rate of decline in infant mortality	1801–*ca.* 1998	2.1	8.6	– 26.8	24.4
	1801–1850	1.0	11.0	– 26.8	20.6
	1851–1900	0.8	9.8	– 20.7	24.4
	1901–1950	3.1	7.1	– 10.6	23.3
	1951–*ca.* 1998	3.7	5.0	– 5.5	14.0
Rate of decline in mortality 15–24	1801–*ca.* 1998	1.5	13.7	– 82.5	72.5
	1801–1850	0.5	15.9	– 47.1	44.1
	1851–1900	– 0.1	10.8	– 38.9	23.9
	1901–1950	3.6	17.8	– 82.5	72.5
	1951–*ca.* 1998	1.8	7.7	– 10.9	18.8
Rate of decline in mortality 35–54	1801–*ca.* 1998	1.1	10.0	– 42.8	50.8
	1801–1850	0.5	15.1	– 33.7	50.8
	1851–1900	0.9	9.3	– 20.2	28.8
	1901–1950	1.9	8.9	– 42.8	33.8
	1951–*ca.* 1998	1.2	2.4	– 3.3	7.3
Rate of decline in mortality 70–89	1801–*ca.* 1998	0.5	7.1	– 18.8	18.8
	1801–1850	0.7	10.0	– 18.8	18.8
	1851–1900	0.3	7.7	– 15.6	15.1
	1901–1950	0.3	6.1	– 11.6	16.3
	1951–*ca.* 1998	0.9	2.6	– 4.5	7.5