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TIME SERIES ANALYSIS OF THE RELATIONSHIP BETWEEN UNEMPLOYMENT AND MORTALITY A SURVEY OF ECONOMETRIC CRITIQUES AND REPLICATIONS OF BRENNER'S STUDIES*

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Abstract—M Harvey Brenner's numerous time-series analyses of the relationship between population mortality rates and aggregate unemployment rates have attracted considerable attention from academics, policy-makers and the mass-media Over the course of the last few years, however, Brenner's studies have begun to be subjected to critical scrutiny by econometricians This paper provides a survey of these studies and concludes that—contrary to what is often claimed—Brenner's analyses do *not* provide convincing evidence that the social costs of unemployment include premature deaths

I INTRODUCTION

Concern has been voiced in recent years over the possibility that unemployment and fear of unemployment may have serious adverse effects on physical health Much of this concern has derived from a belief that the social costs of unemployment are generally underestimated by economic policy makers In the forefront of the debate on the health consequences of unemployment and economic change have been M Harvey Brenner's numerous time series analyses of the relationship between population mortality rates and aggregate unemployment rates In one study Brenner [1] has claimed that an increase in the U S unemployment rate of one percentage point results in an extra 36,887 deaths over the course of the following 6 years Brenner's claims have attracted considerable attention from policy-makers The aforementioned estimate derives from a study prepared for the Joint Economic Committee of the United States Congress, in 1980 Brenner gave evidence to the British House of Lords Select Committee on Unemployment [2], and in a recent Swedish Government health services policy document his results have been described as "a model of how unemployment affects health" [3] That Brenner's results are apparently being accepted so unquestioningly by policy-makers is somewhat alarming in view of the findings of several recent studies in which they have been subjected to critical scrutiny by econometricians

The purpose of this paper is to provide a survey of these studies, indicating the major criticisms which have been levelled at the econometric methodology underlying Brenner's work and examining the extent to which replications of Brenner's '*Lancet*' model [4] lend support to his claims

*[Unfortunately, overseas commitments prevented Professor Harvey Brenner from sending a Comment in time for appearance in this issue However, a paper by Professor Brenner entitled "Economic Change, Life Stress and Mortality Evolution and Critique of a Model" will shortly be published in this journal —Ed]

The paper begins in Section II with a review of Brenner's hypotheses and presents the results of his Lancet model [4], the model which has received closest attention from econometricians but which bears a close resemblance to Brenner's subsequent work Section III summarizes the criticisms which have been levelled at Brenner's econometric methodology and Section IV undertakes a survey of the various replications of the Lancet model The final section—Section V—contains a summary and discussion

II BRENNER'S '*LANCET*' MODEL

It should be emphasized at the outset that Brenner's interest lies in the impact of economic instability on health, rather than with the effect of unemployment *per se* Brenner's thesis is that economic instability, in the form of recession and swift economic growth, entails life changes, or expectations of life changes, which are potentially harmful to an individual's health In times of recession the health of the unemployed is argued to suffer due in part to the psychosocial stress associated with unemployment (see for example [5, 6]) and in part to the financial hardships unemployment imposes Brenner argues that health changes may come about for any or all of three reasons (i) as a direct result of psychosocial stress, (ii) as a result of increased consumption of alcohol, tobacco and other potentially harmful commodities induced by stress and (iii) as a result of a drop in expenditure on heating, food, clothing and other items in the household budget beneficial to health brought about by reduced income Those not unemployed may, Brenner argues, also experience health deteriorations during recessions, due to the stress associated with fear of job loss an individual's stress may be due to his being fearful of losing his own job, or it may be due to his fear of others—such as his family—losing theirs' It is also argued that those in work may suffer deteriorations in their health due to their being subjected to more stressful work routines and their experiencing reductions in income

Times of rapid economic growth are also argued to be stressful, particularly for those being absorbed into the workforce after spells of unemployment

In an attempt to test his hypothesis Brenner has performed several time series analyses of the relationship between population mortality rates and macroeconomic variables such as the unemployment rate and per capita income His analysis for England and Wales published in *The Lancet* [4] is reasonably representative of these studies The period covered is 1936–1976 In common with writers such as McKeown [7], Brenner argues that the decline in mortality between 1936 and 1950 was due primarily to improvements in nutrition, sanitation, and the chemotherapeutic advances of the 1930s and 1940s Thereafter, claims Brenner, mortality declined largely because of reductions in the severity of fluctuations in economic activity Brenner maintains that fluctuations around the secular decline in mortality can be attributed to fluctuations in economic activity—recessions followed by rapid growth

Specifically, Brenner postulates that the population mortality rate in year t, $m(t)$, is linearly related to (i) the trend level of real per capita disposable income, $y^*(t)$, (ii) the difference between actual and trend real per capita disposable income, $y(t) - y^*(t)$, (iii) the difference between real per capita disposable income in years t and $t - 1$, $y(t) - y(t-1)$, (iv) government welfare transfer payments as a proportion of total government expenditures in year t, $w(t)/g(t)$, (v) the unemployment rate in year t, $u(t)$ and (vi) the lagged unemployment rates for the previous 10 years, $u(t-1), \ldots, u(t-10)$ Variables (ii) and (iii) are used as indicators of 'rapid economic growth' and unemployment as an indicator of recession The rationale for including lagged values of the last is that 'economic trauma' may—like unemployment—take time to have an impact, and may initiate a 'chain of distressing events' [8]

†Brenner clearly anticipates the mortality responses to mirror the pathological responses

‡Brenner did not report the standard errors in the *Lancet* paper

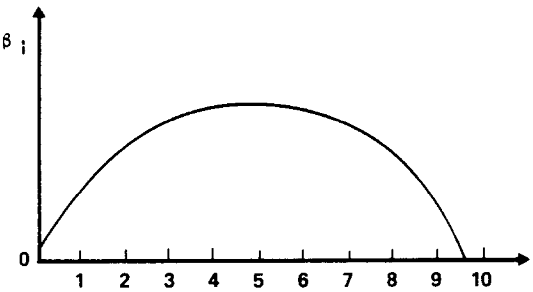

Fig 1 Brenner's hypothesized pattern for β_i

The equation estimated is

$$m(t) = \alpha_0 + \alpha_1 y^*(t) + \alpha_2[y(t) - y^*(t)] + \alpha_3[y(t) - y(t-1)] + \alpha_4[w(t)/g(t)] + \sum_{i=0}^{10} \beta i u(t-i) + \varepsilon(t)$$

where $\varepsilon(t)$ is an error term and $y^*(t)$ is derived by fitting an exponential trend over the period in question Brenner anticipates α_1 to be negative and α_2, α_3, $\beta_0, \ldots, \beta_{10}$ to be positive The βi are constrained to lie on a second degree polynomial (i e $\beta i = \lambda_0 + \lambda_1 i + \lambda_2 i^2$), it being anticipated that "the pathological reactions to economic trauma would build up over time, come to a high point and ultimately decline" [8]† No end-point restrictions are imposed, although it is clear from Brenner [8] that the mortality effects are thought likely to have worked their way through before the end of the 10 year period Thus Brenner anticipates the βi to follow the quadratic illustrated in Fig 1 The $w(t)/g(t)$ term is included "to test the hypothesis that government transfer payments for public welfare purposes reduce mortality" [4], so that α_4 is expected to be negative

Brenner's results for total mortality reported in *The Lancet* are reproduced in line 1 of Table 1‡ With the exception of α_2 the coefficients are of the expected signs The total estimated effect of the unemployment variables is large and is significant at the 95% level The values of the individual βi were not included in the *Lancet* paper, so that one cannot establish whether the coefficients followed the expected pat-

Table 1 Brenner's (1979) results

Age	Intercept	$y^*(t)$	$y(t) - y^*(t)$	$y(t) - y(t-1)$	$w(t)/g(t)$	$\Sigma\beta i$	R^2	Durbin–Watson statistic	F statistic
Total‡	12 57†††	−0 099†††	−0 033	0 022	−0 33	20 68†††	0 97	2 30	166 66†††
Infants	59 76†††	−0 05†††	−0 004	0 033	−17 79††	156 57††	0 99	1 73	387 98†††
1–4	4 31††	−0 002†††	−0 033	0 0005	−6 57†††	19 59†††	0 95	1 69	97 50†††
5–9	1 22	−0 001	0 003†	0 007	−0 54	9 97†††	0 94	1 92	67 89†††
10–14	0 73†††	−0 0007†	0 0001	0 002†	−0 14	5 26†††	0 98	2 00	232 37†††
15–19	0 64†	−0 0003	0 0004	0 004††	−0 075	11 04†††	0 98	2 05	197 97†††
20–24	1 24††	−0 0009	−0 0005	0 004††	−0 18	13 00†††	0 98	1 55	223 17†††
25–34	1 86†††	−0 001	−0 001†	0 005††	−0 26	10 79†††	0 98	1 41	230 35†††
35–44	3 91†††	−0 003†††	0 0001	0 003†	−0 16	12 84†††	0 98	1 93	185 32†††
45–54	7 59†††	−0 003	−0 002	−0 002	−0 70	19 53†††	0 95	2 09	95 84†††
55–64	21 72†††	−0 01	−0 002	−0 002	0 74	27 06†††	0 89	2 08	38 16†††
65–74	57 63†††	−0 030	−0 006	−0 011	3 82	47 23†††	0 85	2 22	26 31†††
75–84	145 48†††	−0 079	−0 055†	−0 025	14 09	100 28†††	0 82	2 12	21 09†††
85 +	312 05†††	−0 16†	−0 056	−0 12	41 65	300 86†††	0 64	2 24	8 48††

For t (columns 2 7) and F †$P < 0\ 05$ ††$P < 0\ 01$ †††$P < 0\ 001$
For age-group 5–9 Cochrane-Orcutt transformation was used
‡Age-adjusted mortality, based on 1940 population age structure

tern Results obtained for age-specific death rates are reproduced in rows 2 and below in Table 1 for all age groups $\hat{\alpha}_1$—the estimate of α_1—is negative as expected (although not always significant at the 95% level), and the estimate of $\Sigma\beta$ is positive and significant at at least the 90% level The signs of the other coefficients, however, are much less stable and are rarely significantly different from zero at conventional significance levels The general impression is, however, that the results lend reasonably strong support to Brenner's hypothesis that economic instability, and in particular unemployment, have a detrimental effect on a nation's health

III CRITICISMS OF BRENNER'S STUDIES

Criticism of the econometric methodology underlying Brenner's work has come in the main part from economists Important contributions include those of Gravelle and Hutchinson [9], Gravelle *et al* [10], Stern [12, 13], McAvinchey [14, 15] and Søgård [16, 17] Kasl [18, 19] also offers several criticisms The criticisms to date may be broadly divided into (1) those concerning the definitions of variables included in the model, (2) those concerning the adequacy and reliability of Brenner's data, (3) those relating to the selection of independent variables, (4) those voicing concern about the time series fallacy, (5) those questioning the true strength of the underlying links in the Brenner model, (6) those concerning Brenner's technique of choice of lag length and (7) those relating to the use of aggregate data

Variable definitions

Gravelle and Hutchinson [9] and Gravelle *et al* [10] point out several important shortcomings in Brenner's operationalization of his theoretical variables They note that Brenner's definition of income as personal disposable income implies that an increase in tax-financed public expenditure—on health services, for example—would reduce $y(t)$ and hence would increase mortality GDP is suggested to be a more satisfactory measure Several problems with Brenner's definition of rapid economic growth are noted For one, because it is measured in terms of income differences, and not—as Brenner claims—in terms of "changes in per capita income" or "changes in the growth rate", an acceleration in economic growth will have equal effects at both high and low levels of income Moreover, since sometimes the variables take on negative as well as positive values in the estimation period (cf Fig 1 panels (b) and (c) in [4]), below-trend income, or a fall in income, will have the opposite effect on $m(t)$ to above-trend income, or to a rise in income Gravelle and Hutchinson recommend use of the absolute value of the percentage annual change (or difference) Their final point concerning variable definitions is that Brenner's welfare variable is inappropriately defined, since even increases in government expenditure on projects which are likely to reduce mortality (e g projects on road safety) will reduce the value of $w(t)/g(t)$ and therefore—if α_4 is negative–be seen to increase mortality in the model rather than reduce it Real per capita welfare expenditure is argued to be more appropriate

Data

In their critique of Brenner's *Lancet* paper, Gravelle and Hutchinson [9] draw attention to several shortcomings in Brenner's data They note that the series used by Brenner are geographically inconsistent (the mortality series referring to England and Wales and the economic series to the U K , which includes, in addition, Scotland and Northern Ireland), that Brenner's mortality series includes civilian mortality "due to the operations of war", and that the unemployment series—referring as it does to the insured working population only—overstates the interwar unemployment rates and hence exaggerates the fall in unemployment associated with the reduction in mortality over the period 1936–1976 Brenner's estimate of $\Sigma\beta$ will, because of this, be downward biased*

Selection of independent variables

Several writers have argued that Brenner's model suffers from omitted variables bias Gravelle and Hutchinson [9], Gravelle *et al* [10, 11] and Stern [13] point to the exclusion of variables capturing the antibiotic revolution and nutrition improvements Both these omissions are argued to be potentially important on account of the fact that the most significant improvements in nutrition and the antibiotic revolution occurred at precisely the time when there was a major fall in unemployment (the late 1930s and the early years of the following decade) (cf [12, pp 45–46, 9 Fig 4]) It is therefore highly likely, it is argued, that the unemployment variables in Brenner's model are picking up the effects of these two major developments McAvinchey [15] notes the exclusion of education, McAvinchey [14] and Søgård [16] note the exclusion of cigarette and alcohol consumption, and Søgård [16] argues that Brenner's model suffers due to its exclusion of environmental variables More generally, Kasl [18] has argued that "studies of the business cycle and mortality should be carried out, as much as possible, in the context of examining other known biological and psychosocial risk factors, rather than in splendid isolation away from all of them" This failure on the part of Brenner to specify a theoretical model, in which the hypotheses relating to all the relevant independent variables (and not just those concerning economic instability) are elaborated is also emphasized by Gravelle *et al* [11]

This raises the whole issue of what *type of equation* is appropriate in the present context, an issue not addressed in the criticisms which have been levelled to date Is the appropriate equation a 'production function', linking mortality to behavioural (i e 'endogenous') variables or 'risk factors' (such as cigarette consumption, medical care utilization etc) and to technological variables? Or is the appropriate equation a 'demand function', linking mortality to those 'exogenous' variables which affect individuals' ability to 'purchase' improvements in health, such as income, public welfare spending and the state of health

*The overstatement of interwar unemployment rates is due to the fact that those who were not insured pre-World War II tended to have lower unemployment rates care technology? Estimating a hybrid equation which is neither a production function nor a demand function is best avoided, since it is impossible to decide which type of variables are relevant and which are not Brenner's equation is capable of being interpreted in terms of a demand function he includes the trend income term because economic growth has had "major influences on nutrition, sanitation and education up to the time when infectious diseases ceased to be important causes of death" and has been associated with "technological developments in medicine" [4] One might argue therefore that it would in fact be inappropriate to include behavioural variables (although subsequently Brenner did—see Brenner [20] for example) on the grounds that they are not relevant in a demand function This though is not the end of the story One might reasonably suppose that such a demand function is likely to have shifted over time in response to breakthroughs in medical science (the antibiotic revolution is an example), to sudden changes in the composition of mortality (between 1941 and 1951, for example, the percentage of deaths accounted for by cancer and cardiovascular disease increased from 26 to 43%—see [21]), and to changes in government policy (e g policies in the early years of World War II toward school milk, school lunches and flour milling regulations—see [12]) However, without a properly specified theoretical model in which all the relevant relationships are elaborated it is difficult to see how much progress can be made

The time series fallacy

Søgård [17] has voiced concern over the use of standard time series techniques in the present context He notes the ease with which researchers can commit the 'time series fallacy', a fallacy committed "when two or more time series variables are said to be (causally) related, when in fact the statistical association reflects casual covariance due only to concomitant time series structure in the variation pattern of the individual series" He also undertakes a Monte Carlo study and claims that the results lend support to his view that it is relatively easy, in a distributed lag framework, to produce statistically significant coefficients which are known not to reflect any genuine causal relationship Søgård's results include several statistically significant relationships between mortality and lagged values of a random walk series, which are argued to be due to the particular structures of the data series

The strength of underlying relationships

Stern [12] has raised several points concerning the strength of the causal relations underlying Brenner's hypothesis He argues that in Brenner's age-specific mortality equations the highest unemployment effects are to be found in those age groups one would least expect to find a strong impact, namely the 85+ and 74–84 age-groups and infants This point is not, however, quite so clear-cut One might reasonably expect the health of the old, infants and expectant mothers to be particularly susceptible to changes in the economic situation of those on whom they depend Stern notes that, with a 2 year lag, the unemployment effect on infant mortality occurs before the child was born and possibly before it was conceived He also draws attention to the fact that, contrary to Brenner's presumption, high levels of unemployment have been historically associated with rising—and not falling—standards of living for the employed Finally, Stern questions the strength of the relationship between fear of unemployment and consumption of cigarettes and alcohol, noting that per capita alcohol and tobacco consumption have tended to grow more slowly during periods of high unemployment than during periods of modest unemployment He urges the estimation of demand functions to establish whether there is any such relationship

Determining appropriate lag structures

Another set of criticisms concerns Brenner's procedure for estimating lag structures Brenners so-called 'standard' procedure [22] for determining appropriate lag lengths and polynomial degrees appears to involve estimating the model several times, including one lagged value of $u(t)$ at a time and increasing the lag length until the coefficient on the lagged unemployment variable which happens to be in the equation is not significant Thus, if the coefficients on $u(t-1), \ldots, u(t-7)$ were statistically significant when included separately, but the coefficient on $u(t-8)$ was not significant when $u(t-8)$ was included, Brenner would choose a lag length of 7 Gravelle *et al* [11] argue that such a procedure is 'arbitrary', noting that it would be very difficult to apply any of the usual hypothesis tests to it and that it is likely to generate lags that are spuriously long Brenner's procedure is *not* the 'standard' procedure used by econometricians when attempting to establish unknown lag lengths and polynomial degrees When the lag length is known, nested likelihood ratio tests can be employed to test the validity of different assumptions about the polynomial degree However, when both the lag length and polynomial degree are unknown, likelihood procedures cannot be used (the hypotheses are non-nested) and estimation of the appropriate lag lengths and polynomial degree becomes somewhat complicated Judge *et al* [23] in their (highly-respected) econometrics text present and discuss several available procedures Brenner's 'standard' procedure is conspicuous by its absence Kasl [18] emphasizes that "the selection of a proper lag (length) should neither be an *a priori* arbitrary decision, nor an *a posteriori* optimizing-of-results decision, but should be carried out with reference to relevant data from independent studies" He notes that, as yet, insufficient evidence is available for researchers to be sure what lag lengths are appropriate when modelling the health consequences of stressful life events such as unemployment In the meantime, Kasl argues, "the prudent investigator without an axe to grind would do well to simply display the full set of results for the various lag periods examined"

The ecological fallacy

The final criticism concerns the use of aggregate data Some writers—Kasl [18], for example—have expressed disquiet about the use of macro-level studies in this area, pointing to the so-called 'ecological

Table 2 Comparison of replications of Brenner's (1979) study

	Brenner (1979)	Gravelle *et al* (1981)	McAvinchey (1983)	John (1983)
1 Country	England and Wales	England and Wales	Scotland	West Germany
2 Period	1936–1976	1936–1976 1936–1951 1952–1976 1922–1976 1922–1951	1960–1978	1950–1979
3 Lag length	10	10	9	5
4 Restriction on β s	Quadr	Quadr, Cubic None	Quadr	None
5 Definition of $\Delta v(t)$	$\Delta v(t)$	$\Delta v(t)$	$\Delta gr(t)$	$\Delta gr(t)$
6 Age patterns examined?	Yes	No*	Yes	Yes
7 Are β's reported individually?	No	Yes	Yes	Yes
8 Comments	Data not geographically consistent, unempt series poor			

*Gravelle and Hutchinson (1980) examine age patterns

fallacy', the issue of whether anything can be concluded about relationships at an individual level from studies using ecological (i e aggregate) data Kasl argues that "ecological analyses can produce correlations as high as the mid-0 90s with variables, which to be best of our current knowledge, are likely to reflect spurious associations only" Kasl cites Robinson [25] who, in what is often regarded by sociologists as a classic paper, argues that aggregate data cannot be used to study the properties of individual members of these aggregates Robinson's paper is often taken to mean that ecological data are unsuitable for analyses of individual behaviour and that statistical analyses based on microdata are unambiguously better Hanushek *et al* [26], however, have shown convincingly that both assertions are quite false and the Robinson's argument is unsound One of the problems with ecological data is that, if not performed on a random basis, aggregation is likely to increase the sample correlations between the relevant explanatory variables As a result any omitted variable bias in a regression equation is likely to be much larger at the macro-level that at the micro-level* Thus, if the coefficients of a model estimated on ecological data exceed the coefficients derived from the micro-level estimation, then the chances are that omitted variable bias (and possibly multicollinearity) is responsible It is *not* the case that coefficients obtained from macro-level analysis are necessarily meaningless, nor is it the case that analyses based on micro-data are unequivocally more reliable than analyses based on macro-data This is not to say, however, that macro-studies are always acceptable or that time series analyses on aggregate data are the best way to go about testing Brenner's hypothesis As Hanushek *et al* note, not all micro-relations can easily be aggregated to the macro-level (cf, for example, Maddala [27, pp 207–217]) In fact, in the macro-level studies in the unemployment-health field, it is not at all clear that there is actually a sound micro-relation underlying the estimated macro-relation

*Multicollinearity is also likely to be more of a problem if a model is estimated on macro-data than if it is estimated on micro-data

IV REPLICATIONS OF BRENNER'S MODELS

Several of the authors mentioned in the previous section have, despite their misgivings about Brenner's specification, replicated his *Lancet* model [9, 10, 14, 28] The basic details of each of the studies are recorded in Table 2 and the results of the studies are reproduced in Tables 3–6 This section discusses

Table 3 Results of Gravelle and Hutchinson's (1981) replications of Brenner's model

Independent variables	Quadratic	Unrestricted
Constant	15 84*	17 93*
	(13 35)	
Income trend	−0 003*	−0 005*
	(−3 960)	(−4 06)
Residuals from income trend	−0 001	0 005
	(−0 330)	(1 16)
Change in income	0 003	−0 003
	(1 380)	(−1 09)
Welfare government	−0 068**	−0 067**
expenditure	(−1 810)	(−1 95)
Unemployment lag (year) 0	12 04**	9 71
	(1 88)	(0 77)
1	8 61*	12 02
	(2 20)	(0 92)
2	5 73*	20 13**
	(2 99)	(1 85)
3	3 41*	6 73
	(4 42)	(0 65)
4	1 65)	−18 91**
	(1 29)	(−1 79)
5	0 45	21 26
	(0 24)	(1 82)**
6	−0 20	−23 48*
	(−0 09)	(−2 14)
7	−0 28	2 47
	(−0 14)	(0 26)
8	0 19	−8 81
	(0 12)	(−0 95)
9	1 22	24 92**
	(0 89)	(2 47)
10	2 80	−15 35**
	(1 22)	(−2 06)
Sum of lagged unemployment	35 61*	30 69*
coefficient	(4 82)	(2 71)
$\bar{R}^2$	0 94	0 95
D W	2 33	1 98
F-statistic	86 23	55 59

Figures in parentheses are t-statistics
*Coefficient significantly different from zero at the 95% significance level
**Coefficient significantly different from zero at the 90% significance level

Table 4 McAvinchey's (1984) results

	$\Sigma\beta$	y^*	$y(t) - y(t-1)$	$\Delta gr(t)$	$w(t)/g(t)$
M1	−0.9261 (−1.3192)	−20.0490 (−6.6631)	−0.0075 (−9.1657)	0.0520 (1.6489)	0.0904 (−0.3927)
M2	−0.1164 (−2.7453)	−0.4896 (−2.0743)	−0.0023 (−3.7346)	0.0061 (2.4721)	0.0043 (0.2359)
M3	0.1133 (1.9381)	−0.4289 (−3.3442)	−0.0002 (−3.4818)	−0.0023 (−1.3970)	−0.0024 (−0.4588)
M4	0.0009 (0.0289)	−0.0014 (0.0069)	−0.0001 (−0.6199)	−0.0014 (−0.6827)	−0.0226 (−1.4764)
M5	−0.0503 (−0.5403)	0.4674 (2.2926)	0.0001 (1.2098)	−0.0034 (−1.3516)	0.0085 (1.0573)
M6	−0.1770 (−5.5305)	0.3663 (2.4794)	0.0001 (1.7208)	−0.0032 (−2.0445)	0.0081 (0.7189)
M7	0.1907 (1.4407)	−1.1314 (−3.8908)	−0.0005 (−3.0075)	0.0120 (3.5645)	−0.0041 (−0.3653)
M8	1.4500 (5.6935)	−2.5575 (−4.8054)	−0.0016 (−0.6153)	−0.0064 (−0.8977)	−0.0515 (−1.7644)
M9	0.4196 (0.6026)	−4.7924 (−2.9336)	−0.0015 (−3.4499)	0.0543 (3.1769)	0.0489 (0.3914)
M10	0.5739 (0.2336)	−8.1240 (−1.5255)	−0.0036 (−1.3228)	0.0528 (0.7885)	−0.3254 (−1.5324)
M11	9.7564 (1.4613)	−42.0840 (−2.8752)	−0.0168 (−2.2506)	−0.0392 (−0.2161)	−0.6483 (−1.1246)
M12	15.2110 (0.8511)	−57.9320 (−2.1557)	−0.0190 (−1.3880)	0.4379 (1.3117)	0.4213 (0.3978)
F1	−0.8583 (−1.3868)	−15.2850 (−4.9200)	−0.0059 (−6.998)	0.0344 (1.0574)	0.1335 (0.5619)
F2	−0.1105 (−2.2643)	−0.4870 (−2.0355)	−0.0002 (−2.6846)	0.0030 (1.2052)	−0.0121 (−0.6594)
F3	−0.0772 (−1.0897)	0.0497 (0.3197)	0.0001 (0.2670)	0.0027 (1.3804)	−0.0030 (−0.4825)
F4	−0.2260 (−3.3869)	0.3151 (2.1514)	0.0002 (2.7971)	0.0025 (1.3606)	0.0297 (5.0493)
F5	−0.1286 (−2.1479)	−0.3305 (−2.3527)	−0.0001 (−2.1065)	0.0007 (0.4820)	0.0284 (2.6450)
F6	−0.0862 (−1.9716)	−0.6774 (−7.2418)	−0.0002 (−4.3586)	0.0015 (1.1600)	−0.0151 (−2.9352)
F7	−0.0797 (−1.9392)	−0.4797 (−2.4831)	−0.0001 (−2.6822)	0.0044 (2.1654)	0.0106 (0.7210)
F8	−0.0359 (−5.3677)	0.7689 (1.8581)	0.0001 (1.2887)	0.0046 (1.0511)	−0.0224 (−0.7108)
F9	0.1663 (2.3786)	−1.1434 (−1.0125)	−0.0002 (−0.6563)	0.0253 (2.1375)	−0.0834 (−0.9661)
F10	0.1258 (0.2491)	−8.9728 (−3.8125)	−0.0029 (−4.4915)	0.0567 (2.2990)	0.2675 (1.4861)
F11	1.2603 (0.8115)	−28.8330 (−3.3428)	−0.0097 (−4.1400)	0.2057 (2.2779)	0.0978 (1.1484)
F12	13.2763 (2.8828)	−42.7240 (−1.4858)	−0.0142 (−1.8307)	0.5444 (1.8079)	1.0141 (0.4611)

Age groups	0	1–5	5–10	10–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85+
Males	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Females	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12

t Values in parentheses

Table 5 John s (1983) results

	C	$\Sigma\beta_i$	β_0	β_1	β_2	β_3	β_4	β_5	$u^*(t)$	$u(t)-u^*(t)$	$\Delta gr(t)$	$R^2(\bar{R}^2)$	F	D W
M01T	80 65	1 21	0 02	−2 04	0 59	0 70	−0 15	2 09	−0 0037††	0 0068	0 8988	0 9682	50 76†	0 97
			(0 00)	(0 94)	(0 29)	(0 37)	(0 08)	(1 66)	(4 21)	(1 08)	(1 66)	(0 9491)		
M05T	103 43	0 23	−0 85	−0 86	1 89	−0 57	0 49	0 13	−0 0050††	0 0036	0 3063	0 9913	94 55††	2 54
			(0 90)	(0 45)	(1 37)	(1 44)	(1 41)	(0 16)	(8 41)	(0 84)	(0 83)	(0 9723)		
M10T	114 58	−1 95	−2 66	−0 32	0 39	1 07	0 44	−0 87	−0 0039††	0 0158	0 7804	0 9565	17 92††	1 09
			(1 65)	(0 13)	(0 16)	(0 49)	(0 22)	(0 60)	(3 92)	(1 30)	(1 25)	(0 8639)		
M15T	111 79	−1 63	−1 91	0 61	−0 99	2 22	−0 79	−0 77	−0 0037††	0 0073	0 6310	0 9078	7 81††	0 97
			(0 98)	(0 20)	(0 35)	(0 83)	(0 32)	(0 44)	(3 20)	(0 82)	(0 84)	(0 7185)		
M20T	77 21	−0 61	−1 24	−0 30	−1 37	2 56	−2 47	2 21	0 0025	0 0129	0 6473	0 5076	0 58	1 00
			(0 38)	(0 06)	(0 29)	(0 57)	(0 60)	(0 75)	(1 24)	(0 87)	(0 51)	(−0 1878)		
M25T	84 71	1 78	−0 60	0 21	−1 75	1 60	0 01	2 31	0 0001	−0 0010	0 0419	0 8788	5 65†	2 37
			(0 28)	(0 06)	(0 55)	(0 53)	(0 00)	(1 18)	(0 09)	(0 10)	(0 05)	(0 6356)		
M30T	102 61	0 21	−2 04	0 40	0 44	1 32	−0 25	0 34	−0 0023†	0 0091	0 0053	0 9501	15 45††	1 34
			(1 46)	(0 18)	(0 22)	(0 69)	(0 15)	(0 27)	(2 56)	(1 43)	(0 00)	(0 8442)		
M35T	101 33	0 40	0 84	−0 45	−0 99	1 41	−1 33	0 92	−0 0016†	0 0002	−0 0447	0 8730	5 34††	0 85
			(0 66)	(0 23)	(0 53)	(0 81)	(0 84)	(0 80)	(1 99)	(0 05)	(0 09)	(0 6195)		
M40T	91 58	−0 41	−0 69	0 18	−0 22	0 70	−1 18	0 80	−0 0002	0 0043	0 3110	0 6130	1 00	1 19
			(0 70)	(0 12)	(0 15)	(0 53)	(0 97)	(0 91)	(0 36)	(0 97)	(0 82)	(0 0012)		
M45T	77 91	0 05	0 25	−0 88	−0 001	−0 41	−0 24	1 33	0 0015	0 0088	0 2240	0 5697	0 80	0 82
			(0 16)	(0 35)	(0 00)	(0 18)	(0 12)	(0 91)	(1 47)	(1 20)	(0 36)	(−0 0807)		
M50T	87 92	0 65	−0 26	0 92	−0 61	1 38	−1 10	0 32	0 0007	0 0028	0 0462	0 6752	1 40	1 25
			(0 24)	(0 55)	(0 39)	(0 93)	(0 82)	(0 33)	(1 01)	(0 57)	(0 11)	(0 1295)		
M55T	107 64	0 09	0 40	0 01	0 26	−0 18	−0 63	0 23	−0 0014†	0 0051	−0 0253	0 8194	3 42†	1 53
			(0 44)	(0 00)	(0 19)	(0 15)	(0 55)	(0 27)	(2 43)	(1 22)	(0 07)	(0 4742)		
M60T	121 27	−1 13	−1 21	0 11	−0 56	−0 05	0 18	0 40	−0 0018††	0 0041	−0 2167	0 9683	25 02††	1 72
			(1 67)	(0 10)	(0 53)	(0 05)	(0 20)	(0 61)	(3 86)	(1 22)	(0 77)	(0 9001)		
M65T	143 47	−2 41	−1 81	1 88	−2 29	2 16	−2 03	−0 32	−0 0028††	0 0046	−0 1617	0 9505	15 58††	2 12
			(1 94)	(1 29)	(1 67)	(1 68)	(1 74)	(0 38)	(4 84)	(1 09)	(0 45)	(0 8454)		
M70T	134 73	−2 96	−1 69	0 19	0 63	−0 64	−1 07	−0 38	−0 0017	0 0124	0 0742	0 8147	3 29†	1 01
			(0 88)	(0 06)	(0 22)	(0 25)	(0 45)	(0 22)	(1 39)	(1 43)	(0 10)	(0 4621)		
M75T	110 17	−1 38	−1 58	1 00	0 22	−0 33	−1 03	0 34	0 0001	0 0106	0 0049	0 5993	0 93	0 98
			(0 77)	(0 31)	(0 07)	(0 11)	(0 40)	(0 18)	(0 07)	(1 13)	(0 00)	(−0 0253)		
M80T	96 39	−0 05	−0 85	0 52	0 07	−0 43	−0 42	1 06	0 0004	0 098	0 0937	0 3929	0 30	1 59

t-Values in parentheses †Significant at the 0 05-level, †† significant at the 0 01-level

Table 6 John's (1983) results—2nd model

Dep var	C	$\Sigma_{i=2}^{4} u(t-i)$	$y^*(t)$	$y(t)-y^*(t)$	$\Delta gr(t)$	$R^2(\bar{R}^2)$	F	D W
M01T	101 10	0 4735††	−0 0055††	0 0052	0 2732	0 9809	50 76††	0 97
		(4 31)	(14 69)	(0 90)	(0 67)	(0 9550)		
M05T	107 74	0 2757††	−0 0054††	0 0008	0 0414	0 9908	94 55††	2 54
		(3 96)	(22 90)	(0 22)	(0 16)	(0 9872)		
M10T	122 76	−0 2085	−0 0047††	0 0109	−0 0280	0 9342	36 03††	0 73
		(1 50)	(10 24)	(1 50)	(0 06)	(0 8486)		
M15T	113 08	−0 2147	−0 0038††	0 0045	0 1165	0 8897	19 94††	1 02
		(1 45)	(7 70)	(0 57)	(0 21)	(0 7519)		
M20T	94 97	−0 1498	0 0010	0 0099	0 2522	0 5004	1 75	0 88
		(0 61)	(1 30)	(0 84)	(0 30)	(0 1077)		
M25T	105 86	0 5253††	−0 0017††	−0 0017	−0 1394	0 8589	14 77††	1 94
		(3 26)	(3 20)	(0 19)	(0 23)	(0 6878)		
M30T	110 53	0 2291†	−0 0030††	0 0051	−0 2555	0 9400	39 83††	1 16
		(2 16)	(8 28)	(0 91)	(0 65)	(0 8614)		
M35T	103 98	0 0635	−0 0018††	0 0016	−0 1053	0 8745	17 08††	0 91
		(0 71)	(5 89)	(0 34)	(0 32)	(0 7648)		
M40T	96 57	−0 0686	−0 0007††	0 0025	0 1611	0 5556	2 35	1 17
		(0 99)	(2 81)	(0 67)	(0 63)	(0 1771)		
M45T	88 94	−0 0104	0 0006	0 0083	0 0185	0 5123	1 87	0 63
		(0 10)	(1 45)	(1 41)	(0 05)	(0 1219)		
M50T	85 48	0 1901††	0 0009††	0 0026	0 1930	0 6413	3 67†	1 49
		(2 58)	(3 59)	(0 66)	(0 71)	(0 2991)		
M55T	104 91	−0 0530	−0 0011††	0 0054	0 1431	0 8075	9 84††	1 62
		(0 84)	(5 36)	(1 62)	(0 61)	(0 5858)		
M60T	131 04	−0 3093††	−0 0026††	0 0021	−0 3914	0 9395	39 48††	1 54
		(4 71)	(11 92)	(0 60)	(1 61)	(0 8603)		
M65T	141 43	−0 7210††	−0 0027††	0 0028	−0 0637	0 9072	24 40††	1 83
		(8 36)	(9 30)	(0 61)	(0 20)	(0 7892)		
M70T	135 11	−0 8724††	−0 0017††	0 0087	−0 0669	0 8128	10 22††	0 91
		(6 14)	(3 78)	(1 21)	(0 13)	(0 5960)		
M75T	112 43	−0 3925††	−0 0001	0 0072	0 0536	0 6377	3 60†	1 10
		(2 82)	(0 27)	(0 98)	(0 11)	(0 2937)		
M80T	104 00	−0 0563	−0 0003	0 0077	0 1672	0 3261	0 63	1 49
		(0 53)	(0 79)	(1 38)	(0 42)	(−0 0639)		

t-Values in parentheses †Significant at the 0 05-level, ††significant at the 0 01-level

these replications The discussion is structured around two issues which would appear to merit close attention if one is to establish whether Brenner's results are indeed meaningful or whether they constitute statistical artifacts The first concerns the pattern of the βi coefficients The interesting questions here are (i) when the coefficients are restricted to lie on a second order polynomial, do they follow the pattern predicted by Brenner? and (ii) is such a restriction consistent with the data? The second issue concerns the question of structural stability is the relationship stable over time, and across countries, or are the *Lancet* results peculiar to a particular period or a particularly country? This question should be asked, not only of the model for all mortality, but also for the models for age specific mortality

Patterns of lag coefficients

Both the results reported in Gravelle and Hutchinson [9] and Gravelle *et al* [10] and those in John [28] shed light on the issue of the pattern of lag coefficients Of the two, only Gravelle and Hutchinson's study estimated the model with the β's constrained to lie on the second degree polynomial favoured by Brenner Their results are reproduced in the first column of Table 3 There are some minor differences* from those of Brenner The most important of these differences are that the three income coefficients are (in absolute value) smaller in the replication, the sum of the unemployment coefficients is larger, the coefficient on the government welfare variable is statistically significant and the value of the F-statistic is smaller* Broadly speaking, however, the two sets of results are much the same It is interesting therefore to note that the βi in the replication follow precisely the opposite pattern to that anticipated by Brenner† Figure 2 plots the coefficients for the replication, Brenner's anticipated

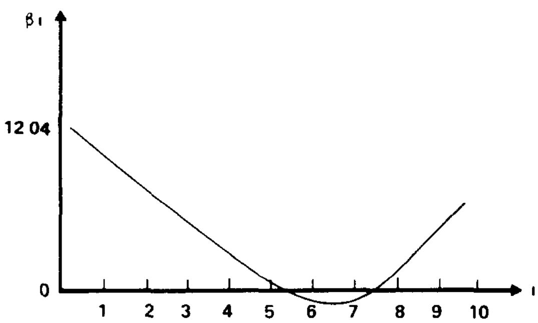

Fig 2 Gravelle and Hutchinson's estimation of β_i

*The differences arise, at least in part, from Gravelle and Hutchinson's use of geographically consistent data and from their use of Feinstein's unemployment series which includes occupational groups who were uninsured pre-war and therefore more comprehensive than that used by Brenner

†Brenner [22] indicated that in his *Lancet* model there was a "concentration of significant relations at the beginning and the end of the eleven year span", suggesting that his estimates of probably did follow the same pattern as that of Gravelle and Hutchinson

pattern was graphed in Fig 1 Bearing in mind that the hypothesis concerning the time pattern of health responses to economic change is one of the few falsifiable hypotheses proffered by Brenner—Brenner's [4] paper is, as Kasl [19] has noted, characterized by *post hoc* rationalization of results—this result does cast doubt over the validity of Brenner's claims

The fact that when they are constrained to follow a second degree polynomial, the coefficients follow precisely the opposite pattern to that predicted by Brenner, suggests that the imposition of this particular restriction may be inappropriate Gravelle and Hutchinson examine three possible lag restrictions, the quadratic favoured by Brenner, a cubic restriction and an unrestricted pattern the quadratic was not rejected against the cubic restriction, but it was rejected against the unrestricted pattern McAvinchey, in his tests, also found the quadratic to be rejected against the unrestricted pattern in most age groups Gravelle and Hutchinson's results for the unrestricted pattern are reproduced in column 2 of Table 3 Note the absence of any clear pattern in the unemployment coefficients and the relatively small value of the t-statistic on the sum of coefficients John also estimated his model using an unrestricted lag structure the results are reproduced in Table 5 The left-hand column indicates the age-group to which the estimates refer thus M30T, for example, indicates male mortality in the 30–35 age-group None of the βi in any equation is statistically significant* Note too that in only two of the 17 equations do the βi follow the predicted pattern of Fig 1

There is, then, no evidence in these studies (or apparently in his own paper) to support Brenner's hypothesis that "the pathological reactions to economic trauma would build up over time, come to a high point and ultimately decline" The fact that there is such an absence of a clear pattern in the coefficients lends support to the argument that unemployment is picking up the effects of omitted variables

Structural stability

All the replications mentioned above are of interest from the point of view of structural stability Gravelle and Hutchinson explore the issue of temporal stability at some length No formal tests of cross-country stability have been performed, but comparisons of results obtained in the different countries are instructive in themselves

Gravelle and Hutchinson's tests for temporal stability are suggestive—although not conclusive—of there being a structural break at the beginning of the 1950s The estimate of $\Sigma\beta$ is only significant for Brenner's chosen period (1936–1976) and for the sub-period 1936–1960 When Brenner's period is split at 1951, the estimate of $\Sigma\beta$ is not significant at conventional levels for either sub-period The same is true when split is made at 1960 Moreover, when the model is estimated for the period 1922–1976, the estimate of $\Sigma\beta$ is not significant Nor were any of the estimates significant when the 1922–1976 period was split at 1950 and 1945 The authors suggested subsequently [11] that such a break may have come about as the result of the introduction of the NHS Another, and possibly more plausible, reason is the sudden growth in the 1940s in the proportion of total mortality attributable to the so-called diseases of affluence†

Brenner [22] admits that "the structure of lagged relations of unemployment to total mortality is subject to change from period to period" However, he argues that it is precisely because of this that his model should not be estimated for any period other than that chosen (1936–1976) The grounds for this curious—and incorrect—assertion are that "specification of a relation that averages two or more different periods will differ somewhat from the form of the relation within any one homogenous period" Brenner continues "the empirical models I reported are not an artifact, but the valid, calculated result of estimating the combined effects of relations pertaining to two somewhat different periods " As Gravelle *et al* [11] stress, it is precisely the failure to allow for structural breaks that renders Brenner's results suspect the significance of the replication results lies, not in the fact that the two sub-models yielded significantly different coefficients, but that in both sub-periods the estimate of $\Sigma\beta$ did not differ significantly from zero

Comparisons of results obtained for different countries reveal several inconsistencies, notably in the patterns of coefficients for different age groups Note how in McAvinchey's results (Table 4)—in contrast to Brenner's results in Table 1—the sign of the sum of unemployment coefficients varies (and does so considerably) across age groups In the male mortality equations, 4 of the 12 unemployment coefficients are negative, two of these being statistically significant at even the 99% level In the female mortality equations, 8 of the 12 unemployment coefficients are negative, and in 6 instances these negative coefficients are statistically significant at the 90% level In both the male and the female mortality equations there are only two positive unemployment coefficients which are statistically significant at the 90% level

*Another striking thing about John's results is how poorly-determined several of the equations are in 6 equations the value of the F-statistic is below the critical value for the 95% level In 5 of these 6 equations (and in one other) the coefficient on the trend income term is of the 'wrong' sign

†Before the 1940s the majority of deaths had been due to conditions which became rarer or less apt to kill as living standards improved (particularly infectious diseases) However, after the 1940s a major proportion of deaths have been due to conditions which have become more common-place as living standards have risen Fuchs [29] has shown that if one groups all deaths together and estimates a mortality equation along the lines of equation (1), then the income coefficient will be a weighted average of the cofficients for different causes, where the weights are equal to the fraction of deaths accounted for by each cause Because of this the sudden jump in the proportion of mortality accounted for by conditions with positive income elasticities in the 1940s would seem to be a plausible candidate as an explanation of any structural break around that time

Coefficients on the other variables in McAvinchey's model are also unstable across age groups, indeed remarkably so in comparison with Brenner's results Note in particular how, in Brenner's equations, the coefficient on trend income, although not always statistically significant, was negative for all age groups By contrast, in McAvinchey's, the trend income coefficient is positive (and significant at the 95% level) in the male 15–25 and 25–35 age groups, and positive in the female 5–10, 10–15 and 45–55 age groups* One might be tempted to conclude that the reason for the differences between Brenner's and McAvinchey's results is that the model specifications differ Gravelle and Hutchinson [30], in an attempt to establish how far the differences in model specification significantly affected the results, estimated McAvinchey's model on their data and compared the results with the results they obtained using Brenner's original specification (Table 2) They concluded that the estimates of the unemployment coefficients were sufficiently insensitive to the changes in specification as to allow one to regard McAvinchey's replications as a valuable means of assessing the robustness of Brenner's results concerning the impact of unemployment on mortality In view of the major differences between McAvinchey's and Brenner's results, one can but conclude that Brenner's results should be treated with caution

John's [28] results make the picture even more confused In his initial estimates (Table 5) 9 of the 17 estimates of $\Sigma\beta$ are negative, namely those for the three age-groups in the 10–25 band, the 40–45 age-group coefficient and the coefficients for the four age-groups in the 60–80+ age band These results contradict those of McAvinchey, who obtained positive coefficients in the 10–15 age-group and for all the age-groups above 35 In an attempt to reduce the effects of multicollinearity amongst the lagged values of the unemployment variables, John re-estimated the model using an alternative definition of the unemployment variable, namely $u(t-2)+u(t-3)+u(t-4)$ This is in fact equivalent to a distributed lag model where the βi are constrained to follow (curious) pattern $\beta_0=\beta_1=\beta_5=0$, $\beta_2=\beta_3=\beta_4=\text{const}$ The results are reproduced in Table 6†

In these results, as well as in the earlier results, the estimates of the $\Sigma\beta$ are largely inconsistent with those obtained by McAvinchey In 11 of John's 17 male mortality equations in his re-estimated model, the coefficient on the unemployment variable was negative (i e the 'wrong' sign) In four of these age-groups (the 60–65, 65–70, 70–75 and 75–80 age-groups) the negative coefficient was statistically significant at the 95% level McAvinchey, by contrast, in his male mortality equations, obtained positive coefficients in his three age-groups in the 55–85 age band John obtained positive coefficients in the 0–1, 1–5, 25–29, 30–35, 35–40 and 50–55 age groups, all coefficients except that for the 35–40 age-group being significant at the 95% level McAvinchey, on the other hand, obtained negative coefficients in the 1–5 15–25 and 25–35 age-groups, although only that in the 25–35 age-group was significantly different from zero at the 90% level Note too how McAvinchey obtained the largest negative impact (i e the most beneficial effect) in the case of infants, while John records his second largest *positive* impact in the case of infants McAvinchey obtains the two largest positive (i e harmful) impacts in the 85+ and 75–85 age-groups respectively, while John obtains negative coefficients in his 75–80 and 80+ age-groups Moreover, John's coefficient for the 75–80 age-group is statistically significant In view of the similarities between John's two sets of results, and in view of the similarities between McAvinchey's model and John's first model, it seems unlikely that the differences between the two authors' results can be explained entirely by different lag structures and lengths, although these are undoubtedly contributory factors

Taken together the results of this sub-section are strongly suggestive of the existence of misspecifications in Brenner's model the results of the formal tests of structural stability over time in Gravelle and Hutchinson's study and the inconsistencies between age patterns of coefficients between Brenner's, McAvinchey's and John's studies are difficult to explain simply in terms of genuine structural differences in the model They are much more likely to be due to the problems of model specification discussed in Section III

V SUMMARY AND DISCUSSION

Brenner has advanced the hypothesis that economic instability—recession followed by swift growth—entails sufficiently stressful life changes for the mortality experience of the population concerned to be adversely affected He has emphasized that even those not unemployed may experience stress-induced health deteriorations at times of high unemployment A testable feature of Brenner's hypothesis is the belief that "the pathological reactions to economic trauma would build up over time, come to a high point and ultimately decline" [8] It is clear from Brenner's discussion that mortality responses are also expected to follow such a pattern Brenner's results for England and Wales [4] appear to lend support to his basic hypothesis The sum of the coefficients on the lagged unemployment variables is large and statistically significant in all age groups It is well-known, however, that it is possible in time series analysis to obtain results that suggest the existence of a causal relationship when in fact none exists The chances of discovering a meaningless relationship in time series analysis seem to be increased, as Søgård [17] has demonstrated, when lagged values of explanatory variables are introduced, a phenomenon apparently due to the 'time-series fallacy' In analysing Brenner's results it is therefore important to ascertain how far his other hypotheses are supported by the data and how far the

*The coefficient is significantly different from zero at the 90% level for only the 10–15 and 45–55 age groups

†In three of the equations the fit is improved by the re-specification in the remainder, however, the adjusted R^2 is lower in the second model Moreover, the pattern of the sums of unemployment coefficients in the second model is virtually identical to that of the first model—there are two sign changes Under the new specification, however, some of the coefficients become statistically significant

results stand up to rigorous statistical diagnostic checks routinely applied in econometric time-series analysis

All those replications which reported the individual unemployment coefficient (and so it would seem Brenner's own *Lancet* estimates), failed to support the subsidiary hypothesis that the pathological reactions to unemployment would build up over time, reach a peak and then decline When constraints were imposed on the unemployment coefficients which would have permitted the estimated coefficients to follow such a pattern, they followed precisely the opposite pattern

These results are strongly suggestive of model-mis-specification it seems more than likely that unemployment is picking up the effects of omitted variables Other findings to emerge from the replications to date include evidence of structural instability (Brenner's results could only be replicated for his chosen period), lag mis-specifications and data inconsistencies Furthermore, several objections have been raised to Brenner's specification for example, it is argued to suffer heavily from omitted variable bias and from incorrect variable definitions

The greater part of the debate concerning the soundness of the econometric methodology underlying Brenner's work has centred around the *Lancet* model It should be emphasized, however, that the criticisms levelled at that model apply with equal–if not greater–force to Brenner's subsequent work The choices regarding lag length and lag shape in Brenner [32], for example are clearly arbitrary without consideration of the possibility and consequences of mis-specifications in the lag structure, it would be improper to accept such results at face value, particulary in view of the lessons learned in the Gravelle/Hutchinson replications

It is difficult to see how the issues surrounding model specification can be resolved in the absence of a theoretical model in which all the relevant hypothesized relationships are elaborated It is clear too that greater attention needs to be paid to the problems concerning the operationalization of the theoretical constructs The shortcomings in Brenner's indicators of rapid economic growth have already been noted The question of whether the unemployment rate is the most appropriate indicator of economic recession in the present context is also an important one and one which merits closer consideration in future work

It has been suggested that exercises of the type discussed in this paper are of rather little value In a letter to *The Guardian* newspaper in 1980 Draper [31] suggested that "there is a tendency for economists particularly to nitpick over statistical details and avoid the main results, not only of Brenner's work, but also of the wealth of other studies (of relevance to this particular issue)" This charge is difficult to sustain If one is genuinely interested in arriving at a clear picture of the strength of the causal relations between economic instability and mortality at the population level, then it is important that further careful modelling efforts along the lines of Gravelle and Hutchinson and McAvinchey are undertaken In the meantime it would be most unwise for policy makers to go on accepting Brenner's results as readily as has apparently been the case hitherto This is not to say, however, the unemployment does not have adverse effects or physical health this paper has been concerned only with the (often cited) evidence from time series analyses of the Brenner variety Numerous other studies of the unemployment–health relationship have been undertaken using several different research strategies It may be the case that these studies taken together yield convincing evidence in support of the hypothesis that unemployment causes deteriorations in physical health Ascertaining whether or not such is the case, however, lies beyond the scope of the present paper It should also be emphasized that the time series methodology may yet yield convincing evidence at a macro-level that the social costs of unemployment and rapid growth include premature deaths At the moment, however, there is no such convincing evidence

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