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Does "community social capital" contribute to population health?

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Abstract

Robert Putnam showed that a social capital index, created as a weighted sum of 14 variables chosen to describe the civic degree of sociability and community mindedness, is correlated with many community outcomes, such as education, child well-being, crime, and the total mortality rate. Although correlation does not establish causation, we can find that in a large number of studies this index, a selection of its elements, or similar measures register as significantly correlated with health variables, virtually always in a direction consistent with the hypothesis that social capital improves health. The potential benefit of this relationship is substantial, especially if it proves to be robust to differences in time and place, statistical contexts, and ultimately if the relation can be supported to be causal. This paper subjects the social capital and health hypothesis to an expanded set of rigorous tests, which, by surviving, it becomes stronger or, by failing, its weaknesses are better revealed.

The paper seeks to extend this body of research by a combination of study characteristics that are each relatively unusual in social capital and health research. Though causality cannot be established by these tests, the work shows that the association of social capital with health is quite robust when challenged in the following ways: (1) seven different health measures are studied, including five mortality rates; (2) the 48 contiguous states are observed at six points in time covering the years from 1978 to 1998 over four year intervals, thus forming a panel; (3) the multivariate tests feature economic variables from the production of health literature; and (4) a statistical method (instrumental variables) is applied to account for the possibility that omitted variables are confounding the social capital estimates. The results and the discussion find cases for which the social capital and health hypothesis performs only weakly, but, on the whole, the hypothesis is remarkably robust to these variations.

Keywords: USA; Social capital; Community health

Introduction

Do a community's sociability and community mindedness help to improve the health of its population? The large literature that has grown up around the work of people such as Robert Putman and Ichiro Kawachi strongly suggests that it does. Yet, our awareness of the substantial benefit to society were social capital to improve community health, as well as the substantial cost were the reported benefits to prove misleading, suggests the need to rigorously test the hypothesis. Ultimately we want to be able to support the claim that the relation is causal.

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In some ultimate, philosophical sense, proof of causation will remain elusive. However, in a practical sense we can progress toward that goal by the step-by-step elimination of the impediments, such as possible confounding factors and worrisome questions about the robustness of our results for other samples. The present paper contributes to this effort in several ways. Seven health indicators are treated as dependent variables. Complete samples of the 48 contiguous US states are taken in 4-year intervals beginning in 1978 and ending in 1998. An econometric technique (instrumental variables) is applied; it is a familiar approach by which to assess the possible influence of unknown omitted variables that might affect the social capital coefficient estimates. And, finally, the health economist's production of health approach is applied; in the present case this means that a set of variables typical of production of health functions is included in a multivariate estimation setting.

"The Literature Providing a Starting Point for the Present Paper" discusses the literature on which this study is based. "Theoretical Considerations" draws on and adds to previous theory describing how social capital affects health. "The Data" describes the data and "Testing the Hypothesis by Extending Putnam's Framework" presents bivariate analyses, extending this literature by treating six time periods ranging from 1978 to 1998. "Social Capital in the Production of Health" develops multivariate estimates that incorporate the economic variables for the six cross-sections formed as a panel. "Are the Social Capital Coefficients Confounded by Omitted Variables?" addresses the confounding problems that might arise if relevant variables have been omitted; it applies the instrumental variables technique. "Regressions on Changes in the Variables" regresses changes in the health measures on changes in the independent variables. A discussion and summary conclude the paper.

The literature providing a starting point for the present paper

Putnam's (2000) book, *Bowling Alone*, demonstrated that state aggregate measures of social outcomes that most of us care about were correlated with a social capital index of his devising. His work, including the earlier papers (e.g. 1995) probably did the most to popularize the social capital concept even though several predecessors have been discovered. Many would cite Coleman (1990) as the concept's originator, others cite Loury (1977). But early contributions also have been recognized, such as Marx, Jacobs, Marshall, Hume, and Aristotle (Durlauf & Fafchamps, 2004; Islam et al., 2006). The contemporary literature on social capital and health is substantial, and an excellent, comprehensive survey can be found in Islam et al. (2006). What is also clear is that we are in the midst of a boom in social capital interest and publications.

A closely related approach, the study of income inequality and health, has also generated a large literature (see Kawachi, Kennedy, & Wilkinson, 1999; and Macinko et al., 2003). The income inequality approach is not a competing hypothesis to that of using the Putnam style variables, such as trust and neighborliness, because both can be valid (Kawachi et al., 2004), and income inequality may prove to be a determinant of social capital elements measured in the Putnam style (Kawachi et al., 1997). But integration of the two approaches is beyond the scope of the present paper, which incorporates only variables of Putnam's type. This should cause no confusion as the Putnam variables are the ones most frequently referred to as "social capital" in published papers.

Many social capital studies have been bivariate, especially in the earlier work. Typically, areawide health variables and social capital variables were studied by correlation analysis. Examples include: Weitzman and Chen (2004); Lynch et al. (2004); Putnam (2000); and Kawachi (1999). Their importance was to establish a strong, *prima facie* case that social capital affects many measures of community health in varied settings. A drawback of bivariate statistics is that virtually all potentially relevant variables are omitted from study. This omission can cause the measurement of the role of social capital to become biased, and one's claim that social capital matters to health may be false. It is a natural progress that most of the recent work has been multivariate.

Multivariate studies proliferated in recent years, and these include: Poortinga (2006); Lindstrom (2006); Araya et al. (2006); Sirven (2006); Kim et al. (2006); Mohan et al. (2005); Saegert and Winkel (2004); Kim and Kawachi (2006); Blakely et al. (2006); Turrell, Kavanagh, and Subramanian (2006); Lochner et al. (2003); and Subramanian, Kim, and Kawachi (2002). Most of these are of very recent origin. With multiple independent variables chosen carefully, the social capital and health hypothesis is subjected to more challenging and rigorous tests.

One aim of the present study is to explore the influence of several economic variables: per capita income, percent in poverty, percent unemployed, education level, and health expenditures per capita. These are common to health economic studies of the production of health, and they are developed here both to provide a different, rigorous challenge to the social capital and health hypothesis as well as to further the interdisciplinary cross-fertilization that already benefits this line of research. Of the multivariate studies listed above, most included a measure of income or economic disadvantage, education measures were often used, and I found single cases each of the inclusion of unemployment or health expenditures per capita. Where some of these variables were employed, they did not appear intended as a production of health approach, and the use of the set of five economic variables together as done here is rare if not unique.

Another feature of the present research is to combine six different cross-sections of the 48 contiguous states to form a panel, sampling every 4 years over the period 1978–1998. The advantages are several: we can test the robustness of the social capital hypothesis by examining several time periods, we can develop coefficient estimates that represent the experience of the entire period, and we can create tests that account for local area characteristics, which could interfere with our estimates of the social capital effect. Few panel studies exist in the social capital and health literature, though examples include Poortinga (2006), Bolin et al. (2003) and Kennelly, O'Shea, and Gavey (2003).

Finally, the literature surveyed usually studies self-reported health or total age-adjusted mortality; the health and mortality measures studied here include (all are age-adjusted where appropriate): total mortality, infant mortality, percent of births that are low weight, and mortality from cardiovascular disease, cancer, accidents, and suicide. An advantage of using several different rates is that we may find different effects by disease that can clarify how health is affected by social capital. See Blakely et al (2006) for similarly designed research framework.

Theoretical considerations

Several definitions of social capital exist (Durlauf & Fafchamps, 2004; Szreter & Woolcock, 2004), and these often contrast group versus individual approaches. I propose that individual relationships form the basic elements of social capital, both group and individual. This is consistent with several views. Glenn Loury proposed that social capital is "naturally occuring social relationships among persons…" (as quoted in Islam et al., 2006, p. 4). It also fits Putnam's view that social capital is "connections among individuals in social networks and norms of reciprocity and trustworthiness that arise from them (Putnam, 2000, p. 19). Note that Putnam includes the characteristics and qualities of these relationships, similarly, Robison, Schmid, and Siles (2002), Robison & Flora (2003), Robison and Hanson (1995) describe the essential relationship as "sympathetic."

An implication for the present study is that one distinguishes economic variables from the social capital effects, treating them as separate independent variables. This choice sets the "psychosocial" and the "political economy" variables in the same equation. Some writers treat psychosocial and political economy theories as competing models, but there is no reason why both cannot be valid (Szreter & Woolcock, 2004).

Although family relationships are not included in the present study, it is worth noting that by defining social capital as something formed by human relationships, the conception logically includes family relationships. Putnam (1995, p. 65) recognized early on that "…the family is the most fundamental form of social capital." Marriage clearly affects health, and it modifies a person's propensity to engage in health risky behaviors (Akerlof, 1998; Cohen, 1997; DeLeire & Levy, 2001; Folland, 2006).

Given this description of social capital, the central hypotheses of the present study are that, all other things held constant, community social capital improves each of a variety of community health status variables. The following suggests possible avenues by which social capital might affect health:

1. Reducing stress: Stress reduction through social capital, sometimes called buffering stress, stands as a central theme describing how health can be improved through social ties (Kawachi & Berkman, 2001; Szreter & Woolcock, 2004). Stress reduction plays a role in the association of social capital and mental health (Silva et al., 2005). The benefit to health from stress reduction is described in many studies (e.g. Cohen & Wills,

1985; Cohen et al., 1997), and it is a principal finding of recent brain research (Sapolsky, 1998). Stress reduction of this sort can affect community health (Kawachi et al., 1997). Using the context of health economic modeling, stress reduction from social capital might be interpreted as an input in the production of health function. LaPorte and Ferguson (2004) approached the problem in this way, an idea developed out of Grossman's (1972) model of the demand for health capital.

2. Coaching: Sympathetic relationships might serve as coaching, urging healthful practices. The idea is similar to why people hire trainers for health and fitness. The coaching function can be interpreted in a production of health context as an input to production, or alternatively as an enhancement to the individual's productivity, much as education is described.
3. Providing information: A social network expands one's knowledge base from which to improve health. For example, knowledge of the availability and purpose of prescription drugs, the understanding how alcohol affects health, and the awareness of the role of physical activities can each be provided through social networks. Information can eliminate mistaken perceptions regarding the role of health care in a way that can improve personal well-being (Phelps, 2000).
4. Increasing responsibility: One's role in the community develops a sense of responsibility for the well-being of others. Much like the responsibility for one's family, responsibility to others requires at a minimum that one stay alive and healthy. Folland (2006) demonstrated that community social capital as well as family ties tend to modify an individual's propensity to adopt healthy risky behaviors (see also DeLeire & Levy, 2001; Robison & Hanson, 1995).

The data

Six matched cross-sections of the 48 contiguous states taken in 4-year intervals form the panel studied in this paper. Social capital was measured by taking 6 of the 14 variables employed by Putnam in his *Bowling Alone* study. The 6 variables were measured as US state means in each of the study years; they were derived from the DDB Life Style Database 1975–1998 generated by DDB Worldwide of Chicago. These 6 variables correlate well with Putnam's original index; treating his index as the dependent variable and the 6 indicators as independent variables, over 80 percent of the variation in his index is explained for the 1994 cross-section that Putnam published (Appendix B). The *Current Population Reports* provided population data for the various years. Table 1 presents descriptive statistics of the study data for the 1994 cross-section. Table 2 describes the 6 social capital variables, and it also reports their average period change. Putnam showed that many social capital indicators declined in America between the 1950s and the 1990s, and we notice that most of the individual indicators in this panel declined as well.

Table 1
Social capital, economic and health variables: 1994 cross-section

Variable	Mean	Std. Dev	Minimum	Maximum
Social capital index (Putnam)	0.059	0.790	−1.430	1.710
Baccalaureates, pct	21.644	4.266	11.400	30.100
Personal Income per capita	14139	1980.8	10694.0	19841.1
Poverty, pct	0.131	0.039	0.076	0.259
Unemployment, pct	5.634	1.279	2.900	8.900
Health expenses per capita	304.3	41.03	222.6	413.9
Total mortality rate (age adj)	8.236	0.7631	6.341	10.245
Life expectancy from birth	75.641	1.310	73.030	78.210
Infant mortality rate	7.924	1.341	5.000	11.000
Low weight births, pct	7.462	1.307	5.200	10.200
Heart mortality rate, (age adj)	87.9	21.37	48.0	143.0
Cancer mortality rate,(age adj)	193.77	20.588	130.377	226.30
Accident mort. rate,(age adj)	37.398	8.459	21.051	62.562
Suicide rate (age adj)	13.099	3.464	7.228	23.564

Note: Variable definitions and sources are described in the text. For each of these variables, the number of observations is 48, one for each of the contiguous 48 states. In several cases, the variable value was not available for 1994, and the nearest available year was substituted.

Table 2
Definitions of the DDB social capital indicators, all years

Indicator	Ave change	DDB definition
Social Capital "Index"[a]	−0.4487	Weighted sum of the effects of the listed indicators (See note below)
Club Meetings	−0.7972	Went to club meetings (frequency in the past 12 months)
Community Projects	−0.1902	Worked on community projects (frequency in the past 12 months)
Entertained	−1.1554	Entertained people in my home (frequency in the past 12 months)
Volunteered	0.3514	Did volunteer work (frequency in the past 12 months)
Most are Honest	−0.0564	'*Most people are honest*': 1. definitely disagree; 2. generally disagree; 3. moderately disagree; 4. moderately agree; 5. generally agree; 6. definitely agree
Visited Friends	0.0213	'I spend a lot of time with friends': 1. definitely disagree; 2. generally disagree; 3. moderately disagree; 4. moderately agree; 5. generally agree; 6. definitely agree

Note: These were available for nearly all years from 1975 to 1998 from the DDB Worldwide, Inc. Chicago, also on-line.See Appendix B for this regression.

[a]Putnam's social capital index does not exist for years other than 1994. To simulate the progress over time of such an index, this row defines an index by application of the regression coefficients of the six indices weighted by their mean values.

Table 3
Social capital indicators, economic and health variables: panel

Variable	Mean	St. Dev.	Minimum	Maximum
Club Meetings	7.501	1.944	1.750	14.870
Community Projects	2.461	0.830	0.329	6.900
Entertained	11.926	2.572	6.480	20.450
Volunteered	7.237	1.764	1.540	13.500
Most Are Honest	3.866	0.686	3.300	4.61
Visited Friends	3.012	0.222	2.000	3.84
Baccalaureates, percent	18.975	4.891	9.100	34.000
Personal Income per capita	13634	2429.9	8611.8	22898.3
Poverty, fraction of population	0.127	0.038	0.047	0.329
Unemployment rate, percent	6.198	2.264	2.200	15.500
Health expenses in ratio to pop.	206.06	108.77	3.75	491.26
Total mortality rate	939.7	83.83	692.7	1127.6
Infant mortality rate	9.975	2.667	4.500	18.200
Low weight births, percent	7.052	1.031	4.300	10.800
Heart mortality rate	113.8	36.9	41.0	213.0
Cancer mortality rate	186.2	18.2	132.0	283.0
Accident mortality rate	41.5	10.2	20.0	93.0
Suicide rate	13.38	3.46	7.0	30.0

Notes: For "Club Meetings" through "Visited Friends", see Table 2 explanations; "Health Expenditures per Capita" is defined as inflation adjusted personal health care expenditures in millions per population (reduced by a factor of ten); "Total Mortality" and "Infant Mortality" are age-adjusted death rates per 100,000 people and deaths per 1,000 live births respectively; "Heart Mortality" through "Suicide Rate" are age-adjusted deaths per 100,000 population. Age-adjustment is standardized to the 2000 US population.

The descriptive statistics for the panel are reported in Table 3. The remaining variables shown are in 2 groups: economic measures and population health status variables.

The several economic variables are derived from standard sources. Personal income per capita, percent of population in poverty, percent of population holding the baccalaureate (BA) degree, and percent of labor force unemployed derive from the Census Bureau reports various years (see also the *Statistical Abstract*). Personal health care expenditures in hundred thousands per million population per capita derive from the Center for Medicare and Medicaid Services, various years.

Several population health status variables are from the *Monthly Vital Statistics Report* various years and are defined as follows: The *Infant Mortality Rate* is the ratio of deaths to infants 0–1-year-old to the total number of live births; and the percent of *Low Weight Births* is based on the

reported total low weight (under 2500 g) births as a ratio to the total live births. *Life Expectancy* is calculated from birth. The other mortality rates included are *Total Mortality*, *Heart* (myocardial infarction), *Cancer* (malignant neoplasms), *Accident* (including motor vehicle), and *Suicide,* each calculated per 100,000 population. The mortality rates are each age-standardized to the 2000 population distribution and are derived from the online "CDC Wonder" provided by the Center for Disease Control.

Finally, Putnam's results for several other variables were reproduced to verify the compatibility for comparisons of the 2 frameworks. These included measures of the crime rate, percent voting in the most recent presidential race, and average educational outcome scores; these results corresponded closely to Putnam's published results.

Testing the hypothesis by extending Putnam's framework

Putnam published predominantly bivariate analysis in his book, *Bowling Alone,* and much other early work was bivariate, so let us begin the same way. Bivariate regressions on the 1994 cross-section reproduce Putnam's result but add a wider variety of health variables. His finding for the total mortality rate extends well to these several health measures (Table 4).

Table 5 selects two of the most often discussed health status variables, the total age-adjusted mortality rate and the infant mortality rate, and it tests them on each cross-section in the panel. For this test, the combined effects of the six social capital variables were estimated and significance calculated using the LIMDEP 7.0 program. The significance column lists the probability of the null hypothesis that the social capital variables in combination have no effect. The association of social capital with ill health is negative in each case and predominately significant, supporting the social capital and health hypothesis and suggesting that it is robust over this quarter century.

Social capital in the production of health

Nevertheless the limitations of bivariate analysis leave many questions unanswered. Is it the social capital that leads to better health, or is it merely standing in for other variables? For example, do maternity outcomes improve with sociable activity or do higher income areas simply provide both more social capital and health? As a general statement, omitted variables may cause bias in the social capital coefficients.

The proposed multivariate specification borrows from the health economist's production of health analysis, and it includes per capita income, the unemployment rate, the poverty rate, and the percent of the population holding the baccalaureate degree, and the per capita health expenditures. Recent multivariate social capital studies often include income and/or a measure of income inequality.

Table 4
Health status and Putnam's social capital index in a 1994 cross-section of the 48 contiguous states

Health status indicator	Soccap coeff.	$\|t\|$
Total mortality rate	−0.531	5.08
Percent low weight births	−0.917	4.42
Infant mortality rate	−0.748	3.29
Heart mortality rate	−21.284	3.37
Cancer mortality rate	−10.485	3.38
Accident mortality rate	−2.812	1.98
Suicide rate	−0.372	0.22
Life expectancy at birth	1.394	11.58

Note: Total mortality, heart, cancer, accident, and suicide rates are each adjusted for the population's age distribution using the US 2000 as the standard. The center column reports the regression coefficient for Putnam's social capital index.

Table 5
Does the social capital hypothesis work in other periods?

Health status indicator	Period	Effect social capital	Test signif.
Total mortality rate	1978	−583.7	0.001
Infant mortality rate	1978	−12.33	0.052
Total mortality rate	1982	−337.5	0.075
Infant mortality rate	1982	−2.238	0.178
Total mortality rate	1986	−383.4	0.031
Infant mortality rate	1986	−9.84	0.020
Total mortality rate	1990	−1237.9	0.000
Infant mortality rate	1990	−9.45	0.036
Total mortality rate	1994	−585.8	0.002
Infant mortality rate	1994	−14.95	0.002
Total mortality rate	1998	−1289.0	0.000
Infant mortality rate	1998	−20.23	0.000
Total mortality rate	All years	−573.5	0.000
Infant mortality rate	All years	−8.93	0.022

Note: The Social capital effect column reports the sum of the mean values of the six social capital indicators each weighted by their regression coefficients. The Significance test column is the probability of the null hypothesis of no social capital effect.

Kawachi et al. (1997) describes the idea that income pressures may work on health psychosocial avenues. But the economic variables may alternatively affect health through their effect on availability and accessibility of health care resources, thus they should appear independently of social capital.

Tables 6A & B present the results of regressions on the panel data with the seven health variables as the dependent variables. In each case of a health variable, the equation is estimated and reported twice, in the first instance, in Table 6A, as panel estimates with time period effects. The second instance, in Table 6B, reports the random effects model (REM); Hausman statistics indicated for all seven-health measure equations that the random effects model dominates the fixed effects model. The random effects model captures the influence of unobserved characteristics of the states, and the fact that social capital does somewhat "poorer" in the REM models suggests that state characteristics account for part of the formerly perceived effect of social capital. Yet the predominance of negative signs supports the social capital hypothesis generally, and the results also suggest the speculation that the effects of social capital where they exist, may be different for different mortality categories. This seems reasonable. Might not heart disease and cancer be less amenable to community sociability than for example, the case of pregnant women and their birth outcomes?

Table 6

	Total mortality	Infant mortality	Low weight %	Heart mortality	Cancer mortality	Accident mortality	Suicide rate
(A) *Social capital as an input to the production of health, panel data* (*Note*: Regressions are based on the panel with time period dummy variables, "Period Effects")							
Social capital	−480.7	−5.653	−10.26	7.516	−67.587	−21.88	−4.899
	(6.77)	(2.75)	(7.78)	(0.28)	(2.99)	(2.72)	(1.17)
BA %	−8.23	−0.166	−0.082	−3.710	−1.613	0.131	0.125
	(7.38)	(5.16)	(3.78)	(8.87)	(4.55)	(1.04)	(1.83)
Personal income per	0.011	0.0004	0.0003	0.001	0.003	−0.001	−0.0004
capita	(4.51)	(5.24)	(4.79)	(1.07)	(3.63)	(3.66)	(2.83)
Poverty rate	491.9	17.95	17.73	−18.052	28.65	102.83	0.762
	(4.39)	(5.54)	(6.59)	(0.43)	(0.81)	(8.09)	(0.11)
Unemp rate	0.0185	−0.000	−0.001	0.012	0.033	−0.011	−0.003
	(1.08)	(0.53)	(1.89)	(1.88)	(0.61)	(5.85)	(2.56)
Health expends. per	−0.345	−0.016	−0.002	−0.092	0.025	−0.029	−0.009
capita	(6.24)	(10.61)	(1.03)	(4.44)	(1.45)	(4.75)	(2.82)
Constant	1426.1	14.72	14.17	183.18	234.74	69.739	24.356
R^2(p for F)	0.609	0.715	0.441	0.743	0.232	0.610	0.213
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(B) *Social capital as an input to the production of health, panel data, applying the random effects model* (*Note*: These regressions include period effects as well as random group effects)							
Social capital	−18.50	−2.386	−3.941	28.61	−0.681	−12.659	−0.800
	(0.48)	(1.49)	(3.98)	(1.65)	(0.05)	(2.55)	(0.31)
BA %	−3.379	−0.036	−0.044	−1.79	−0.869	0.093	−0.111
	(3.49)	(0.98)	(1.86)	(4.12)	(2.41)	(0.77)	(1.80)
Personal income per	−0.003	−0.001	0.000	−0.001	−0.001	−0.001	−0.001
capita	(1.26)	(1.72)	(0.15)	(1.59)	(0.62)	(2.31)	(1.13)
Poverty rate	−1143.1	−48.71	−16.522	−530.7	−345.3	199.67	94.65
	(1.53)	(1.90)	(0.97)	(1.69)	(1.34)	(2.17)	(1.96)
Unemp rate	−3.925	−0.032	−0.073	−0.564	−0.241	−0.820	0.088
	(3.61)	(0.69)	(2.63)	(1.17)	(0.57)	(5.81)	(1.24)
Health expends. per	−0.076	−0.004	0.001	−0.085	0.003	0.004	0.003
capita	(1.69)	(2.03)	(0.83)	(4.51)	(0.16)	(0.60)	(1.31)
Constant	1106.5	16.275	12.066	164.55	213.1	63.32	16.497
R^2(p for F)	0.950	0.923	0.865	0.953	0.857	0.938	0.885
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Are the social capital coefficients confounded by omitted variables?

Durlauf (2002) showed that the greatest threat to the validity of the social capital and health hypothesis is the question of whether the observed coefficients identify the true coefficients or whether they are confounded by other variables. This "identification" problem, he pointed out, is especially difficult to resolve for social capital studies and even more so for those using aggregated data. Commonly, identification is confounded when the social capital variable is correlated with the equation's error term, but the problem can also arise from other sources. The solution proposed here, is the use of instrumental variables; while this is well known, its application to social capital is relatively new, and the following should be regarded as exploratory.

But before developing this analysis, it is useful to consider the relation of identification to the question of causality. Even the correctly identified social capital coefficient from an ideal model does not by itself imply causality; correlations never imply this. Instead, the approach in economics, called Granger causality, requires data from tests both of whether past values predict the present and whether future values back predict the present. The time series available in the present study is not adequate for that purpose. Future developments of time series datasets as well as the discovery of natural experiments may better unravel the issue of causality. As the literature continues to grow, however, development of social capital theory should help to generate theoretical predictions that distinguish the social capital hypothesis from alternative hypotheses; our confidence in the social capital and health hypothesis will more likely grow out of such theoretical insights. In the Popperian sense, confidence grows when a hypothesis survives more and more challenging tests.

The estimation issues in our present case are made explicit by Durlauf. He describes a set of assumptions under which an identified model of the social capital effects could be formed. The conditions are:

(1) There is no feedback effect, that is, the population's expectation about the community health measure does not affect the community health measure.
(2) The information set that individuals use in making decisions is common to all individuals.
(3) There is at least one exogenous variable that is predictive of social capital but takes a zero coefficient in the respective health measure equation.

It is proposed here that condition (1) is plausibly met for the health variables studied. Knowledge of their state's mean levels of these health variables is probably not in citizen's information sets (as, in contrast, news of infectious epidemics would be). (2) Is attained if, as seems plausible, the majority of Americans acquire a common information set largely through a commonly share mass media. Finally, (3) describes conditions common to the instrumental variables technique.

As an application of this framework, an instrumental variables model using the following three instruments is proposed, each is followed by a justifying argument: (1) the employment per capita—work is a socializing experience and helps to build social capital, yet it is unlikely to be a health input per se; (2) geographic latitude—the North South pattern of social capital in the United States is very noticeable, and Putnam reported that the strongest single predictors of his social capital index were "Distance from Canada" and "Percent Scandinavian Ethnicity"; northern European immigration to the United States is overrepresented in the northern tier of states, and this same ethnicity is reported to score high in social capital in Europe (Islam et al., 2006; Poortinga, 2006); I assume however that this ethnicity is not per se a benefit to health; and (3) state government contributions to colleges per capita—in economic theory, the public contributes to education so as to reap the external benefits of a better citizenry; as such, the College variable is a plausible indicator of the community's commitment to a form of social capital yet not one that is closely correlated with local education levels, which in contrast do relate significantly to population health (Lleras-Muney, 2005).

These instruments were tested first in regressions of social capital to assure that they predicted significantly, and they performed well. These instruments and the exogenous variables together explain about 50 percent of the variation in social capital. The crucial test, however, is whether the instruments prove to be uncorrelated with the residuals of each health equation. Table 7 reports the correlation coefficient between each instrument and each residual of the respective equations.

Table 7
Correlations of instruments and the health equation residuals

Health equation	Employment per capita	Latitude	College funding per capita
Total mortality	0.012	−0.117	−0.091
Infant mortality	0.000	−0.194**	0.116*
Low weight births	0.037	−0.308**	0.110*
Heart	−0.044	−0.018	0.003
Cancer	−0.064	0.010	−0.199**
Accidents	0.102*	−0.063	−0.000
Suicide	0.092	0.007	−0.460

Note: **Indicates significance at the 0.05 level. *Indicates significance at the 0.10 level.

Table 8
The production of health with instrumental variables

	Total mortality	Infant mortality	Low weight %	Heart mortality	Cancer mortality	Accident mortality	Suicide rate
Social capital	−37.23	0.675	−0.055	3.805	−4.895	−2.127	−0.703
	(6.07)	(3.27)	(0.37)	(1.65)	(1.75)	(3.07)	(1.85)
BA %	−8.30	−0.200	−0.58	−4.286	−1.857	0.217	0.155
	(7.57)	(6.63)	(2.67)	(10.12)	(5.23)	(1.76)	(2.28)
Personal income	0.013	0.0004	0.003	0.003	0.0003	−0.001	−0.0004
per capita	(5.00)	(6.15)	(2.74)	(1.99)	(4.51)	(4.18)	(2.72)
Poverty rate	441.5	23.199	16.399	−8.722	22.45	100.14	−2.497
	(3.71)	(7.04)	(6.83)	(0.19)	(0.61)	(7.47)	(0.34)
Unemp rate	0.027	−0.0003	−0.0002	0.019	0.005	−0.019	−0.002
	(1.52)	(0.32)	(0.54)	(1.80)	(0.93)	(5.69)	(2.72)
Health expends. per	−0.375	−0.013	0.002	−0.142	−0.005	−0.019	−0.006
capita	(7.79)	(7.56)	(1.86)	(7.89)	(0.22)	(3.55)	(2.00)
Constant	979.0	8.174	3.797	195.3	169.77	48.248	19.068
R^2(p for F)	0.580	0.711	0.275	0.717	0.155	0.575	0.130
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: Values for the t statistic are in parentheses, except that the last row parentheses contain probability values for the F statistic.

The table shows the instruments to be suitable, though with some exceptions. By dropping ones from equations where the correlation is significant at the five percent level, the remaining sets appear useable, though the two equations describing birth outcome are the least adequate. Table 8 reports the results of regressions on the health measures using this approach.

The results in Table 8 support the social capital and health hypothesis in the main, but imperfectly. As in the previous regressions, the heart mortality equation exhibits a "perverse" effect of social capital. Unfortunately the infant mortality and low weight births equations, where the instruments performed the poorest (see Table 7), also indicate a weak social capital performance. The results we have seen previously for total mortality, cancer, accidents and suicide, are generally sustained under this application.

Regressions on changes in the variables

This final section sketches a few of the rudiments of a dynamic model of social capital and health. A beginning step is to report the mean changes in the variables over the range of periods from 1978 to 1998. Please recall that each of the six periods spans 4 years. Table 9 reports these data.

The mean changes confirm both some well-known facts as well as some claims. We note that the steepest declines in mortality rates occurred for infant mortality and mortality from heart disease. Among the social capital variables, most have

Table 9
Mean changes in the variables over the four year periods ranging from 1978 to 1998

Variable	Mean change	Standard deviation in the change
Health status indicators		
Total mortality rate	−25.61	25.255
Infant mortality rate	−1.254	1.123
Low weight births % of births	0.115	0.729
Heart disease mortality rate	−17.025	9.109
Cancer mortality rate	0.675	9.288
Accident mortality rate	−0.545	4.369
Suicide rate	−0.129	1.668
Social capital indicators		
Attended club meetings	−0.7972	1.701
Helped community projects	−0.1902	0.959
Entertained at home	−1.1554	1.744
Volunteered	0.3514	2.101
People are generally honest	−0.0564	0.190
Visited friends	0.0213	0.212
Economic variables		
Baccalaureate percent	1.995	1.518
Personal income per Capita	0.359	0.123
Poverty rate	−0.0003	0.0015
Unemployment rate	−0.251	2.709
Health expenditures per capita	57.809	30.129

Note: Changes are calculated from one four year period to the next.

declined, as claimed by Putnam (2000). We should note and emphasize, however, that not all social capital indicators have declined. Finally, most economic variables have improved. The high rate of growth in per capita health expenditures generates frequent comments, and many critics find this to be a fault of the health system. In contrast, Cutler (2004) finds the value of the decline in infant mortality and heart disease mortality to be well worth the excess cost. A reminder in reading these numbers (Table 9) is that they are means across the states and for 4-year periods, thus they will differ from reported national, annual rates of change.

Table 10 reports regressions of changes in each health variable on changes in the independent variables. So as to avoid unnecessary detail, only the combined social capital effect and its t statistics are shown. The social capital was calculated as the sum of the changes in the six social capital variables weighted by their mean

Table 10
Regressions of changes in the health variables on changes in the independent variables

Equation	Social capital effect	Absolute value of the t statistic
Total mortality rate	−0.0025	0.475
Infant mortality rate	−0.0022	0.794
Low weight birth (%)	0.0002	0.099
Heart mortality	−0.0326	1.601
Cancer mortality	0.0623	3.139
Accident mortality	0.0047	0.505
Suicide rate	0.0011	0.296

Note: The social capital effect column is the Wald coefficient, where the Wald function is defined as the sum of the social capital coefficients weighted by the mean changes in social capital. All variables (the economic variables and constant are not shown in the table) in the regression are the period-to-period changes in the original variables.

values. The several low reported t values imply that we cannot rule out the null. A caution is warranted that null results here do not negate our previous findings (see Tables 6 and 7); the present estimates suggest instead the pattern by which these results had evolved over time. This exercise suggests that a simple model regressing changes in the dependent variables and changes in the independent variables does not fully capture the true dynamic model of how social capital and health may interact over time. Developing such a model, however, is beyond the scope of the present paper.

Discussion and conclusions

The present study, more or less in the spirit of Popperian science, is aimed at providing statistical tests of the social capital hypothesis, tests for which the hypothesis could fail. The paper tries the social capital and health hypothesis on a variety of time periods, on a production of health framework, on a panel of data, on instrumental variables, and on changes in the variables. These efforts reveal both weaknesses and strengths in the hypothesis. The weaknesses include that (1) heart disease mortality does not respond to social capital measures in these data, (2) area-specific effects appear to influence social capital so as to bring noticeable erosion in the social capital effect for some diseases, and (3) instrumenting the social capital measure also brings some erosion in its observed effects.

Overall, however, social capital performs reasonably well. It is strong across time periods in the United States, it distinguishes a clear effect independent of the economic variables, it performs well in the panel, and in many cases it distinguishes an effect separate from the previously mentioned local characteristics as well survives in several cases an exploratory application of instrumental variables.

At least two limitations of this study need to be discussed. First, although it is argued here that the social capital effect can be identified with instrumental variables in these aggregate data, it must be recognized that finding suitable and strong instruments requires considerable exploration. Other approaches to identification may prove as effective or more effective. This suggests the benefits of those studies that combine individual and aggregate measures. However, state aggregate data applications have well-known precedents in social capital literature, and the present study describes extensions that help to understand those studies and in principle can be applied to many others. Second, it can be argued that stronger confidence in the social capital and health hypothesis may ultimately come from other kinds of approaches. For example, it may be possible to find and analyze natural experiments where people have undergone identifiable changes in social capital and their behavior and health conditions can be followed before and after this change.

The best conclusion may be to describe the present work as an empirical reinforcement to the view of Durlauf (2002), in which he draws attention to the need to address the statistical problems that affect social capital estimates. Adjusting for local area effects and removing biases caused by flaws in estimation are steps that are clearly needed, this was shown in that the steps taken here brought changes to the estimated social capital effects. These issues raise deeper statistical questions of what the effects we observe mean and ultimately whether the social capital and health hypothesis is causal. Further still, we must explain whether one can invest in social capital, and whether doing so will bring the results we commonly desire.

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Appendix A

Indicators composing Putnam's Social Capital Index:

Measures of community organizational life:
Served on committee of local organization in last year (pct)
Served as officer of some club or organization last year (pct)
Civic and social organizations per 1,000 population
Mean number of club meetings attended last year
Mean number of group memberships
Measures of engagement in public affairs:
Turnout in presidential elections
Attended public meeting on town or school affairs in last year (pct)
Measures of community volunteerism:
Number of nonprofit (501c3) organizations per 1000 population
Mean number of times worked on community projects in last year
Mean number of times did volunteer work in last year
Measures of informal sociability:
Agree that "I spend a lot of time visiting friends"
Mean number of times entertained at home in last year
Measures of social trust:
Agree that "Most people can be trusted"
Agree that "Most people are honest"

Source: Putnam (2000, p. 291).

Appendix B

Table 1A shows regression of six social capital measures on Putnam's index.

Table 1A
Regression of six social capital measures on Putnam's index

Variable	Coeff (t value)
Constant	−6.604 (7.61)
Club Meetings	0.265 (3.89)
Community Projects	0.462 (3.16)
Entertained	0.180 (2.70)
Volunteered	0.163 (2.24)
Most are Honest	0.013 (0.37)
Visited Friends	0.098 (0.33)
R^2 (probability of F)	0.802 (0.000)

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