Neighbourhood social capital improves individual health quality of life in a national sample from Wales

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By Gindo Tampubolon*

Neighbourhood social capital is often claimed to improve health but in Britain this claim finds little support. I examine the effects of neighbourhood social capital on the Welsh health quality of life in 2007 using instrumental variable estimator. By extending the influential Grossman health production model and borrowing from the Blume-Brock-Durlauf statistical mechanics of social interactions model, suitable instruments for identification are readily obtained. Instruments (neighbourhood ethnic diversity and residence length) were collected from separate survey. Neighbourhood social capital and deprivation measures were likewise independently gathered from measures of individual socioeconomic status and health (SF-36). In the national sample there are 13,557 respondents residing in 1,152 neighbourhoods. Neighbourhood deprivations invariably reduce individual health quality of life but neighbourhood social capital more than compensate for this. Because the instruments are strong enough to identify the effects, I show that friendly neighbourhood and friendly neighbours, sense of community in the neighbourhood, trust, ready exchange of information and goods, and sense of belonging improve residents' health. Public health practitioners have these measures as additional tools in their box when formulating policy to improve public health.

Claim that social capital matters seems intuitive; yet supporting evidence remains elusive. Studies in the U.S. show that neighbourhood social capital correlates with individual health (Ichiro Kawachi, Kimberly Lochner Bruce P Kennedy and Deborah Prothrow-Stith 1997, Ichiro Kawachi, Bruce P. Kennedy and Roberta Glass 1999, S. V. Subramanian, Daniel Kim and Ichiro Kawachi 2005, Kasisomayajula Viswanath, Whitney Randolph Steele and John R. Finnegan, Jr 2006, Stephanie A. Farquhar, Yvonne L. Michael and Noelle Wiggins 2005, Megan Perry, Robert L. Williams, Nina Wallerstein and Howard Waitzkin 2008). In Britain however comparable evidence is difficult to find (Craig Duncan, Kelvyn Jones and Graham Moon 1993, Andrew Sloggett and Heather Joshi 1998, John Mohan, Liz Twigg, Steve Barnard and Kelvyn Jones 2005, Carol Propper, Kelvyn Jones, Anne Bolster, Simon Burgess, Ron Johnston and Rebecca Sarker 2005, Mai Stafford, Mary J. De Silva, Stephen Stansfeld and Michael Marmot 2008). Studies from other countries such as New Zealand and Sweden have failed to settle the issue (Tony Blakely, June Atkinson, Vivienne Ivory, Sunny Collings, Jenny Wilton and Philippa Howden-Chapman 2006, M. K. Islam, Juan Merlo, Ichiro Kawachi, M. Lindström, K. Burström and U. G. Gerdtham 2006). The claim continues to retain its appeal.

Ichiro Kawachi and Lisa F. Berkman (2003) clarify the mechanisms relating neighbourhood social capital and individual health. First, more cohesive groups are bet-

* Tampubolon: Institute for Social Change, University of Manchester, g.tampubolon@manchester.ac.uk. I thank the Welsh Assembly Government – Llywodraeth Cynulliad Cymru – for funding this work. Data used in this analysis are provided by the Government under contract designed to protect the anonymity of respondents and neighbourhoods. They are not available from the author. Ichiro Kawachi and Subu Subramanian have been especially generous with their ideas for which I am grateful.

ter equipped to mobilize collective action such as preventing the excursion of fast food outlets through the use of zoning restriction. Second, more cohesive groups are better equipped to maintain social norms, hence maintain residents' sense of health. Though social norms can also influence health in negative ways as shown in the case of obesity (Nicholas A. Christakis and James H. Fowler 2007, Gindo Tampubolon, Ichiro Kawachi and S.V. Subramanian 2009). The last mechanism is indirect; collective efficacy and informal control in preventing crime and violence, in turn, reduces residents' exposure to daily environmental stresses and insults.

Despite these clear mechanisms, gaps remain in the literature. Most importantly, studies on social capital fail to connect with the theoretical model of health production, in particular the influential Grossman model. How neighbourhood social capital produces health quality of life among residents is less well-specified. Moreover, previous studies of social capital and health outcome have relied upon individual reports of their neighbourhood social environment. The assessment of social capital was obtained from the same individuals in whom health outcomes were measured. This raises reflection problem potentially preventing identification (Charles F. Manski 1993). Next, the level of spatial aggregation to define 'neighbourhoods' has varied across previous studies. For example, studies in Britain commonly use the administrative wards to define 'neighbourhoods' which many consider to be rather heterogeneous in terms of studying the impact of social influence on health behaviors. Finally, rarely does a study on social capital examine its effect on health outcome measured using widely validated health instrument. Notably, the few existing studies of social capital and health in Britain have failed to find a general association between social capital and health outcomes (Duncan, Jones and Moon 1993, Sloggett and Joshi 1998, Mohan et al. 2005, Propper et al. 2005, Stafford et al. 2008).

In addressing these gaps, I first propose an extension to the influential Grossman model of health (Michael Grossman 1972*a*). The new model explicitly incorporates the multilevel influences of neighbourhood social capital and environmental deprivation that affect processes of health maintenance and health production function; in short, health behaviours and health outcome. Thus recent scholarships in public health and epidemiology are used to augment this influential model with neighbourhood effects. It follows that in establishing causality, instruments or exclusion restrictions that are theoretically motivated within the extended Grossman model are readily obtained. Also, the neighbourhood is defined as the local super output area, a geography purposefully designed for social research, and comprising about 500 households. This standardised geography enables independent measures of neighbourhood social capital and neighbourhood deprivation, obtained from independent and administrative sources, to be used. Of equal importance, a widely validated instrument of health related quality of life, SF36, is used to measure health outcome.

I. Neighbourhood social capital and health

Social capital is a crystallisation of the ideas that have been around since researchers began to examine systematically the relationships between society, especially neighbourhood, and individual health. A definition that will suffice for our purpose is due to Robert D. Putnam (1993): "social networks and norms and trustworthiness" residing in a neighbourhood. It is obvious that social networks, norms and trust grow out of and circulate in social interactions. The literature on social interactions model will be one of the main sources of modelling ideas drawn upon in this study.

Recent works in social epidemiology have attempted to be more specific about how social capital influences health and well being (Lisa F. Berkman and Ichiro Kawachi 2000, Kawachi and Berkman 2003). Kawachi and Berkman write about mechanisms linking neighbourhood social capital and individual health. First, more cohesive groups are better equipped to mobilize collective action and distribute information. Second, more cohesive groups are better equipped to enforce and maintain social norms. It is now recognised that social norms can also influence health in negative ways. The last mechanism is indirect. Collective efficacy and informal control in preventing crime and violence, in turn, reduce environmental stresses suffered by residents in their day to day activities and increases take up of health maintenance behaviour such as physical exercise. The recent focus on and specification of mechanisms (what goes on in a neighbourhood) are welcome. They remind us that social process remains to an important extent a spatial process. A formal model of neighbourhood social capital and health draws from Grossman health model and the increasingly popular social interaction model.

II. The Grossman model of health & its extensions to neighbourhood effects

An influential model of health production is due to Grossman (1972*a*); see also Michael Grossman (1972*b*). Following the notation of Anne Case and Angus Deaton (2005), assume there is an instantaneous felicity function $\nu(c_t, H_t)$ where t is age, c_t is consumption, and H_t is the stock of health. Health is produced according to

$$H_{t+1} = \theta m_t + (1 - \delta_t)H_t \tag{1}$$

where m_t is the decisions and behaviours for maintenance of health (including medical care bought and health behaviours like regular physical exercise, m_t^+, and smoking, m_t^-), θ is the efficiency or conversion factor which is affected by education (and other socioeconomic status) and δ is the rate of health deterioration at t. People maximise a life cycle welfare function

$$U = \sum_0^T (1+\rho)^t \nu(c_t, H_t) \tag{2}$$

where ρ expresses time preference, and T is the length of life. The welfare is optimized subject to full wealth constraint incorporating both wealth and time limits:

$$\sum_0^T \frac{c_t}{(1+r)^t} + \sum_0^T \frac{p_m m_t}{(1+r)^t} = W_0 + \sum_0^T \frac{y_t(H_t)}{(1+r)^t} \tag{3}$$

where r is the market rate of interest, p_m is the price of medical care and other health behaviours, W_0 is initial assets, and $y_t(H_t)$ is earning, a function of health.

Optimising the welfare function subject to the constraint as the health stock changes gives insights into, among others, the role of education and inequalities in health. These have been widely tested empirically by assuming functional forms for the elements of the theory (often of Cobb-Douglas form). Adam Wagstaff (1986) provides some example assumptions which enable empirical estimation. On estimation, Eddy K.A. Van Doorslaer (1987) recommends a focus on health production function to avoid problems when estimating health demand function. Equations for health production function and for health maintenance suitable for estimation are:

$$H = H(M, W, X, \mu_h) \tag{4}$$

and

$$M = M(W, Y, \mu_m) \tag{5}$$

where W is wealth, X and Y include age, education and other exogeneous variables; and the μ's are residuals.

This is emphatically a recursive or triangular system as M, in turn, enters the health production function. This system is also known as multiprocess system. Recently, for example, Silvia Balia and Andrew M. Jones (2008)[1] estimated a similar recursive system of health maintenance behaviour, health outcomes and mortality. Their recursive structure is intuitively and formally in that order: health maintenance, health outcome, mortality. They recognise the correlated structure of the system and estimate the system's parameters including residual cross-correlations using simulated maximum likelihood.

I propose an extension broadening the formal model to include neighbourhood effects. This extension acts as a bridge between the economics of health and epidemiology and public health. In the Grossman model, demand for the maintenance of health, M, is narrowly and individually defined. However, if we construe maintenance to include general maintenance of health and avoidance of risks which affect health then we are in a position to include neighbourhood effects. The benefits of this extension include increased scope of explanation and scope of policy intervention.

A. *Statistical mechanics of social interactions, social capital and health*

Theoretical justification for including broader actions, specifically neighbours' actions, on resident's individual health is grounded in works on social interaction and its identification (Lawrence E. Blume 1993, William A. Brock 1993, Manski 1993, Steven N. Durlauf 1997, H. Peyton Young 1998, Gary S. Becker and Kevin M. Murphy 2000, Charles F. Manski 2000, William A. Brock and Steven N. Durlauf 2001*a*, William A. Brock and Steven N. Durlauf 2001*b*, Edward L. Glaeser and José A. Scheinkman 2001, Steven N. Durlauf 2002, Edward L. Glaeser, David Laibson and Bruce Sacerdote 2002, Edward L. Glaeser and José A. Scheinkman 2003, David Cutler and Edward L. Glaeser 2005, Steven N. Durlauf and Marcel Fafchamps 2005, Lawrence E. Blume and Steven N. Durlauf 2005).

Blume, Brock and Durlauf in a series of papers cited above draw upon statistical mechanics to understand the process of social interactions and how individual choices within them give rise to interesting aggregate behaviors.[2] In our context, social interactions facilitate the various forms of social capital which give rise to aggregate or widespread health behaviors such as jogging or smoking in the neighborhood.

I follow closely Durlauf (1997) and Brock and Durlauf (2001*a*) which consider a binary choice setting.[3] This setting allows all parameters to be given their structural interpretation and facilitates econometric identification. Other works (Brock and Durlauf 2001*b*, Durlauf 2002) discuss identification in linear-in-means setting as discussed below. Each individual is set in a population N where social interactions are present. Each individual chooses a binary action m_i with support $\{-1, 1\}$. This support, instead of the usual

[1] The published version dropped citation to Grossman and introduced a typographic error compared to the working paper version.

[2] The neighbouring field of spatial statistics which is interested in *spatial* interactions also draws upon the same statistical mechanics literature, see Brian D. Ripley (1990).

[3] Their model parallels the probability structure of the so-called Curie-Weiss model in statistical mechanics. Brock and Durlauf (2001*a*, p. 240) refer to Richard S. Ellis (1985, chapter 4). Giorgio Parisi (1988, p. 24ff §3.2) and Rodney J. Baxter (1982, p. 39ff §3.1) give somewhat more accessible accounts of Ising model with 'mean field' Hamiltonian which results in similar 'magnetization' m^*.

$\{0,1\}$, is common in social interactions model and shows its provenance in statistical mechanics. There the support is typicaly 'spin up' and 'spin down' and the aggregate behavior of 'population' of interest is typically macroscopic magnetization.

Individual utility $V(m_i)$ is assumed to consist of three terms, i.e. private utility associated with a choice ($u(m_i)$); social utility associated with the choice ($S(.,.)$); and a random utility term ($\epsilon(m_i)$) which is independently and identically distributed, in the following equation,

$$V(m_i) = u(m_i) + S(m_i, \mu_i^e(m_{\setminus i})) + \epsilon(m_i). \tag{6}$$

The term $\mu_i^e(m_{\setminus i})$ denotes the conditional probability resident i puts on the choice of others at the time of making its own decision. In case of indiscriminate or total strategic complementarity, this social utility depends solely on $\overline{w}_i^e = (N-1)^{-1}\sum_{i\neq j} w_{i,j}^e$, where $w_{i,j}^e$ denotes the subjective expected value from the perspective of resident i of resident j choice.

Brock and Durlauf assume parametric forms for the social utility term and the probability density of the random utility term.[4] They consider forms of social utility which exhibit indiscriminate strategic complementarity, as above, and are constant. The social utility then obeys $\frac{\partial S(m_i,\overline{w}_i^e)}{\partial m_i \partial \overline{w}_i^e} = J > 0$. These forms allow capture of the degree of dependence across residents in a single parameter. With the constant degree of dependence to obey, two forms of social utility can be used. First, $S(m_i, \overline{w}_i^e) = J m_i \overline{w}_i^e$ which exhibits proportional spillovers (strength of dependence). Second, $S(m_i, \overline{w}_i^e) = -\frac{J}{2}(m_i - \overline{w}_i^e)^2$ which exhibits conforming or restraining norms. This form penalises deviations from the mean more strongly than the first form. Additionally, the two forms differ in levels.

With ϵ's assumed to be independent and extreme-value distributed, the differences in the errors become logistically distributed. This widely used assumption in discrete choice literature, see e.g. G. S. Maddala (1983), allows a direct link between the theoretical model and its econometric estimation.

To derive equilibrium condition, assume that decisions are made in noncooperative fashion, that is, each resident makes a choice without strategic communication or coordination. It follows from the extreme-value distribution assumption that

$$\text{Prob}(m_i) = \frac{\exp(\beta(u(m_i) + J m_i \overline{w}_i^e))}{\sum_{n_i\in\{-1,1\}} \exp(\beta(u(n_i) + J n_i \overline{w}_i^e))}. \tag{7}$$

The parameter β gives the extent to which the deterministic components of utility determine actual choice. Because of independence, the joint probability over all choices is

$$\text{Prob}(\mathbf{m}) = \frac{\exp(\beta(\sum_1^N (u(m_i) + J m_i \overline{w}_i^e)))}{\sum_{n_1\in\{-1,1\}} \cdots \sum_{n_N\in\{-1,1\}} \exp(\beta(\sum_1^N (u(n_i) + J n_i \overline{w}_i^e)))}. \tag{8}$$

In the absence of social interaction effect, $J = 0$, the probability above is proportional to logistic density; in the presence of social interaction effect, $J \neq 0$, it captures interaction influence on behaviors in the neighbourhood.

[4]Physicists, instead, start with the working assumption that the coordinates and momenta in the equation of motion, at equlibria, follow the canonical distribution given by the so-called Boltzmann formula. See Parisi (1988, eq. (1.5) p.2) or Baxter (1982, eq. (1.4.1) p.8).

They then linearise the private utility $u(m_i) = hm_i + k$ with a further inspiration from statistical mechanics.[5] With this linearization, and using the definition of hyperbolic functions, the expectation becomes

$$\text{E}(m_i) = \tanh(\beta(h + J(N-1)^{-1} \sum_{i \neq j} m^e_{i,j})). \tag{9}$$

Furthermore, self-consistent and symmetric beliefs of residents in the model (no residents are privileged) give $\text{E}(m_i) = \text{E}(m_j) \forall i, j$. Together with the last equation, these guarantee there exists at least one expected choice level m^* (Brock and Durlauf 2001*a*, Proposition 1):

$$m^* = \tanh(\beta(h + Jm^*)) \tag{10}$$

Existence of equilibrium is one thing; its identification is another. Identification has always been a fraught issue in social interaction models. As examples, Charles F. Manski (1995) and Durlauf (2002) have done a lot of works on deriving conditions for identification in linear and non-linear models of social interaction. Manski (2000, p. 129) lists possibilities of identification including lag individual behaviors, non-linear model such as Brock and Durlauf's above or other non-linearity e.g. median neighbourhood behaviour, and instrumental variable which affects the outcomes of a subset of the neighbours. The last one is most relevant here. Durlauf (2002, Proposition 3 p. F468) demonstrates that two or more instruments are needed to estimate the effect of neighborhood social capital on an individual outcome; see also Brock and Durlauf (2001*b*) on linear-in-means model identification.

In sum, social interaction models lay the foundation for understanding the effects of social interaction in neighbourhood on individual resident behavior. With suitable instruments, the effect of social interaction facilitating social capital on individual health can be estimated. In fact, the formal model shows that ignoring social interaction may lead to under-specified model. Leaving out social interaction effectively assumes its effect to be negligible, $J = 0$, and admits no possibility of its effect to be positive or negative, $J \neq 0$.

Somewhat more prosaically, obesity can be used as an illustration of social interaction. We are told that food portions in America have increased in the last three decades (Samara Joy Nielsen and Barry M. Popkin 2003). Finishing the increasingly hearty plate clean, while dining out with friends, is an instance of social interaction influencing health behaviour in a negative way, m_t^-. What one orders to begin with ("Just a salad for me." Or "The full monty, please") and what one finishes are not unrelated to what everyone else around the table order or finish. This scene extends, with attenuation, over to the neighbourhood and over time. For instance Christakis and Fowler (2007) suggest that in Framingham, greater Boston, network of friends act as conduit of acceptable norm of body weight. Operating over 30 years, these networks of friends, led to increase in obesity through these social interactions. The authors were careful to account for individual socio-demographic factors and other place-based factors. Across the Atlantic, Tampubolon, Kawachi and Subramanian (2009) find, in a national sample in Wales, that friendly neighbours and neighbourhoods also lead to increase in obesity. They also separate out the effect of individual sociodemographic and geographic factors in a multilevel multiprocess model which simultaneously explain consumption, physical exercise and obesity. Both these empirical studies go some way into revising the notion that social capital is

[5]Again see (Parisi 1988, p. 2ff) on h the magnetic field and k the Boltzmann coefficient.

always or primarily associated with positive benefits; hence tempering the comments of Durlauf and Fafchamps (2005).[6]

Glaeser and Scheinkman (2003, p. 352) show that, for estimable discrete equilibria, it is sufficient that the second derivative of utility with respect to one's own action is greater than partial cross-derivative between one's own action and the neighbours' group action. Or $\left|\frac{\partial^2 v_i}{\partial m_i^2} / \frac{\partial^2 v_i}{\partial m_i \partial S_i}\right| > 1$. This they call moderate social influence condition. It means the effect of one's action on one-self must be greater than the induced effect through social interaction on one's neighbours.

Again, using obesity as an illustration: jogging, a health maintenance behavior m_t^+, by an individual should improve the individual's body mass composition. This improvement should be greater than induced improvement in the body mass composition of the neighbours. Some neighbours were inspired to take up jogging while others were not. Or, take smoking, a known health risk. Smoking by an individual harms the individual's health. This deleterious effect should be more severe for that individual than induced harm in the health of the neighbours through either passive smoking or through social interaction or social norm effect. Excessive drinking and social drinking work similarly. In these cases, the moderate social influence condition is satisfied. One case where the condition is perhaps not satisfied is unprotected sex. Fortunately, I am not applying this extended theory to this case.

Because social interaction can produce discrete multiple equilibria in health behaviours, it is not surprising to observe different neighbourhoods in greater Boston (for instance, Framingham versus Backbay) to possess different obesity rates. The discreteness, hence the possibility of estimating them, is guaranteed by the moderate social influence condition.

Notably, this moderate social influence condition is consistent with the basic tenet of epidemiology or public health research (Geoffrey Rose 1992) or the so-called 'mass-population strategy'. In the words of Rose (1992, p. 135) "A 10 per cent lowering of the population's levels of blood cholesterol can be expected to reduce coronary heart disease by 20-30 per cent, and such a reduction of a condition that now kills one-quarter of the population would be a benefit indeed. A reduction of one-third in the nation's salt intake, ... might also reduce by up to one-half the number of people requiring drug treatment for hypertension." It is well known that neighbourhood effect of health behaviour is usually smaller, often an order of magnitude smaller, than the individual effect or coefficient (in individual regression or in multilevel regression). The threshold for effect magnitude in a public health setting is can be lower than that in a clinical setting. An intervention bringing two percent decrease in the average population body mass index is already considered important though an order of magnitude effect is perhaps needed for a clinically obese individual. This lower threshold for population or higher sensitivity is accepted because one bears in mind that the ultimate effect is for the whole population and not confined to a single individual.

In parallel to theoretically recognising the importance of social interaction, it is practicaly acknowledged that built (physical) and social features of neighbourhood can induce

[6] In this connection, none other than Brock and Durlauf (2001*b*, p. 166ff) would welcome such empirical studies. "... this hardly means that these literatures [under-theorised empirical studies in the sense below] are incapable of providing useful insights. In this respect, we find arguments to the effect that because an empirical relationship has been established without justification for auxilary assumptions such as linearity, exogeneity of certain variables, etc., one can ignore it, to be far overstated. In our view, empirical work establishes greater or lesser degrees of plausibility for different claims about the world and therefore the value of any study should not be reduced to a dichotomy between full acceptance or total rejection of its conclusions. Hence the determination of the plausibility of any exclusion restriction is a matter of degree and dependent on its specific context."

benefits as well as pose risks of health (Shobha Srinivasan, Liam R. O'Fallon and Allen Drearry 2003). In sum, the recursive system (equations 4 & 5) incorporating insights from social interaction (equation 10) is modified by including neighbourhood effects. These include effects such as neighbourhood social capital and neighbourhood deprivation (to capture lack of leisure space for social interactions), Z, in both health production function and maintenance demand. The former is estimated below as a reduced form using instrumental variable estimation.

The extended model can also be presented as in Figure 1 where it is depicted that processes determining health are not circumscribed entirely within the individual but are also affected by neighbourhood social capital and deprivation. By implication, although this extended model is conceived to explain health related quality of life, its application is broad and encompasses other health outcomes such as obesity and mental health. The demonstration below shows promising ways of examining multiple pathways of how individual and neighbourhood factors bring about healthy outcomes.

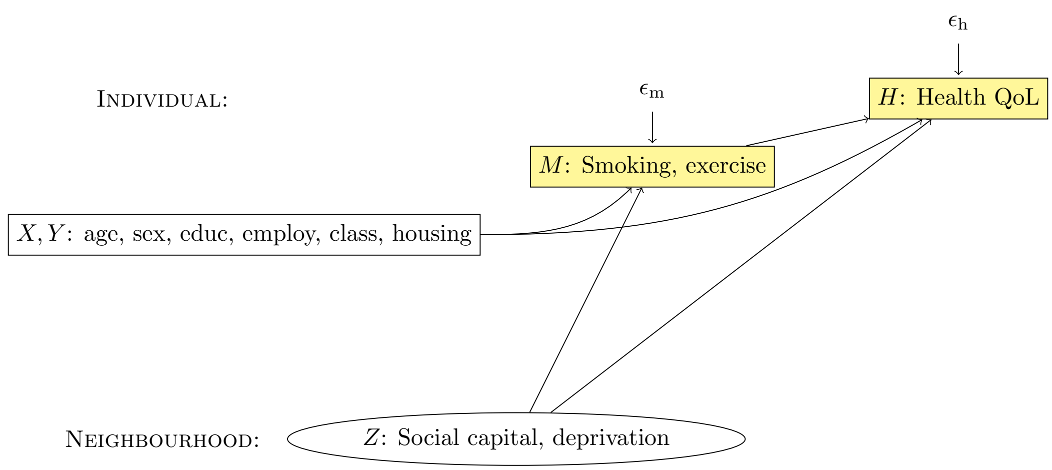

Figure 1. Health maintenance (M) and production (H) in their individual and neighbourhood contexts.

B. Instruments for estimation of neighbourhood effect

The moderate social influence condition is not a constructive condition though; it does not show how to estimate the effect of individual and neighbourhood factors. In the absence of randomised experiment moving residents from one neighbourhood to another, instrumental variable estimation is deemed second best. Instruments, v, must satisfy both exclusion restriction, $\mathrm{E}(v, \epsilon) = 0$, and relevance condition, $\mathrm{E}(v, Z) \gg 0$. It is well known that the exclusion restriction is essentially untestable due to unobserved ϵ hence strong theory like the extended Grossman model is needed; whereas the strength of the correlation is routinely judged using a rule of thumb of F statistics greater than ten

(Joshua D. Angrist and Jörn-Steffen Pischke 2009, A. Colin Cameron and Pravin K. Trivedi 2005).

Neither the original Grossman model nor the proposed extension has any role for neighbourhood ethnic diversity, hence $E(\text{diversity}, \epsilon) = 0$. Ethnic diversity as an instrument thus satisfies the exclusion restriction. Furthermore, Robert D. Putnam (2007) demonstrates that ethnic diversity can erode social capital. This motivates the instrument's relevance. Such test of relevance will be provided below. Lastly, the length of residence proxies attachment to the neighbourhood. Hence the felt erosion intensifies with length of residence. Phrased differently, transient resident may not be affected one way or another by changes in neighbourhood ethnic diversity or social capital; long-time residents are. In summary, neighbourhood ethnic diversity and average length of residence are the instruments.

III. Data

The Welsh Assembly Government generously provided two independent surveys: *Welsh Health Survey 2007* (WHS) and *the Living in Wales 2007* survey. The WHS selected a random sample of postcode sectors from the Post Office's Postcode Address File. The sample was stratified by the 22 unitary authorities where 30 addresses were selected in each of them. Measurements of height and weight were requested for adults and all selected children aged between 2 and 15 years old. Written consent, in English or Welsh, to these measurements was obtained in advance. Interviewers, who speak English or Welsh, carried out the interviews and measurements according to a standardised written protocol. Adults response to the survey is 82.1 percent. More details are available in the technical report (Elizabeth Fuller and Frances Heeks 2008).

The neighbourhood here is defined as the local super output area, a geographical unit purposefully designed for social research and comprises an area of about 500 households (Policy Action Team 18 2000, The Office for National Statistics and the Office of the Deputy Prime Minister 2004, The Office for National Statistics and the Office of the Deputy Prime Minister 2005). Such definition of an area compares favourably with other studies using wider definition of neighbourhood.

I select neighbourhood and individual variables to conform to the extended Grossman model. The neighbourhood deprivation measure is the official index of multiple deprivations for Wales 2005 which captures lack of access to various facilities. Neighbourhood social capital measures capture the 'bonding' and 'network' social capital available in the neighbourhood. The Living in Wales survey collected information on trust, sense of community and friendliness of neighbours. These information are averaged for each neighbourhood to provide the neighbourhood social capital measures. The social capital questions follow.

- Would you say that you trust 'most of the people in the neighbourhood', 'many', 'a few', or 'do not trust people in the neighbourhood'.
- What do you like most about living in this neighbourhood? What else? Options include 'Friendly people or neighbours', 'Sense of community', 'I feel like I belong to this neighbourhood', 'If I needed advice I could go to someone in my neighbourhood', 'I exchange favours with my neighbours', 'I would be willing to work together with others to improve my neighbourhood'.

The instrument of ethnic diversity is constructed using the Herfindahl indext scaled to range between 0 and 1 as is common in the literature on ethnic diversity and social capital (Putnam 2007, Natalia Letki 2008). The average length of residency is constructed from the Living in Wales survey accordingly.

Linking the Welsh Health Survey and Living in Wales Survey

The WHS is augmented with neighbourhood social capital information from the LiW using the unique local super output area (neighbourhood) assigned to each WHS respondent. A total of 1152 local super output area were matched where 13917 respondents reside. In the result, there reside around 19 residents per neighbourhood with a minimum of 1 and a maximum of 56. Some of these respondents did not provide sociodemographic information required by the model, hence they are removed. The final file comprise of 13557 respondents with information on health, sex, social class, education, and employment, plus neighbourhood information such as social capital and deprivation.

IV. Results

Basic description about the sample, given in Table 1, shows that it is gender balanced though tend to be older (range 16 to 75). Trust is quite abundant since residents tend to trust many around them, about one in five mentioned the sense community and more than two in five mentioned friendly neighbours or place as things they like most about their area of residence. Neighbourhood deprivations tend to be on the high 70s (range: 0 to 100).

Table 1—Basic description of the sample

Variable	Mean/mode*
SF36 physical summary	48.0
Women	54%
Age (5 yr group)*	55-59,75+
Employed	47%
Unemployed	1.4%
Professional	35%
Intermediate	19%
Tenure own	78%
Tenure private	7.4%
Degree educated	15%
Neighbourhood deprivation: IMD 2005	20.88

The results of instrumental variable estimator is given in Table 2. I elaborate on the neighbourhood deprivation and social capital effects first. Over and above individual determinants and behaviours, neighbourhood effects matter sizably and significantly. Neighbourhood deprivation harms physical health quality of life. However, various aspects of neighbourhood social capital more than compensate for this deleterious effect. Living in a trusting neighbourhood (compared to living in less trusting neighbourhood) independent of whether the resident is trusting of other people, increases the resident's physical health quality of life by nearly one standard deviation. Recall that SF 36 is constructed to have mean of 50 and standard deviation of ten. Next in gainful benefit is sense of community where it gives nearly half standard deviation effect. The significance of 9 percent is not worrying given the overall significance of other aspects of social capital. Living in a friendly place or around friendly neighbours, a sense of belonging to the neighbourhood, neighbours exchanging advice or information or goods readily, and a sense of belief in working together, each of these improves health quality of life. Only one aspect fails to reach significance. Given the predominantly null findings in the literature(Duncan, Jones and Moon 1993, Sloggett and Joshi 1998, Mohan et al. 2005, Propper et al. 2005, Stafford et al. 2008), I am not unduly worried about this exception. The overall pattern of significant effects of different forms of social capital is encouraging.

Tests of instruments' strength and relevance (F and χ^2) confirm the usefulness of the instruments in identifying the effects of social capital. In this context, one should not read too much into the substance of the instruments' relationships with social capital (i.e. as captured in the implicit 'first stage' regression). There is nothing inevitable nor immutable about the relationship between ethnic diversity and residence length on the one hand and social capital on the other. For contrasting views about this, see Putnam (2007) and Letki (2008).

Individual effects

Men claim to be healthier; age does take a toll (perhaps a curvilinear effect should be allowed for). Health inequality in occupational status is apparent here: the manual workers (compared to the professional and intermediate workers) tend to be less healthier. Other measure of socioeconomic status, education, exerts strong and significant influence on health quality of life.

A measure of wealth, housing tenure, has the second strongest and significant influence on health. Residents who own their houses or flats have their health quality of life improved by a third of the standard deviation of SF36. This is unsurprising given wealth is well known to improve health since it allows access to healthy foods and active leisure among others.

V. Discussion and conclusion

Unlike some of the recent studies on neighbourhood social capital and health in developed countries such as Sweden, New Zealand and England, this study presents a visible contrast (Blakely et al. 2006, Islam et al. 2006, Duncan, Jones and Moon 1993, Sloggett and Joshi 1998, Mohan et al. 2005, Propper et al. 2005, Stafford et al. 2008). Neighbourhood social capital is beneficial to individual health directly.

An extended theoretical model allows causal effects of neighbourhood social capital to be estimated. It achieves this by motivating strong instruments which help to recover the effect of neighbourhood social capital on individual health related quality of life. Various aspects of neighbourhood social capital, including social cohesion aspects (trust, sense of community) and network aspects (friendly neighbours), are effective in improving individual health. Any of these social capital is shown to more than compensate the deleterious effect of overall neighbourhood deprivation. These causal effects help to point out entries for public health interventions in the neighbourhood as well as the individual. For instance, interventions to make neighbourhood spaces more friendly for interaction can prove to be beneficial to health quality of life.

Given that the effect of neighbourhood social capital on individual health is elusive in other industrial countries, why is it different with Wales? It might be tempting to explain this result in the commonly accepted argument of egalitarian society (Islam et al. 2006). In highly unequal society, neighbourhood social capital tends to be effective to fill in the vacuum of needed health services that are not provided by the state or other organisations. Yet this is not the case with Wales since the UK National Health Service provides such services.

The extended Grossman health production function combined with independent neighbourhood social capital measures may have uncovered the elusive effect of neighbourhood social capital. Previous studies may not have benefited from recent methodological development nor have the fortune of access to independent data. Mohan et al. (2005) for instance desired for the latter to address their null finding on the effect of social capital. The extended multiprocess model is applicable in settings other than health quality of life and it is now easier to trace the mechanisms how neighbourhood social capital improves individual health.

This empirical study is far from a definite statement about how social interactions, social capital, and health are inter-related. It rather seeks to provide useful concepts and demonstrate their efficacies in empirical setting. Notwithstanding its many shortcomings, including certain challenging problems of dynamics and neighbourhood selection,[7] it is my belief that further progress can be made after demonstrating fruitful avenues of exploration. Given these challenges, and the undeniable importance of social interactions, social capital, and health,[8] this paper should be taken as an initial and promising foray. Its conclusions must be revised or confirmed with further evidence (at different time, place, and outcome).

The last words should probably go to Geoffrey Rose. Despite the difficulties, anticipated by prominent economists[9], facing researchers setting out to examine the effects of social interactions and social capital on individual health, one should not be disheartened. Ultimately, as Rose (1992, p. 161) insisted, "The primary determinants of disease are mainly economic and social, and therefore its remedies must also be economic and social. Medicine and politics cannot and should not be kept apart."

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[7]Following the theoretical papers cited above including Brock and Durlauf (2001*a*, p. 254), I set aside the issue of neighbourhood selection for future work. This is likely to need longitudinal data on both neighborhood and residents to do justice to its complexity.

[8]Robert E. Lane (2000) goes so far as recommending companionship or social interaction as a virtue given the apparent paradox of stagnating happiness on the face of increasing affluence in Western societies.

[9]Some samples follow. Partha Dasgupta (2000, p. 4) notes, 'the idea of social capital sits awkwardly in contemporary economic thinking. Even though it has a powerful, intuitive appeal, it has proven hard to track as an economic good . . . it is fiendishly difficult to measure . . . because we don't quite know what we should be measuring.' Kenneth J. Arrow (2000, p. 4) warns, 'I would urge abandonment of the metaphor of capital and the term social capital.' And Robert M. Solow (2000, pp 6,9) chooses 'to be critical of the concept of social capital and the way it is used . . . [however] there is something to look for that is at least capable of being found.'

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Table 2—Neighbourhood social capital effect and individual health (SF36)

	β p	β p	β p	β p	β p	β p	β p
Neighbourhood							
Deprivation	-0.103	-0.063	-0.057	-0.076	-0.077	-0.084	-0.075
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Trust	2.386						
	0.003						
Friendly place		9.167					
		0.011					
Sense of community			4.330				
			0.089				
Belong to nhood				2.086			
				0.001			
Nhood advice					2.138		
					0.005		
Nhood exchange						2.951	
						0.047	
Nhood work							2.899
							0.040
Individual							
She	-0.864	-0.830	-0.863	-0.859	-0.840	-0.846	-0.845
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Age	-1.650	-1.663	-1.664	-1.656	-1.654	-1.662	-1.670
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Professional	1.712	1.551	1.655	1.681	1.623	1.706	1.719
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate	1.202	1.074	1.200	1.144	1.119	1.242	1.205
	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Own house	3.697	3.523	3.618	3.755	3.617	3.626	3.679
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private renter	1.561	1.203	1.863	1.649	1.333	1.371	1.704
	0.004	0.041	0.000	0.002	0.017	0.022	0.001
Degree educated	1.959	1.986	2.097	1.952	1.964	2.025	2.047
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	63.823	62.229	58.703	60.578	59.991	59.173	61.648
Kleibergen-Paap LM	25.773	10.969	20.131	60.146	22.224	8.384	9.989
p	0.000	0.004	0.000	0.000	0.000	0.015	0.007
Kleibergen-Paap F	13.208	5.655	10.647	34.891	10.086	3.667	4.292
Hansen J	0.363	0.877	4.831	0.070	1.938	2.185	6.489
χ^2 p value	0.547	0.349	0.028	0.791	0.163	0.139	0.011