Social capital and health: preliminary work on a system dynamics 'concept model'

John Cody[a], Robert Y Cavana[b] & David Pearson[c]

[a]Social Worker, PO Box 50-302, Porirua, New Zealand
jrcody@xtra.co.nz

[b]Reader, Victoria Management School, University of Wellington,
PO Box 600, Wellington, New Zealand.
Ph: +64-4-4635137; Fax: +64-4-4635253; Email: bob.cavana@vuw.ac.nz

[c]Reader, Humanities and Social Sciences, School of Social and Cultural Studies,
Victoria University of Wellington, PO Box 600, Wellington, New Zealand
Email: david.pearson@vuw.ac.nz

Prepared for the
25th International Conference of the System Dynamics Society
Boston, USA, 29 July – 2 August, 2007

Abstract

Health disparity is a current public policy issue. This creates possibilities for public discussion of dynamics that stratify population health status. A short review of current discussion in public health and sociology is used to create a conceptual framework that might account for some factors causing disparity, namely dominance, disorder and isolation. The framework provides the basis for a system dynamics 'concept model'. Work in progress on the model is outlined. The usefulness of the model will be explored in discussion about the extent to which local civic action can address health disparities.

Keywords: system dynamics, sociology, social stratification, public health, health disparities, deliberative democracy, New Zealand, Runciman.

Introduction

This discussion presents work in progress identifying concepts from sociology and system dynamics that might help structure public discussions about health disparities. The aim of the project is to create a generic framework that can capture the essential features of each case and also allows consistent comparisons among settings and populations.

The concept of social capital is current in discussions of population health status. High social capital has been associated with good population health and strategies to reduce health disparities. Others criticise references to social capital because the concept is poorly defined, it shifts attention from public health policies to community and household activities, and it implicitly assumes capitalist economics and rational action theory. The discussion has been summarised by Blaxter (2004:117-121)

Both arguments seem to have merit. Citizens can assess the relative merits if we can discuss and share our understandings of the features of social structure that affect health. This type of discussion is problematic for many reasons including differences of language, experience, commitments and power. This paper does not review these wider aspects. It has the limited objective of exploring the use of system dynamics (SD) in deliberative discussions.

The sections that follow: briefly describe a context for the issue; propose a general cause of health disparity (Wilkinson, 2000; Wilkinson, 2005); summarise some social theory that seems relevant ((Runciman, 1989; Coleman, 1990; Runciman, 1999); reviews relevant work by SD modellers; and speculates about the application of this material.

Local setting

Approximately 50,000 people live in Porirua City and 62,000 in the immediate catchment of local health services. By New Zealand (NZ) standards the city is geographically divided between high and low deprivation neighbourhoods and has a relatively high proportion of the population in the most deprived deciles (see Figure 1) (Crampton et al., 2004:112).

Figure 1
Population structure of Porirua City and the Wellington Metropolitan Area

The implications of these indicators for relative health and health services have been documented over the last three decades (Salmond, 1975; Reinken et al., 1980; Gould, 1992; Central Regional Health Authority, 1994; National Research Bureau Ltd, 1994; Porirua City Council, 1999; Porirua Kapiti Healthlinks Project, 2000).

Each study has confirmed that access to resources and health status are strongly and inversely related.

Recently 'health disparity' has been defined as a national public issue. Conceptually discussion of health disparities in NZ follows a similar course to that in the United Kingdom, the United States, the World Health Organisation, and the European Union. The distinctive difference is that Maori (the indigenous people of NZ) and Pacific people (migrants from Pacific nations and their descendants) are the main ethnic populations identified as adversely affected by disparity. Recent legislation, policy frameworks and substantial research programmes have shaped the responses. For example the NZ Public Health and Disability Act 2000 s.22(f) directs District Health Boards 'to reduce, with a view to eliminating, health outcome disparities between various population groups within New Zealand by developing and implementing, in consultation with the groups concerned, services and programmes designed to raise their health outcomes to those of other New Zealanders.' This illustrates two features of current policy: ambitious objectives and localised responses – localised both geographically and within the health sector (Director-General of Health, 1997b; 1997a; Ministry of Health, 2002).

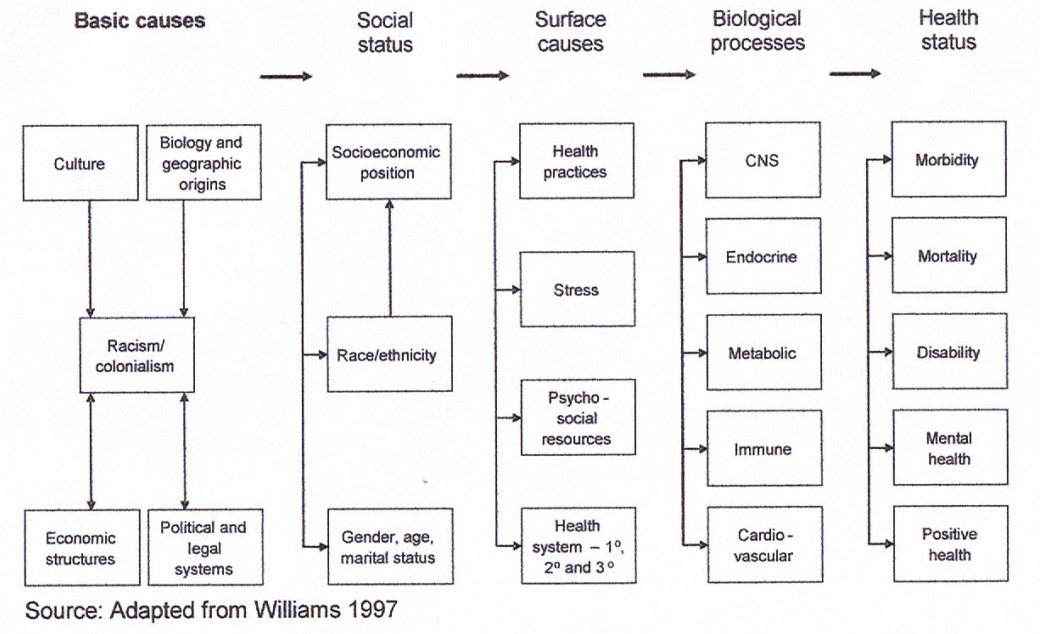
This approach has produced a series of initiatives to improve access to community health services in high deprivation areas, particularly reorganisation of primary health services and development of an integrated continuum of care and public health programmes. Local participation in health issues has been reviewed. The Porirua City Council included improved health status among its strategic goals; previously health was regarded as the responsibility of central government only. There was local mobilisation to retain and improve local health services, particular re-thinking the role of the community hospital as a hub for integrated care. 'Clustering' has been promoted to create local capacity across the public health spectrum and offset the limiting effects of competitive tendering with government agencies and tightly defined programme delivery. This was intended to introduce 'common cause' into the activities of health professionals and interested members of communities and thereby create additional social capital (Williams, 1997b) and perhaps seed changes in civic culture (Putnam, 1993; Pearson, 2004:308-310).

The approach has evolved into a proposal to create a Centre of Excellence (Blakeley, 2006) with a major goal 'to eliminate disparities in health status'. This is a substantial attempt to create the local infrastructure required to address this issue and sharpens questions about feasible strategies and system design. To this point communities adversely affected by disparity have not engaged with the process. The most recent report on the topic concludes current processes are 'too hard'. Energy is reduced by 'mistrust and tension', 'views that have gone unchallenged', 'communities passive in seeking advice', and the 'relentless' action of large organisations (Smith, 2006). Emphasising 'disparities' is probably not going to address those points. The comparisons and indicators implicit in the term are often rejected by those affected directly. A similar response seems to occur when the issue is named as 'inequality' (Blaxter, 1997). There is also a question of scope; for example to what extent will housing, income and employment be included in the agenda of the Centre? Are those factors to be regarded as indicators or causes?

Health disparities

Wilkinson and Marmot provide a considered explanation of health disparities that reaches similar conclusions to lay 'common sense' about causes of poor health ((Cody, 1999:57; Milstein, 2005:17 quoting JM Mann 1999). They argue that the social gradient in health (at least in 'developed economies') is due to the distribution of stress created by hierarchies of dominance, social isolation and disorder. The processes that translate social relations into physical effects are probably associated with fight-flight responses. This capacity evolved when the response required was intense, short-lived, and essential for survival. Social conditions have changed over the last 15,000 years and this type of stress has become chronic, particularly for those lower in hierarchies. The effect is, in a sense, physical 'wear and tear' and is reflected in different rates of mortality and chronic disease among stratified populations. Peer relations can offset the impact of dominance to some extent. The framework adopted in the NZ study 'Decades of Disparity' (Williams, 1997a; Fawcett et al., 2006:3) seems to adopt a similar line of argument (see Figure 2).

Figure 2
Health inequalities framework in 'Decades of Disparity'



Source: Adapted from Williams 1997

Both Wilkinson and Marmot reflect on the implications of their position. Their views are repeated here, partly because they are informed commentators and partly because they are common responses from commentators seeking to reduce inequality. In an early overview Wilkinson asserted that:

"If it is possible for some people to have death rates as low as those in upper social classes, then it should be possible to achieve equally low death rates in all groups" (Wilkinson, 1996:59)

Some years later Marmot takes a different position:

"All societies will have social rankings; ergo all societies will have health gradients. . . . I ask myself if I can envisage a society where all are equal. My answer is not in real life. Hence, health gradients are inevitable." (Marmot, 2004:25)

Then Marmot seems to shift his position. Firstly he qualifies his comments by introducing a delay:

"There is no reason why the health of today's lowest social group should not, tomorrow, be as good as the health of today's highest group." (Marmot, 2004:255)

Finally he concludes:

"There will always be inequalities in society but the magnitude of their effects on health is within our control." (Marmot, 2004:266)

Can sociology help structure a response to questions about the inevitability or necessity of inequalities in health?

Social theory

Dominance, isolation and disorder were identified as the main factors creating inequalities in health status among sub-populations of a society. For these purposes physical stress is taken to be a direct consequence of relatively high effort and risk.

Coleman makes some precise comments about how social capital can be introduced into this discussion. In his use of the concept:

"The power of an actor at equilibrium . . . is a direct measure of the social capital available to the actor within that system" (Coleman, 1990:315)

And when discussing public policy decisions based on the criterion of efficiency he says:

'The calculation of economic efficiency can be carried out only after a particular distribution of power or resources is taken as given . . . all persons' benefits and costs are not counted equally.' (Coleman, 1990:799)

So social capital is essentially a measure of power and when 'efficiency' is a primary criterion it is likely that those with less power will be required to commit proportionally more effort or resources than those with greater power. Lin outlines some applications of the concept. His contribution provides the basis for distinguishing between 'lateral' relations based on trust or a freely given mandate to exercise authority, and 'vertical' relations when there are structural differences in power (Lin, 2001:Chap 10).

Coleman described the value of the concept of social capital in these terms:

"Whether social capital will come to be as useful a quantitative concept in social science as are the concepts of financial capital, physical capital, and human capital remains to be seen; its current value lies primarily in its usefulness for qualitative analyses of social systems and for those quantitative analyses that employ qualitative indicators." (Coleman, 1990:305-6)

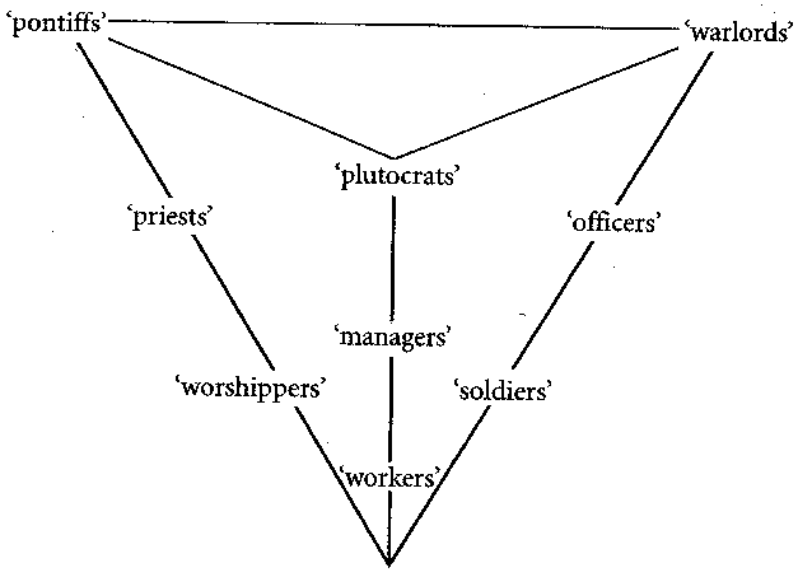
That describes what is being attempted here.

Coleman concluded that he had exhausted the potential of linear modelling of social interaction. He anticipated evolutionary modelling would address some of the limitations (Coleman, 1990:931). Turner subsequently indicated how the central element of Coleman's theory (the development of norms) related to his theory of societal evolution (Turner, 2003:15).

Runciman seems to be the sociologist who uses evolutionary theory to frame the modelling issues most succinctly. He proposes a scheme based on two modes of interaction between institutionalised roles – dominance and co-operation. Unique social configurations emerge from combinations of selection pressures and random variations. The elementary structure of the system is depicted in Figure 3.

Figure 3

Runciman's 'device' for visualizing the social space created by power



Source: (Runciman, 1999:72)

The figure represents the three dimensions of power – economic, ideological and coercive – defined in terms of institutionalised roles (Runciman, 1999:71). (Runciman cites Lenski (1966), see also (Lenski, 2005).) The depth of the diagram indicates the extent of inequality in the system; roles at the same level can interact laterally. This scheme seems to be generally applicable.

Sympathetic commentators have noted two problems with Runciman's approach. Anderson (1992:218-224) is not convinced that Runciman has adequately defined and applied the concept of 'selection pressure'. That problem is also a feature of the approach outlined here. (See Beinhocker (2006) for more specific comment on this process in the commercial sector.)

Carling (2004) points to problems with conflating the orientation of role holders and the nature of the relation. Taking Carling's point, Runciman's scheme has been amended here so that his 'interaction' is interpreted as the 'orientation' of a role. That implies there are four aspects to social capital: cooperation (two co-operators); conflict (two dominators); dominance (a dominator and a co-operator); and an absence of any relation. This is similar to many other schemes, for example the 'boundary relations' identified by Tilly (1998) as the basis of durable inequality, and the cycles of asibya, conflict and imperial dominance that Turchin (2006) identified in the historical dynamics of empires. The framework might provide a basis for sketching a concept model.

System dynamics modelling

Sociologists seem to have made relatively little use of system dynamics models and the weight of opinion favours agent-based modelling (Halpin, 1999; Macy and Willer, 2002; Sawyer, 2003; Cederman, 2005; Gilbert and Abbott, 2005; Gilbert and

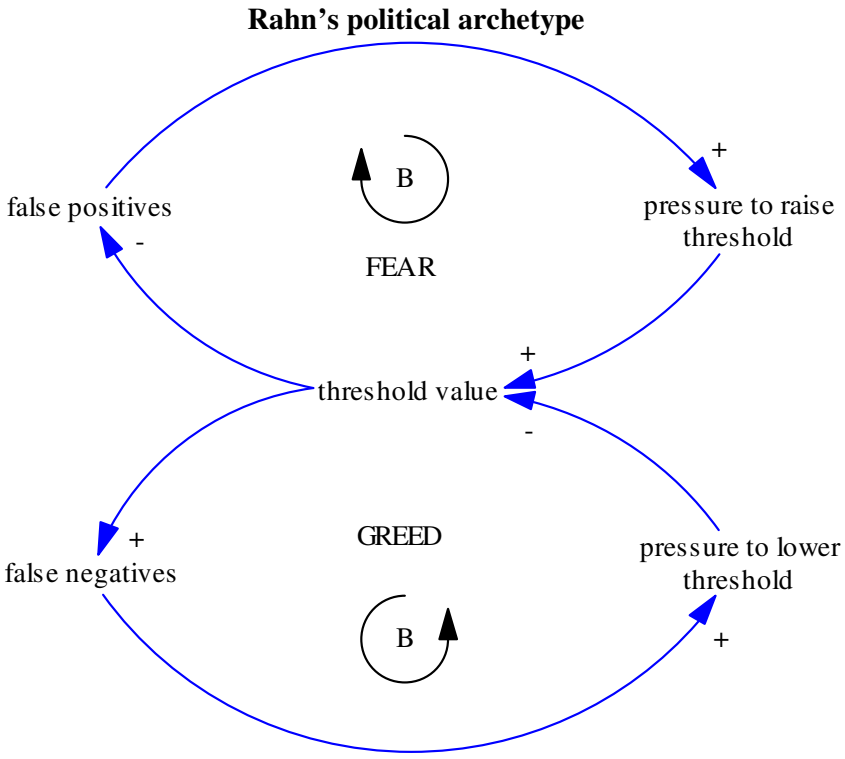
Troitzsch, 2005). The main SD models reviewed for this project are an early model by Phillips (1972) with Senge, a substantial body of work by Hanneman and colleagues (Hanneman and Collins, 1987; Hanneman, 1988; Jacobsen and Hanneman, 1992; Hanneman, 1995; Hanneman et al., 1995; Collins and Hanneman, 1998), and other work by Jacobsen (1987; 1990; 1995; 1999a; 1999b). The SD literature contains one extended argument suggesting that SD modellers make greater use of social theory, Giddens in particular (Lane, 2001a; 2001b).

There is a great deal of implicit social theory in SD models developed to address topics related to public policy, economics and environmental impacts. While this makes models practical and useful to specific users it may constrain the range of options that can be envisaged.

Two sets of SD models are directly relevant to this project. Firstly, the cumulative discussion of health service organisation and health outcomes (Koelling and Schwandt, 2005) that has recently addressed political dimensions of system change (e.g. Hirsch, 2006; McDonnell et al., 2006). The models are designed for 'decision makers' who are familiar with the sector. For these purposes the models are important because they introduce political factors and have a generic core that can be used with the module outlined below. The core is an 'ageing chain' depicting relative health in a population as flows through levels of those in good health, at risk, afflicted, and afflicted with complications (Homer et al., 2004; Rees, 2005; Homer et al., 2006; McLeroy et al., 2006). The single published SD model that addresses the dynamics of social capital, defined as trust, supplements this set (Dudley, 2004).

Secondly, there are the 'small' and 'concept models' provided by Richardson (Richardson, 2006). Rahn (2005) has drawn on other aspects of Richardson's work (Weaver and Richardson, 2006) to propose an SD representation of a political archetype. The archetype (see Figure 4) consists of two balancing loops oscillating around a threshold. The loops represent constituencies that seek to either lower or raise the value of the threshold.

Figure 4



Source: (Rahn, 2005:6)

This research is seeking to establish whether this dynamic can be applied to social structure more generally. If it can it would emulate a form of theorising advocated by sociologists such as Fararo (1989:72), Mackenzie (2005:57) and Faia (1986; 2002). It also offers the possibility of reducing the complexity of numerous causal loops and intervening variables that can stifle users' responses (Woog et al., 2006).

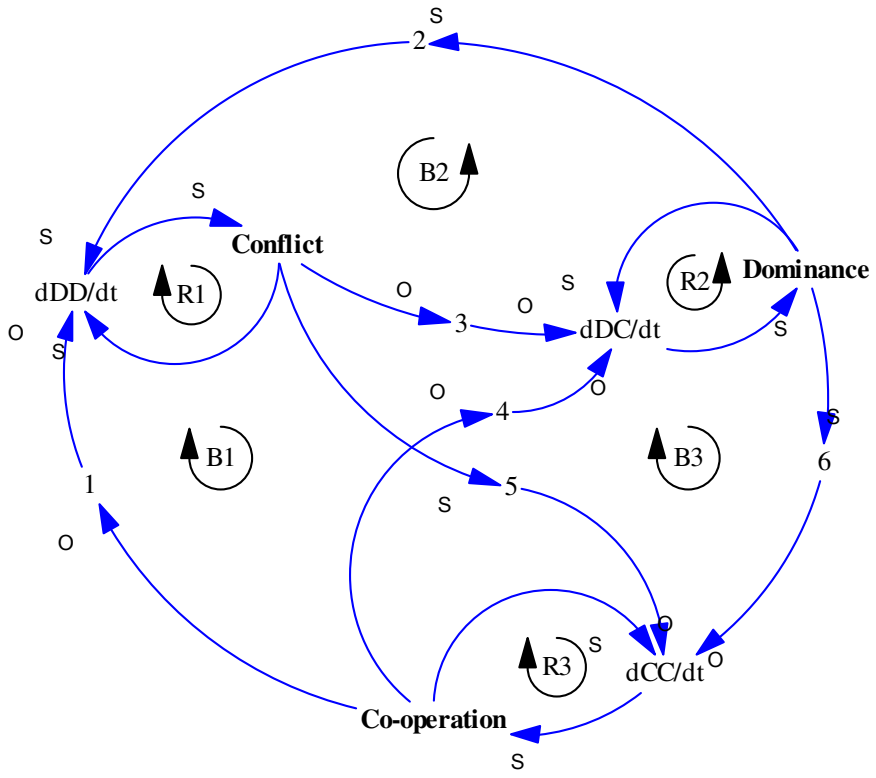
An unanswered question at this stage is whether making greater use of the tacit knowledge of participants can offset the loss of detail. The working assumption is that people who are active in their communities develop common sense knowledge that is well grounded. Ford and Sterman (1998) provide a way to introduce this type of knowledge into SD models through structured development of non-linear functions as Lookup Tables. In principle this seems similar to Turner's 'quasi-mathematics' (Turner, 1984:19-28; 2004). The wider issue of how tacit knowledge can be elicited from diverse participants and then organised (Maani and Cavana, 2000; Woog et al., 2006) is not included in this discussion.

Application

Can this selection of concepts be drawn together to structure a response to the issues raised by Wilkinson and Marmot?

The following Causal Loop Diagram (CLD) (in Figure 5) takes the Rahn archetype and extends it to include three sources of pressure all created endogenously by the social structure. If this has merit the model could be progressively developed by refining endogenous and exogenous 'selection pressures', bearing in mind Wolstenholme's (2003) distinction between problem and solution archetypes.

Figure 5
The basic Causal Loop Diagram for the proposed model



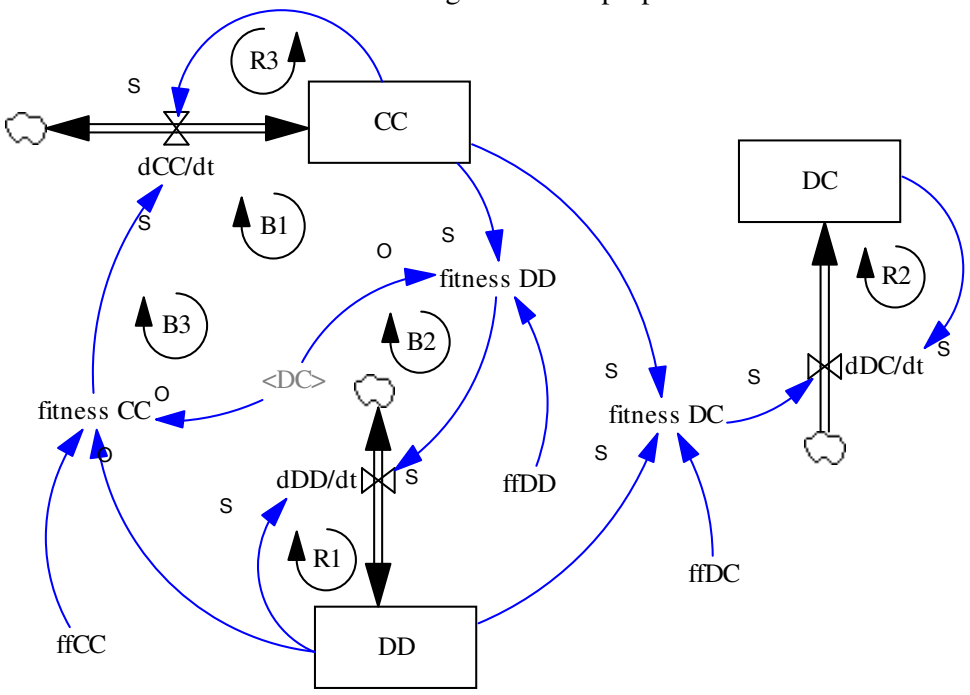
The numbers denote different sources of pressure.

The assertion that significant selection pressures are inherent in social structures is a working hypothesis. It has not been adequately argued at this point but relates to three observations. Firstly, in situations when absolute health improves significantly disparities are relatively stable. Secondly, activity to address disparity tends to ebb and flow rather than maintain a continuous trend. Thirdly, advocacy, policy changes and service improvements often generate benefits in a way that confirms existing relations, particularly hierarchies. If Wilkinson and Marmot are correct service development of that kind will maintain disparities.

The stock-flow representation of the CLD is provided in Figure 6.

Figure 6

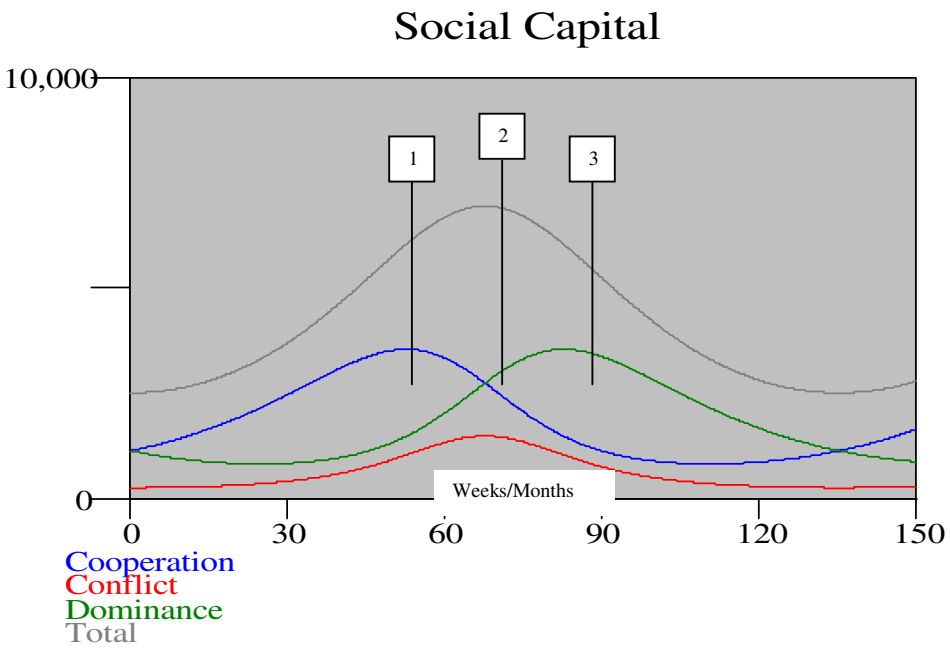
The Stock-Flow Diagram for the proposed model

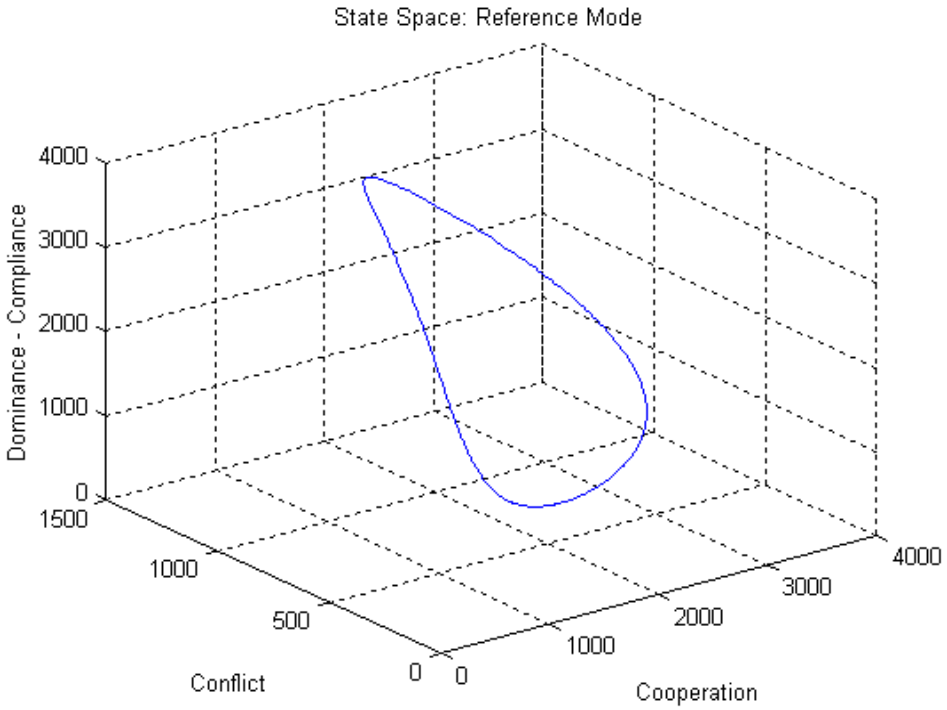


The abbreviations used to name variables indicate the combination of orientations: CC – cooperation, DD – conflict, and DC – dominance-compliance.

An indicative reference mode for the model is in Figure 7. The illustration is exaggerated for effect and produced using linear functions however it has features of the base case.

Figure 7
Reference mode - behaviour over time and state-space graphs





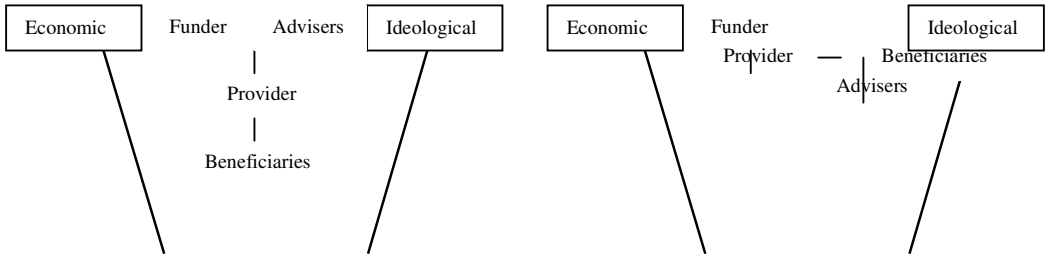
In this example the maximum number of interactions in the system is about 10,000 per iteration. Each iteration is of the same duration in the order of a week or month. Initial levels of interaction are a quarter of the maximum with equal levels of cooperation and dominance. A strong assumption is that the system is sensitive to conflict, which is actively managed. Cooperation increases when conflict is low. Increasing cooperation increases conflict [1]. Dominance rises to contain conflict [2]

and depresses the level of cooperation so total interaction falls [3]. The system oscillates.

An initial scenario could be based on a 'cluster' option that aims to maintain higher levels of interaction with less dominance while conflict is contained (see 'Local Setting' above). One aspect of the general approach is increased participation of community members in the governance of community organisations and primary health providers. In the terms used by Tew (2006:41) a move from 'power over' to 'power together' and leaving open Tew's second question about whether the dynamic becomes productive or constraining.

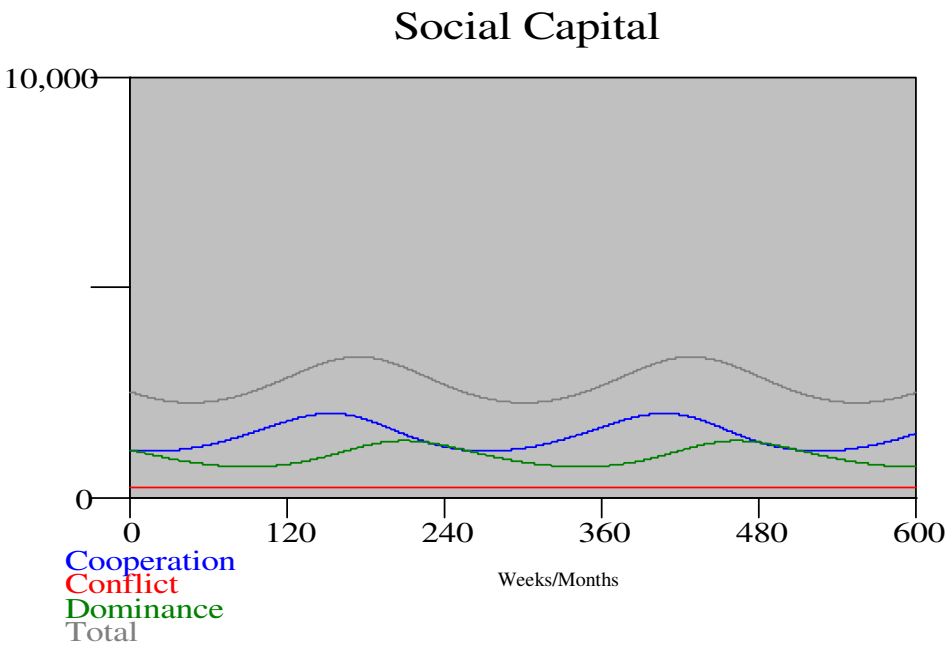
Using Runciman's scheme this implies redrawing a segment of the 'map' of institutionalised roles as shown in Figure 8. The figure is simplified and, at this point, the dimension of coercion is left in the background.

Figure 8
A small example of restructured roles illustrated using Runciman's 'device'



A change of this nature may be plausible if participants are willing to make a substantial investment in information sharing, networking and shared projects. In modelling terms this implies a reduction in the effective range of selection pressures, a small decrease in the gradient of dominance, an increase in the gradient of cooperation and maintenance of conflict at the background level. This produces the behaviour over time graph in Figure 9.

Figure 9
A 'cluster' scenario – behaviour over time



On the basis of this representation of the implications those involved might turn their attention to the way the strategy appears to affect total participation and evaluate the level shown either positively or negatively.

Concluding comments

This discussion has outlined the exploratory phase of a project that aims to use System dynamics modelling to represent the composition of social capital. The next phase is to develop a systematic rationale for the shape of fitness functions and, in the process, critique the position outlined above. Many issues have yet to be addressed such as concepts of causality, the varied and changing meaning of variables, and logical implications of using a 'genetic' template for the model (Hannon and Ruth, 1997:99-108).

The initial motivation for the study was to develop a structured approach that could be used during public discussions about population-level health disparities. Typically statements have been recorded on paper and written up for reference after the meeting. This restricts consideration of the implications and seems to lead to a premature sense of consensus or, alternatively, argument on poorly defined issues and options. System dynamics modelling might contribute to more deliberative public discussion.

References

Anderson, P. (1992). *English Questions* London, Verso. ISBN 0 86091 591 3.

Beinhocker, E. D. (2006). *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics* Boston, Harvard Business School Press. ISBN 1-57851-777-X.

Blakeley, R. (2006) *Centre of Excellence of Health for Porirua Basin: Strategic Framework* Porirua

Blaxter, M. (1997). "Whose Fault Is It? People's own conceptions of the reasons for health inequality." *Social Science and Medicine* 44(6): 747-56.

Blaxter, M. (2004). *Health* Cambridge, Polity Press. ISBN 0-7456-3082-0.

Carling, A. (2004). "The Darwinian Weberian: W.G. Runciman and the Micofoundations of Historial Materialism." *Historical Materialism* 12(1): 71-95.

Cederman, L.-E. (2005). "Computational Models of Social Forms: Advancing Generative Process Theory." *American Journal of Sociology* 110(4): 864-93.

Central Regional Health Authority (1994) *Strong Links: Building better services to meet the health and disability support needs of people in Porirua* Wellington

Cody, J. R. (1999). Social Capital and Health: Community Health Activity in Porirua. Social Capital in Action. D. J. Robinson, Ed. Wellington, Institute of Policy Studies, Victoria University of Wellington.

Coleman, J. S. (1990). *Foundations of Social Theory* Cambridge, Mass., Belknap Press of Harvard University Press. ISBN 0-674-31226-0.

Collins, R. and R. Hanneman (1998). Modelling the Interaction Ritual Theory of Solidarity. The Problem of Solidarity: Theories and Models. P. Doreian and T. Fararo, Eds. Amsterdam, Gordon and Breach.

Crampton, P., C. Salmond and R. Kirkpatrick (2004). *Degrees of Deprivation in New Zealand: An atlas of socioeconomic difference* Auckland, David Bateman. ISBN 1-86953-540-5.

Director-General of Health (1997a). *Strengthening Public Health Action: The background paper* Wellington, Ministry of Health. ISBN 0-478-20818-9.

Director-General of Health (1997b). *Strengthening Public Health Action: The strategic direction to improve, promote and protect public health* Wellington, Ministry of Health. ISBN 0-478-20817-0.http//www.moh.govt.nz

Dudley, R. G. (2004). *The Dynamic Structure of Social Capital: How Interpersonal Connections Create Communitywide Benefits*. 22nd International Conference of the System Dynamics Society, Oxford, England. http://www.systemdynamics.org/conf2004/indexpapers.htm

Faia, M. A. (1986). *Dynamic functionalism: strategy and tactics* Cambridge, Cambridge University Press. ISBN 0 521 32657 5.

Faia, M. A. (2002). "Differential Equation Modeling as a Source of Theoretical Insight: Four Disparate Examples." *Quality and Quantity* 36: 169-95.

Fararo, T. J. (1989). *The meaning of general theoretical sociology: Tradition and formalization* Cambridge, Cambridge University Press. ISBN 0-521-27258-5.

Fawcett, J., T. Blakely, B. Robson, M. Tobias, R. Harris and N. PakiPaki (2006) *Decades of Disparity III: Ethnic and socioeconomic inequalities in mortality, New Zealand 1981–1999* Wellington http://www.moh.govt.nz

Ford, D. N. and J. D. Sterman (1998). "Expert knowledge elicitation to improve formal and mental models." *System Dynamics Review* 14(4): 309-40.

Gilbert, N. and A. Abbott (2005). "Introduction." *American Journal of Sociology* 110(4): 859-63.
Gilbert, N. and K. G. Troitzsch (2005). *Simulation for the Social Scientist* Maidenhead, Open University Press. ISBN 10 0 335 21600 5.
Gould, J. (1992) *Porirua City Council Health Report* Porirua
Halpin, B. (1999). "Simulation in Sociology." *The American Behavioural Scientist* 42(10): 1488-508.
Hanneman, R. and R. Collins (1987). A Dynamic Simulation of Marx's Model of Capitalism. The Marx-Weber Debate. N. Wiley, Ed. Newbury Park California, Sage.
Hanneman, R. A. (1988). *Computer-assisted Theory Building: modeling dynamic social systems* Newbury Park, Cal, Sage. ISBN
Hanneman, R. A. (1995). "Simulation Modeling and Theoretical Analysis in Sociology." *Sociological Perspectives* 38(4): 457-62.
Hanneman, R. A., R. Collins and G. Mordt (1995). "Discovering Theory Dynamics by Computer Simulation: Experiments on State Legitimacy and Imperialist Capitalism." *Sociological Methodology* 25: 1-46.
Hannon, B. and M. Ruth (1997). *Modeling Dynamic Biological Systems* New York, Springer-Verlag. ISBN 0-387-94850-3.
Hirsch, G. B. (2006). *Expanding Health Coverage and Access for the Uninsured: A Model of Common Factors in the Experience of Several States*. 24th International System Dynamics Conference, Nijmegen, The Netherlands, System Dynamics Society. http://www.albany.edu/cpr/sds/conf2006/proceed/index.htm
Homer, J., G. B. Hirsch, M. Minniti and M. Pierson (2004). "Models for collaboration: how system dynamics helped a community organize cost-effective care for chronic illness." *System Dynamics Review* 20(3): 199-222.
Homer, J., B. Milstein, W. Dietz, D. Buchner and E. Majestic (2006). *Obesity Population Dynamics: Exploring Historical Growth and Plausible Futures in the U.S.* 24th International System Dynamics Conference, Nijmegen, The Netherlands, System Dynamics Society. http://www.albany.edu/cpr/sds/conf2006/proceed/index.htm
Jacobsen, C. (1999a). "The Process of Crescive Legitimation: Theory, Simulation Model, and Three Empirical Tests." *Adaptive Behaviour* 7(3/4): 255-68.
Jacobsen, C. (1999b). Social Dynamics: Theory and Research. Technion
Jacobsen, C. and R. Bronson (1987). "Defining sociological concepts as variables for system dynamics modeling." *System Dynamics Review* 3(1): 1-7.
Jacobsen, C. and R. Bronson (1995). "Computer Simulations and Empirical Testing of Sociological Theory." *Sociological Methods and Research* 23(4): 479-506.
Jacobsen, C., R. Bronson and D. Vekstein (1990). "A Strategy for Testing the Empirical Adequacy of Macro-Sociological Theories." *Journal of Mathematical Sociology* 15(2): 137-48.
Jacobsen, C. and R. Hanneman (1992). "Illegal Drugs: Past, Present and Possible Futures." *The Journal of Drug Issues* 22(1): 105-20.
Koelling, P. and M. J. Schwandt (2005). *Health Systems: A Dynamic System-Benefits from System Dynamics*. 2005 Winter Simulation Conference.
Lane, D. C. (2001a). "Rerum cognoscere causas: Part I— How do the ideas of system dynamics relate to traditional social theories and the voluntarism/determinism debate?" *System Dynamics Review* 17(2): 97-118.

Lane, D. C. (2001b). "Rerum cognoscere causas: Part II— Opportunities generated by the agency/structure debate and suggestions for clarifying the social theoretic position of system dynamics." *System Dynamics Review* 17(4): 293-309.

Lenski, G. (2005). *Ecological-Evolutionary Theory: principles and applications* Boulder, Paradigm. ISBN 1-59451-100-4.

Lenski, G. E. (1966). *Power and Privilege: A Theory of Social Stratification* New York, McGraw-Hill Book Company. ISBN

Lin, N. (2001). *Social Capital: A Theory of Social Structure and Action.19*. Cambridge, England, Cambridge University Press. ISBN 0-521-47431-0.

Maani, K. E. and R. Y. Cavana (2000). *Systems Thinking and Modelling: Understanding Change and Complexity* Auckland, Prentice Hall. ISBN 1-877258-00-8.

Mackenzie, A. (2005). "The Problem of the Attractor: A Singular Generality between Sciences and Social Theory." *Theory, Culture and Society* 22(5): 45-65.

Macy, M. W. and R. Willer (2002). "From Factors to Actors: Computational Sociology and Agent-Based Modeling." *Annual Review of Sociology* 28: 143-66.

Marmot, M. (2004). *Status Syndrome: How Your Social Standing Directly Affects Your Health and Life Expectancy* London, Bloomsbury Publishing. ISBN 0 7475 7049 3.

McDonnell, G., J. Dewdney and S. Wilson (2006). *Exploring the Political and Economic Dynamics of Health Policy*. 24th International System Dynamics Conference, Nijmegen, The Netherlands, System Dynamics Society.

McLeroy, K., S. J. Leischow and B. Milstein, Eds. (2006). American Journal of Public Health. Special Issue on Systems Models and Systems Thinking. ISBN

Milstein, B. (2005). Selected Concepts in Health System Dynamics

Ministry of Health (2002) *Reducing Inequalities in Health* Wellington

National Research Bureau Ltd (1994) *Assessment of Health Needs in the Porirua Area* Porirua

Pearson, D. G. (2004). Rethinking Citizenship in Aotearoa/New Zealand. Tangata Tangata: The Changing Ethnic Contours of New Zealand. P. Spoonley, C. Macpherson and D. G. Pearson, Eds. Southbank, Victoria, Thomson.

Phillips, B. S. (1972). *Worlds of the Future: Exercises in the Sociological Imagination* Columbus, Charles E. Merrill Publishing Company. ISBN 0-675-09085-7.

Porirua City Council (1999) *A new hospital for the Wellington region at Kenepuru* Porirua

Porirua Kapiti Healthlinks Project (2000). *Porirua City Health and Disability Report and Plan* Wellington, Ministry of Health. ISBN 0-478-23981-5.

Putnam, R. D. (1993). *Making Democracy Work: Civic Traditions in Modern Italy* Princeton, Princeton University Press. ISBN 0-691-03738-8.

Rahn, R. J. (2005). *FEAR & GREED - A Political Archetype*. 23rd International System Dynamics Conference, Boston, System Dynamics Society. http://www.albany.edu/cpr/sds/conf2005/proceed/index.htm

Rees, D. (2005). *System Dynamics Modeling as a Tool in Healthcare Planning*. 11th Australia New Zealand Systems Society Conference, Christchurch, New Zealand, ANZSYS. http://isce.edu/ISCE_Group_Site/web-content/ISCE%20Events/Christchurch_2005/Papers/Rees.pdf

Reinken, J., A. de Lacey and C. Salmond (1980) *Community Attitudes to Sickness and Health: Stimulus and Response* Wellington

Richardson, G. (2006). *Concept Models*. 24th International System Dynamics Conference, Nijmegen, The Netherlands, System Dynamics Society. http://www.albany.edu/cpr/sds/conf2006/proceed/index.htm
Runciman, W. G. (1989). *A treatise on social theory.Volume II: Substantive social theory*. Cambridge, Cambridge University Press. ISBN 0 521 36983 5.
Runciman, W. G. (1999). *The Social Animal* London, Fontana. ISBN 0 00 686382 5.
Salmond, G. C. (1975) *Maternal and Infant Care in Wellington: A health care consumer study* Wellington
Sawyer, R. K. (2003). "Artificial Societies: Multiagent Systems and the Micro-Macro Link in Sociological Theory." *Sociological Methods and Research* 31(3): 325-63.
Smith, L. (2006) *Porirua Healthlinks Communityy Voices Annual Report: 1 July 2005 to 30 June 2006* Porirua http://www.phics.org.nz/
Tew, J. (2006). "Understanding Power and Powerlessness: Towards a Framework for Emancipatory Practice in Social Work." *Journal of Social Work* 6(1): 33-51.
Tilly, C. (1998). *Durable Inequality* Berkeley, University of California Press. ISBN 0-520-21171-5.
Turchin, P. (2006). *War and Peace and War: The Life Cycles of Imperial Nations* New York, Pi Press. ISBN 0-13-149996-3.
Turner, J. H. (1984). *Societal Stratification: A Theoretical Analysis* New York, Columbia University Press. ISBN 0-231-05741-5.
Turner, J. H. (2003). *Human Institutions: A Theory of Societal Evolution* Lanham, Rowman & Littlefield. ISBN 0-7425-2559-7.
Turner, J. H. (2004). "Toward a General Sociological Theory of the Economy." *Sociological Theory* 22(2): 229-46.
Weaver, E. A. and G. Richardson (2006). "Threshold setting and the cycling of a decision threshold." *System Dynamics Review* 22(1): 1-26.
Wilkinson, R. G. (1996). *Unhealthy Societies: The Afflictions of Inequality*, Routledge. ISBN
Wilkinson, R. G. (2000). *Mind the Gap: Hierarchies, Health and Human Evolution* London, Weidenfeld & Nicolson. ISBN 0 297 64648 6.
Wilkinson, R. G. (2005). *The Impact of Inequality: How to Make Sick Societies Healthier* New York, The New Press. ISBN 1-56584-925-6.
Williams, D. R. (1997a). "Race and Health: basic questions, emerging directions." *Annals of Epidemiology* 7: 322-33.
Williams, I. F. (1997b). Choral Societies and Export Growth. Social Capital and Policy Development. D. J. Robinson, Ed. Wellington, Institute of Policy Studies, Victoria University of Wellington.
Wolstenholme, E. F. (2003). "Towards the definition and use of a core set of archetypal structures in system dynamics." *System Dynamics Review* 19(1): 7 - 26.
Woog, R., R. Y. Cavana, R. Roberts and R. Packham (2006). "Working at the Interface between Systems and Complexity Thinking: Insights from a Market Access Design Project for Poor Livestock Producers." *Systems Research and Behavioural Science*.

Authors:

John Cody is a social worker. He has been involved with child care and protection services, community health programmes, community organisation and research on income adequacy. His research interests relate to social stratification and processes of

public deliberation. He has a BA (Sociology) and Dip Soc Wk from Victoria University of Wellington, New Zealand.

Bob Cavana is Associate Professor in Systems & Logistics with the Victoria Management School at the Victoria University of Wellington, New Zealand. He holds a PhD in management science (system dynamics) from the University of Bradford, England and is a Chartered Member of The Institute for Logistics & Transport in NZ. He has co-authored two books: Systems Thinking and Modelling: Understanding Change and Complexity (Pearson Education NZ, 2000) and Applied Business Research: Qualitative & Quantitative Methods (Wiley, Brisbane, 2001; Chinese edition 2004). He is currently the Vice President at Large of the System Dynamics Society and a Managing Editor of System Dynamics Review.

David Pearson is a Reader in Sociology with the School of Social & Cultural Studies and Research Fellow at the Centre for Applied Cross Cultural Studies at Victoria University of Wellington, New Zealand. He holds a PhD in Sociology from Leicester University, England. He is author, co-author and co-editor of 11 books and many articles and chapters. Key works have focussed on ethnic politics in New Zealand, Australia, North America and Britain, as well as local texts on class, gender and ethnic inequalities, social mobility, and community studies. His main current areas of research interest include the role of citizenship as a theoretical and empirical guide to ethnic social inclusion and exclusion; contrasting migrant and indigenous ethnic politics in settler societies; and the influence of transnationalism and regional devolution on ethnic and national identity in multi-cultural societies.