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2 Predicting the socio-technical future (and other myths)

Ben Anderson , Paul Stoneman

A snooker ball model implies that simple, linear and predictable social change follows from the introduction of new technologies. Unfortunately technology does not have and has never had simple linear predictable social impacts. In this chapter we show that in most measurable ways, the pervasiveness of modern information and communication technologies has had little discernable 'impact' on most human behaviours of sociological significance. Historians of technology remind us that human society co-evolves with the technology it invents and that the eventual social and economic uses of a technology often turn out to be far removed from those originally envisioned. Rather than using the snooker ball model to attempt to predict future ICT usage and revenue models that are inevitably wrong, we suggest that truly participatory, grounded innovation, open systems and adaptive revenue models can lead us to a more effective, flexible and responsive innovation process.

2.1 Introduction

Much human conduct is designed to avoid hazards and to promote beneficial returns. Indeed, this is the premise of the notion of 'risk societies' (Beck and Beck-Gernsheim, 2002) where individuals rely on past and current information to determine their future, predominantly risk aversive, behaviours. This idiom of human affairs embraces most areas of life. Meteorologists can (sometimes) help us avoid bad weather; seismologists can warn of areas of pending earthquakes and volcanic eruptions; economists inform business and governments of forthcoming growth trends and market stability; political scientists tell us which party is most likely to form the next government and climatologists warn of the dire consequences of global warming. Of course the central tenet of forecasting and prediction is that by studying past information we can - with some 'reasonable' degree of accuracy - project what is likely to happen in the future. However, there is no such thing as an exact science, and the confidence with which we can predict the future depends on the phenomena in question, the information available and the granularity of prediction that we require.

This chapter concerns itself with predicting the future 'social implications' of Information Communication Technologies (ICTs). It is sobering to remember that the telephone was not originally conceived as a means of human to human (or human to machine) communication. This form of usage evolved over time often in direct contradiction to notions of 'proper use' (Pool, 1983, Fischer, 1992). Despite this, it became the driving revenue stream for all telecommunications companies. Indeed, recent empirical studies of attempts at futurology have suggest that, amongst other problems, major reasons for failure have been an over-emphasis on technology determinism, a poor understanding of social trends and change, and finally, the over-reliance on a linear progression model of change (Geels and Smit, 2000, Bouwman and Van Der Dun, 2007)

Here we examine long-term societal trends in behaviour using time use data from the 1970s to the new millennium to show that in most measurable ways, the undoubted pervasiveness of modern information and communication technologies has had little discernable 'impact' on most human behaviours of sociological significance. We contrast this with observations from qualitative studies which illustrate how ICTs are changing the ways in which these behaviours are achieved; in other words, how ICTs are increasingly mediating (rather than impacting) everyday social practices. Historians of technology such as David E. Nye (Nye, 2006) remind us that human society co-evolves with the technology it invents and that the eventual social and economic uses of a technology very often turn out to be far removed from those originally envisioned. This position enables us to think more clearly about the ways in which people's behaviours adapt to technologies and how supply and demand side interaction can lead to the co-adaptation of technologies.

2.2 Implicit Predictions

It is widely accepted that the natural world is governed by causal laws that provide a certain level of predictability for natural phenomena such as weather systems and animal behaviour (Hume, 1748, Hempel and Oppenheim, 1948). The social world, populated by slightly more anarchic humans, is less certain. This has led some critics to argue that attempts at predicting human behaviour may be fruitless (Hart et al., 2007). However, despite huge problems predicting the future behaviour of individuals, it is possible to make reasonable predictions about *groups* of individuals (see for example (Clark, 2003). A Humean view of society suggests that much like natural phenomena, human thought and behaviour are also governed by hidden laws creating stable and repeated outcomes. On this reading, human behaviour is far from random; we can with the appropriate data describe similar patterns of thought and behaviour across individuals and, combined with the appropriate methods, explain at least in part why they think and act the way they do.

Despite this, social scientists still see the primary role of theory as a way of providing explanations not predictions (Popper, 1959). But the move from explanation to prediction is only one short hop – it could be argued that every explanation necessarily contains within it a prediction. Let us take a pertinent example. Climate change has focused much attention on the atmospheric movements of greenhouse gases, notably CO2. An understanding of future emissions and movements helps us to predict the degree of hazard global warming (as a result of human activity) will pose on human populations.

> One way to gain perspective about the potential future trajectory for atmospheric CO2 is to examine the geologic record of its concentration in the past. How high has the CO2 concentration been in the past? How fast did it reach past high levels? (Shlesinger, 2003)

Modelling the relationship between previous levels and previous global temperatures provides an insight into how future levels of CO2 emissions might impact global temperatures. Of course, the past and future impacts will never be the same – no two time periods will possess exactly the same conditions. But by making use of past information to make future projections we move out of the realm of explaining only, and in terms of the future, out of the realm of guesswork and into the realm of forecasting and predicting. By doing so, futures become less uncertain.

2.3 Socio-technical Futures

The future of democratic societies are often couched in social-technical terms such as the creation of Information Societies (May, 2001) and e-Democracies (OECD, 2004). Such futures often imply radical transformations perhaps by creating new forms of civic engagement or by helping social life to flourish. The main reason that such radical changes can be hypothesised is the huge dispersion of ICTs in society. Indeed, the most prominent of all ICTs, the internet, can be thought of as the 'new television' in terms of uptake and usage. In 1950, only 10 percent of Americans had a television set; by 1959, this figure had soared to 90 percent, "probably the fastest diffusion of a major technological innovation ever recorded." (Putnam, 1995). The internet demonstrates similar figures. For example, in the United Kingdom between 1999 and 2005, the number of people (as a percentage of the adult population) who went online rose from 14 percent to 61 percent[1]. In the US, 69 percent of the adult population now have internet access[2], compared to only 20 percent 6 years ago.

Two schools of thought emerged for possible internet effects – the utopians (Baym, 1997, Tarrow, 1999) and the dystopians (Nie and Hillygus, 2002). The first set of scholars believe that the Internet will restore a sense of community by providing a virtual meeting place for people with common interests (such as astronomy), which overcomes the limitations of space and time and where online communities could promote open, democratic discourse (Sproull and Kiesler, 1991), allow for multiple perspectives (Kapor, 1993), and even some political scientists believe it will help to mobilize collective action (Tarrow, 1999). Governments acknowledging the positive role of social capital and efficient information exchange have likewise posited the internet as a radical and positive driving force for democratic society:

> Broadband enabled communication, in combination with convergence, will bring social as well as economic benefits. It will contribute to e-inclusion, cohesion and cultural diversity. It offers the potential to improve and simplify the life of all Europeans and to change the way people interact, not just at work, but also with friends, family, community, and institutions… (CEC, 2005)

Other scholars express reservations, providing two responses to the previous arguments. First, not all uses of the Internet are social - the predominant activities are ones based around seeking information and engaging in solitary recreations (Nie and Erbring 2000). Second, many 'social' activities online (for example, email) are asynchronous; responses and feedback are delayed until the recipient signs on, reads the message, decides to answer, and the original sender eventually receives the answer. If this is being done instead of a phone call or perhaps even a face-to-face meeting, then such virtual communicating will give off the impression of maintaining the relationship, whilst in fact the quality of the relationship severely suffers (Gustein,

[1] http://www.statistics.gov.uk/CCI/nugget.asp?ID=8&Pos=6&ColRank=1&Rank=192
[2] http://www.internetworldstats.com/stats2.htm

1999). This is a way of saying that the Internet may be diverting people from 'true' community relations.

The implications for internet based socio-technical futures on either reading are clear; either it will continue to facilitate the growth of social and civic society or it will undermine them. Both of these arguments represent a type of thinking characterised as the snooker ball model.

2.4 The Snooker Ball Model

The causal nature of this model is essentially Newtonian and characterised by two conditions. First, there is a clear observable effect between a causal (independent) variable and an outcome (dependent) variable. For example the presence or level of internet usage is an independent variable and social and civic participation is the dependent. Second, that this relationship is unconditional, that is, wherever the presence of the causal variable is found so too is the outcome variable (hence, a deterministic model). These clear and necessary impact effects are summarised in Figure 1.

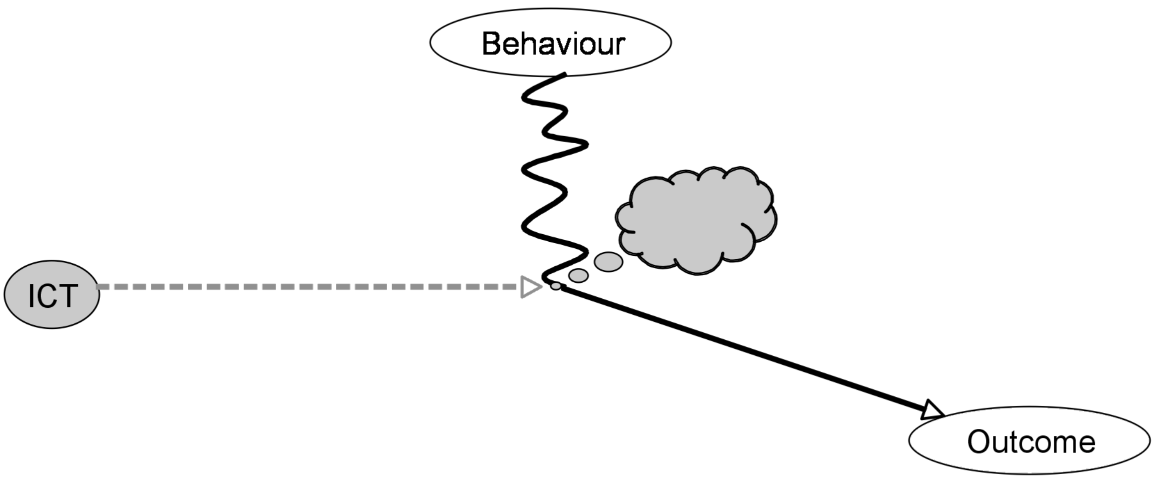


Figure 1: The Snooker Ball Model

Here we can see how the model derives its name. Patterns of behaviour are happily meandering along until individuals begin to adopt ICT usage and then are suddenly cannoned off into a new direction creating a different outcome. As long as the ICT usage prevails, the effect will be sustained creating a new equilibrium outcome.

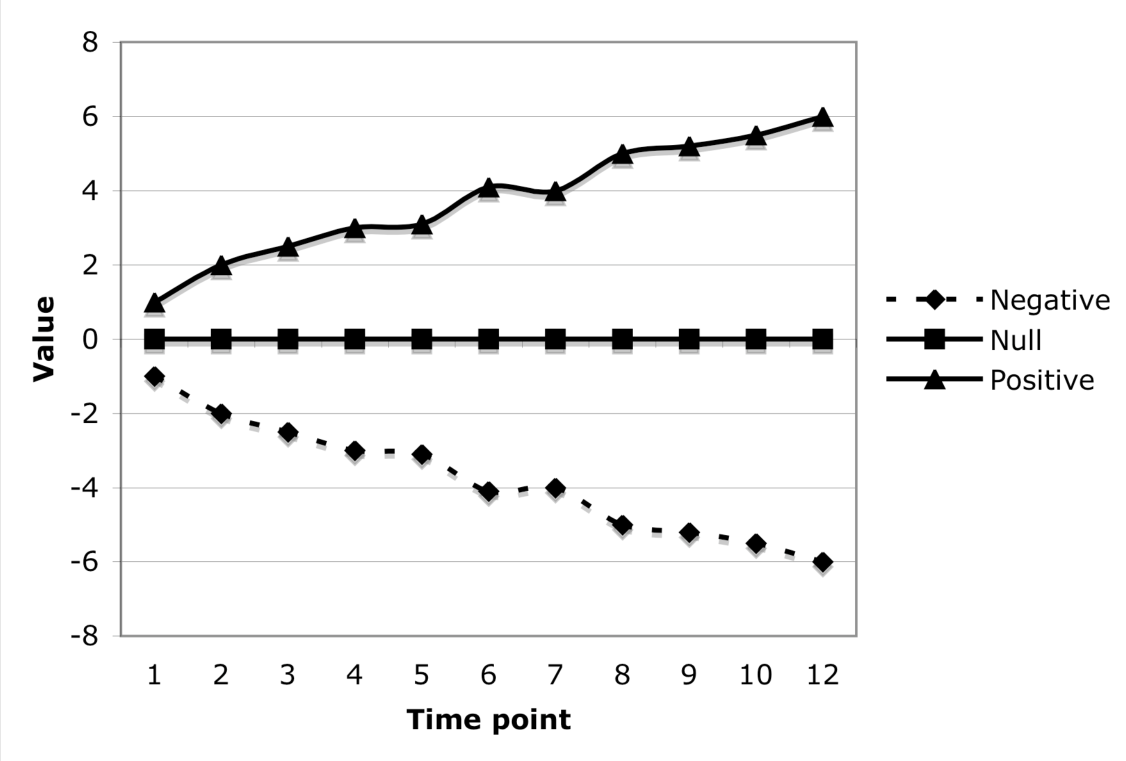
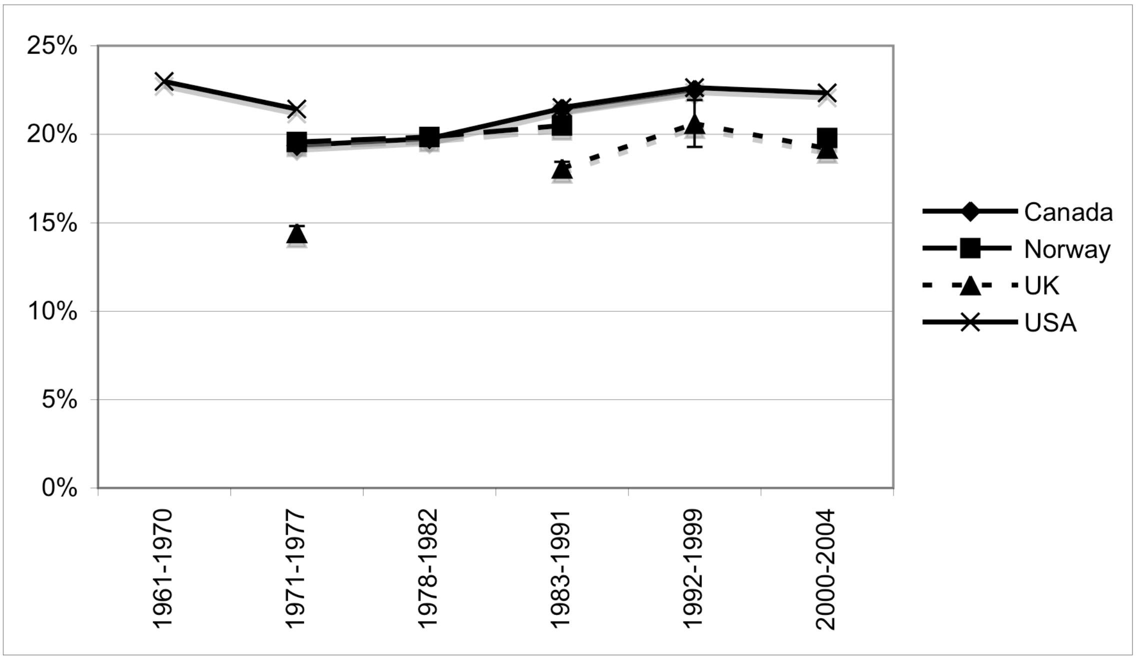


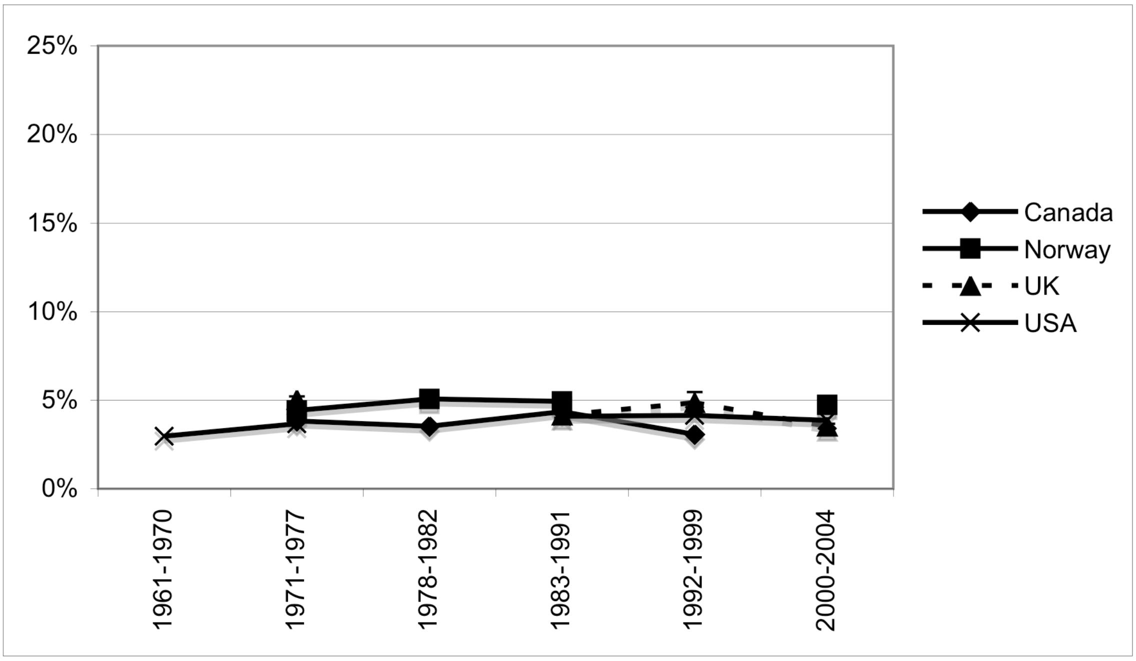
Figure 2: Observing the Snooker Ball Model

Figure 2 demonstrates how in empirical terms we can observe the presence of such effects. Time runs along the X axis, while the vertical Y axis plots levels of a behavioural outcome, such as levels of social interactions. Between time points 1 and 3, social life exists without mass ICT usage. At time point 3, major ICT uptake begins so that by time point 9, a clear behavioural change can be observed. The three lines represent three different hypothetical scenarios. The blue line represents a lasting negative effect of ICT usage, the red line no effect at all, and the yellow line a positive effect.

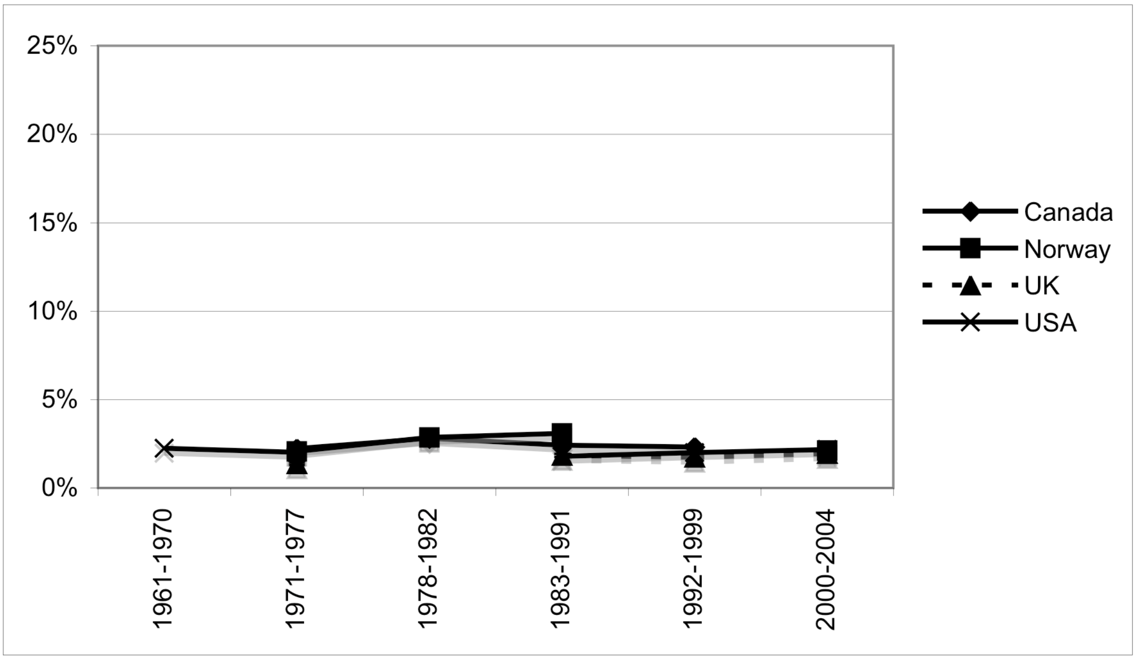
As long as time series data is available on both the important variables – ICT usage and behavioural outcomes – then it is possible to test which of the three hypothetical scenarios actually apply to the effects of recent ICT uptake and usage. It turns out that historical time-use data that is now becoming available suggests very little significant change in the major uses of time over the last 20 years as uptake and usage of the internet and mobile telephony has exploded in developed nations. Figure 3 below outlines data from time use diaries that demonstrate that the average time in each of four developed nations allocated to employment, social activities, watching TV and reading demonstrate little or no variation at all across time (see also Partridge 2007).



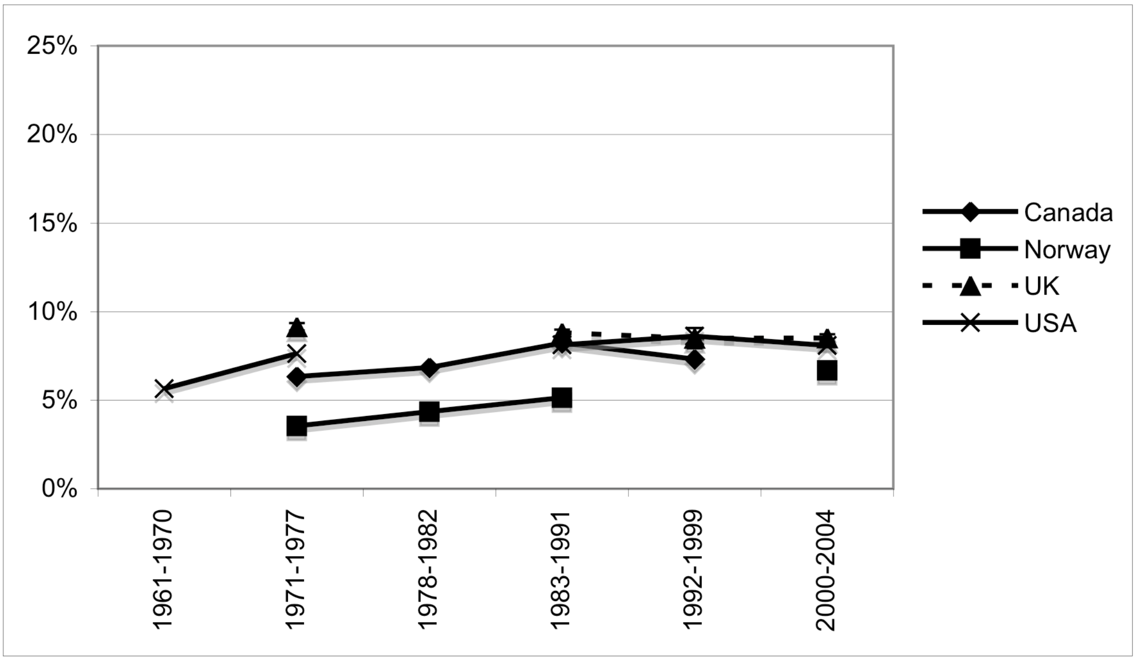
Employment



Social activities



Reading



TV watching

Figure 3: Historical trends in time use (MTUS, Mean % of 24 hours for weekdays, all aged 20-59, error bars shown for UK only are +/- 95% CI)

In other words, in most developed societies we see that shifts towards 'e-Societies' and the widespread ICT usage it brings does not translate into signs of significant social transformations despite the promulgations of various futurologists (Bell, 1973, Harvey, 1997, Castells, 2000).

The data suggest therefore that a Newtonian/deterministic view of technology is not just simple but simplistic. So while Newtonian physics made way for quantum mechanics, the simple snooker ball model of socio-technical futures must likewise give way to a more nuanced understanding of cause and effect between society and technology.

2.5 The Conditional and Co-adaption Model

If the past is prologue, then the preceding ten years suggest that not much will happen with socio-technical futures – at on level the everyday lives of citizens look very much the same now as they did 30 years ago. But is that the end of the story? There are two reasons to think not. The first reason is similar to the weakness of Newtonian physics. Once mainstream science began to reduce the world to a lower level of analysis (particles and sub-particles), it was clear a new way of thinking was required. Cue quantum mechanics. The second reason is an issue of time. While we cannot currently observe widespread positive or negative ICT effects, this might be because users haven’t yet fully adapted to the potential usages of such tools.

Reducing socio-technical issues to a lower level of analysis requires a move away from whole population models and population averages. Specifically, this means rethinking the snooker ball model by abandoning the unconditional assumption described above. The world is just too messy for this to be the case. As soon as this condition is ditched, the idea of heterogeneity within a population and thus heterogeneity in responses to technological innovation becomes a primary empirical concern. Internet usage, for example, might facilitate further civic participation for some groups of people but not others.

As an example, Figure 4 and Figure 5 present graphs of general election turnout by levels of internet usage (for political information) throughout the last British election campaign using the British Election Study 2005. In Figure 4 the sample population has been restricted to those individuals that express high levels of political interest and as we can see, for these people more or less internet usage for information seems to have no relationship with propensity to vote. The implication is that the strong level of political interest already found within the sample overrides any possible internet effects.

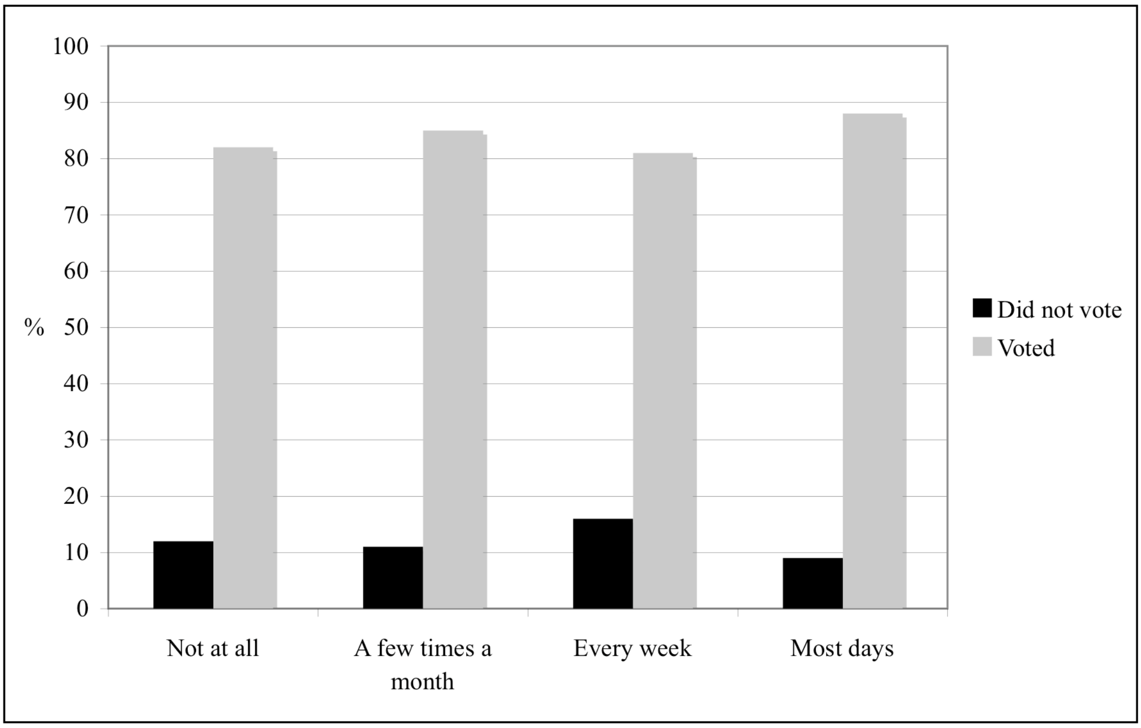


Figure 4: Vote turnout and Internet usage (all persons with high levels of political interest, British Election Survey 2005)

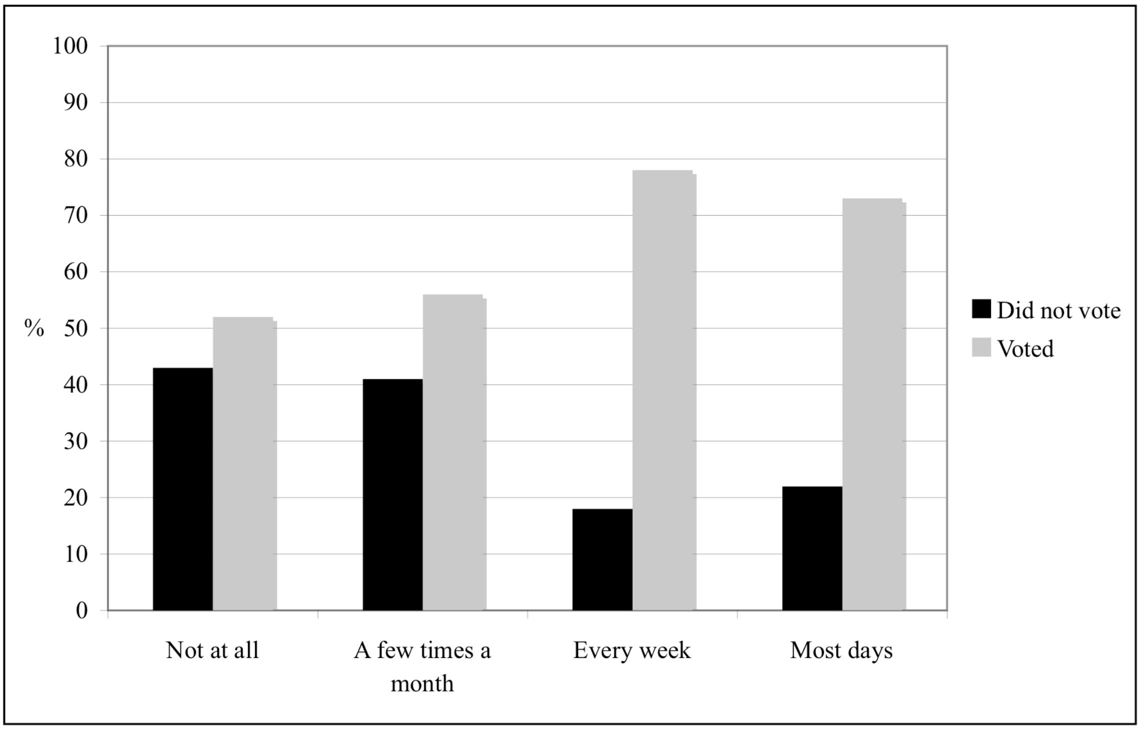


Figure 5: Vote turnout and Internet usage (all those with no or little political interest, British Election

Survey 2005)

Figure 5 however, paints a different picture. The working sample for this analysis was restricted to those that express none or low levels of political interest. As the figure demonstrates, for this group internet usage seems to boost turnout at higher levels. So by incorporating heterogeneity based on different levels of political interest into the analyses and moving away from 'one model fits all' type thinking, it is possible to demonstrate *conditional* positive internet effects.

While belonging to a type of group can represent a conditional factor for internet effects, so too can the length of internet usage. The concern here is that relatively new users might not have had time to change their behaviour as a result of going online perhaps due to inexperience of the technology. Conversely, it might be the case that new users suffer from a 'new toy' effect so that the internet is used more than will be the case. Both scenarios demonstrate the importance of allowing users to settle on a normal pattern of usage before any judgements are made regarding its impact on behaviour.

By making use of longitudinal time use diary data from the Home Online survey (Anderson and Tracey, 2001, Anderson, 2005), it is possible to demonstrate this because we have 'before' and 'after' measures of behaviour (cf Figure 2). Using multivariate regression analysis, it is possible to isolate whether more or less time spent on the internet correlates with more or less time spent socialising as well as a range of other variables (Stoneman, To Appear). The results show that in the first year of internet use, time spent surfing the internet has no significant correlation with time spent socialising. However further analyses demonstrate that for this data time spent web-browsing is mainly substituting time spent watching TV and doing nothing.

Repeating the analysis for a longer time-frame (the first two years of internet use) on the other hand demonstrates small but significant and negative internet effects on time spent socialising. Although the effect of internet use on socialising is marginal (every extra hour spent online produces a net effect of 6 minutes less on social activities), the difference in the two sets of results demonstrate the importance of allowing users to settle upon a normal routine of usage before searching for possible effects.

The implication of these analyses is that, far from having a direct impact on populations, technologies conditionally co-adapt with social life. Across time, individuals may or may not use innovations such as ICTs to support current behaviours and might even occasionally, once familiarity with the tool is established, create new patterns of behaviour. Socio-technical change is thus far from simple and as a corrective to the snooker ball model we must turn to a co-adaptation model.

In this model we see that behaviours and usages are not straightforwardly predictable from the affordances of the ICTs as they depend on a range of contingent and contextual factors including lifestage, skills, needs and resources . Users may adapt their behaviour to make use of the affordances of the ICTs and in turn the ICT producers act on these new behaviours. Some behaviour may simply be a continuation of the past whilst others may be generally new or disruptive (Gower et al., 2001) in an ongoing process of domestication (Silverstone and Hirsch, 1992, Haddon, 2006).

2.6 Feedback Mechanisms and the Evolutionary Model

The line of thinking behind the co-adaption model is now well established in social scientific studies of technology (Bijker et al., 1987, MacKenzie, 1998, Nye, 2006). By positing conditional effects, we begin to speak of *probable* causes and outcomes as opposed to the rather crude and simple 'if A then B' logic and we also begin to speak of iterative cycles of causal processes. But how far does the uncertainty principle go in the realm of socio-technical futures? If we observe a probable cause of an outcome now, how sure can we be this will occur again the future?

A major problem is that the interactions between people, technologies and the producers of those technologies are rather more complex even than this. For one thing technologies have always generated unanticipated uses. This tradition of finding uses for technologies that their designers and marketers did not perceive still continues. This issue has been well known in the field of Computer Supported Co-operative Work (CSCW) for some years (Robinson, 1993) where it is common place for users of office systems to adapt them to their own purposes in ways that were not foreseen by the designers of the systems. Rather than viewing these new uses as 'improper' or 'user error', CSCW sees in them an opportunity to capture users' creativity and fold these uses back into the product or system. In other words, the users become the co-designers of the system and the result is usually a workplace system that is far better suited to the work practices of those users and therefore far more likely to be used.

We attempt to capture this complexity and reflexivity in terms of an evolutionary co-adaptation model which is intentionally represented as complex and dynamic (Figure 6). Here we can see the myriad of feedback loops that exist between behaviours directly and indirectly related to ICT usages and in turn the complex and iterative evolutionary relationship between these and the design and production of ICTs. In this model the term evolutionary comes to the fore as we suggest that usages (behaviours) and technologies are engaged in a form of evolutionary co-adaptation where changes on one 'side' are intimately related to changes on the other and can frequently lead to startling innovations (Krebs and Davies, 1997).

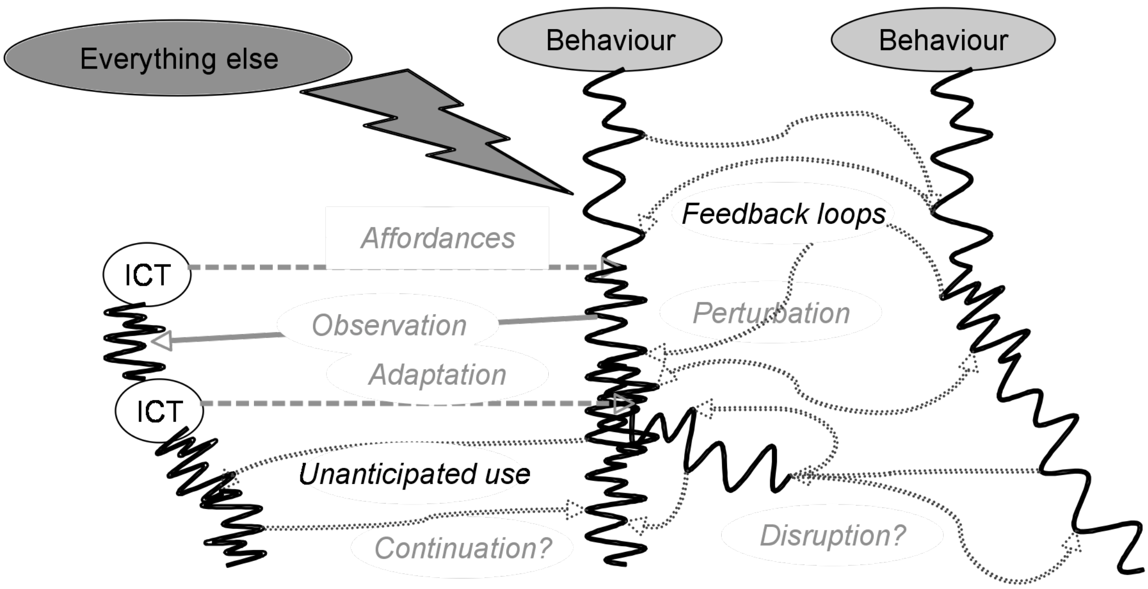


Figure 6: The evolutionary system model

In the context of predicting future technology usages this model inevitably reduces our confidence in our ability to make sensible statements about what might happen and it is, in particular, the likelihood that unanticipated usages (and thus revenues) will come to the fore that drives this uncertainty. Who would have predicted that SMS would turn out to be used as a de facto means to keep in touch, to gift friendship, to dump boyfriends, to send intimate images, to organise protest or to look busy (Rheingold, 2002, Ling, 2004)? Or that Bluetooth mesaging would be used to gift pornography, to send threats, to project sexualities, and to hide identities (Bond, 2007)?

It seems plausible therefore that the diversity of users and usage contexts for *malleable* consumer technologies means that both of these may be unknowable at the time of conception and design. Thus perhaps the most fundamental challenge facing the design of products and services is that what a thing is for, and who its users will be, can rarely be defined in advance. This means that any approach to the design of artefacts that assumes that the confident definition of user, task and goal is possible will be of limited use (Lacohee and Anderson, 2001).

2.7 Implications for forward thinking

The crucial aspect captured by an evolutionary understanding of socio-technical futures is the importance of a feedback mechanism between innovators and users. The implication is that innovators perhaps need to innovate less and listen and observe more whilst placing more control over product development in the hands of customers. Whilst most commercial organisations would see this as deeply threatening, new models of customer-led innovation and indeed customer-generated innovation are showing how these phenomena can be turned to profit. Such models can provide essentially free research and development (the customers do it themselves), will construct services 'developers' would never have dreamed of, will meet customers' own heterogeneous needs and can generate unanticipated revenues.

These models acknowledge that many people like to consume, many like to customise and more than are commonly supposed will seek to construct products and services for themselves (Oudshoorn and Pinch, 2003). Drawing on a range of empirical studies Eric von Hippel for example estimates that up to 40 percent of users actively develop or modify products (von Hippel, 1986). First mooted under the rubric of mass customisation (Davis, 1987) and more recently observed and advocated again by von Hippel (2005) amongst others, the model involves the potential users/customers in a rapid cycle of design, use and re-design – betaworld.

To give one excellent example, a recent study of the creation of a teen-oriented website recorded the rapid transition of the site from an 'Editors know best: we create, you use" model to a "They know best, we supply the framework, they do the content model" (Neff and Stark, 2004). Indeed the executive interviewed said

> *"We don't have people sitting around thinking. 'What do teens want?' It doesn't work. Even if you could figure it out, it wouldn't last. You can try to*

> *write for them but it doesn't work. Now 95% of our content is written by teens themselves."* (Neff and Stark, 2004)

This model can now be seen at work in a plethora of internet-based services which implicitly or explicitly support users in the creation of their own content (blogs, wikis, flickr, facebook, youtube et al) and their own applications and services (google, facebook, ning). It is a model radically different from the traditional 'innovate, design, build, launch, market, sell, wait for revenue' pipeline model because it allows the business case/model to evolve during development, and thus respond to unanticipated use, rather than being (usually) incorrectly specified in advance. It may be that such *adaptive revenue models* are one part of a response to the problem of responding to disruptive technologies. If uses and thus revenues cannot be predicted in advance then at least we can put in place adaptive organisational mechanisms so that emerging uses and revenues can be exploited rapidly. This requires commercial organisations to admit both institutionally and emotionally that they are no longer in control of their product and service lines.

This then is our partial answer to the problem posed in the introduction. Rather than persisting in attempting to predict future ICT usage and revenue models and thus producing future visions and business cases that turn out to be wrong, we suggest that truly participatory designs (Bjerknes et al., 1987), grounded innovation (Anderson et al., 2002), open systems and adaptive revenue models can lead us to a more effective, flexible and responsive innovation process. On current trajectories it will certainly provide us with an explosion in novel tools with which to live our lives. In terms of who uses what for which purpose, this does not make socio-technical futures more certain. It does, however, acknowledge that socio-technical futures now passed were *never* certain, and there is no reason to believe current futures will be any different. Nonetheless, our answer is not simply que sera sera. By working with uncertainty as opposed to projecting regardless of it, one thing will become more certain – a more user informed innovation process leading to significantly improved business models.

Acknowledgments

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Earlier forms of these arguments were presented at an ESRC e-Society Workshop in 2006 entitled 'The Internet in Britain: Statistical Analyses' and at a BT Masterclass in 2007 entitled 'Social innovation in a world of malleable technology'.

References

ANDERSON, B. (2005) The value of mixed-method longitudinal panel studies in ICT research: Transitions in and out of 'ICT poverty' as a case in point. *Information Communication & Society,* 8**,** 343-67.

ANDERSON, B., GALE, C., GOWER, A. P., FRANCE, E. F., JONES, M. L., LACOHEE, H. V., MCWILLIAM, A., TRACEY, K. & TRIMBY, M. (2002) Digital Living - People-Centred Innovation and Strategy. *BT Technology Journal,* 20**,** 11-29.

ANDERSON, B. & TRACEY, K. (2001) Digital Living: The 'Impact' or otherwise of the Internet on Everyday Life. *American Behavioral Scientist,* 45**,** 457-76.

BAYM, N. (1997) Identity, Body, and Community in On-Line Life. *Journal of Communication,* 47**,** 142-48.

BECK, U. & BECK-GERNSHEIM, E. (2002) *Individualization: Institutionalized Individualism and Its Social and Political Consequences,* London, Sage.

BELL, D. (1973) *The Coming of Post-Industrial Society,* Harmondsworth, Penguin.

BIJKER, W. E., HUGHES, T. P. & PINCH, T. J. (1987) *The social construction of technological systems : new directions in the sociology and history of technology,* Cambridge, Mass. ; London, MIT Press.

BJERKNES, G., EHN, P., KYNG, M. & NYGAARD, K. (1987) *Computers and democracy : a Scandinavian challenge,* Aldershot, Avebury.

BOND, E. (2007) mobile phone = bike shed? Children, mobile phones and sex. *Chimera Seminar Series.* Chimera, University of Essex.

BOUWMAN, H. & VAN DER DUN, P. (2007) Futures research, communication and the use of information and communication technology in households in 2010: a reassessment *New Media & Society,* 9**,** 379-99.

CASTELLS, M. (2000) *The Rise of The Network Society, The Information Age - Economy Society and Culture, Vol 1.,* London, Blackwells.

CEC (2005) Working together for growth and jobs: A new start for the Lisbon Strategy. *Communication to the Spring European Council.* Brussels, Commission of the European Communities.

CLARK, A. (2003) Self-perceived attractiveness and masculinization predict women''s sociosexuality. *Evolution and Human Behavior,* 25**,** 113-24.

DAVIS, S. (1987) *Future Perfect,* London, Addison Wesley.

FISCHER, C. (1992) *America calling: a social history of the telephone to 1940.,* Berkeley, CA., University of California.

GEELS, F. W. & SMIT, W. A. (2000) Failed technology futures: pitfalls and lessons from a historical survey. *Futures,* 32**,** 867-85.

GOWER, A. P., LACOHEE, H., JONES, M. L., TRACEY, K., TRIMBY, M. & LEWIS, A. (2001) Designing for disruption. *BT Technology Journal,* 19**,** 52-59.

GUSTEIN, D. (1999) *E.con: how the Internet undermines democracy,* Toronto, Stoddart.

HADDON, L. (2006) The Contribution of Domestication Research to In-Home Computing and Media Consumption. *The Information Society,* 22**,** 195-203.

HART, S. D., MICHIE, C. & D.J, C. (2007) Precision of actuarial risk assessment instruments: Evaluating the ‘margins of error’ of group v. individual predictions of violence. *British Journal of Psychiatry,* 190**,** s60-s65.

HARVEY, D. (1997) *The condition of postmodernity : an enquiry into the origins of cultural change,* Oxford, Basil Blackwell.

HEMPEL, C. G. & OPPENHEIM, P. (1948) Studies in the logic of explanation. *Philosophy of Science,* 15**,** 135-75.

HUME, D. (1748) *Enquiry concerning Human Understanding. Sections IV-VII (paras. 20-61)*, Oxford University Press.

KAPOR, M. (1993) Where is the digital highway really heading? *Wired,* 94 (July/August)**,** 53-59.

KREBS, J. & DAVIES, N. (1997) *Behavioural Ecology: An Evolutionary Approach*, Blackwells Science.

LACOHEE, H. & ANDERSON, B. (2001) Interacting with the telephone. *International Journal of Human Computer Studies,* 54**,** 665-700.

LING, R. (2004) *The Mobile Connection: The Cell Phone's Impact on Society,* London, Morgan Kaufmann.

MACKENZIE, D. (1998) *Knowing Machines: Essays on Technical Change* Boston, MIT Press.

MAY, C. (2001) *The Information Society: A sceptical view,* London, Polity Press.

NEFF, G. & STARK, D. (2004) Permanently Beta: Responsive Organization in the Internet Era. IN HOWARD, P. N. & JONES, S. (Eds.) *Society Online.* London, Sage.

NIE, N. H. & HILLYGUS, D. S. (2002) The impact of internet use on sociability: time-diary findings. *IT & Society,* 1**,** 1-20.

NYE, D. E. (2006) *Technology Matters: Questions to Live With,* Cambridge, MA, MIT Press.

OECD (2004) *Promise and Problems of E-Democracy: Challenges of Online Citizen Engagement*, Organisation for Economic Cooperation and Development.

OUDSHOORN, N. & PINCH, T. J. (2003) *How users matter : the co-construction of users and technologies,* Cambridge, Mass. ; London, MIT Press.

POOL, I. D. S. (1983) *Forecasting the Telephone. A retrospective technology assessment,* Norwood N.J., Ablex.

POPPER, K. (1959) *The Logic of Scientific Discovery,* London, Hutchinson.

PUTNAM, R. (1995) Bowling Alone: America's Declining Social Capital. *The Journal of Democracy,* 6**,** 65-78.

RHEINGOLD, H. (2002) *Smart Mobs,* Cambridge, MA, Persius.

ROBINSON, M. (1993) Design for Unanticipated Use. IN DE MICHELIS, G., SIMONE, C. & SCHMIDT, K. (Eds.) *ECSCW '93: 3rd European conference on computer-supported cooperative work.* Milan; Italy, Dordrecht; London; Kluwer Academic Publishers.

SHLESINGER, W. H. (2003) The carbon cycle: human perturbations and potential managements options. IN GRIFFIN, J. M. (Ed.) *Global Climate Change: The Science, Economics and Politics.* Cheltenham, Edward Elgar Publishing.

SILVERSTONE, R. & HIRSCH, E. (1992) *Consuming technologies : media and information in domestic spaces,* London, Routledge.

SPROULL, L. & KIESLER, S. (1991) *Connections: new ways of working in the networked organization,* Cambridge, Mass, MIT Press.

STONEMAN, P. (To Appear) Exploring time use - "web-use and net-nerds". *Information Communication & Society*.

TARROW, S. (1999) *Power in movement. Social movements and contentious politics,* Cambridge, Cambridge University Press.

VON HIPPEL, E. (1986) *The Sources of Innovation,* Boston, MIT Press.

VON HIPPEL, E. (2005) *Democratizing Innovation,* Boston, MIT Press.

