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Triple Helix and the Circle of Innovation[1]

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This paper positions the triple-Helix as a meso-level notion, an epicycle in a grander circle of technological change, institutional change, and psychological change. Because of the differing speeds of these several kinds of change, speed is proposed as a high-level system metric. This implies that what we commonly call bridging agencies or facilitators – lawyers, venture capitalists, incubators, etc. – are better called buffering agencies, as they help to engage entities changing at different speeds. They use human judgment as well as information technologies to choose feasible timing for these engagements.

The paper highlights implications for thinking about innovation diffusion: The grand cycle of socio-technical change means we should, rather, think in terms of innovation reinforcement, or a circle of innovation.

KEYWORDS: Triple-Helix; Knowledge-based economic development; Innovation; Social Change

Introduction

This conceptual paper introduces a tri-level schema of technological and social change. In this schema, the triple helix sits at the middle, or meso-level, as an epicycle in a grander cycle of technological, psychological, and institutional change. Micro-level dynamics take place within organizations and within individuals, sending rippling effects upward to the meso and macro levels.

These cycles-within-cycles are loosely and intermittently coupled, with the result that the individual cycles progress at differing speeds. Indeed, most of the problems we face (and attempt to model) in the management of technology stem from the fact that technology, institutions, and individual psychology – or businesses, universities, and governments – proceed at different speeds.

Phillips (2011) notes the difficulty of measuring social change, especially as a rate distinct from the speed of technological change. So, though it is offered here as a conceptual rather than

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a computational quantity, speed (differentials) as a system metric helps us understand the interaction of technology and society.

For this reason, and if one accepts the "speed of change" metaphor, the current business buzzword "engagement" takes on unexpectedly profound importance: In an automobile, we "engage" the clutch in order to reconcile the rotational speeds of the crankshaft and the driveshaft, through the intervention of the transmission, without causing shock or damage to the mechanism. This paper goes on to relate current discussions of "engagement" to the tri-level scheme. It addresses the roles of buffering institutions and ICT in effecting smart engagement, and offers remarks on applying 3-helix in the developing world and thereby learning lessons valuable for the wealthy countries. The paper concludes with a mention of implications for policy and for research.

Industry-Government-Academic Interaction

George Kozmetzky, US National Medal of Technology winner and mentor to Michael Dell, first drew Figure 1 in the early or mid 1980s, at a time when Austin, Texas was emerging as the leader of first-generation echoes of Silicon Valley. The University of Texas was spinning off companies, and Silicon Valley veterans were migrating to Austin for its clean environment and ample knowledge work force in order to start their next ventures. The figure has since appeared in dozens of publications by authors unaffiliated with IC^2 or with Austin. This is an acknowledgment of the immense impact Kozmetsky's IC^2 Institute had on knowledge-based growth in Austin and around the world (Cooper et al., 1996).

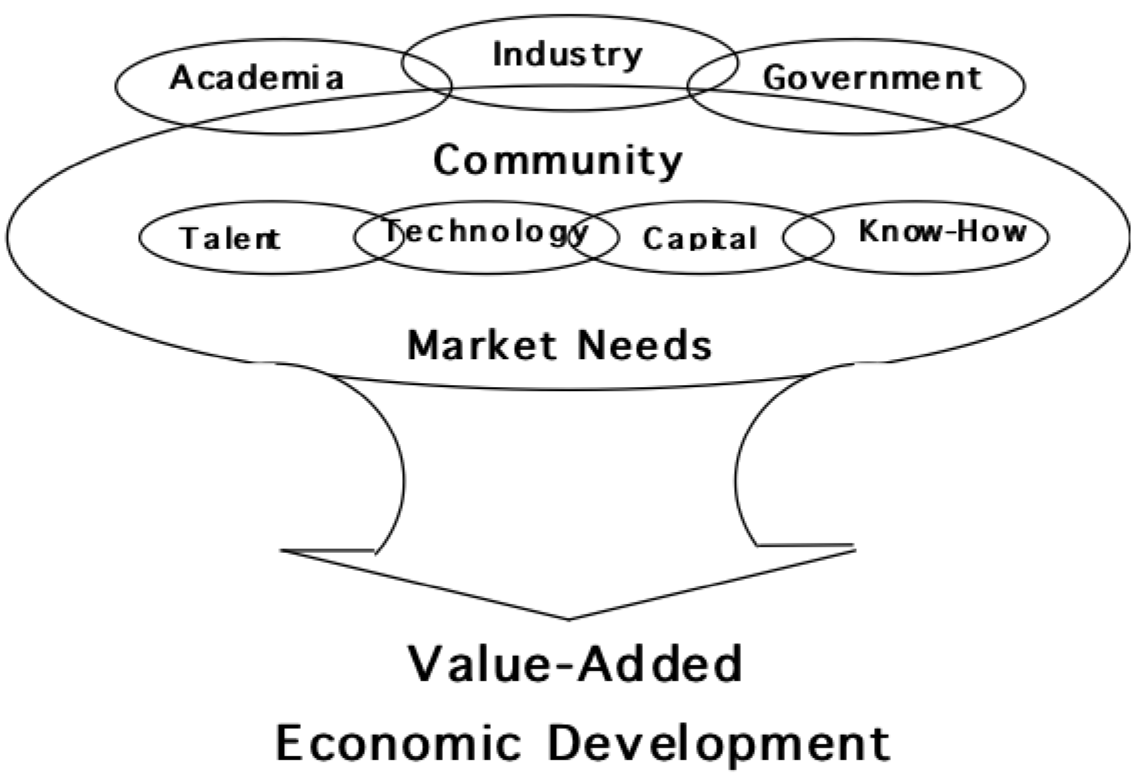

Figure 1. The IC^2 Model of Technology-Based Regional Economic Development

The figure preceded the triple helix model by several years. It captured the essential triple-helix elements of University-industry-government interaction, and further indicated four elements of techno-entrepreneurship success and the fact that it "takes a village" of community support, social capital, and supporting institutions to make a viable regional techno-economy. In Austin the triple-helix of inter-sectoral cooperation was and remains highly effective.

Only parts of the IC^2 model were made mathematical (e.g., Bard et al., 1999). One of Etzkowitz and Leydesdorff's contributions was to remind us of the mathematical interest of tripartite inter-sectoral cooperation.

The roots of this math go back to Isaac Newton and the three-body problem in astronomy. These interesting dynamics give us a platform for (one hopes) further productive modeling of innovative cluster formation. However, they are just part of a bigger picture.

A multi-level view

The "bigger picture" can be understood by sandwiching the meso-level triple helix between a macro level and a micro level with which it engages intermittently.

Macro-level

Figure 2 shows the cycle of innovation and change, from lab to society and back again. In this figure, technological change leads to new products and services, which in turn change the way we use products and services. These new usage modalities require changes in the way we organize our firms and institutions. New ways of organizing generate demands for still newer technological fixes, and the cycle repeats.

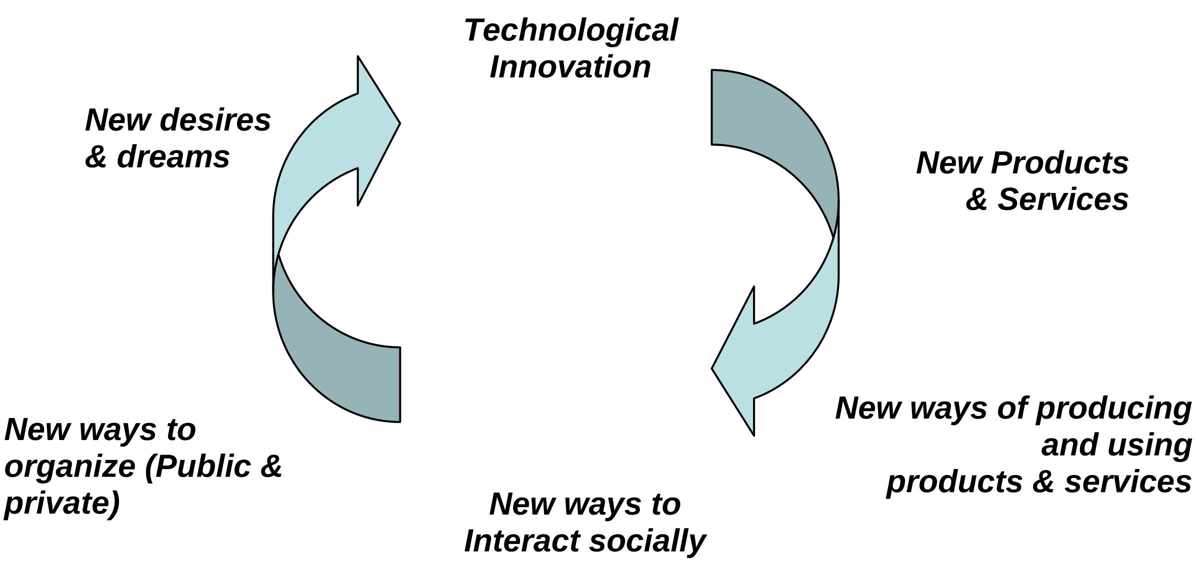

Figure 2. Technological innovation self-reinforces via social change.

Contrast this scheme to the more linear model of Rogers (1962), in which the innovator segment exhibits latent demand for the innovation, but which does not explain the source of this latent demand. Although Rogers' diffusion model does include some "loops, short-cuts or interruptions" (Prager and Posthumus 2010)[3], our focus is on the grand loop depicted in the Figure 2.

To further clarify, the classic innovation/product "life cycle" is a cycle only in the sense of birth-to-death (or more recently, cradle-to-cradle). It is not a cycle in the systems-theoretic sense of providing feedback from users to creators. Moreover, the classical theory allows for technological substitution at the end phases of the life cycle, but assumes the substituting technology provides the same user benefits as the senescent technology. What is proposed here is that social changes generate demand for new and different benefits, of kinds that were not provided by any existing technologies.

This we will call the circle of innovation. It does not circle back to a previous state of affairs, and so might better be envisioned as a helix. But for simplicity, and to distinguish it from the meso-level triple-helix, we stick with the "circle of innovation" label.[4]

A quirky but nontrivial example: Advances in information technology facilitated international collaborative virtual research teams and wider access to scientific journals. This, plus the general globalization that is also enabled by new IT, raises research capacity in developing nations. In turn, many more researchers from many more countries produce work publishable in top international journals. Distinguishing among researchers having similar names (or names inconsistently transliterated into Western alphabets), never much of a problem heretofore, becomes an issue and an entrepreneurial opportunity. The universal researcher identifier is invented and promulgated. Publishing companies' author and reviewer databases now need to be modified to carry the extra data field "universal author identifier." The earlier cozy research communities where (as in the US television program "Cheers") "everybody knows your name" morphs into a more impersonal but perhaps more productive enterprise.

In this example, as in Figure 2, technical change led to new ways to use technology, which led to new organizational forms. These in turn created demand for new technological solutions. These, once provided, led to still newer usage modalities and a new round of social change in research communities. The wheel takes another turn.

The creative reader of this paper will think of several more such examples, so they will not be belabored here.

Meso-level

The grand cycle (macro level) relates changes in technology, institutions, and psychology. The triple-helix dynamic takes place largely within the "institutions" component of the larger cycle. This is depicted by the small 3-helix icon in Figure 3. One might object that we are concerned here with technological progress, and therefore triple-helix ought to be more closely associated with technology in the diagram. Moreover, technological advance takes place inside institutions – universities, government and corporate labs, etc. Though these points are valid, I place the triple-helix inside the institutions box because it is primarily concerned with institutional dynamics and change, and I place the technology box distinct from the institutions box because technological advances rarely cause fundamental change to the institutions where they originate. (General Motors invented the automatic transmission, for example, but the invention did not fundamental-

[3]And an otherwise misguided blog at WIRED magazine (Downs and Nunes, 2014) correctly notes that online and Twitter reviews, which elsewhere in this paper we call "engagement," provide additional nonlinearity to the adoption cycle.

[4]T.S. Eliot reminded us that the end of a circle need not be identical to its beginning: "The end of all our exploring will be to arrive where we started and know the place for the first time."

ly change General Motors.)

Micro-level

The micro level has to do with dynamics within people and within organizations – the smaller gears in Figure 3. Aldrich (1999) and others have written about the dynamics that take place within a single organization, or between organizations in the same sector. There is of course a huge psychological literature on intra- and inter-personal dynamics. Much of what is currently appearing on "engagement," the topic of this paper's next section, addresses this micro-level of dynamics, though the question of engagement is central to all three levels.

Micro-level dynamics also include the life cycles of individual technologies and products.

Engagement

If all elements of the macro level – technological change, organizational and institutional change, psychological change, and social needs – were fully engaged at all times, they might move together in an orderly way. Clearly, though, they do not, especially in a free-market economy. They continually engage and disengage. Sometimes they move each other only by friction – in both senses of the word "friction." In fact, I believe ninety percent of technology management and technology policy problems (in research and in public life) stem from the differing speeds of change of the three sectors.

An example in transportation: Mobile-web rideshare services gain venture capital investment, start operations, and are shut down by city governments trying to regulate them under old taxi rules. Institutions have changed more slowly than technology and social demand.

An example in health: An elderly person dies because he was too proud to wear a medical bracelet or an emergency signaler. Psychology has changed slower than technology.

An example in software: Record companies and publishers sue student MP3 pirates, develop digital rights protection software that further alienates customers, and cannot adapt away from paper and CD publishing.

In these examples business organizations change more slowly than technology and social demand. Technology, however, is not always the hare outpacing tortoise organizations and people. More and more often these days, social/institutional change outpaces technological change (Phillips, 2011) – or will do so soon. In most of the world, an excess of funds is chasing too few growth investment (technological entrepreneurship) opportunities. Fewer US companies are making initial public stock offerings. The rapidly growing movement of small-government activists rails indiscriminately against direct government monetary support for new technologies.

These examples show that technology, institutions, and individual psychology are engaged with each other loosely or intermittently. This loose engagement can be good. Individual creativity may bloom. Mistakes can be undone efficiently and don't necessarily infect the whole system. On the other hand, disengagement can be bad, resulting in alienation, lack of coordination and cooperation, reduced institutional or organizational creativity, waste and pollution, and lives lost.

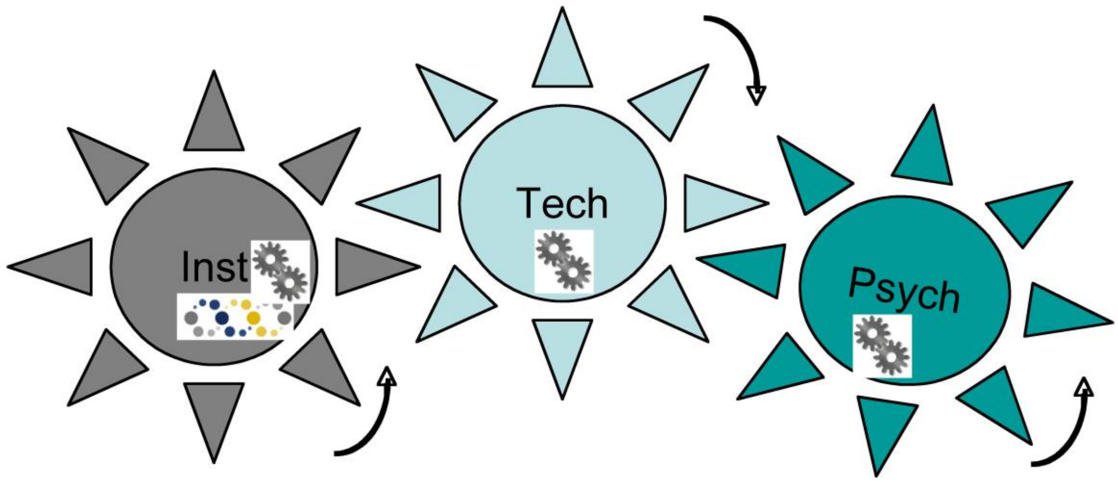

Figure 3. Triple-Helix as meso-level construct: An epicycle within the Technological-Psychological-Institutional dynamic

What causes Technological-Organizational-Psychological-Institutional disengagement?

Common sense tells us disengagement can result from bad marketing, bad market research, from mistrust, from bad service, from technology inaccessible to underserved populations, from competition among de facto standards (e.g., VHS vs. Beta), from lack of vision, from poor design of information and communication products and programs, and from culture gaps.

Disengagement frequently results from a misunderstanding of "engagement." "Engaging" doesn't mean "attractive nuisance." It doesn't mean intruding on an audience, or overwhelming an audience with information overload, or loud shouting.

Marketing guru Geoffrey Moore says, "People have disengaged, for ... self-preservation." This has "consequences for consumer and brand marketing, and long-term implications for education, health care, citizen participation, and workforce involvement." Moore concludes, "Engagement is rightfully going to be a big investment theme."

Moore provides these examples in support of the idea that engagement is taking center stage in business.

- "Design thinking creates products, services, and programs that begin with engagement instead of trying to tack it on as an afterthought. *Examples: IDEO and the Stanford D-School.*
- "Shift toward video snippets displacing static display ads as the fundamental unit of consumer communication, with engagement metrics coming from *companies like Visible Measures.*
- "Hybrid outreach campaigns that begin digitally but end personally are driving contact center innovation in consumer services *companies like Analyte Health.*
- "Bring-Your-Own-Device support projects coming out of enterprise IT organizations maintain workforce engagement.
- "Massive shift in enterprise spending priorities from 'old IT' Systems of Record to 'new IT' Systems of Engagement, both for B2B collaboration and B2C experiences."[5]

[5] https://www.linkedin.com/today/post/article/20121211105523-110300724-big-idea-2013-engagement

Moore is saying that advertising used to be loud and annoying, with the result that consumers intentionally disengaged. Now, with social media, mobile web, Yelp.com, etc., consumers share product reviews and complaints. Advertisers must treat consumers more gently, to make us want to continually re-engage. Engaging doesn't mean shouting.

ICT for an Intelligently Engaged Society?

What kinds of ICT foster positive, voluntary engagement? Why? What kinds of ICT discourage it? Why? Figure 4 shows one product that allows discretionary engagement with the machine and between people, and another product that encourages a compulsion to 24-7 connection with work and social networks, to the detriment of human interaction.

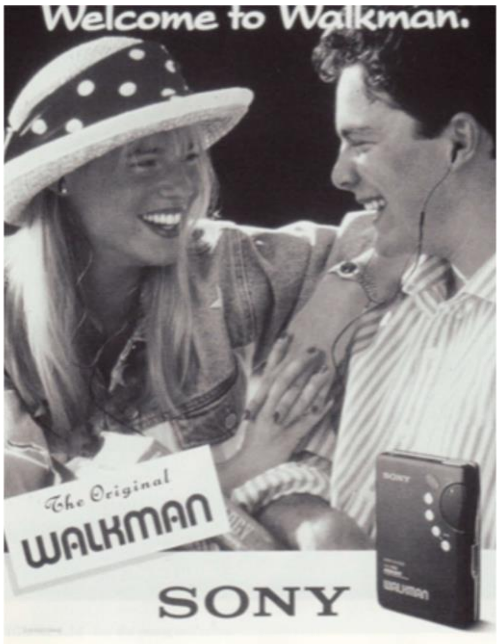

Figure 4 (a) The Walkman enabled a couple to enjoy the same music at the time and place of their choosing. (b) The insistent smartphone presents "urgent" messages, potentially harming interpersonal relationships.

People are proud to participate electronically, in fighting crime (the Zapruder film of the John Kennedy assassination; videos of the police beating of Rodney King), in supporting favorite businesses, authors (Amazon and TripAdvisor reviews), and for post-disaster aid (crowd-mapping post-earthquake Haiti; crowd-funding research projects and entrepreneurs), though there are abuses.

Most research on engagement has been at the micro level. Hinchcliffe (2013), for example, shows the limited ICT impact on employees' engagement with employing firms (which in fact remains dismal); Hinchcliffe defines it as *the measure of whether employees merely do the minimum required of them, versus proactively driving innovation and new value for the organization.* He concludes that engagement "can only ever be partially accounted for by deploying the latest new collaborative technology, and probably significantly less than many of its proponents would have you believe."

Ganti et al. (undated) have begun to design hardware/software architectures for sensing the mood and receptiveness to engagement. This work is preliminary, and for the present, ICT alone cannot create or sustain engagement. However, human intervention, via buffering institutions, can achieve ICT-*aided* engagement. ICT, especially sensing and crowdsourcing, may assist in deciding *when* to engage, thus achieving smart engagement. This principle applies to all 3 levels (macro, meso, micro) of our multi-level Technology and Society diagram.

***Speed of change* as the system metric**

The issue is really speed *differentials* among the sectors. To remedy excessive friction, a "clutch" and a "transmission" are needed. The question is less *how* to engage, but rather, *when*, and the key is not engagement *per se*, but smart (well-timed) engagement.

Table 1. Examples of buffering organizations

•Civic groups •Workforce training programs •Economic development agencies •Technology brokers •Open innovation integrators •Accountancies •Industry associations	•Trade associations •Incubators •Law firms •Venture capital •Technology transfer offices •NGOs

For this purpose it is helpful to view the institutions listed in Table 1 not as bridging organizations, but as *buffering* organizations. *The buffering institutions span all 3 levels,* macro, meso, and micro. These examples are by no means exhaustive:

Macro: Training companies help business firms put technological advances to efficient (and often new) uses. Qualified trainers are available on short notice, buffering the gap between speed of new releases and users' absorptive capacity.

Meso: Technology brokers and new business incubators smooth the path of university technologies into the business world. They buffer the speed gaps among grant cycles, patent application times, insistent demands of VCs, and time taken for market scanning.

Micro: Team-building consultants and executive coaches buffer interpersonal and inter-organizational stresses, forcing managers to slow down in order to express pent-up frustrations. They uncover conflicts in which one participant has "moved on" and the other still cherishes the grievance.

Triple Helix in developing nations: Lessons for technology-leader countries

In many countries where central government direction is the norm, triple-helix thinking is premature. In these countries, all universities may be national universities operating under a strong Education Ministry. Almost all companies may be state-owned enterprises. Under these conditions, one cannot say there are three sectors, reacting to each other but making mostly autonomous decisions; there is only one sector, the government. Its officials may view triple-helix as a trendy phrase or a good hook for capturing international development funds, but it is not a realistic basis for planning.

In two developing nations in which this author has recently consulted, government officials excluded university and business participants from an international forum on triple-helix! In one of these countries, a post-Soviet republic, all the dynamics were at the micro level, as three different factions within the government vied to dominate the viewpoint from which plans would be drawn. One faction wanted sincerely to foster growth in the country. A second wanted simply to carry out the new law concerning science and technology parks. A third faction appeared to pine for the days of communist support for inefficient and favored industries, and to hope to use the buzzwords "innovation" and "triple-helix" as covers to acquire capitalist support for inefficient and favored industries. Clearly little progress will happen in this country until the first two factions ally against the third one.

When one of the three sectors (factions) dominates the others – or when two of them "gang up" (collude) against the third – triple-helix does not seem to be the best analytic frame. One may instead turn, e.g., to game theory. (See Charnes, Littlechild, and Sorensen (1973) for a description and solution of the "big man, little men" game in which two relatively powerless parties must negotiate with a third and more powerful party in order to win a payoff that none can win alone.)

In the USA, industry lobbyists present a related but slightly different problem. These well-funded lobbyists have a disproportionate impact on government, making it appear that industry and government are aligned against the common citizen. Moreover, industry-funded "small government" advocates back efforts to shrink funding for public universities. Indeed in every country, the question of coalitions (as they are called in game theory) complicate the triple-helix dynamic, and has not yet been captured by theory.

These instances show us that micro-level dynamics inform the triple-helix discussion; and that the conditions for a healthy triple-helix dynamic – namely, three responsive but semi-autonomous sectors of society – may be hard to find, either in developing or in developed nations. Extensions to the theory are needed, and the tri-level perspective suggested in this paper may be helpful.

An aside: Spatializing an innovation diffusion model

Phillips (2007) put forth a system-theoretic model of innovation diffusion in the presence or organizational resistance to change. It turned out to have similarities to a model of chemical reactions authored by none other than Alan Turing (1952) fifty-five years earlier. Turing was interested in the long-term distribution of reaction products in a petri dish, when reaction facilitators and inhibitors are initially randomly (or purposefully) distributed across its surface. Figure 5 shows the result of iterating the Turing model under certain parameter values. The same kind of spot-stripe patterns emerges regardless of the initial distribution of reagents and inhibitors.

Figure 5: Iterating the Turing model. Source: http://www.cgjennings.ca/toybox/turingmorph/

If the Phillips model were rendered 2-dimensionally and similarly iterated, a like pattern would result. As regions and countries (as described in the section above) vie to win Silicon Valleys of their own, we might ask, why does the geographical arrangement of the world's technopoles not look like Figure 4? One answer is that the real world has mountains, oceans, highways, the Internet and other facilitators and inhibitors of (sometimes long-distance) spatial interaction - unlike the Turing model, in which all interactions take place locally on a featureless surface. Most nascent technopoles are aware that networking with distant technopoles is a critical success factor. Another answer is that the simple, aggregate portrayal of local facilitators and inhibitors is not sufficient to model the real world. In other words, researchers need the more nuanced and detailed triple helix model, and its future extensions, and other models that bring forth the subtleties of human, technological, and institutional interaction.

Discussion and implications

In sum, the difficulties we face in reconciling changes in technology, institutions, and individuals is not dis-engagement, but mis-engagement among governments, people, organizations and products, due to speed differentials (e.g., poor timing), lack of vision, and poor design of information and communication products and programs. This last includes problems stemming from lack of feedback; excess complexity (Linstone and Phillips 2013), leading to slow comprehension and adoption; excess technology push (solutions without problems); excess demand pull (unrealistic expectations), and other factors.

This paper's arguments have implications for many parties:

For IT designers, the implications have to do with meeting users halfway, and relying on computer-aided (rather than computerized) means of achieving engagement with users.

Managers should map out engagement plans for each constituency, taking into account the unique characteristics of each.

For teachers: The grand cycle of innovation and social change proposed here means we must take a still more systemic approach to the classroom teaching of innovation diffusion. Feedback is an essential feature of the cycle at several levels – i.e., the imitation effects noted by Rogers (op cit.) and Bass (1969), and the grand cycle put forth herein.

For policy makers: Once a society boards the innovation wagon, it can be exceeding difficult to get off – barring a severe economic crisis. There is much about the grand cycle that appears self-perpetuating.

Theorists may well focus on modeling the moderating effect of buffering institutions and the impact of coalitions on the triple-helix dynamic - keeping in mind that the math of academic-government-industry dynamics is interesting and valuable, but is just part of a bigger picture.

Further research should combine social science and computer science to find principles of IT design that more quickly lead to engagement that is well-timed, smart, and satisfying for individuals, businesses, government institutions, and technology developers. This should all lead to secure applications in several techno-policy domains (health, energy, etc.).

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