AUSTRALIAN NATIONAL UNIVERSITY

COLLABORATIVE ENTREPRENEURIAL INNOVATION

Benjamin John Heslop

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Declaration

The work in this thesis is my own except where otherwise stated.

Benjamin John Heslop

Acknowledgements

Many helped me on this long, ten-year journey:

Gerard let me do what I wished.

Tony treated me like a son.

Boyd persevered.

Annalese listened and read.

Radio National gave insight and inspiration.

Abstract

Innovation is an often used yet poorly understood word. A critique of government policy to promote innovation demonstrates it to be incoherent and not informed by theory. Its fragmented approach is shown to not overcome market failures to innovate, while creating bureaucratic load for applicants. It is proposed that a deeper understanding of collaboration should inform government policies intended to promote market-based innovation.

This research is a first approach by the author to understand, evaluate and improve collaborative performance, such as between business and research. An iterative, recursive methodology gathers data from interviews held with university commercialisation facilitators. It is found that a collaboration 'system' consists of five parameters that can be traced back to approach/avoid response of the mammalian brain. When the model is examined for feedback, a bias towards stability emerges, with innovation atypical. The parameter 'Identity' is critical in withstanding the instability of innovation. Leadership roles that optimise each of the parameters are discussed, as are reasons why government should not undertake them.

This pragmatic understanding of collaboration theory allows crafting of coherent policy to promote innovation. The primary measure is subsidising of membership fees and audit of collaboration leadership, with a secondary measure being reduction of patent terms to five years to reduce costs associated with intellectual property. In combination, this policy builds an adaptive ecosystem of innovative collaboration, similar to Silicon Valley. Economies are grown by liberating under-employed human capacity using policy informed by a theory of collaborative entrepreneurial innovation systems (CEISYS).

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People who make it into the establishment work and play well with others. They are part of the same overlapping social networks, and inevitably begin to perceive the world in similar, conventional ways. They thrive in institutions where people are not rewarded for being cantankerous intellectual bomb-throwers (1)[1]

Chapter 1.   Introduction

Innovation usually connotes consumer gadgets and factory production lines, but this research is concerned with innovation in the context of collaboration and entrepreneurship. Specifically, how can entrepreneurs innovate more successfully from within diverse collaborations, such as those between business owners and university researchers?

The author began this research when part of a university technology project. There was an interesting aim: use of ex-television spectrum radio waves to connect remote communities to the internet. The project needed to find business partners to produce, on a commercial scale, transceivers we had designed. One partner was a large corporation that, in order to make an investment, needed us to form a venture separate from the university; a *spin-out*. It was however revealed that, since our project leader was a university employee, they owned our project's intellectual property [IP]. Since the university had no interest in forming a risky, complicated spin-out, the project eventually died. These events did however spike the author's interest in policy on collaboration and innovation, and led to this research.

1.1   Australian Innovation

Australia places fourth last in collaboration between universities and firms. Worse is venture capital involvement in high-technology companies, in which Australia places absolute last. While there is not a diametric correlation between nations in Figs. 1 and 2 since their variables are merely indicative, the message is nevertheless that collaboration and innovation tend to fail or succeed in tandem, since:

> *As the volume of knowledge grows, complex technologies proliferate, and supply chains become more specialised, it is getting harder and harder to innovate in isolation. Networking and collaboration are essential. Australia's weakness in this area puts us at a serious disadvantage. (2 p. 59)*

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[1] David Brooks provides an alternative perspective for each chapter.
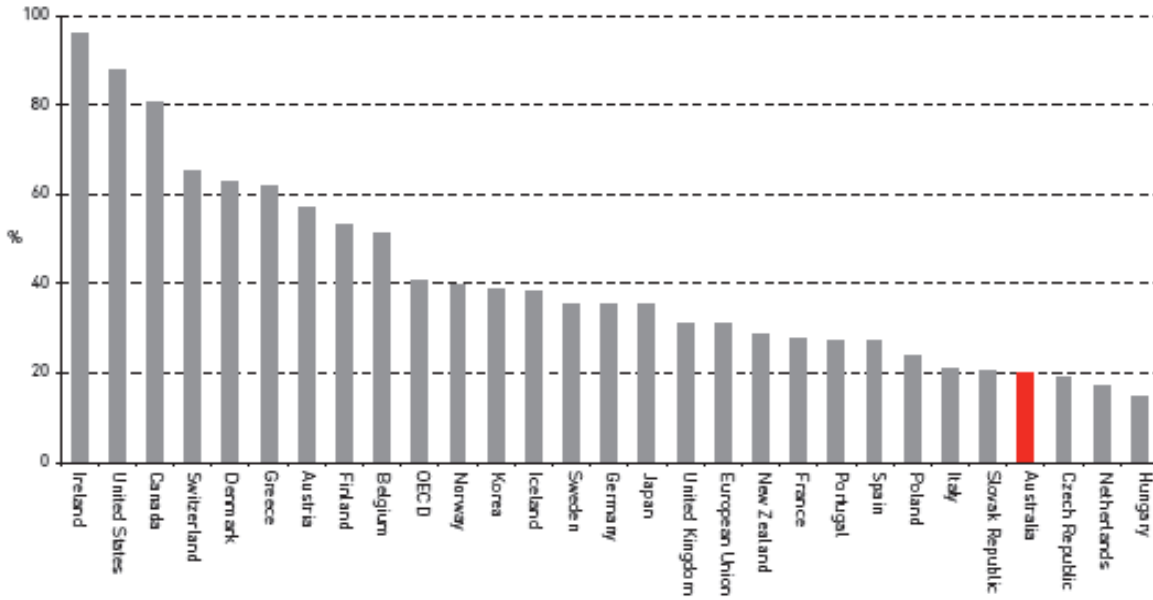
Figure 1: Firms collaborating in innovation with higher education institutions, 2002–04 (3)
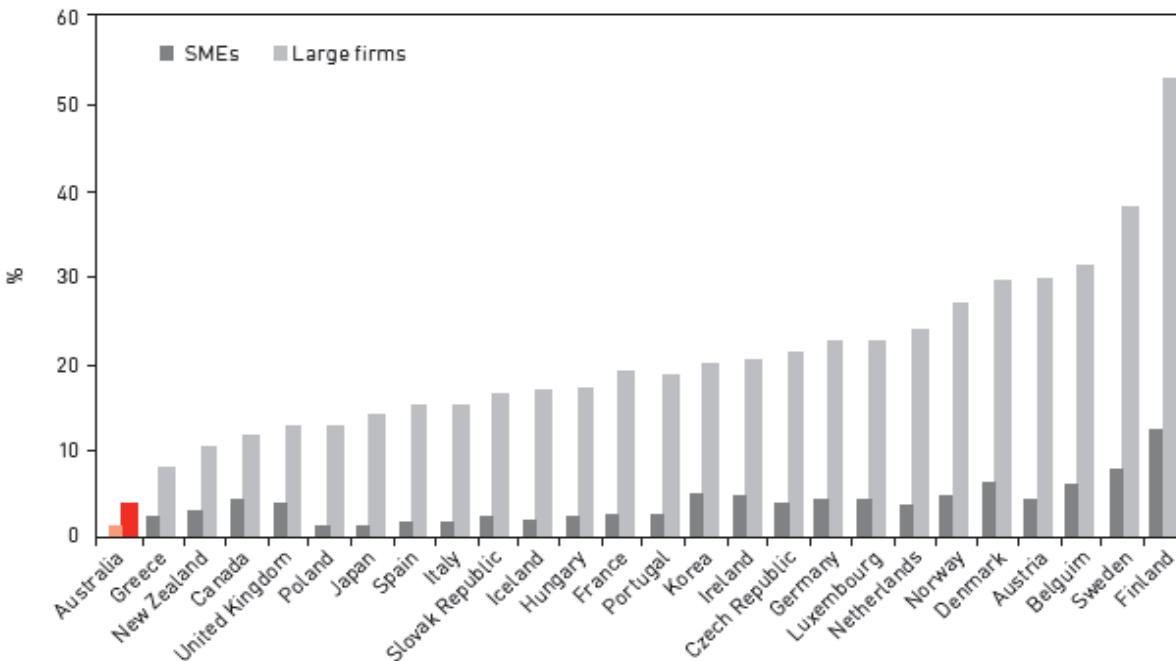
Figure 2: Share of high-technology sectors in total venture capital (3)

With increasing complexity and competitiveness of technology and supply lines, innovation requires access to global markets of knowledge. Business culture must not only embrace new ideas, but build external linkages. This becomes most obvious when dealing with the sometimes-antithetical priorities of business and academia.

> *It is essential that we bridge the cultural divide that still separates the research and business communities. This will require adjustment on both sides. Researchers and business too often take an instrumental view of each other, expecting immediate answers to self-interested questions. Researchers cold-call industry with their latest*

bright idea; businesspeople cold-call researchers with their latest problem. This is not collaboration. Collaboration is about building lasting relationships based on shared trust, shared goals, and shared respect for each party's expertise. (2 p. 62)

With collaboration providing an environment conducive to innovation, the aims of this research are now stated.

1.2   Research Aims

The Australian government's most recent policy document on innovation is extensively critiqued in Appendix A. Its recommendations are found to be unsupported by theory or by case study, but rather underpinned by two assumptions: that innovation should be directly funded by government and that outcomes must be numerically countable (§A.2). This research will show that both approaches are ineffective for promoting innovation, and rather lead to undesirable consequences. An alternative approach will be created.

First Aim: **Create a useful theory of innovation**

Theory must always be subject to testing, but in the human realm this is not straightforward. Innovation requires people to dedicate their time, energy and money, making experiments impractical, expensive and possibly unethical. Requiring significant investment, full scale trials are politically sensitive and success takes years to prove. Yet political considerations can still allow success stories to be ignored (§A.4). This research will endeavour to find instances of functional innovation to compare with, and hopefully support, theory.

Second Aim: **Find evidence to support theory**

After theory has been created and validated by case study, this research will strive to develop coherent policy to promote innovation; one that replaces the current confusing multiplicity of funding programs and exclusive reliance upon accountability-in-hindsight (§A.3).

Third Aim: **Recommend coherent policy**

Since collaboration was found to be fundamental to innovation, a study of collaboration is a natural first step to address these questions. One approach, used in chemistry, physics and biology, is investigation of the smallest possible functional unit. In terms of collaboration, this is a single communication, or transfer, of knowledge.

Over the past century or so, people have built various systems to help them understand human behaviour: economics, political science, game theory and evolutionary psychology. These systems are useful in many circumstances. But none completely explain behaviour because deep down people have passions and drives that don't lend themselves to systemic modelling. They have yearnings and fears that reside in an inner beast you could call The Big Shaggy (4)

Chapter 2.   Discussion

Powering Ideas (2) has established that modern innovation requires collaboration and the author has hypothesised that collaboration is founded on knowledge transfer. It will be demonstrated why this latter logic fails to deliver useful theory; an understanding which will give rise to the more comprehensive methodology of Chapter three.

2.1   Knowledge Transfer

Market competition and division of labour separates knowledge into silos whilst collaboration allows combining of diverse skills and experience. On the assumption that knowledge transfer is critical to collaboration, knowledge and transfer are first explored individually before being examined in concert. 'Knowledge' has two dictionary interpretations as a noun (5).

- *The fact or condition of knowing something with familiarity gained through experience or association;*
- *Acquaintance with or understanding of a science, art, or technique*

'Transfer' is a transitive verb with three meanings (6).

- *To convey from one person, place, or situation to another;*
- *To cause to pass from one to another;*
- *To make over the possession or control of*

In all but one of the five interpretations of knowledge and transfer, transfer's third, a person is explicitly required to be involved. It is evocative of conveyance of property title; "to make over the possession or control of." This requires legal ownership, which can include incorporated entities. However both definitions of knowledge require 'knowing' or 'familiarity' and these cannot be achieved collectively. An entity cannot 'know' or gain 'familiarity' as a person does. A reasonable assertion therefore is knowledge transfer requires two[2] people, one choosing to

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[2]Broadcast of knowledge can be considered multiple parallel acts of one-to-one transfer; coincidentally having the same source.

make knowledge available before the other chooses to absorb it. Any intervening documentation or other communication is merely the medium by which transfer occurs.

Knowledge Management (7) has a slightly contrary view, with knowledge being perceived by two prominent authors as:

> *…a fluid mix of framed experiences, values and contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices and norms. (7 p. 5)*

The first sentence broadly accords with Merriam-Webster while the second makes human involvement necessary. The third sentence expands the definition to include knowledge codified within the inanimate mediums or systems of an organisation, confusing storage with familiarity.

According to the dictionary meaning of knowledge and transfer, knowledge is in transit until a human understands it. If instructions are followed without comprehension, no knowledge is involved. Only if there is some conscious manipulation of knowledge can it be considered transferred. Knowledge creates artefacts[3] that can be used without technical appreciation. The importance of absorbing knowledge, rather than blindly acting upon or utilising it, is subtly corroborated later by the same author.

> *While we'll consider various knowledge transfer issues and strategies in this chapter, many of them come down to finding effective ways to let people talk and listen to one another. (7 p. 88)*

The sentiment is repeated at the conclusion of the same chapter.

> *Too often, knowledge transfer has been confined to such concepts as improved access, electronic communication, document repositories and so forth. We believe it is time for firms to shift their attention to the more human aspects – from access to attention, from velocity to viscosity, from documents to discussion. (7 p. 101)*

It is however possible to unite "documents" and "discussion" since both implicitly require comprehension. An 'indirect' communication medium such as a document still transfers knowledge from the writer to the reader, but without physical or temporal co-location. This is a more robust approach to knowledge transfer.

> *Knowledge transfer involves two actions: transmission (sending or presenting knowledge to a potential recipient) and absorption by that person or group. If knowledge is not absorbed, it has not been transferred. (7 p. 101)*

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[3] For example, the mobile phone is an artefact rich in 'embedded' knowledge.

Rather than residing in an inanimate object, knowledge may be considered en route from a transmitter to a receiver. This holds true for conversation, where communication includes some combination of words, tone of voice and body language. A unification of direct and indirect mediums gives rise to a model of knowledge transfer (Fig.3).
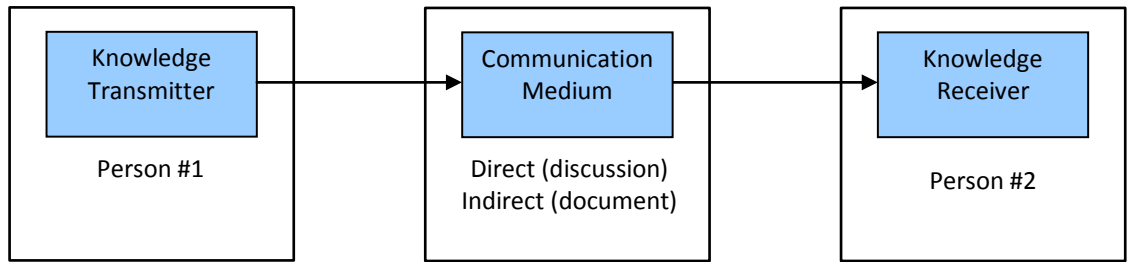
Figure 3: Model of knowledge transfer

The OECD makes a similar distinction between types of industry-science collaboration (Fig. 4).
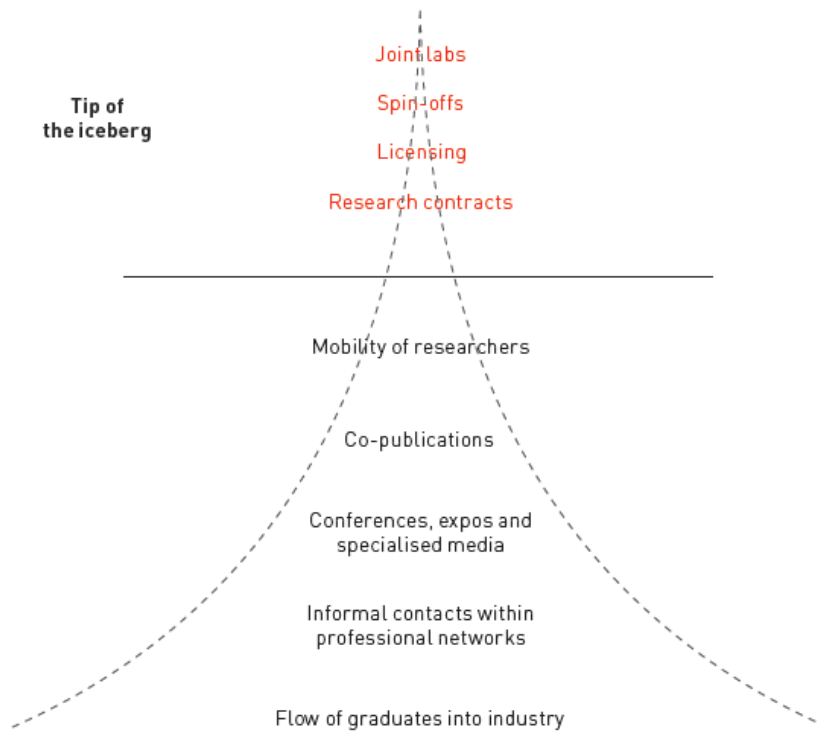
Figure 4: Industry-science relationships (3)

The 'tip of the iceberg' is collaboration characterised by quantifiable agreements. Joint labs are formal arrangements between university and industry laboratories to share research findings. Spin offs are formal agreements between university researchers and investors to commercialise research within a dedicated vehicle. Licensing is a formal agreement between a researcher and industry partner to license a research discovery for use in commercial production. Research contracts are paid arrangements where companies pay researchers to

pursue a line of enquiry, or solve a problem. All are identified by formal agreements that policy makers can easily attribute as successful outcomes.

Supporting these formal agreements are more numerous direct knowledge transfers below the 'waterline'. People interact with one another, be it at a conference, a workplace or to complete a publication. As indicated by the BER policy response (§A.4) they are of less interest to governments since they are difficult to measure, and therefore to provide accountability for. This research aims to find theory allowing better policy that does not discriminate against direct knowledge transfer that is critical for collaboration and thereby innovation.

2.2   Explanations for Failure

Powering Ideas (2) does not have a monopoly on theoretical paucity or policy incoherence. Four policy documents from the first decade of the 20th century, one British and three Australian and are now briefly mentioned. Thereupon, failures of theory and experiment (including the author's) are explained.

2.2.1   Failure of Policy

The featured policy documents are similar to Powering Ideas in that little theory is cited. The Lambert Report (8) is convincing and globally-lauded with findings taken up elsewhere (Australia excepted). The Standing Committee on Science and Innovation (9) puts a range of views without making firm recommendations, with Lambert among those considered. The Productivity Commission (10) defends the status quo with selective case studies and unfounded assertions. This is endorsed by a response to the draft report written by eight of Australia's universities (11) - complaints the final report ignored.

While the Productivity Commission is criticised by the author for using opaque, inconsistent rationale, Lambert himself only relies upon deductive logic and common sense. Given a lack of theoretical basis for decision-making, government policy cannot explain why theory is not utilised. Guidance can however be found in the reasons preferred by social scientists themselves for not resolving complexity.

2.2.2   Failure of Theory

The difficulty with generating theory of collaboration and innovation is two-fold. Weick (12 p. 520) considers that all natural and social sciences begin with an observation or problem statement that "consists of some description that can vary in fineness of detail, accuracy, and explicitness of assumptions which it incorporates". The nuisance of generating theory around

an abstraction like 'innovation' is that none of these can be described with any surety. Any one instance of innovation is different to another, and it is awkward to unite them coherently.

Building theory of collaboration is further challenged by a lack of numerical data that would otherwise allow objective analysis. The Lambert Report drew upon numerical data when it could, but where it could not, used common sense in place of true theory. Its comparative success is explained by the other reports being written in a political context, whereas Lambert seemed to have free reign to address the subject. Additionally, Lambert put his name to the report while others were collectively authored by committee (discussed later §7.6).

This alludes to the second problem where 'success is claimed by all but failure is an orphan.' Every member of a particular group has a subjective opinion of why it has succeeded, but failure usually involves blaming someone else (13). We are genetically inclined to see ourselves and our actions in a positive light as a result of ancestors who fought and survived against overwhelming odds (14). This inherent subjectivity means there is no "problem statement" since in any collaboration everyone has a different idea of the problem, confounding data gathering (15). All of social science involves collaboration to some extent, and this explanation goes part way to understanding why no definitive theory has arisen.

> *By their very nature the problems imposed on organisational theorists involve so many assumptions and such a mixture of accuracy and inaccuracy that virtually all conjectures and all selection criteria remain plausible and nothing gets highlighted or rejected. (12 p. 521)*

In managing this multiplicity of plausible conjectures Thorngate (16) suggests not attempting universally-applicable theory. Thorngate's postulate of commensurate complexity, cited by Weick (17), states it is impossible for a theory of social science to be simultaneously general, accurate and simple since "the more general a simple theory is, for instance, the less accurate it will be in predicting specifics" (17 p. 35). Ignoring this apparently-immutable reality exacts a price for the researcher.

> *Failure to accept the inevitable trade-offs implied in the GAS (Generality-Accuracy-Simplicity) formulation seems to be at the heart of many current research problems. Investigators act as if they simultaneously accomplish all three aims in their explanations, and that delusion is at the heart of much trivial, inconclusive research. (17 p. 36)*

Social scientists are also excused by the political sensitivity and inherent subjectivity of their task (12 p. 521). The natural sciences benefit from studying innocuous subjects and can test a theory against numerical data that will objectively show validity. Social scientists must both set the problem and validate the solution, creating potentially-inescapable bias in assessment of one's own theory.

Regardless of how the trigger to theorising is described, it consists of some description that can vary in fineness of detail, accuracy, and explicitness of assumptions which it incorporates. The theoretical problem that trial and error thinking tries to solve is equivalent to the adaptation problem that trial and error locomotion tries to solve. A conjecture that solves a theoretical problem is equivalent to an action that discovers a niche. In both cases, the likelihood of a solution is determined in part by the way the environment is represented or perceived. The two cases differ, however, in a crucial way. Theorists both choose the form of the problem and declare when their thought trials have solved the problem they pose, a sequence that resembles artificial selection. Theorists are both the source of selection and the source of variation. (12 p. 520)

Weick believes the only path for social science to achieve an approximation of GAS is the summation of heterogeneous conjectures. Achieving this requires "blind thought trials" that allow the process to be "smarter than the people who run it." Grafted from the scientific standard of 'double blind trials' Weick believes that if social scientists are unaware of how their conjecture fits, the best truth of many can be selected. Limiting truths means attendant limitations of scope while "middle range theories" allow accuracy and simplicity to be maintained:

Middle range theories are solutions to problems that contain a limited number of assumptions and considerable accuracy and detail in the problem specification. The scope of the problem is also of manageable size. To look for theories of the middle range is to prefigure problems in such a way that the number of opportunities to discover solutions is increased without becoming infinite. […] When faced with a problem, the theorist generates conjectures about how to solve it. These conjectures, usually in the form of if-then sentences, vary at least in the number of trials generated and the heterogeneity between the trials. In general, a theorising process characterised by a greater number of diverse conjectures produces better theory than a process characterised by a smaller number of homogenous conjectures. (12 p. 521)

Putting aside fallacious comparison with the natural sciences, Weick's recommendation of heterogeneous theory is highly problematic. Since human reality cannot be cleanly delineated, separate theories in different problem spaces allow policy makers resort to select whichever theory they wish. This decision will be typically based upon either good intentions or political self-interest, but as Powering Ideas has shown, the former can be just as detrimental without comprehensive understanding.

In addition, policy duplication is expensive, confusing to participants and adds bureaucratic load, such as writing grant proposals[4]. Also, because the electorate is unable to evaluate multiple policy initiatives with multiple theoretical justifications, they cannot punish bad governments nor reward good ones. For these reasons, and even though it declaims the idea,

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[4] In discussions with the author, academics admitted to spending 30-50% of their time grant writing rather than teaching, researching or innovating. While useful for planning, grant writing is poor use of their expertise.

Powering Ideas' morass of funding schemes and committees is doomed to failure[5]. Even if it succeeded, how can the public appreciate policy without underlying theory that takes decades to deliver results?

2.2.3 Failure of Experiment

When applied to innovation research, the heterogeneous approach was also found to be deficient by Lane et al (18) in their review of *Absorptive Capacity* literature. Absorptive Capacity is a firm's ability to utilise externally-sourced knowledge and involves three sequential processes (19 p. viii).

- *Recognising and understanding potentially valuable new technology outside the firm through exploratory learning.*
- *Assimilating valuable new knowledge through Transformative Learning*
- *Using the assimilated knowledge to create new knowledge and commercial outputs*

Yet Lane (2006) concludes that over a decade of citation and research, the field had failed to usefully converge.

> *…while many of the empirical studies have focused on similar R&D contexts, they have tended to use differing measures, with little concern for triangulation with prior studies. This has resulted in a scattered pattern of knowledge accumulation, in which studies are statistically significant, but theoretically fragmented, a problem common to most areas of organizational research. (18 p. 27)*

To attempt to unify the field Lane et al (2006) models a business using transformative learning (Fig. 5). In proposing such a holistic theory, Lane has identical intent to this research and indeed, the author published a model (Fig. 6) showing remarkable similarity. The line of enquiry was however abandoned since it risked inaccuracy when applied to different contexts and was too complex for general policy recommendations.

This demonstrated to the author that extrapolating theory from knowledge transfer did not lead to a GAS theory. Yet policy application the strictures on GAS theory must be somehow defeated. From a systems perspective, this means finding a method to address and manage complexity that allows convergence across multiple problem spaces.

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[5] Minister Kim Carr was sacked for unstated reasons attributed by the media to disloyalty (217) but this author believes policy underperformance (216) contributed due to a lack of results since Powering Ideas. Certainly nothing has been heard in the media from the various committees set up.
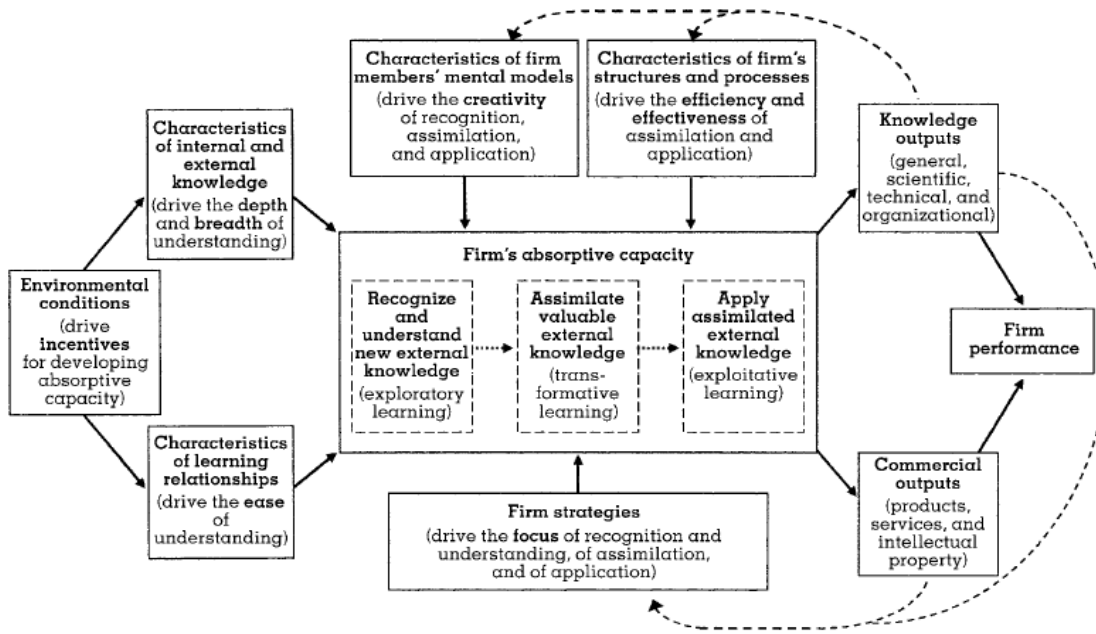
Figure 5: A Process Model of Absorptive Capacity, Its Antecedents and Its Outcomes (18 p. 856)
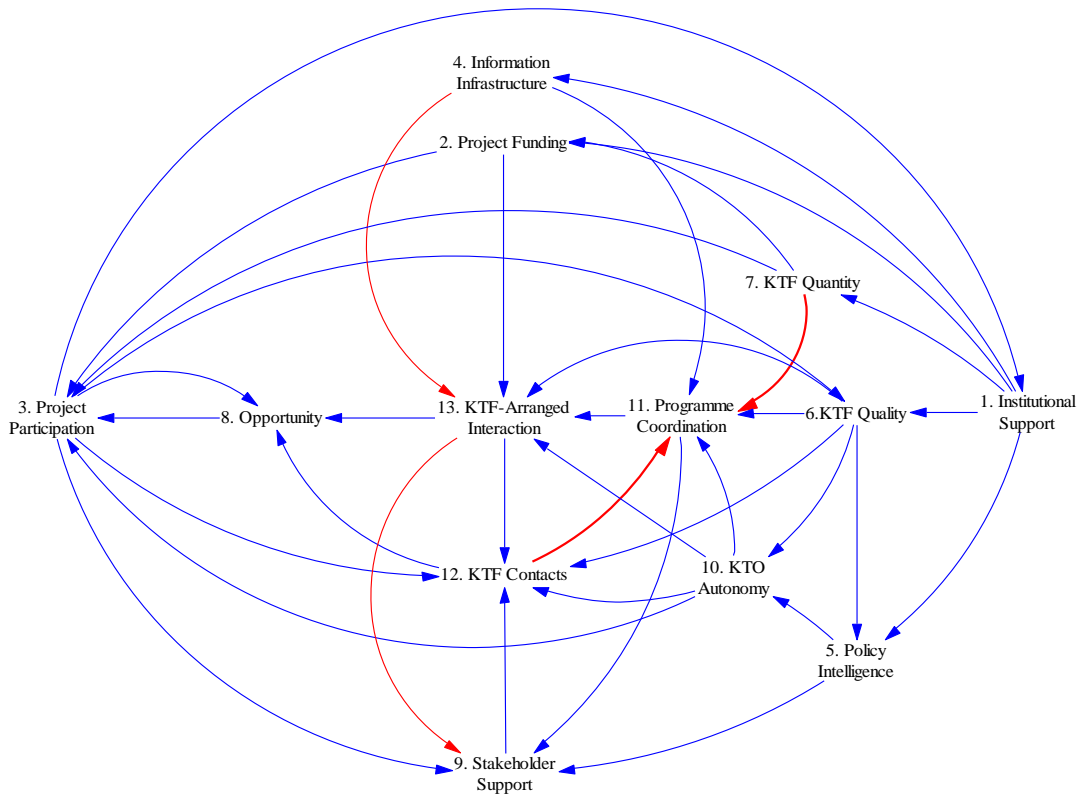
Figure 6: Process Model of University-Business Collaboration, edited[6] for (20)

2.3 Addressing Complexity

Heterogeneous theory is impractical because multiple independent research endeavours cannot easily be combined. Unlike the immutable, fundamental variables of the natural sciences, each social scientist invents their own. Lane et al. found that such a strategy led to shallow, scattered theory, and blamed the pressure to publish and journals' rejection of repeated experiments[7].

> *In short, we suspect that the pressures to jump on emerging research bandwagons, to publish quickly, and to avoid replication are the root causes of the reification of absorptive capacity. While we have no data to verify this, we find this explanation far more plausible than the alternative explanation that the reification was done for other, more self-serving reasons. Moreover, given the increasing pressures to publish and the increasing number of calls for interdisciplinary research, we believe that these potential problems are a timely and important issue for all social scientists. (18 p. 27)*

Complexity Theory (21) asserts that repeated cycles of theoretical testing against reality will uncover complexity. Apparent or perceived complexity is related to the length of the algorithm (or equation) that can reproduce the data, known as Algorithmic Information Content [AIC]. Einstein was celebrated for finding equations with very low AIC[8], while programs that predict the stock market are incomprehensibly long. Restricting research time keeps theory long (and non-GAS) as Lane et al confirmed regarding pressure to publish (Fig. 6).
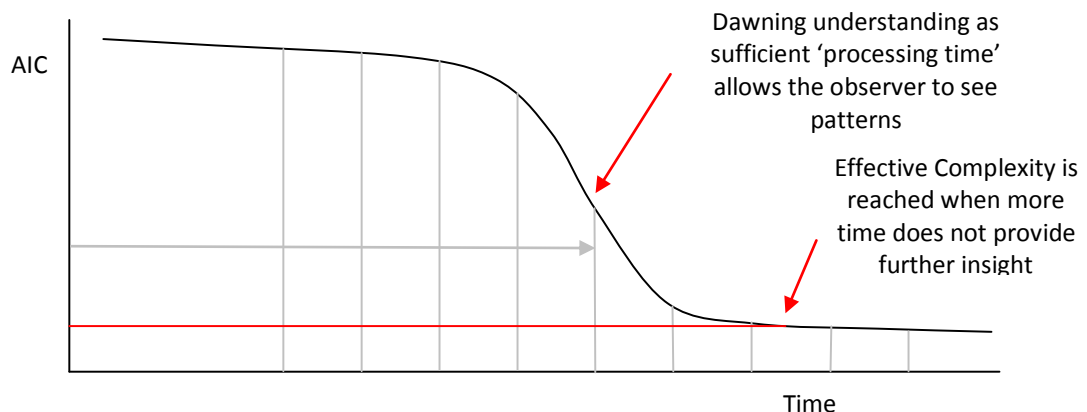
Figure 7: Algorithmic Information Content

Complexity implies interdependency, and theorising from the perspective of a single parameter (such as knowledge transfer) is unlikely to reveal the whole. Rather all parameters must be discovered in concert by examining multiple problem spaces, which for maximum efficiency requires a single team or even a single mind. Numerous teams of researchers

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[7] Rejection of repeated experiments is ironic considering Weick's desire to replicate scientific trials.
[8] $E=mc^2$

attempting to do so would suffer from communication inefficiencies and disagreement that hinder convergence.

If the problem space has more than one pattern to be discovered, more time is required. Some patterns are hidden deeply or require further data to understand, and lead to plateaus waiting for the next discovery. The researcher's growing comprehension of underlying patterns that explain more data and make the problem seem less complex (21) is made apparent In 'Stepped AIC' (Fig. 8).
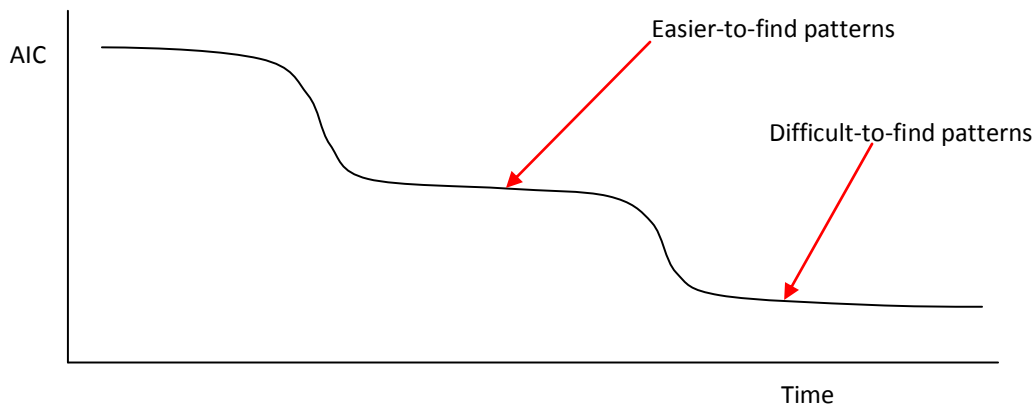
Figure 8: Stepped AIC

A theorist translates raw data into theory by finding patterns within data. Complexity theory postulates a *universal machine* that can find patterns within any digital (for example, 010100011) string. If the data string is allowed to be qualitative, the theorist becomes a universal machine.

> *Complex brains are good at [...] creating high-level neural patterns to make sense of the world. We lack a word to describe this function, but instances abound. A simpler example is our normal three-dimensional visual perception. Here, a network of neurons in the visual cortex compares the slightly offset two-dimensional inputs it gets from each eye. The comparison is used to create an image of a three-dimensional world. Thus we literally see - and not merely infer - real depth. (22)*

Our sight observes a three dimensional world, but a complex system can have more than three dimensions. This research will tease out the complexities of innovation using the mind's capacity to identify patterns, sufficient time to discover them and finding data on collaborative behaviour that is most objective.

Paine believed that societies exist in an "eternal now." That something has existed for ages tells us nothing about its value. The past is dead and the living should use their powers of analysis to sweep away existing arrangements when necessary, and begin the world anew. He even suggested that laws should expire after 30 years so each new generation could begin again (23).

Chapter 3.　Method

This research builds theory of collaboration by combining engineering from *System Dynamics* (§B.1) with social science via *Grounded Theory* (§B.2) alongside *Critical Thinking* (24).

3.1　Critical Thinking

Philosophy's Charles Sanders Peirce has three approaches utilising conceptual information: *induction*, *deduction* and *abduction*. Induction builds theory directly from observed patterns in data.

> *Induction allows inferring **'a** entails **b'** from multiple instantiations of **a** and **b** at the same time. Induction is the process of inferring probable conditional relevance as a result of observing multiple antecedents and consequents. An inductive statement requires empirical evidence for it to be true (25).*

For example, the author inducted that direct (**a**) and indirect (**b**) mediums of communication constitute knowledge transfer, similarly evidenced by the OECD 'iceberg' graphic (Fig. 4) that differentiated between formal and informal collaboration. While induction is useful when data patterns are apparent, deduction can otherwise map disparate logics to an eventual solution. If however assumptions are incorrect, deduced theory will be flawed.

> *Deduction allows deriving **c** as a consequence of **d**. In other words, deduction is the process of deriving the consequences of what is assumed. Given the truth of the assumptions, a valid deduction guarantees the truth of the conclusion (25).*

In Chapter two, dictionary definitions of transfer and knowledge (**c**) allowed deduction of a human-centric model of knowledge transfer (**d**) (Fig. 3). Induction finds patterns in data while deduction extends logic, but abduction can infer false explanations for patterns that appear true. Since there can be multiple explanations for a particular effect, abduction is the most tenuous mental tool.

> *Unlike deduction and in some sense induction, abduction can produce results that are incorrect within its formal system. Hence the conclusions of abduction can only be made valid by separately checking them with a different method, either by deduction or exhaustive induction. However, it can still be useful as a heuristic, especially when something is known about the likelihood of different causes for **f** (25)*

The first instance of abduction was that collaboration consisted of multiple knowledge transfers.

*Abduction allows inferring **e** as an explanation of **f**. Because of this, abduction allows the precondition **e** to be inferred from the consequence **f**. Deduction and abduction thus differ in the direction in which a rule like '**e** entails **f**' is used for inference (25).*

Since communication appeared fundamental, it was thought that all instances of collaboration (**f**) could be explained purely as an environment for knowledge transfer (**e**). This was found to be incorrect through deduction that some model predictions do not accord with reality. For instance, the variable 'autonomy' (Fig. 6) pre-supposed facilitators' wisdom relative to university administrators, but this was clearly unrealistic. Facilitators are human and make mistakes, rendering their autonomy an unreliable parameter. This does not however invalidate facilitators' or knowledge transfer's role in collaboration, and both demonstrate their importance later in the research.

3.1.1   Early Presumptions

Humans may survive as individuals, but only prosper in cooperative groups (26). This implies humans have behavioural patterns that allow effective, reliable collaboration (27). If collaboration is systemic, then its parameters have been evolutionarily selected for. Identifying these parameters may give rise to a model of collaboration.

And it turns out that people are extremely social animals, our species really relies on social interactions to survive or at least it did while we were evolving in the wild and so we have similar unconscious processes that give us a social picture that take information beyond what's actually the data that's out there and factor that in and present to us a filled in, clear looking image that we perceive as being real but is really constructed by our brain just as the visual image is constructed. And that leads to certain kinds of illusions called cognitive illusions that are really the analogies of optical illusions but I really want to stress that the unconscious mind is a gift, even though it is interesting in studying how it works, to examine the illusions, it really works very well and for the most part the illusions are not important. And what is important is that it allows us to function smoothly and quickly whether we are travelling through the physical world or the social world. (28)

Given the number of factors potentially affecting survival, parameters must be prominent or evolution cannot select for them. It is abducted that specific parameters would be foremost in governing behaviour during collaboration.

Early Abduction: **Evolved parameters guide decisions when in collaboration**

Informational relationships between variables are normal in biological systems. If two parameters are intrinsically-unrelated, it is unlikely a biological system (29). Based upon this, it may be deduced that individuals who identify dependence between two previously-unrelated

parameters will make better decisions (30). Those who do so will find evolutionary success, and make permanent the interaction. For example, if the value of a certain parameter is unknown, a new connection to another known parameter would infer it.

If the collection of parameters is considered an engineering system, then parameters are included (or *endogenous*) only when fully connected[9]. An interaction may be slight, but will always be consistently positive or negative. If inconsistent, a third endogenous parameter must be included in the system or else the early abduction is incorrect.

Early Deduction: **All parameters within the 'collaboration system' affect one another**

A system must behave reliably for traits to experience evolutionary forces. This would indicate that the macro behaviour tends towards stability, with collaboration capable of innovation but only through atypical effort. Genes mutate only occasionally, with only a small percentage being desirable and so too would collaboration be dominated by 'business as usual.' Ability to cooperate reliably and efficiently is important in a majority of situations.

Nevertheless, collaboration must have capacity for change in an 'adapt or perish' scenario. Archaeological evidence shows that humanity may have survived a super volcanic eruption with as few as 1000 breeding pairs (31). Others reject this and instead believe that the inherent adaptability of humans minimised the catastrophe's impact (32), which only highlights the importance of group innovation. Surviving occasional but nevertheless unavoidable threats such as food shortages means overcoming a natural resistance to change. Genetic selection had reason to choose both stability and adaption, but stability would dominate given that unless conditions have changed substantially, traditional approaches are usually superior.

Early Induction: **Collaboration is dominated by stability**

Using principles of evolution and biological systems, three presumptions summarise the original premise of this research, with Chapter five later examining their accuracy. Considering the Early Deduction (All parameters within the 'collaboration system' affect one another), the number of interconnections has a factorial relationship to the number of parameters. This potentially-high complexity shows the difficulty of the task, where no one parameter can be considered in isolation.

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[9] Endogenous parameters are those considered to be within the system, exogenous without. The system boundary is a conceptual division separating endogenous from exogenous parameters (§B.1).

3.1.2   Iteration and Recursion

Iteration is taking the result of a completed function and feeding it in next time the function is required. Recursion is nested repetition of a function without the first iteration having finished, but later allowed to. Abduction, induction and deduction can be iterated in sequence, however when flaws become evident, recursion is required.

System Dynamics and Grounded Theory both employ recursive iteration to develop theory (§B.1.2, §B2.2). The former is designed for quantitative applications and the latter qualitative. System Dynamics models a physical system to understand how to optimise it and what undesirable behaviours might arise. Systems can be optimised such as for cost, safety or performance, but since optimisation can lead to fragility, engineers require accurate models to understand their potential for catastrophe[10]. Grounded Theory on the other hand focuses on the vastitudes of qualitative data, with only vague attention given to system behaviour.

System Dynamic's first step in theory building is specification of the system boundary, which the Early Deduction has already accomplished. This methodology's next phase utilises Grounded Theory's identification and utilisation of data sources, explained in the next section. The third step draws upon both schools as well as Critical Thinking to begin building the *collaboration model*.

3.2   Data Sources

The most valuable attribute of data is objectivity, and from the author's experience, the most objective participants in academic-business collaboration were professional facilitators (§7.1.1) employed by the university. In having concurrent and successive responsibility for project outcomes, they have incentive to be objective in assessing reasons for success or failure. Additionally, university-business collaboration provides the most diverse problem space since a university encompasses many academic specialisations, and each invention produced by them requires different paths to market.

At time of writing Australia's university systems of innovation were haphazard and under-performing, representing an unsatisfactory data source. Two English-speaking nations with a lengthy record of effective innovation policies are the United States and Britain. The US has the longest, but is unfortunately the least 'naturalistic.'

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[10] The classic engineering catastrophe was a bridge that collapsed due to wind-induced oscillations. Modern engineers explore this behavioural mode by modelling the effect of wind before the bridge is built. This allows a design that reduces materials and so optimises cost, which otherwise makes a bridge more prone to oscillation.

In interviews conducted during the past 15 years the answer to the question 'what motivates your technology transfer activity' quite often was 'we were told to'. That same response often explained much about the increase in CRADA (industry-research collaborations) signings. In short, much public sector technology transfer activity…was a direct result of formal mandate, not bottom-up in the way of doing business. (33 p. 644)

American academics were encouraged to innovate by being given automatic ownership over their intellectual property [IP] regardless of where funding had originated (8). The arbitrariness of this approach contradicts the author's wish to find systemically-reliable collaboration. British universities had various rules; Cambridge followed the American model, but elsewhere ownership was shared amongst funders and institutions. Additionally, the British government had for some years provided dedicated funding for innovation personnel and infrastructure, and this had had time to bear fruit.

The Thatcher administration allowed each university to decide their approach to research commercialisation, and then funded the best plans. Large variations resulted, providing valuable diversity in problem space, which in Britain were in relatively close geographic proximity. With the author's budget[11] limited, Britain was selected, and preference given to universities with longer records and maximum variance in approach.

- Oxford University possessed an impressive and lengthy record of research commercialisation for both licensing and spin-outs.
- Surrey was proximate and had strong links to the largest technology park in Europe.
- Strathclyde had a highly successful early technology incubator as well as dedicated research into, and teaching of, entrepreneurship.
- Bath had a world-famous system of student internships into business, undertaking applied research supervised by academics, often leading to permanent employment.

The next was task was gaining access to these locales.

3.2.1 Gaining Access

To gain access, a relationship was first established with a central commercialisation office, assisted by the offer of a full briefing at the conclusion of proceedings. Since they were usually grappling with the difficult task of managing the system, the opportunity for an external perspective was appreciated. This meant being given status approaching that of consultant,

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[11] Sponsorship from the commercialisation arm of the ANU, ANUTECH allowed a month stay at each university.

with access to employees. After gaining access to each university, interview subjects were selected on depth of experience commercialising academic research.

3.2.2   Interview Technique

Interviews were best delivered when the subject was relaxed and did not feel expectations were being placed upon them. If disclosure was flowing, little attempt was made to guide the interview beyond prompting for extra information, or to move to a new topic once the current one was exhausted.

> *Forrester (1980) identified three types of data needed to develop the structure and decision rules in models: numerical, written and mental. Numerical data are the familiar time series and cross-sectional records in various databases. Written data includes records such as operating procedures, organisational charts, media reports, emails and any other archival material. Mental data span all the information in people's mental models, including their impressions, stories they tell, their understanding of the system and how decisions are actually made (as opposed to what is written in procedures manuals), how exceptions are handled etc. Mental data cannot be accessed directly but must be elicited through interviews, observations and other methods. The numerical data contain only a tiny fraction of the information in the written database, which in turn is miniscule compared to the information available only in people's mental models. Most of what we know about the world is descriptive, impressionistic, and has never been recorded. Such information is crucial for understanding and modelling complex systems. (34 p. 125)*

In order to more-fully engage with the subject, and avoid the distraction (to both parties) of note-taking, interviews were recorded rather than transcribed. In seeking permission to record from the subjects, most expressed no reservations, and many commented positively[12] on the accuracy of the approach.

During the interviews themselves, the major danger was in not reaching beyond formulaic responses. To create a state whereby information was openly divulged, it was sometimes necessary to play mental games. For instance, offering alternative solutions to answers given by the subject created a sense of competition that would prompt further disclosure. Alternatively, one might inject childish enthusiasm into the interview[13] by expressing (usually sincere) wonder at, for instance, the wider implications of a project they had facilitated or enacted. In general, the aim was to bring the subject out of their 'professional detachment' and enable a state where they enthused about their experiences and opinions.

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[12] Upon concluding an interview, subjects occasionally expressed disquiet at their revelation of confidential information.
[13] It was often valuable to exaggerate the Australian stereotype of a relaxed and laid-back attitude.

It is worth noting that people prefer to speak in terms of what *has* rather than what hasn't worked in order to avoid embarrassment to themselves or their colleagues. Yet failures can make invaluable data, since success can remain opaque, but those behind failure are usually painfully obvious – especially to a facilitator not wishing to repeat the mistake on other projects. Insofar as it was appropriate, any hint of past failure attracted immediate attention.

3.3 Cognitive Mapping

In forming a bridge between unstructured interview data and the modelling process, *cognitive mapping* preserved integrity and richness while allowing extraction of qualitative data. The first step is listening to recordings and transcribing statements to concept maps.
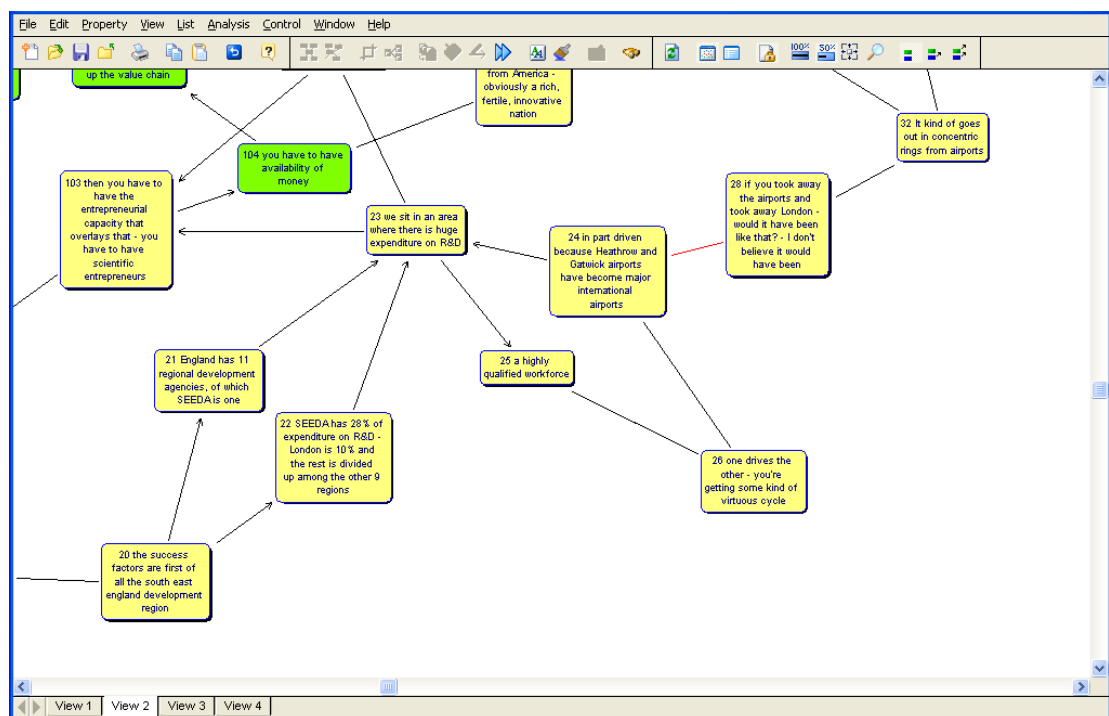
Figure 9: Sample screen shot[14] of concept mapping

3.3.1 Transcribing to Textboxes

Statements made by the subject are recorded within individual text boxes (Fig 9), and numbered for cross-referencing and reproduction. These are joined by causal arrows to show cause and effect, which may be different to the order it was enunciated. Similarity or reference between two statements is indicated by a *connotative* (dashed) link providing clarification of the subject's rationale. *Conflict* links (red) highlight a point of tension within the

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[14] Decision Explorer software published by Banxia.

subject's perception, ambiguity between assertions or an explicit problem raised by the subject.

3.3.2   Visual Geography

In preserving richness, it is preferable to maintain the visual 'geography' of conversation threads as they are laid out. This allows better synchronisation of aural and visual memory. When later recalling and re-examining maps, the geography helps to trigger the recall of details such as tone of voice and inflection. Given the complexity, subtlety and extent of the data, with interviews often approaching an hour, maps allow for quick reference as the data accumulates over many interviews. With the assistance of these visual cues, there was no need to return to the recording, saving time while also reinforcing structured memory.

3.4   Initial Model

The initial model constitutes the first conception of the collaboration model, and provides a base upon which further development can occur. The process iterates between parameter and impact identification. Initially a large number of variables impose a substantial load on cognition, but these gradually resolve into fewer constructs. As iterations of freshly-memorised data and model assessment occurs, parameters and impacts are refined (Fig. 10).

> *…while coding we are constantly moving between inductive and deductive thinking. That is, we deductively propose statements of relationships or suggest possible properties and their dimensions when working with data, then actually attempt to verify what we have deduced against data as we compare incident with incident. There is a constant interplay between proposing and checking. This back and forth movement is what makes our theory grounded (35 p. 111)*

3.4.1   Aural Immersion

In the time taken to visually examine cognitive maps, the modeller can lose track, especially if a number of provisional assumptions are being held. Without context the mind has difficulty absorbing even a relevant piece of data, and a contradictory piece of data calls into question theory to date. With the interview data having thousands of pieces, such destruction is difficult to protect against in early stages of theory development. Aural immersion is undertaken before theory is attempted, since re-listening to number of interviews creates a deeper understanding of the problem space. The brain can then sift data free from expectations of consistency with early theory.

> *Those first pages of field notes are puzzling, you don't know where to start, or even what exactly you're looking for, or whether you'll recognise it if you see it. It's all an undifferentiated mass – all of this [will be] reflected in your early memos. Here is the place to put down, without concern for what others will think or for what is 'correct' or*

true, your first impressions, thoughts and directions to yourself. You can be as insecure as you want in these early stages. Just remind yourself, that if you or even others knew all the answers, there would be no reason to do this particular research. (35 p. 204)
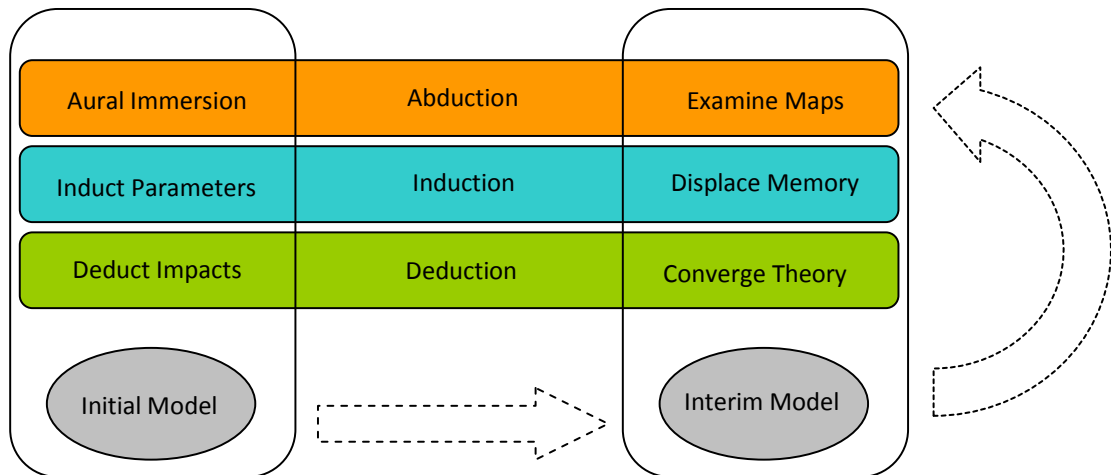
Figure 10: Iterative/recursive process using Critical Thinking

3.4.2   Induct Parameters

The conscious mind has a cognitive limit (36) that prevents immediate creation of theory amid complex data. Using the unconscious, memorised data is correlated and over time patterns emerge from which a set of parameters is inducted.

3.4.3   Deduct Impacts

After settling on a set of parameters, memorised data identifies the existence of impacts between them. As stronger impacts are highlighted, those remaining appear progressively less certain. At the same time, conflicts arise, often as a result of the definition of a parameter 'deformed' by competing rationalisations of impacts. When conflicts arise, the instinctive response is to tighten a loose definition, broaden a tight one or else redefine parameters to achieve separation. However without having the ability the consciously track the full ramifications of a change, it may violate an unconscious but nevertheless important condition.

If too broad, intersection with another parameter may arise when examined in a particular context. Reducing the scope may means it cannot accommodate all impacts. If badly cast, different contexts will give rise to inconsistency within the parameter itself. Unless a conflict can be resolved with a minor change, it preferable to start afresh: removing all impacts and re-inducting the parameters.

3.4.4   Comments on Initial Model

Regrettably the mind has a tendency for 'fractured thought' that reduces its effectiveness as a universal machine. This is similar to George Orwell's 'double think' (37) where an assumption can be made in one circumstance is contradicted in another[15]. The problem is exacerbated when there is insufficient personal experience to ground different circumstances. To counteract inadequate detection of conflicting assumptions, it is necessary to explicitly detail the rationale behind all parameters and impacts.

> *Validating one's theory against the data completes its grounding. One does this by laying out the theory in memos either diagrammatically or narratively. Then statements regarding the category relationships under varying contextual conditions are developed and finally validated against the data. (35 p. 133)*

A written record allows the mind to reliably compare and contrast the assumptions behind conclusions it has drawn, thus revealing inconsistencies. It also helps the unconscious mind to reorganise its data when an inconsistency is detected. The unconscious is powerful, but not necessarily well-ordered.

Fewer parameters reduce the total information in the model, and confidence can requires the number of parameters to be tractable. The unconscious inducts parameters, and is not logically definitive. Parameters are left vague in the expectation they will eventually be revealed[16] but impacts are given explicit attention. The principles of triangulation of evidence means rigorous authentication of impacts against diverse data. Once the initial model adequately represents internalised memory, cognitive maps are examined separately in detail.

3.5   Interim Model

Iterating the *interim model* requires a different approach to that used for the initial model. Whereas previously internalised data generated the model, now cognitive maps are used directly. The mind's tendency to ignore information it does not understand is overcome by exclusively focussing on particular interviews. Forcing the *interim model* to reflect a cumulative proportion of individual interviews improves both it and the modellers' understanding.

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[15] The human mind has evolved to deal with only a single social reality and is why 'culture shock' occurs.
[16] Gravity (a parameter) was discovered through careful observation of the movement of celestial bodies in relation to one another. It was noted that relative distance and mass seemed to interact and produce an inverse square attractive force (the impact) that gave planets elliptical orbits. The existence of gravity was postulated from the behaviour of the planets, but had not been discovered even though the world was permanently under its effects

This identification problem plagues both qualitative and quantitative approaches. In the qualitative realm, ambiguity arises from the ability of language to support multiple meanings. In the quantitative realm, engineers and econometricians have long struggled with the problem of uniquely identifying the structure and parameters of a system from its observed behaviour. Elegant and sophisticated theory exists to delimit the conditions in which one can identify a system from its behaviour alone. In practice, the data are too scarce and the plausible alternative specifications are too numerous for statistical methods to discriminate among competing theories. The same data often support wildly divergent models equally well, and conclusions based on such models are not robust. (34 p. 25)

Identifying relevance to the interim model requires the modeller to comprehend interview data and then compare it with an internal framework, represented by the model (17). Recognition between the cognitive map and interim model sparks further investigation.

3.5.1 Examine Maps

No version of the interim model can fully encapsulate a particular cognitive map since an amount of data will represent exogenous factors. This is a judgement of relevance and veracity, meaning the data is perceived as sufficiently relevant to the theoretical conflict and representative of collaboration rather than aberrant. If the interim model cannot be altered to accommodate disparities, problematic statements are noted and the next map begun. Sometimes the story is powerful but the conflict is incidental or slight, and can be ignored until further confirmation is found.

3.5.2 Displace Memory

As the interim model improves, previous maps are returned to, and new recognitions or conflicts occur. Gradually the modeller develops an ability to distinguish between useful (endogenous) patterns in the data. Earlier conceptions must be degraded through continuous absorption of new data and mental reconfiguration, and cessation of this process may allow them to be re-established. Difficulty arises in prioritising induction of parameters over deduction of impacts since cognition prefers logic.

3.5.3 Converge Theory

While the interim model represents a distillation of accumulated, internalised data, there is a risk that new changes will begin to contradict earlier data (35 p. 217). Conversely, validation of an interview without regard for earlier conclusions risks overlooking data that could potentially unite them. In this way, the modeller can effectively go around in circles, adjusting and readjusting variables around a critical flaw without comprehending it. Once the

methodology was fully adopted, convergence occurred. Developing this methodology was itself exploratory.

3.5.4   Comments on Interim Model

A representative interim model minimises the need to memorise and navigate between large blocks of data. This not only reduces the number of developmental steps, but also means that new data is categorised more accurately. Strauss expresses interplay of relational memory in the unconscious with analytical rationale in the conscious as inductive and deductive thinking respectively.

> *As you have probably noticed, while coding we are constantly moving between inductive and deductive thinking. That is, we deductively propose statements of relationships or suggest possible properties and their dimensions when working with data, then actually attempt to verify what we have deduced against data as we compare incident with incident. There is a constant interplay between proposing and checking. This back and forth movement is what makes our theory grounded! (35 p. 111)*

Extensive conflict between data and the interim model may either indicate that the subject possessed unique insights or the interim model is flawed, and earlier data was incorrectly interpreted.

> *To learn we must use the limited and imperfect information available to us to understand the effects of our own decisions, so we can adjust our decisions to align to the state of the system with our goals (single loop learning) and so we can revise our mental models and redesign the system itself (double loop learning). Yet much of the information we receive is ambiguous. Ambiguity arises because changes in the state of the system resulting from our own decisions are confounded with simultaneous changes in a host of other variables. The number of variables might affect the system vastly overwhelms the data available to rule out alternative theories and competing interpretations. (34 p. 25)*

If it is impossible to know which of these has occurred, the modeller has no choice but to return to earlier versions of the interim model until the conflict disappears. This necessitates complete reinterpretation of relevant interview data, a process that recurs until convergence has recommenced.

A specific example was early dedication of a range of constructs around personnel, reminiscent of the author's process model in Chapter two (Fig. 6). This resulted from early assumptions carried through from the initial model that later introduced irreconcilable conflict. Parameters representing facilitators, administrators and entrepreneurs gave rise to an unmanageable number of impacts, making validation impossible. These parameters were removed, and returned later as exogenous leadership roles (§7.1).

3.6   Final Model

Strauss and Corbin (1990) state that modelling concludes when marginal improvements become allowably small. As the definition of abduction warns (§3.1), abstracted theory can contain flaws that the data appear to support, particularly in a relatively small sample size (twenty five interviews). While the data was rich, and diverse university systems investigated, reaching a final model requires testing of internal consistency to establish theoretical coherency.

3.6.1   Logical Testing

A major use of System Dynamics is the battery of tests that may be applied to models. While many are implicitly used in this research, the primary test is *structure assessment* which asks:

> *…whether the model is consistent with knowledge of the real system relevant to the purpose. Structure assessment focuses on the level of aggregation, the conformance of the model to basic realities such as conservation laws, and the realism of the decision rules for agents. (34 p. 860)*

The early deduction suggests that information relating to parameters is aggregated and utilised as a basis for decision-making by members. Chapter four will show this to be an internal process occurring in all members of collaboration, and is further explored in Chapter five (§5.1).

3.6.2   Summary of Methodology

A method of discriminating patterns in complex data was developed by combining quantitative and qualitative techniques with Critical Thinking. This required selection of appropriate interview subjects in diverse problem spaces, and a method for translating recorded interview data to paper.

A small number of the best interviews were re-listened to, from which an initial model was built. Following its satisfactory development, deeper sequential examination of maps allowed the interim model to converge. The final model then required logical testing based upon the structure assessment test, applied in the next chapter.

People are born with natural desires to be admired and to be worthy of admiration. They are born with moral emotions, a sense of fair play and benevolence. They are also born with darker passions, like self-love and tribalism, which mar rationalist enterprises. We are emotional creatures first and foremost, and politics should not forget that (23).

Chapter 4.   Results

The collaboration model parameters are defined (38) and impacts explained in terms of decisions made by collaboration members. The structure assessment test is applied via equations that explore member behaviour given parameter-specific exogenous factors.

4.1   Defining Parameters

Two primary attributes defining parameters are potential and memory (also discussed §5.6.1).

4.1.1   Parameter Potential

Each parameter is defined conceptually, but also via individual 'potential.' Collaboration performance is the aggregation of member contributions, but is not limited by the sum of their potentials. This implies that members can exceed their individual potential when in collaboration (discussed further §6.1.2). However, members of a poorly-performing collaboration will have low parameter levels compared to their respective potentials.

- *Transfer* describes the rate at which collaboration members receive and transmit knowledge, measured as the rate of information *absorption* (receipt).
- *Activity* is the rate of constructive work accomplished by members of the collaboration, measured *exergy* or 'useful work.'
- *Knowledge* is theoretical and practical knowledge held by the group, measured as known - and therefore *accessible* - expertise.
- *Cohesion* is the health of relationships within collaboration, measured as emotional energy invested.
- *Identity* is the importance members place upon their position within the collaboration, measured as anticipated distress should it be lost or the collaboration close.

4.1.2   Parameter Memory

System Dynamics differentiates between variables with and without memory. Variables with memory, also known as stocks, accumulate or dissipate with past events exerting influence via the accumulated value of the stock. Instantaneous variables without memory value rely solely

upon the current state of the system. Each of the five collaboration variables is now investigated for memory and therefore accumulation.

Plans and timelines coordinate Activity for efficient resource utilisation. Deviation is undesirable since tasks cannot be commenced or halted without repercussion. The parallel considerations of planning make Activity a variable with memory.

People tend to acclimatise to a level of knowledge transfer based upon their accustomed rate of information processing (39). A mind made sharper demands to be exercised with new inputs, and seeks to output knowledge to others. Those unaccustomed to mental exercise find it difficult to quickly adapt to a high rate of knowledge transfer. Transfer is therefore seen to have memory.

According to the model of knowledge transfer, knowledge only resides in the mind. Learning allows knowledge to build slowly, and is only gradually forgotten. Knowledge is therefore seen to accumulate.

Artists commonly feel they are 'only as good as their latest work,' which suggests Identity is changeable. If work is received poorly, the subsequent loss of confidence will cause a sudden drop in Identity. Entrepreneurs are known for their chameleon-like ability to suppress or evoke ego depending upon the situation. This implies that Identity is an instantaneous variable.

Relationships take time to grow or deteriorate, and only children will make friends without question. While friends can be 'dropped' in an instant, the relationship nevertheless persists emotionally. It is more usual for relationships to grow or die over time, and in this sense, Cohesion has memory.

The parameters are now shown in the form of a stock and flow diagram (Fig. 11). Flows supply the attached 'stocks' (parameters with memory) and allow it to be emptied into, or filled by, the 'infinite source' (shown as a cloud), depending upon the directionality of flow.

4.1.3   Impact Equations

Quantitative validation of the collaboration model through numerical data and computer simulation would be desirable but falls outside the scope of this research. Testing logical consistency is however possible using the structure assessment test. A flow is first stimulated by a high or low parameter and the impact ascertained. The parameter is then reversed and it is assessed whether the impact is also reversed. Mathematically, this can be expressed as:

Impact $_{\text{destination flow}}$ (Positive | Negative) = $f_{\text{source parameter}}$ (Level, Factor/s)

Certain exogenous factors have a bearing on decision-making regarding a source parameter, and are introduced at the beginning of each section. Consistency of impact (negative or positive) must be established to satisfy the structure assessment test.
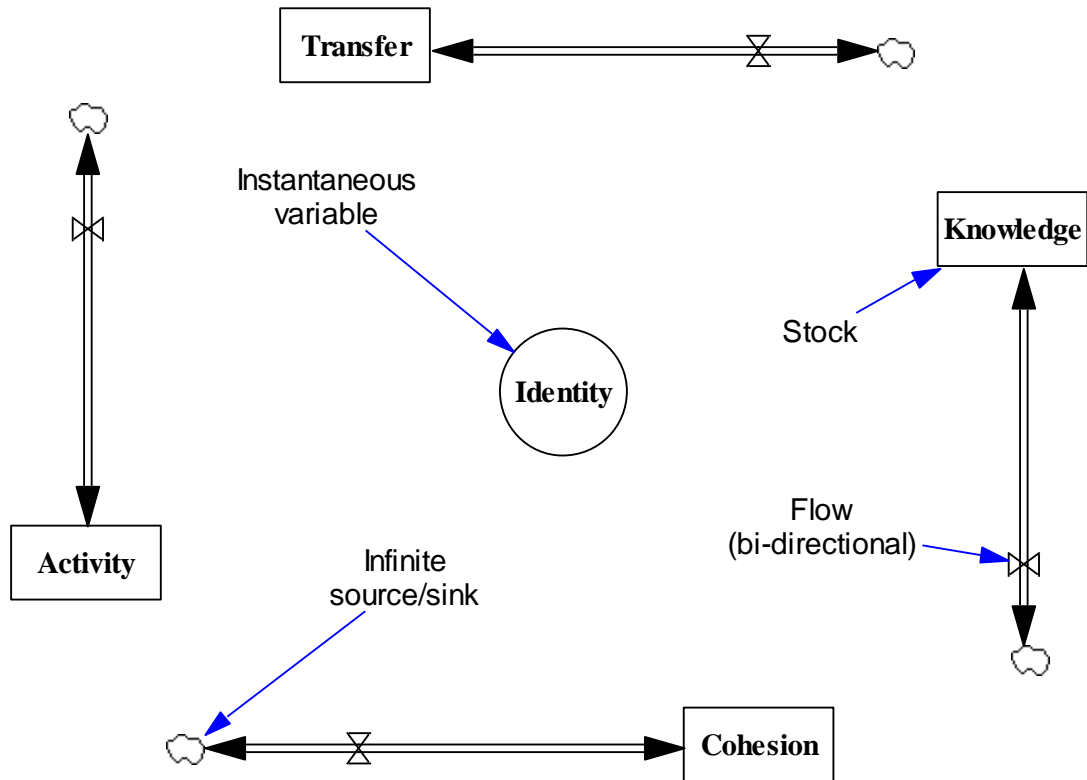
Figure 11: Collaboration model components

4.2   **Impacts of Transfer**

Knowledge transfer is unique[17] among the parameters in that it intrinsically involves at minimum two people. Even if the audience is unknown to the speaker or writer, it is necessary to consider their likely response to the information spoken or written.

When the knowledge transfer is without precedent, and no collaboration yet exists, it is reasonable to posit that occurrence of Transfer invokes the full collaboration model. Invoking the collaboration model provides a means of harmonising future interaction. This means that transmitter and receiver are, however temporarily or slightly, considered in collaboration as a result of their having participated in knowledge transfer. The collaboration might never go

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[17] A relationship can be 'one sided,' such as the fans of music idols, but still have relevance to decision-making.

beyond this act, but while it is remembered, further interaction with that individual (or imagined audience) will be considered in light of it.

The first factor is consistency of impact on the transmitter and receiver of Knowledge. If these impacts opposed one another, the Transfer parameter would not behave consistently. A second factor is that the communications medium can be direct (discussion) or indirect (documents). Both factors are derived from the model of knowledge transfer (Fig. 4).

Whereas other parameters will be seen to have an observer (or 'witness'), Transfer does not. Transfer is not visible to those uninvolved since the actuality of transfer can be easily disguised. The outside observer cannot reliably judge the efficacy of Transfer in which two others have engaged. Listening or reading can be accomplished without actual knowledge being absorbed. According to the structure assessment test, the impact of high Transfer will have opposite effect of low Transfer. A lack of knowledge transfer is a refusal to communicate when an opportunity and need exist. This may take the form of silence or a message empty of Knowledge, or refusal to listen or read, and means Transfer is low.

Impact (Pos) = f (Transfer = Low | High, Transmitter & Receiver, Direct & Indirect)

Impact (Neg) = f (Transfer = High | Low, Transmitter & Receiver, Direct & Indirect)

Transfer is high when opportunities to communicate are taken and low when they are not.

4.2.1 Impact of Transfer upon Activity (T→A)

Tasks that require knowledge exact what is known as 'demand pull' (40). Yet the immediate effect of absorbing new knowledge is distraction from Activity (41). Tasks need focus that is unavoidably lost in the very act of seeking the Knowledge that was demanded by the task. Once knowledge is internalised and ready to apply (K→A), Activity recommences.

Transmitting complex Knowledge is a delicate task that must remain sensitive to the audience. Writing a book requires the author to be cognizant of the state of the listener. Go into too much detail or skim over complexity and the audience become bored or confused. For example, scientists, engineers and other in-depth experts can become distracted from the task of communication by the difficult Knowledge they are transmitting. Receiving Knowledge can also potentially be distracting, for instance internet surfing where an initial query can remain unaddressed after a succession of interesting diversions.

Transfer has a negative effect on Activity; whether direct or indirect and involving the transmitter or receiver.

4.2.2 Impact of Transfer upon Knowledge (T→K)

After absorption, Knowledge is internalised and the mind begins to associate it with pre-existing pieces of information. For both the transmitter and receiver new connections are made and realisations occur. The receiver correlates their new and old Knowledge to extract relevant insights.

The transmitter packages Knowledge to make it coherent and succinct, taking memory and moulding a stream of intelligible, linked concepts. This requires the transmitter to cross-correlate experience and fact with less-certain assumptions and suppositions. Unrecognised flaws and gaps may be uncovered in the process of connecting Knowledge varying by type and context. Authors profess that writing a book is partly to advance and crystallise their own understanding (42).

Does a lack of Transfer then reduce Knowledge? Given a physiological requirement (43) for the mind's connections to be activated in order not to be lost, the answer is yes. Further, as the world itself changes, Knowledge becomes gradually redundant. Transfer is necessary to keep abreast of the latest technology and techniques required by a position.

Transfer increases Knowledge whereas no Transfer decreases Knowledge, whether for the transmitter or receiver, and by direct or indirect means.

4.2.3 Impact of Transfer upon Identity (T→I)

A person's Identity is highly-personal yet multi-layered, and collaboration partly defines it. This may be formalised as a role, such as job title or rank, but also informally understood by the member and their colleagues. Roles are usually associated with specialisation; of responsibility but also of Knowledge. Transfer smoothes out these differentiations by making Knowledge more commonly held. As people become less 'special' they disassociate their Identity from their role and the collaboration in general (44).

A transmitter volunteers to share Knowledge, but in doing so lessens his power and importance. A receiver is the beneficiary of this Knowledge, but is made aware of three potential realities. First, if the existence of the Knowledge was a surprise, they are less knowledgeable than they initially believed. Second, they are less knowledgeable in this matter than the transmitter. Third, the transmitter is liable to share their Knowledge further, rendering the receiver's recent acquisition less valuable still. Any of these three will reduce the receiver's Identity.

Consider now that Transfer is replaced by a message empty of Knowledge, of which religions are perhaps the best known proponent. Supposedly-instructional sermons consist of stock phrases familiar to their congregation. An inherently-unchanging sermon will be attended for years and any deviation from the script is discouraged. No unexpected change to awareness will threaten roles defined by righteous piety. A vacuous message will increase Identity felt by the transmitter and receiver, which not only religions but politicians can use to gain support.

Transfer has a negative impact on Identity, regardless of transmitter or receiver and whether direct or indirect.

4.2.4   Impact of Transfer upon Cohesion (T→C)

Transfer increases Cohesion because it indicates a relationship is strong enough to withstand risk of either transmitter or receiver changing their world view. Both the decision to speak and the decision to listen signify confidence that the relationship can withstand any changes that might ensue. Psychology is familiar with justification-in-hindsight where people post-rationalise decisions (45). Imagined belief in a strong relationship will presage its existence, and in hindsight see that success was anticipated.

The alternative is the transmitter and receiver refusing to Transfer, damaging their relationship. Just as lies breach trust, so silence creates distance.

> *The most important part of telling the truth is that it actually binds you to people,"*
> *explains Seidman, "because when you trust people with the truth, they trust you*
> *back." Obfuscation from leaders just gives citizens another problem - more haze - to*
> *sort through. (46)*

The belief that a relationship is too fragile to withstand Transfer means it is downgraded, perhaps as a risk-minimisation measure, or a loss of respect that the other party had no chance to disprove. A lack of communication is bad for a relationship (47), and while it is acknowledged that truth might be worse, a strong bond makes this unlikely. Otherwise, role-dependent relationships remain stable by selective communication of low-risk information.

In summary, Transfer has a positive impact on Cohesion, for both transmitter and receiver and regardless of the communication medium utilised. This and other impacts of Transfer are added to the previous stock-and-flow diagram (Fig. 11). A descriptive label is affixed to each impact, with blue (solid) arrows positive and red (dotted) arrows negative (Fig. 12).
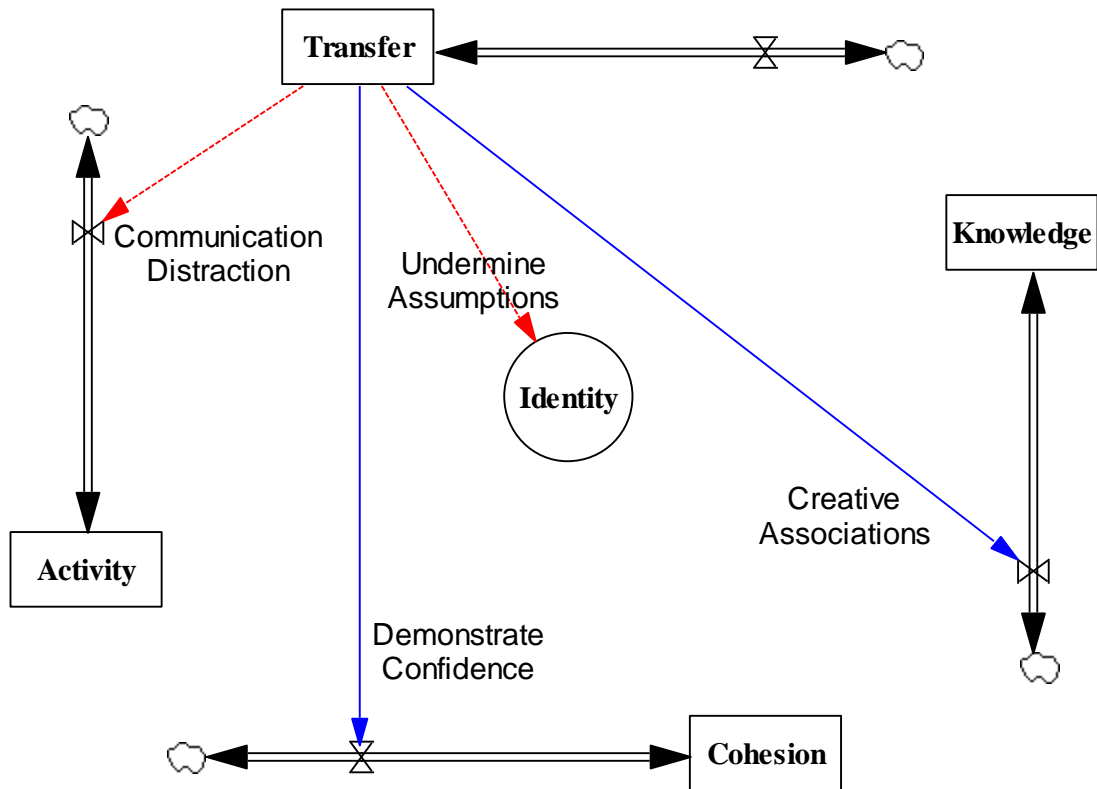
Figure 12: Collaboration model showing impacts of Transfer

4.3   Impacts of Activity

Unproductive endeavours, such as fiddling or procrastinating are a modern phenomenon allowed by economic wealth. In early history, genuine Activity would have been the norm since wastrels threatened group survival and were quickly identified. Activity affects others in the collaboration, and we evolved to notice it. Whether directly observed or indirectly informed, both are considered witnessing. The model must show a consistent reversal of impact between occurrence and non-occurrence of Activity.

It is also recognised that some collaborations tend to be hierarchical with others more anarchic. In the first case Activity is ordered by a superior while in the second it is undertaken on the member's initiative.

Impact (Pos) = ƒ (Activity = Low | High, Protagonist & Witness, Orders & Initiative)

Impact (Neg) = ƒ (Activity = High | Low, Protagonist & Witness, Orders & Initiative)

Activity is high when the protagonist is achieving their potential and low when they are not.

4.3.1   Impact of Activity upon Knowledge (A→K)

Valid Activity builds collaboration-relevant Knowledge. Similarly, watching another undertake Activity can build Knowledge as methods (and mistakes) are observed. Hearing a second hand account of Activity; recounting of an achievement or 'cautionary tale,' can also increase Knowledge. There is no explicit wish to Transfer but a valuable lesson may be imparted nonetheless. Observational or anecdotal learning does not imply Transfer, and vice versa.

While ordered Activity will build Knowledge, anarchic Activity can have greater effect since the protagonist's curiosity will deliberately be made to match a gap in understanding. Activity undertaken against orders is exogenous since it betrays the definition of Activity as being planned within a collaborative context.

The impact of Activity on Knowledge is positive for both protagonist and witness, regardless of being taken on orders or initiative.

4.3.2   Impact of Activity upon Transfer (A→T)

Activity gives rise to situations that require Knowledge to be attained. Successful completion of tasks will often require Knowledge that necessitates Transfer (48). It could be assumed that absent Activity, more time would be available for Transfer. Yet people become accustomed to a certain level of productivity, and when indolence is the norm, additional effort to learn or teach is unwelcome. Busy people are more likely to both transmit and receive.

Observing others as busy will stimulate Transfer. If transmitters observe Activity that requires their knowledge, they will endeavour to assist. Witness receivers will learn in anticipation of duplicating colleague's endeavours.

Taken together, Activity has a positive impact on Transfer

4.3.3   Impact of Activity upon Identity (A→I)

Accomplishment valued by the protagonist is a source of pride and allows increased investment in a position. This is a subjective evaluation whether under orders or initiative. A witness can also increase their Identity observing another's achievement because difficult and subtle details of a task are not apparent. Just as an acrobat's performance looks easy to the untrained eye, so a witness to Activity feels greater pride in their own accomplishments.

Not undertaking Activity means the protagonist's time is underutilised. If due to a supervisor's neglect or incompetence, the protagonist loses attachment to a role in which they are not valued. If this is due to the protagonist's lack of initiative then internal guilt or external blame

is conceived. This is evident when lazy employees complain that a job is uninspiring. When idleness is observed, pride in the witnesses' own Activity is diminished. Observing another's irresponsibility is cause for witnesses to question their own dedication, perhaps seeing it as foolishness instead. This loss of confidence may spread, for instance workplace strikes that grow quickly.

Whether under orders or initiative, lack of Activity reduces protagonist and witness Identity, while the opposite is true for occurrence of Activity.

4.3.4 Impact of Activity upon Cohesion (A→C)

Collaborative Activity requires a team, which builds Cohesion. For example close-knit units in guerrilla or regular armies demonstrate the effect regardless of orders or initiative.

A witness to a team is prone to be well inclined to those they observe. Successful teamwork is a recommendation of good character and also signifies a desirable ally. Alternatively, not being a part of a team is an undesirable social signal that threatens existing relationships and causes those in potential to be avoided.

Activity has a positive impact on Cohesion, along with all other impacts (Fig. 13).
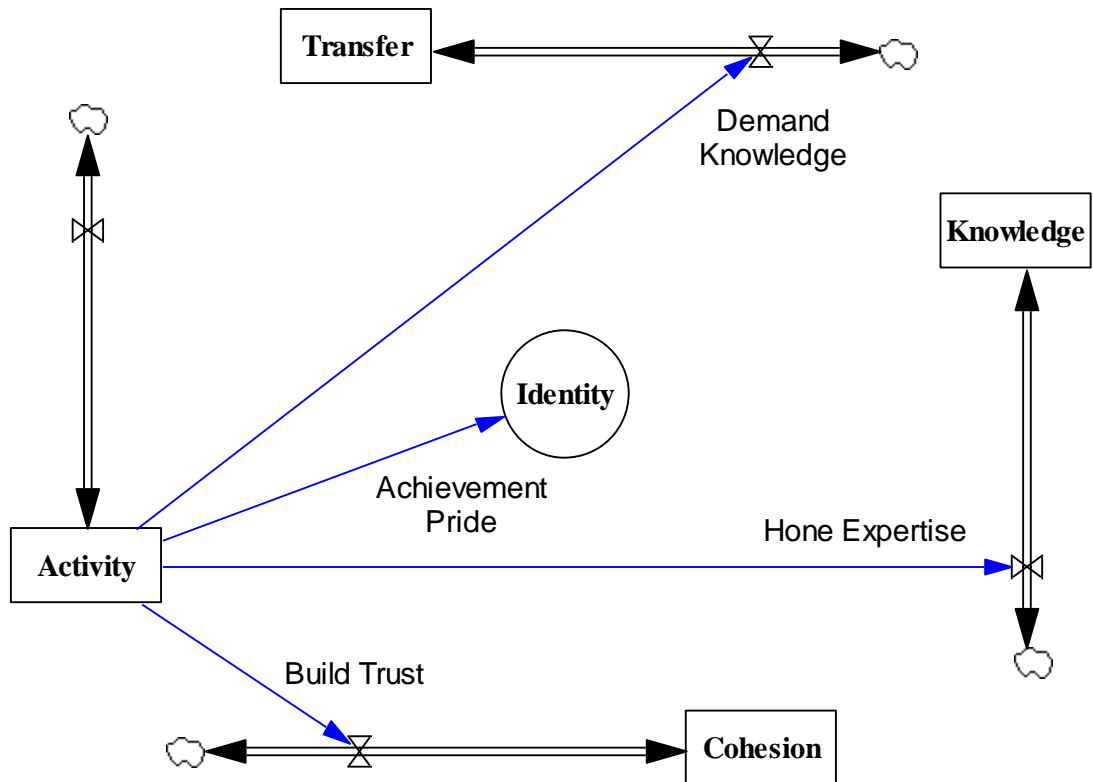
Figure 13: Collaboration model showing impacts of Activity

4.4   Impacts of Knowledge

It is important to note that a particular collaboration will decide what constitutes 'their' Knowledge. Objective truth exists but collaborations are not mechanisms to identify it. For instance, religion and science have different opinions of truth, yet a scientist will be unable to carry out a priest's responsibilities, and vice versa.

Innovation can be helped by unorthodox Knowledge, often sourced from outside the collaboration. While not officially approved, unorthodox Knowledge can provide alternative perspectives and approaches. Highly-proficient individuals often possess unorthodox Knowledge alongside mainstream. People new to the collaboration will tend to focus on attaining mainstream knowledge first.

Knowledge cannot be directly observed, but Activity and Transfer tend to reveal it. Licenses and accreditation are no guarantee of expertise. A witness to Activity and a recipient of Transfer will infer another's level of Knowledge.

Impact (Pos) = f (Knowledge = Low | High, Protagonist & Witness, Mainstream & Unorthodox)

Impact (Neg) = f (Knowledge = High | Low, Protagonist & Witness, Mainstream&Unorthodox)

Knowledge is high when people know how to perform their jobs, and weak when they do not.

4.4.1   Impact of Knowledge upon Activity (K→A)

Activity requires knowledgeable protagonists for optimal undertaking. Activity is also encouraged when Knowledge is witnessed. A witness calculates that if the protagonist has substantial Knowledge in one arena, they are likely to possess it in another and can help if called upon. If Knowledge is observed to be lacking, the opposite conclusion is drawn.

While promoting Activity, unorthodox Knowledge may also have undesirable political consequences. Melbourne's 'Father Bob' was by congregation size and charitable works a successful priest. Yet his unorthodox attitudes on contentious subjects, including equality of religion, rendered him a political threat (49). Here, witnessing unorthodox Knowledge encouraged Activity in the form of attendance at church, but also removing him from office.

Collaboration will allow unorthodox Knowledge if it achieves a desired result. While often producing surprising rulings (50), notably in litigation, the legal system does not adapt itself to

allow child witnesses to testify on camera (51). Christianity[18] invents the quasi-science of 'intelligent design' (52) or justifies wealth-seeking Pentecostalism (53) but proscription against homosexuality and abortion remain core dogma[19]. Yet if unorthodox Knowledge is not permitted to prove itself, it cannot become mainstream, and innovation is prevented. Market capitalism is innovative when it comes to results the consumer judges are important but in the arena of environmental protection, trees or whales do not have buying power. For this reason, market solutions such as carbon trading are intrinsically unworkable since no consumer exists to provide oversight on results (54).

Knowledge has a positive impact on Activity for the protagonist whether mainstream or unorthodox. For the witness, only mainstream Knowledge consistently increases Activity.

4.4.2   Impact of Knowledge upon Transfer (K→T)

Knowledge is valuable when utilised (55) rather than kept hidden, and the protagonist's desire for recognition drives their transmission. Academic publication without prior demand is known as 'supply push' (40) but low quality findings reflect poorly and will not be disclosed. Similarly unorthodox Knowledge may not be well received and does not necessarily encourage transmission.

Learning becomes easier once a mental framework exists. A knowledgeable protagonist will seek to receive more Knowledge since less effort is required, and staying informed is preferable to being found ignorant, with ensuing reputation damage. A results-driven collaboration will expect an expert to have unorthodox Knowledge, and new ventures employ eccentric geniuses for this reason (56). On the other hand, a 'learning curve' means substantial time before Knowledge is useful, and is why companies prefer to avoid the expense of training.

A witness to Knowledge will themselves be encouraged to Transfer. In undertaking interviews, the author professed personal theories to elicit data from subjects. Being rare, unorthodox Knowledge was potentially of greater value, and inclined the subjects to transmit themselves. Teachers can foster class interaction by allowing children to demonstrate specific Knowledge. Alternatively, transmission after witnessing ignorance is an unfair exchange as the witness has less to gain in collaborating. Witnessing ignorance will reduce Transfer, and if smarter children in a class are not listening to the teacher, others will follow.

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[18] Marxism is similar to a religion, and the author's critique of Foucault (233) was deemed "wrong" by a sociology professor as a result of its (unwelcome) conclusions rather than method.
[19] Ironically there is clear instruction against wealth in the Bible, but little mention of abortion or homosexuality.

In summary, Knowledge has a positive impact on transmission and receipt for both the protagonist and witness. Unorthodox Knowledge may have political implications in some instances but otherwise follows the same pattern.

4.4.3   Impact of Knowledge upon Identity (K→I)

Knowledge is power in the sense that it provides opportunity for effective action. Knowledge often justifies greater pay, respect and authority, all of which signify that the protagonist can feel confident in their ability. This applies equally for unorthodox Knowledge, where even if not useable due to specific restrictions, confidence is still felt.

A protagonist with poor Knowledge cannot build Identity on the basis of their position, regardless of whether they honestly appraise their own value or else dishonestly avoid exposure as a charlatan. Those possessing unorthodox Knowledge are however advised to keep their ego in check, since different does not equal better, yet believing so (C→K) may cause group fragmentation between mainstream and unorthodox supporters

For a witness to low Knowledge, effort will be made to sideline or remove the protagonist in question. Knowledge is position-specific, but the collaboration is collectively rendered weaker, and the witness's position by extension. When the situation is reversed, a capable colleague will have the opposite effect.

Overall, Knowledge has a positive impact on Identity, regardless of protagonist or witness. Identity based upon unorthodox Knowledge may cause group fragmentation.

4.4.4   Impact of Knowledge upon Cohesion (K→C)

Under stress, survival takes precedence and relationships are deprioritised. Knowledge helps relationships by reducing uncertainty and stress. All animals react poorly to unfamiliar surroundings or stimuli, but humans can also be stressed in the abstract. Examples include asylum seekers who under indefinite detention report that their uncertain status is most stressful (57). Another is 'closure' experienced after loved ones are found.

This is also true for witnesses since expert colleagues are reassuring even if never utilised. The appearance of confidence helps, and emergency workers are taught to stay calm. Religious people congregate for mutual reassurance, where personal doubt is assuaged by general fervency.

Overall Knowledge has a positive impact (Fig. 14) on Cohesion for both protagonist and witness. Orthodoxy is irrelevant since confidence is delivered regardless.
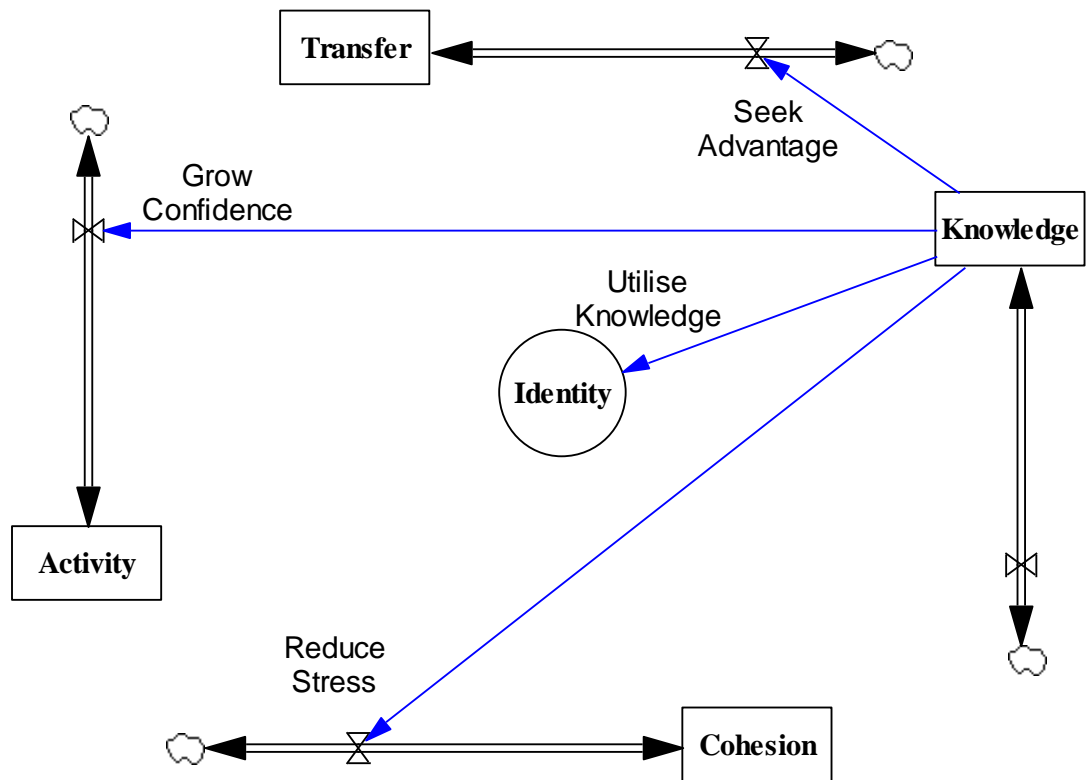
Figure 14: Collaboration model showing impacts of Knowledge

4.5 Impacts of Identity

Every person must identify themselves somehow, often in a variety of ways (58). Employment, family, friends, sports and ethnicity are among a myriad. Having different Identities to draw upon provides resilience as Identity is dynamically assigned depending upon the situation. With no single collaboration being critical a person can adapt easily, and survive failure in one particular realm. The evidence lies in entrepreneurs who graft self-confidence to their business idea, creating motivation to work hard and find eventual success. If the business fails, another is easily embraced (59). Depending upon when it is advantageous, entrepreneurs are arrogant and decisive, yet can also listen and respond with humility,

The opposite of dynamic Identity is that which remains static, and may be high, low or anywhere in between. Identity is static-high when a specific role and collaboration is of great significance. Identity remains low if the person is unable to place enough importance on their own effort. Static-low Identity is apparent in many of those who disassociate after childhood abuse (60). Static-high Identity is often the result of critical and emotionally-distant parents, where over-achievement hopes to find praise (61).

When in power, those with static-high Identity become dictatorial as political threats to a valued position are systematically removed and active worship demanded, such as in Hitler's

Germany or Stalin's Russia. Alternatively, static-low leaders indecisively vacillate between competing forces, such as to tribe, religion or family, Karzai's Afghanistan for instance. An in-between case is 'static-medium' Identity where the nation is ignored as long as the leaders' interests remain unthreatened. Such heartless pragmatism can be seen in many quasi-democracies; Iran and Syria at time of writing or Putin's Russia (62).

Different to Activity and Knowledge, Identity cannot be observed directly and may only be weakly inferred over time as patterns of behaviour are observed and correlated. In some cases Identity may never become apparent, evidenced by long term relationships ended with announcement of homosexuality or similarly emphatic reason.

Impact (Pos) = f (Identity = Low | High, Dynamic & Static)

Impact (Neg) = f (Identity = High | Low, Dynamic & Static)

Identity is high when importance is placed on a position and weak when it is not.

4.5.1   Impact of Identity upon Activity (I→A)

Identity provides an incentive to act since Activity provides evidence of the wisdom of making a personal investment in the position. Strong Identity requires more Activity to substantiate it, whereas weak Identity is justified by a lack of Activity.

Modern India is a blend of traditional castes and British colonial influence (63) that has created today's weak leadership (64). Nineteenth Century Britain was renowned for two things: a diligent public service and an aloof upper class, and many of the latter were sent to manage the Indian colony (65). India had previously been governed by monarchies that were removed or weakened under occupation. There was no Indian tradition of public service to offset introduced British aristocrats and their primary duty of protecting trading interests. Observing lazy, callous British rulers bred an expectation in upper caste Indians that achieving high office only carried responsibility to oneself and powerful interests. Today's Indian leaders corruptly seek alliances with industrialists, but also religious and nationalist zealots (66) (67). None of these is concerned with outcomes such as poverty, education, health (including family planning) and infrastructure (68) (69).

Such behaviour is not limited to India, and America's religious conservative politicians are commonly caught in corruption or sexual scandals. Collaboration's tendency towards conservatism is dangerous in the fast changing modern world. In earlier times, the tribe depended upon tradition as a record of survival measures, and altering what had worked in the past was supremely dangerous. Yet today's technology advances, population increase and

ecosystem failure requires society to adapt. Conservatism is no longer appropriate, and worse, leads to corruption as old methodologies become irrelevant and institutions find themselves without true responsibility and in a position to extract advantage. Social innovation requires entrepreneurial leaders with dynamic Identity (70) but unfortunately the Western norm is career politicians with an early and exclusive dedication to politics, and resulting static-high Identity from narrow rather than extensive collaboration.

Overall, Identity has a positive Impact on Activity.

4.5.2 Impact of Identity on Transfer (I→T)

A position usually has associated responsibilities to teach and learn, and those who place more importance on their position take these responsibilities more seriously. This includes a senior instructing a junior, but also a junior reporting upwards. Entrepreneurs are known for a capacity to listen when appropriate, and teach or otherwise delegate when required. Seniors with static-low Identity will not care to teach but those with static-high Identity will not delegate, so there may be no one to listen.

Low Identity means not feeling compelled to transmit requisite information, nor listen when it is made available. Those with low Identity will tend to not Transfer, but if they do, their Identity is lowered further (T→I), making the decision to not Transfer a self-preservation measure. For instance, the psychological state of those who are 'quieter than usual' will be enquired into. The audience to Transfer can offset ensuing low Identity by reflective listening (K→I) and shared solution development (A→I). On the other hand, if too warmly expressed, thanks can diminish Identity (C→I) and may be unwelcome if Identity is already low.

From the transmitter's point of view, those with static-high Identity experience conflicting emotions in the act of knowledge transfer. They are initially compelled to speak at length, but if the audience provides an informed response, they feel threatened and resentful as their Identity moves uncomfortably lower.

Overall, Identity has a positive impact on Transfer.

4.5.3 Impact of Identity upon Knowledge (I→K)

A side effect of strong Identity is a tendency to exclude information that does not support their ability to carry out responsibilities. Those with high Identity must believe in their capacity, and evidence that threatens this belief is unwelcome. Additionally, logical conflicts potentially threatening decision-making are found and removed. Over time, systemic analysis

and censoring of internal memory means becoming progressively less knowledgeable as conflicting, yet potentially useful, information is lost.

Alternatively, low Identity allows all Knowledge to be kept, since it makes no difference if it threatens a position. While this allows logical conflicts to persist (§3.4.4), the bulk of Knowledge remains in place. This may explain why some people are good at trivia or remembering jokes, while others are not.

In anticipation of this, the entrepreneur will lower Identity to consider new business opportunities or to understand threats. Managers with static-high Identity will use their (exogenous) authority to exclude Knowledge they find uncomfortable. Business owners with static-low Identity tend to not succeed due to indecisiveness when first operating (I→A) and thereupon employee disrespect (I→C).

Regarding employees, young employees with lower Identity are preferred for ease of training, while a mature worker must reduce their ego to 'learn new tricks'. Young people have intrinsically low Identity because they are still finding out who they are, and it is only unhealthy if persisting into adulthood. Highly desirable is the worker that can transition from static-low Identity when young to dynamic once they enter management ranks.

Identity has been shown to negatively impact Knowledge.

4.5.4 Impact of Identity upon Cohesion (I→C)

Others in collaboration feel more comfortable relating to those who actions and words are appropriate and expected. A strong Identity allows for a stable and comprehensible tone of voice, posture and facial expression. Information communicated in appropriate for the position and relationship.

Since those with low Identity have little of importance associated with their position, they have no compunction acting obliquely or changing style. Without the impetus of Identity, actions are not correlated against a role. Even should they wish to put their audience at ease, the body language and choice of words of those with static-low Identity will seem inappropriate and uncommitted. Others draw away as they instinctively react to perceived disingenuousness. In some cases, stuttering can be assisted by deliberately raising Identity, thereby better enunciating words and putting the audience at greater ease[20].

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[20] Personal experience of the author.

'Confidence men' such as cult leaders initially attract followers, but eventually falter when they cannot adapt to increased exposure to reality (71). The counter example is putting a 'puppet on the throne,' where low Identity is desirable. Before his ascendency Stalin hid his true nature behind a comedic, facile façade and senior comrades who promoted his ascendency (72) as the harmless, manipulable 'compromise candidate' lived to regret it. Stalin was a static-high cult leader who could not adapt, and maintained his power over an unchanging nation with a combination of brutality and propaganda.

Entrepreneurs respond comfortably to their collaboration's demands to alter Identity. They seamlessly transition between varying situations; whether directing employees, speaking to shareholders or holding media interviews.

Overall, Identity has a positive impact on Cohesion, as shown in Fig. 15.
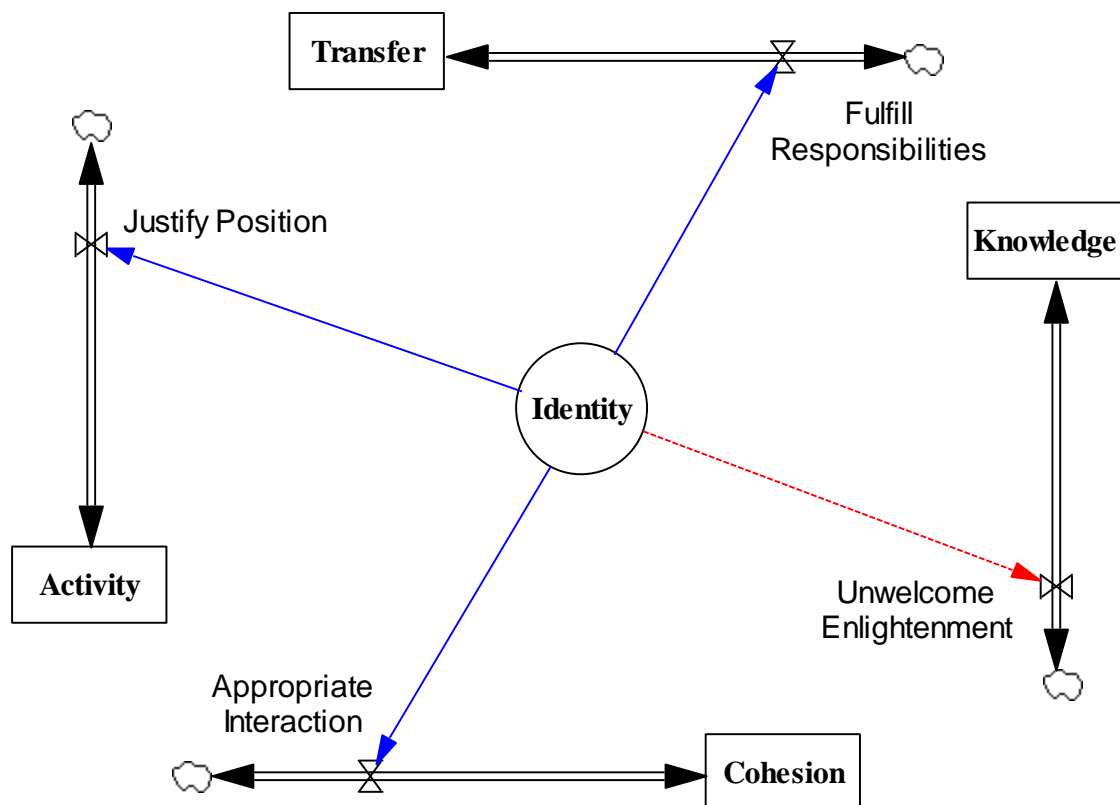
Figure 15: Collaboration model showing impacts of Identity

4.6   Impacts of Cohesion

Cohesion is observable and relationships often the subject of gossip. Witnesses observe relationship health in order to calculate political alliances. Not only is closeness between particular individuals important, but so is the general state of the collaboration.

Impact (Pos) = f (Cohesion = Low | High, Protagonist & Witness, Individual & General)

Impact (Neg) = f (Cohesion = High | Low, Protagonist & Witness, Individual & General)

Cohesion is regarded as strong when people trust and like one another, and low when they do not.

4.6.1　Impact of Cohesion upon Activity (C→A)

Relationships are a powerful motivator to action, and we help those we care about. Military forces are commonly cited examples of sacrifice, but in times of emergency even normal citizens will selflessly help those they have but an implicit relationship to. Alternatively, a country riven by conflict and desperation will see its people ignore one another's suffering[21]. Poor relationships will persist (A→C) as there is no allegiance compelling unified action.

Physical evidence of Cohesion promotes people to act harmoniously, whereas evidence to the contrary produces the opposite result. For example, a famous experiment showed that quickly repairing broken windows in an urban neighbourhood reduced rates of crime (73).

If a person is observed to be popular, action is prompted by potential for a valuable ally, while also avoiding their (and wider) enmity. On the other hand, unpopular loners with poor relationships will not be assisted.

Cohesion has a positive impact on Activity, whether witness or protagonist and individual or general relationships are involved.

4.6.2　Impact of Cohesion upon Transfer (C→T)

We help others by better-informing them, and by listening we help ourselves. We speak or listen to those we like, taking time to write, and read their works. The stronger the protagonist believes the relationship to be, the more Transfer will be sought.

A witness to sincere interaction will seek to replicate it. To be an uncommunicative group in a room full of animated discussions reflects badly, and jovial conversation will be attempted. If however silence reigns, friends will mute their feelings temporarily in order to reduce interaction. It is commonly held that happiness is catching, but the opposite is also true, and catching a scowl will render us less well-disposed to others.

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[21] The Chinese superstition of transmissible misfortune is consistent with their history of turbulence and deprivation.

Both for general and individual, and for protagonist and witness, Cohesion has a positive impact on Transfer.

4.6.3 Impact of Cohesion upon Knowledge (C→K)

'Group think' in tightly-bound collectives (74) centralises views, often toward tradition or accepted perspectives and assumptions. Cohesion unifies thinking through cultural norms that reject unorthodox Knowledge. Mainstream is affected also, since once unorthodox Knowledge disappears, that which is left is re-divided into mainstream and unorthodox. The norm is then narrowed, and rejection of unorthodox Knowledge repeated; a process ironically most common in religious zealots or 'extremists.'

In a further twist, those heading extremist groups are often psychopaths with intrinsically weak individual and general Cohesion, and have no compunction identifying the most beneficial path for themselves or their organisation. They are however intelligent enough to recognise that unorthodox Knowledge threatens their control, and diligently suppress it.

In individual relationships, people will self-censor to 'keep the peace' whereas internet forums characterised by weak relationships are replete with strong opinion. A witness to censorship will be warned to act similarly but a frank exchange allowed by a weak relationship encourages liberated thinking in others.

Cohesion has a negative impact on Knowledge, regardless of whether protagonist or witness and individual or general.

4.6.4 Impact of Cohesion upon Identity (C→I)

Two people in a strong relationship will tend to replicate one another's behaviour[22]. This includes providing constructive feedback to alter another's behaviour, or altering their own in sympathy, such as by adopting mannerisms. Regarding general Cohesion, a member will adopt group norms if they like the collaboration, but will otherwise reject them, as do rebellious children of parents they dislike.

When people copy another's behaviour, they are lowering Identity since a role becomes associated with another, and losing it becomes potentially less painful. For a similar reason, those afraid of failure will not put their best work on display, or even self-sabotage.

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[22] The extreme case of impact of Cohesion on Identity is neatly encapsulated by the 'Borg' from Star Trek who formed a collective consciousness without individual identities.

Relationships are not lost when a position is lost, or necessarily even when collaboration is left. As will be discussed, much of Silicon Valley's success lies in ex-employees maintaining relationships (§6.2.1). If it were true that relationships depended upon position, then Cohesion would have a positive impact on Identity, but this is not the case.

A witness to a group with high Cohesion will accept lower Identity to fit in. Alternatively, groups where members are distant from one anther will encourage the witness to remain independent, with ensuing high Identity.

Cohesion has a negative impact on Identity, for general and individual relationships and both protagonist and witness (Fig. 14).
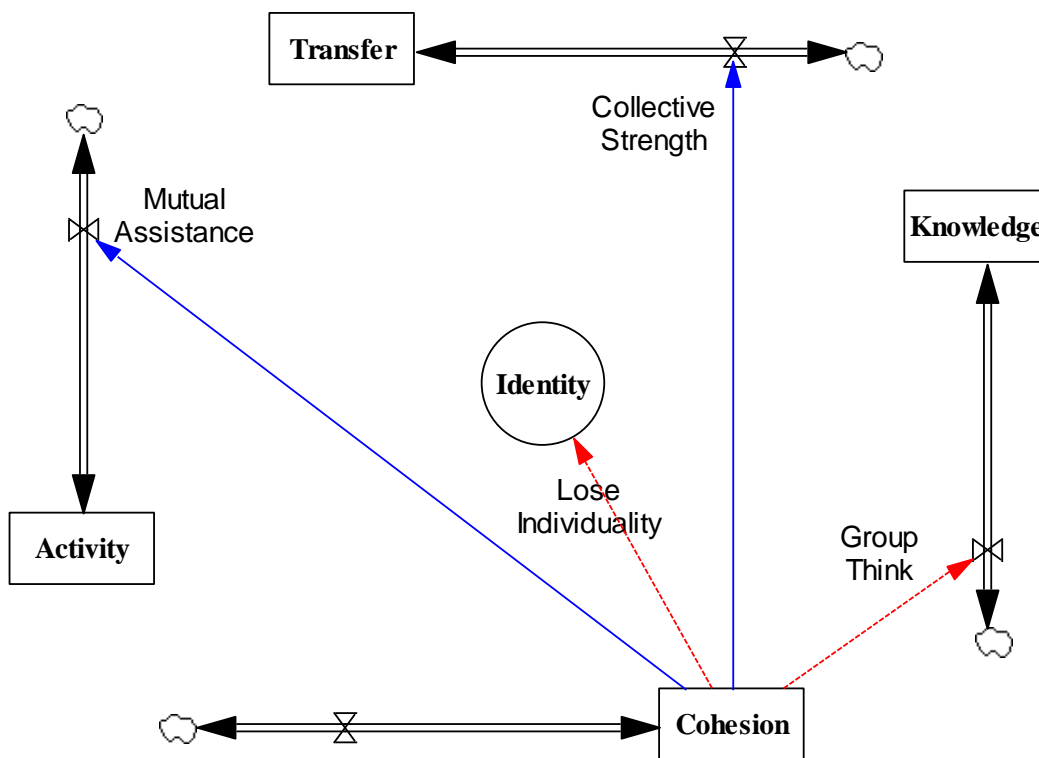
Figure 14: Collaboration model showing impacts of Cohesion

This concludes presentation and logical testing of the collaboration model. Before policy implications are drawn, analysis and further exploration is required.

If your identity is formed by hard boundaries, if you come from a specific place, if you embody a distinct musical tradition, if your concerns are expressed through a specific paracosm, you are going to have more depth and definition than you are if you grew up in the far-flung networks of pluralism and eclecticism, surfing from one spot to the next, sampling one style then the next, your identity formed by soft boundaries, or none at all (75).

Chapter 5.   Analysis

This chapter uses principles of evolution and discoveries on brain structure to test the early abduction; animal and human behavioural models the early deduction; and engineering theory of feedback the early induction.

The early abduction (Evolved parameters guide decisions when in collaboration) is investigated through occurrence of collaboration parameters in modern humans, demonstrating that increasing population forced collaboration into differing environments. As humans moved from tribes into villages and finally towns, the effect of collaboration parameters on decision-making adapted also.

To address the early deduction (All parameters within the 'collaboration system' affect one another) requires peering earlier in evolution, at mammalian behaviour. Human collaboration was critical to overcoming physical deficiencies of speed and power. Since animals collaborate less well, the early deduction implies reduced interconnection of the collaboration model. Showing this may confirm that fully-connected parameters allowed for better decision making, and so was evolutionarily selected for.

Testing the early induction (Collaboration is dominated by stability) requires stability of the collaboration model to be investigated via engineering control theory. Impacts are paired into feedback loops that in concert drive overall model behaviour, showing when stability occurs. First however, the concept of collaborative *engagement* is explored.

5.1   The Decision to Engage

Maslow's 'Hierarchy of Needs' is often assumed to be accurate, but in fact remains only conjectural (76). Other works, popularised by Pink (77) and drawing on Deci & Flaste (78) posit incentives that 'move beyond the carrot and stick' but lacking scientific trials are also conjectural. The collaboration model similarly would be assisted by the scientific evidence that Maslow and Pink are missing.

The highest standard of proof is double-blind trials, but trials on humans, particularly when controlling for complex, qualitative variables are problematic and potentially unethical. An alternative standard is association to scientific findings, here fortunately available by proxy. The SCARF model (79) has itself never been tested experimentally but its underlying rationale is based upon clinical brain research, providing an opportunity for indirect scientific evidence supporting the collaboration model. Expansion into human civilisation and adaption to growing population centres provides differing contexts for validation by proxy (Fig. 15).

Modern mammals	Human ancestors living in small, mobile tribes	Domestication of animals and simple agriculture	First cities arise
200m years	2.5m years	9000 years	6000 years ago
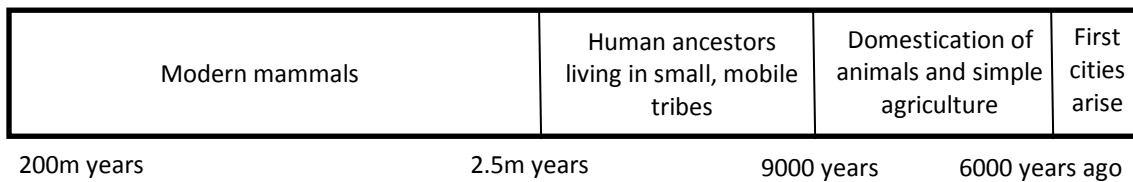
Figure 15: Timeline of engagement contexts (232)

Early in human evolution, threat from wild animals caused a 'fight or flight' (henceforth known as *approach-avoid*) response that reduced cognition in preference for fast reaction and desperate strength. Intelligent thought was shut down and limbs energised in readiness to escape or inflict damage. As threat from animals lessened, approach-avoid circuitry was co-opted for a human enemy (80). Today, an unreasonable fear of change is explained by an over-active avoid response linked to conservative-leaning people (81).

With the vast proportion of human evolution, or indeed mammalian, being spent under threat of wild animals, the 'avoid' response is stronger and more easily triggered than 'approach' (82 p. 2). Even if a person is established as non-threatening, it must still be decided whether or not to engage.

> *Engagement is a state of being willing to do difficult things, to take risks, to think deeply about issues and develop new solutions. An approach state is also closely linked to positive emotions. Interest, happiness, joy and desire are approach emotions. This state is one of increased dopamine levels, important for interest and learning. There is a large and growing body of research which indicates that people experiencing positive emotions perceive more options when trying to solve problems, solve more non-linear problems that require insight, collaborate better and generally perform better overall. (82 p. 3)*

This decision requires subtle revealers of intent that, if the SCARF model is correct, evolved from our ancestral approach-avoid circuitry. In Rock's examination of scientific literature, five domains prompting decision-making in a social context are identified.

> *The SCARF model involves five domains of human social experience: Status, Certainty, Autonomy, Relatedness and Fairness. Status is about relative importance to others.*

Certainty concerns being able to predict the future. Autonomy provides a sense of control over events. Relatedness is a sense of safety with others, of friend rather than foe. And fairness is a perception of fair exchanges between people. (82 p. 1)

Applying the SCARF model to differing collaborative contexts tests the degree of correlation between its domains and the collaboration parameters (Fig. 16). Sequential historical contexts translate SCARF into human civilisation, and showing a viable evolutionary pathway to the present day will support the early abduction. The first collaborative context faced by humans was the tribe, followed by the village and as population densities increased, the town (83).
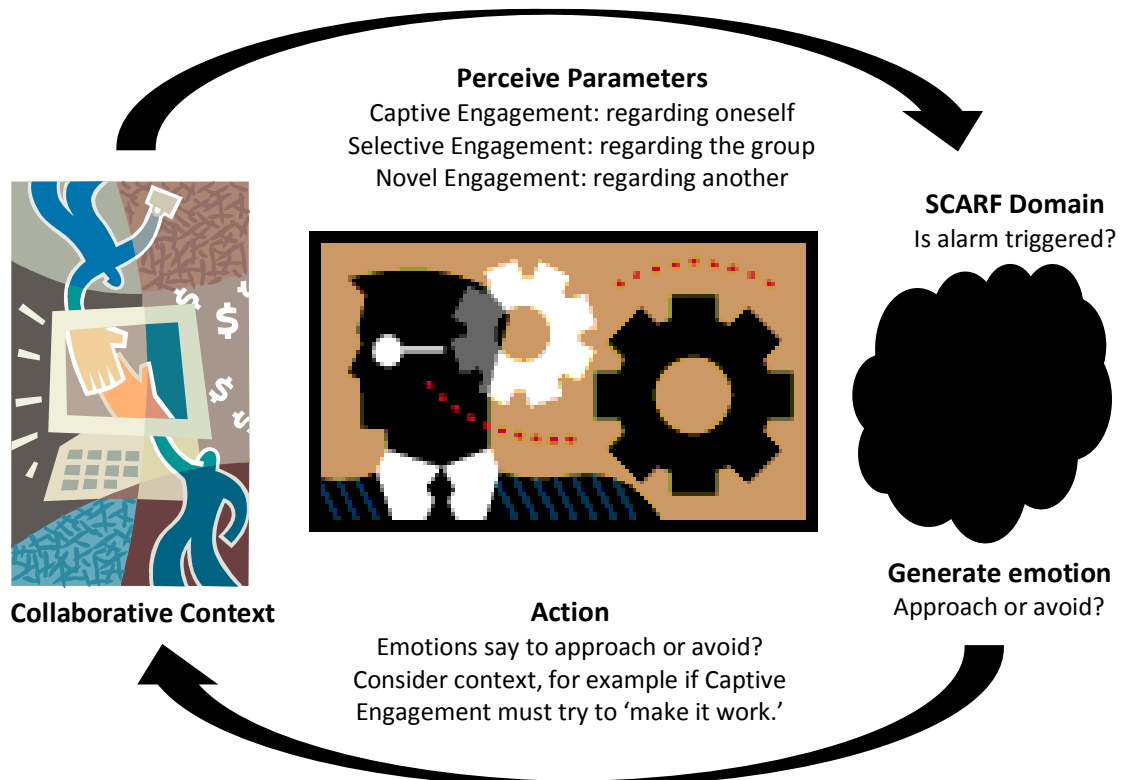
Figure 16: Decision-making using the SCARF domains and collaboration parameters

5.2   Captive Engagement (tribe)

In the modern day, Captive Engagement occurs in situations that aren't easily left such as families, workplaces and friendship groups. Pre-civilisation, leaving an isolated tribe risked death from predators, enemy or starvation. The 'avoid' emotion alerts the protagonist to a problem within collaboration that may need to be addressed. Others will empathise, and if the member is valued, act to prevent their leaving for the good of the tribe.

5.2.1   Captive Identity

Since there is less chance of losing a position, seniority allows for greater personal investment of Identity. It is an unfortunate result of hierarchical organisations that junior members will

avoid investing if superiors make their position insecure. If a member feels their Identity is declining, a threat to status is triggered, and if a position becomes too threatened, the member may consider leaving. Friends will alleviate a situation of low Identity in one of their group by making them feel more important with a demonstration of subservience, such as deferring to their opinion in a less-significant situation. Another response to status threat for the protagonist is to specialise out of the norm, allowing an alternative Identity while also strengthening the collaboration with unorthodox knowledge[23].

5.2.2 Captive Activity

Rock (82 p. 4) asserts that certainty is improved by forward planning, which moves into the realm of Activity. In a confusing and complex world, people prefer to be busy. Activity has the benefit of focusing attention on a specific task and reducing awareness outside that. Women may enjoy soothing pursuits such as yoga, baking or puzzles, while men prefer fishing, golf or watching sport. Any Activity promotes a feeling of certainty, and perhaps explains the ongoing demand for the institution of religion. Obsessive Compulsive Disorder (OCD)[24] has been linked to the Orbital Frontal Cortex (84) which also raises the certainty alarm.

> *Even a small amount of uncertainty generates an 'error' response in the orbital frontal cortex (OFC). This takes attention away from one's goals, forcing attention to the error (Hedden, Garbrielli, 2006). If someone is not telling you the whole truth, or acting incongruously, the resulting uncertainty can fire up errors in the OFC. (82 p. 4)*

The certainty alarm is triggered when the protagonist is not sufficiently busy, and can be remedied by further responsibilities. Even a symbolic role can make someone feel more at ease in a group setting.

5.2.3 Captive Knowledge

Autonomy is "the perception of exerting control over one's environment; a sensation of having choices" (82 p. 5). Such a perception is supplied by Knowledge, where even without actual power, understanding a situation provides a feeling of control. Mastery is the end point of acquiring Knowledge which Pink (77) sees as a powerful motivator. Micromanagement is loss of autonomy (82 p. 5) and often accompanied by withheld Knowledge, which the member may then seek out. In an undesirable situation, Knowledge will at least make people feel that they can predict unfolding events[25], perhaps then influencing

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[23] Unpopular children may become comedians or scholars as defence against low status.
[24] For sufferers of OCD the need to repeat actions such as cleaning or locking doors can become debilitating.
[25] Immigrants to a new country seek education to gain control over their future.

them. Often seen as making people 'feel included,' providing someone information prevents the autonomy alarm being triggered.

5.2.4 Captive Cohesion

Relatedness is perception of a relationship with others, with implications of trust associated with release of oxytocin in the brain (82 p. 6). Relatedness has an obvious link to enemy identification, but in the context of an existing collaboration, indicates how connected the individual feels. When Cohesion is low, relatedness suffers, oxytocin levels drop and the collaboration feels competitive, or even unwelcoming (82 p. 6). The alienated individual can then choose to blame themselves or others. Given isolation is usually disempowering; changing behaviour to accommodate others is the best strategy. If unfriendliness is accidental, once they become aware of the person's relatedness alarm, allies will endeavour to express closeness.

5.2.5 Captive Transfer

Assessment of fairness is negatively affected when power is abused, and positively affected when responsibility is taken. The implicit responsibility of collaborating is sharing knowledge to allow best use. Any decision to not transmit is an abuse of power since the transmitter cannot assume they are best-placed for utilisation. Identically, any decision to not receive knowledge is not taking responsibility for potential utilisation. Therefore, when an individual experiences Transfer, whether as transmitter or receiver, they feel they are being treated, and acting, fairly. If however Transfer is low, the fairness alarm is triggered, and the member will be cautious who they trust and speak to. A group that has not intended to exclude another will endeavour to find subjects around which conversation can be made.

In the context of captive engagement, it has been shown that the individual perceives their own position in light of the five parameters. These affect approach-avoid responses, influencing behaviour within collaboration. In a tribal setting, leaving has lethal consequences, not only for the individual but perhaps also for the group that fragments and loses valuable manpower and knowledge. Captive engagement evolved to reduce this occurrence.

5.3 Selective Engagement (village)

As small tribes became larger villages, collaborative options diversified. Production surplus, greater population, efficiencies of scale and specialisation resulted in multiple collaborations that people could choose between (85). Leaving a particular collaboration was no longer life-threatening and people could choose between alliances. If a particular group was performing

poorly, another could be joined instead; a consequential decision. Those who chose a failing collaboration faced greater deprivation (86) but a wiser allegiance gave better access to food, shelter and safety; promoting gene survival. Once humans moved from tribe to village, ability to select a superior collaboration was therefore critical.

5.3.1 Selective Identity

Selective Identity assesses not whether the protagonist is highly ranked, but whether their collaboration is perceived as successful. Even a senior member of a weak collaboration will feel their status is low, for example the leader of a poor nation seeking international approval. Since those in leadership have greater access to information, Identity placed in their role indicates collaboration's likely success, and leaders will strive to appear confident. Identity in juniors is also important as it indicates members are committed, and is generally helped by a transcendent purpose (77). As before, Identity cannot be directly observed, but if it is inferred that others are withdrawing Identity, the status alarm is triggered.

5.3.2 Selective Activity

Activity implies members are busy and well-utilised. Idleness implies a lack of forward planning and control, making the future uncertain. Inactivity triggers the certainty alarm.

5.3.3 Selective Knowledge

Humans create exergy (§4.1.1) by manipulating their environment. The more expertise involved, the more exergy created from a given level of inputs. The Peter Principle (87) explores situations where employees are promoted above their level of competence, resulting in disastrous consequences for the company and employee both. Low Knowledge means that future choices become restricted as the group produces less, which in villages could be inferred from depleted food stores. For example it is often incorrectly assumed that poor people are unintelligent, however a rational link between Knowledge and production surplus previously existed, and today takes the form of money. When those in collaboration do not seem Knowledgeable and since poverty reduces choices, the autonomy alarm is triggered.

5.3.4 Selective Cohesion

Relatedness applies to member's treatment of one another. A collaboration characterised by reliable and trusting relationships will generally succeed over one that does not. A group with infighting and liable to fragment is less likely to prosper. Observing a Cohesive collaboration creates an engagement response in the approach-avoid circuitry, and one is not triggers the relatedness alarm.

5.3.5 Selective Transfer

Locating and punishing breakers of rules is core to objective fairness. Transfer always fosters fairness because it increases knowledge equality and reduces potential for abuse of power. The more Transfer occurring within collaboration, the less likely transgressors will escape justice. As information of common concern is shared, Transfer also provides oversight and quality control. History shows the importance of independent media to healthy democracy. Since external change against unchanging rules creates loopholes[26] that may be exploited, in a fast-paced world ongoing reform is critical (§4.5.1). Transfer aids this process by educating members and building support (88) for structural change. A lack of Transfer in collaboration triggers a fairness alarm that will prompt potential members to avoid collaboration, and existing members to leave.

5.4 Novel Engagement (town)

The major characteristic of both villages and tribes is that junior members did not meet strangers (89). Whereas previously a new arrival required intervention from a tribal or village chief, townspeople are now expected to meet unannounced strangers and decide whether to engage[27]. Entering into collaboration with a stranger requires further extension of the approach-avoid circuitry. It is more difficult than selective engagement since information comes from observing just a single person rather than an entire group. For example, rural people less accustomed to strangers than urban dwellers may take years to trust a new arrival. Salesmen are skilled at creating a desirable representation in the customer's mind and make a useful comparison that links novel engagement to their manipulation of unconscious approach-avoid responses.

5.4.1 Novel Identity

A salesman will attempt to create an impression that the 'customer is king' by asking questions respectfully, listening closely and following requests with alacrity. This gives the customer a sense of high status that implies should collaboration continue, so will their status. For example, Apple store employees applaud customers making a large purchase. The salesman must simply and sincerely explain the product (T→I) while keeping the customer's Identity sufficiently high so that their status alarm is not triggered.

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[26] External change includes from the criminally-minded who intentionally change behaviour to exploit loopholes.
[27] Was a customer trustworthy or a merchant reliable? Are the songs of a travelling minstrel worth hearing? Is the young man looking for honest work or to steal?

5.4.2   Novel Activity

Shared Activity, such as sport or work, is an easy way to meet new people. With all parties feeling certain of their purpose, new connections are easily made. Music festival attendees are happily busy, making their certainty alarm less likely to trigger. Salesmen employ a similar effect by asking the customer to try the product or making conversation around its use, allowing Activity to be imagined (90). If however the customer is awkwardly waiting for assistance, the certainty alarm will encourage their leaving.

5.4.3   Novel Knowledge

A salesman must explain the product without overwhelming the customer with detail or risk threatening their Identity. The solution is explaining the benefits rather than technical information, which is not only more relevant to eventual usage, but also more relatable. When the customer imagines themselves using the product, they feel empowered through attaining position-specific Knowledge. Conversely if unable to conceptualise themselves in relation to the product (90), low Knowledge triggers an autonomy alarm.

5.4.4   Novel Cohesion

Assessment is quickly made when meeting someone for the first time (91). If a friendly stranger, Cohesion is created, and good salesmen are particularly friendly. However if no connection is made, low Cohesion triggers the relatedness alarm.

5.4.5   Novel Transfer

It is fair to be given knowledge before deciding to engage, and fair on the stranger to learn about you. Yet a silent stranger is acceptable if you feel comfortable talking, and indeed many enjoy being listened to. Others like to listen and are content to let another dominate the conversation. Fair is subjectively calculated based upon respective personalities, and two pleasant people may not get along because their mutual communication needs are not met. Even silence can be enjoyable, and communication continues through body language. If however silences are awkward or if people are talking over one another, the fairness alarm is triggered. A good salesman will detect a customer's preference and adjust their communication style accordingly.

5.4.6   Early Abduction Proven?

The original intent of SCARF was to establish the link between approach-avoid response and personal engagement. Broadening this into captive, selective and novel engagement has

demonstrated subtle differences depending upon collaborative context. For instance, 'status' has been seen as a) the status of oneself in collaboration, b) the status of collaboration at large and c) the future status of oneself when considering collaboration with a stranger. These are all viable and important contexts that begin to reflect the real complexity of human social behaviour, and in turn supporting the early abduction (evolved parameters guide decisions when in collaboration).

The next step in analysis is to move further back in evolution (Fig. 15) and investigate expression of collaboration parameters in mammals.

5.5   Mammalian Collaboration

The structure of mammal brains is consistent with humans (92) and since all mammals have an approach-avoid response[28] aspects of the collaboration model may be demonstrated. Showing that mammals have less interconnection of parameters will support the early induction.

5.5.1   Mammals' Expression of Impacts

Many of the SCARF dimensions are present in animals: they form relationships, recognise status, find repetitive action comforting[29] and dislike unfamiliar surrounds. Regarding fairness, in some animal cooperatives turn is taken keeping watch rather than gathering food (93). While less comprehensive than humans, such parallels demonstrate the potential application of the collaboration model to mammals.

Regarding the parameters, Transfer is present albeit without using complex language[30] and at low information rates[31]. Animals undertake collaborative Activity that aids the group, such as hunting or rearing of young. Knowledge concerning their surroundings is accumulated, sometimes using advanced reasoning (94). Animals differentiate roles, such as intricate distraction ploys of monkey gangs to steal food from market stalls, or gorillas removing poacher's traps (95).

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[28] Primates are affected by approach-avoid to a greater extent than other animals (215).
[29] Dogs under stress will lick hair from their skin and are treated with drugs also proscribed for humans.
[30] Chimpanzees have been taught to use symbolic language (212) and working dogs understand complex commands.
[31] Whales have the largest brain by volume yet whale song has only one tenth the information rate of human speech (213).

In assessing the early deduction, it is useful to isolate uniquely-human impacts in the collaboration model. Do animals also have full interconnection of collaboration parameters, or are humans unique in achieving this?

Source	Impact		Name	Type	Rationale/Example
ACTIVITY	Knowledge	Pos	Hone Expertise	Animal	Monkeys learning to use tools
	Identity	Pos	Achievement Pride	Animal	Cats 'showing off' animals caught
	Cohesion	Pos	Build Trust	Animal	Gorillas grooming one another
	Transfer	Pos	Demand Knowledge	Human	Require (Req.) language
KNOWLEDGE	Activity	Pos	Utilise Knowledge	Animal	Knowledge of tool usage employed
	Identity	Pos	Grow Confidence	Animal	Monkeys become bolder as they lose fear of non-lethal responses.
	Cohesion	Pos	Reduce Stress	Animal	Unfamiliar surroundings create stress
	Transfer	Pos	Seek Advantage	Human	Req. abstraction of benefit/need
IDENTITY	Activity	Pos	Justify Position	Animal	Herbivore dominance displays
	Knowledge	Neg	Unwelcome Enlightenment	Animal	Dominant dogs ignore owners
	Cohesion	Pos	Appropriate Interaction	Animal	Unsocialised dog problems.
	Transfer	Pos	Fulfill Responsibilities	Animal	Alarm calls in communal mammals

COHESION	Activity	Pos	Mutual Assistance	Animal	Shared parenting
	Knowledge	Neg	Group Think	Animal	Squabbling monkeys adapt to avoid fights
	Identity	Neg	Lose Individuality	Animal	Domestic dogs that develop pack mentality with other dogs
	Transfer	Pos	Mutual Assistance	Animal	Adult chimps teach young to make nests
TRANSFER	Activity	Neg	Communication Distraction	Human	Req. significant information content[32]
	Knowledge	Pos	Creative Associations	Human	Req. significant information content and cognitive ability
	Identity	Neg	Undermine Assumptions	Human	Req. significant information content and cognitive ability
	Cohesion	Pos	Demonstrate Confidence	Human	Req. significant information content and empathy

Table 1: Human and animal impacts within the collaboration model

While gleaned from popular media, this assessment confirms a widely-held view that complex language set humans on the trajectory to dominion (Fig. 17). Animals have their own languages, but with limited communication of complex information, the Transfer parameter is largely discluded. A virtuous loop of creativity and cooperation between Knowledge and Transfer meant humans adapted quickly and exploited effectively[33]. In addition, high cognition and dynamic Identity allowed selective collaboration within large populations. Such flexibility and large scale mobilisation underlies the overwhelming success of our species.

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[32] The exception is bees 'dancing' to communicate food location. Insects such as ants and bees transfer information but not conscious knowledge. Insect 'neurons' cannot achieve necessary critical mass or efficiency to allow collaboration between ant nests or bee hives.
[33] 'Exploit' is defined here as exergy generation.
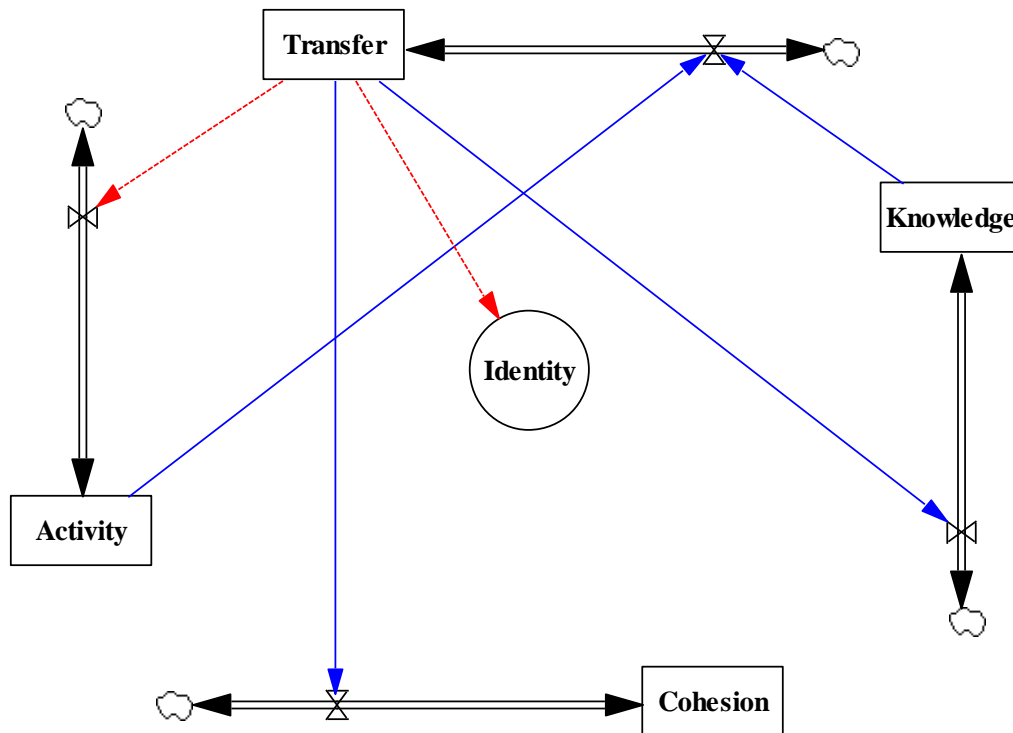
Figure 17: Collaboration model showing human-only impacts

5.5.2 Empathy and Conscience

Two negative impacts are the price of Transfer paid by humans. Communication has a price in terms of productivity (T→A), exemplified by hesitancy of companies to invest in training. Training is expensive and distracts skilled staff but does not deliver immediate revenue. Increasing the productivity of existing workers preferable (K→T) to training new.

> *The need for skills does not necessarily translate into recruitment of new apprentices. It was argued that employers are able to increase productivity and at the same time upskill their workforce without taking on new workers or apprentices. (96 p. 9)*

Regarding the second negative impact; whereas animals react on instinct, humans can be flummoxed by excessive choice (T→I) which may lead to depression (97). Those able to make quick decisions are generally excluding information not impacting their self-interest. In the extreme case, people who do not consider the good of others are labelled psychopaths, yet they prosper in situations where decisive action is necessary. Successful companies that respond quickly to changing situations are acting primarily upon their self-interest, and can feature psychopaths in senior ranks (98). Capitalism generally encourages companies that fit the clinical description of a psychopath (99), while socialism encourages their institutional equivalent (100). Yet the effects of unbridled psychopathic behaviour can be dangerous to society at large, or to a workplace, and psychopathic personalities are ill-suited to human-focussed management positions.

While psychopaths are coldly calculating, animals rely upon instinct that balances individual with group survival. Yet due to their partial-exhibiting of collaborative behaviour, humans can derive pleasure and comfort from interaction with animals[34]. Pet owners are less prone to depression and therapeutic horses help psychologically damaged people to relearn trust and eventually social skills (101).

Given the commonality of approach-avoid circuitry between humans and mammals, it is not surprising they share a common instinct for collaboration. In psychopaths however, emotional Cohesion has been supplanted by rational cognition. This enables them to override any normal empathetic tendencies and disregard other's interests in favour of their own. Nevertheless prevalence of such traits indicates its value to species survival, and via specific leadership roles the collaboration model understands how such people are use[35].

5.5.3 Early Deduction Proven?

Regarding the early deduction (All parameters within the 'collaboration system' affect one another) it was stated that:

> *…since the parameters of collaboration are the basis of decision-making, those who found dependence between two previously-unrelated parameters would make better decisions. (ibid §3)*

The mammal collaboration model lacks impacts associated with Transfer because animals do not have complex language and abstract reasoning. Apart from these six impacts, all other aspects of the collaboration model are evident, at least across the spectrum of higher-functioning animals. This indicates that the early deduction is only partly correct. The collaboration parameters are likely intrinsic to cooperative intelligence, and the impacts arise naturally from them.

Thus individuals did not evolve according to impacts but groups evolved according to collaboration parameters (102). People did not out-compete their colleagues, but rather stronger collective expression of parameters across the team dictated better performance (103). Specialisation such as by psychopaths without empathy, which translates to low Cohesion, indicates the group utilises their strength while compensating for weakness. Their continued prevalence is testament to their value in particular roles in society, but when placed incorrectly, psychopaths can be highly detrimental, for instance mistreating juniors who offer

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[34] Dogs have been shown to understand their owner's emotional state (228)
[35] Leadership roles around Knowledge and Transfer (§7.1) are suitable for personality types tending towards extreme self-interest.

no immediate gain (98). In such cases it is important for 'unhealthy' collaborations to be removed, as capitalism and democracy both allow for. A poorly-led company goes bankrupt or a poor government is voted from office, while in a monarchy or one party state they are permanent features.

5.6 Model Behaviour

The advantage of full interconnection of parameters is revealed through system behaviour. Control theory recognises that feedback (104) is the strongest predictor of model behaviour. The necessary condition of feedback is that a change at one point will eventually come back to affect it again.

Feedback is either self-reinforcing or self-correcting. Feedback is also designated by order that depends upon the number of impacts (order = impacts - 1). All else being equal, the lower the order, the more immediate and powerful feedback will be. Prioritising 0th and 1st order feedback allows behavioural analysis of the collaboration model, even without knowing the relative strength of particular impacts.

5.6.1 Self-feedback (0th order)

Self-feedback [SF] involves one impact and is therefore 0th order (1-1=0). To simplify presentation, SF has not been represented thus far, however all SF in the collaboration model is based upon the assumption that people prefer to perform at their potential (§4.1.1).

- Potential Transfer combines 'mental fitness' and natural cognitive ability. Operating at a higher level is uncomfortable and at a lower level boring.

- Potential Activity combines physical fitness with focus and attention to detail. Operating at a higher level is exhausting and at a lower level unsatisfying.

- Potential Knowledge is memory capacity. If information is added beyond capacity then older information is lost. Below memory capacity, expertise is continually gained.

- Potential Cohesion is dictated by introversion or extroversion and a person's available emotional warmth. If emotionally over-extended, the introvert will seek time alone. To satisfy their need for Cohesion, the extrovert seeks further relationships, or greater closeness in those existing.

- Identity is instantaneous and therefore without feedback. Dynamic Identity is capacity to adjust quickly without discomfort, while those with static Identity prefer their set level. Nevertheless, Identity is still set by other parameters and the person wishing to behave consistently within collaboration must accede to it. Those leaving as a result of

oscillations do so because they cannot tolerate being forced to assume an unwelcome Identity during cycles of peak amplitude. For example, if given high Identity by the collaboration but preferring low Identity, psychological illness may result[36].

SF can be self-reinforcing or self-correcting but all four SFs just discussed are self-correcting since they automatically return to a preferred value. This can be shown graphically in the case of a positive change to a parameter then forced to return (Fig. 18).
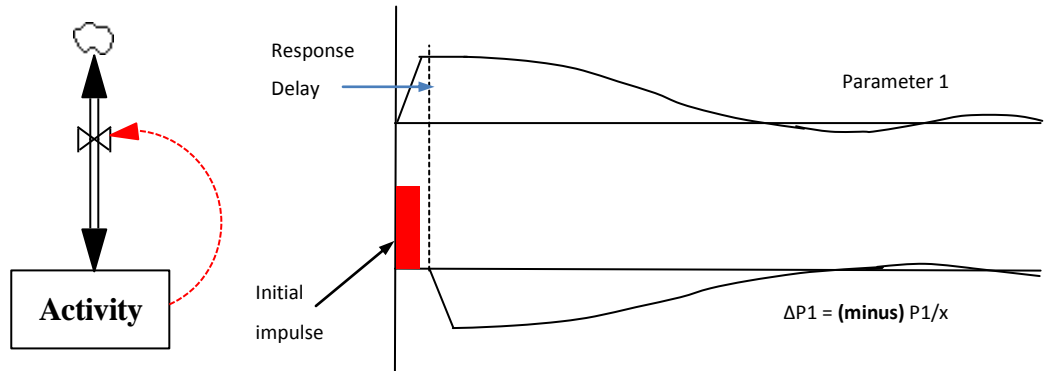
Figure 18: Self-correcting SF

5.6.2 First Order Feedback

While 0th order feedback includes only one impact, 1st order has two, which can be exclusively positive or negative or a mixture. Two positive impacts are termed *positive self-reinforcing* [SR] and an initial change in one parameter will become amplified in both parameters (Fig. 19). Two negative impacts are called *negative self-reinforcing* and one parameter will increase while the other decreases. There are none of these in this collaboration model.
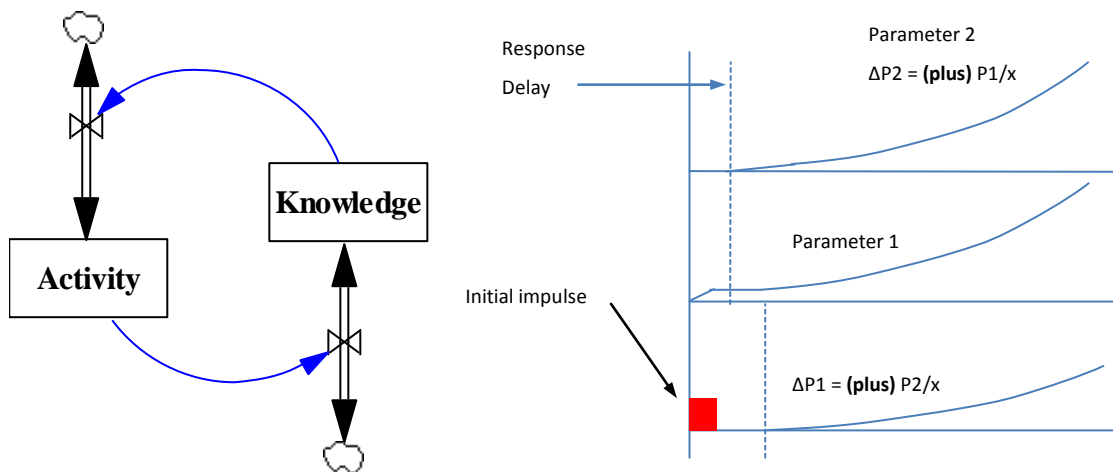
Figure 19: Positive self-reinforcing 1st order feedback

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[36] The troubled winner of a television talent contest, Susan Boyle is a recent example (229).

If one impact is negative and the other positive, feedback is *self-correcting* [SC] and any initial change will cause oscillations that eventually return to their starting levels (Fig. 20). Acting like a spring and dampener system, the energy of the original impetus is absorbed over time. If the first parameter is increased, the second parameter will either increase or decrease, with the return leg having an opposite effect.

Parameter 2

$\Delta P2 =$ **(minus)** P1/x

Parameter 1

$\Delta P1 =$ **(plus)** P2/x

Initial impulse (larger to clearly show oscillations)
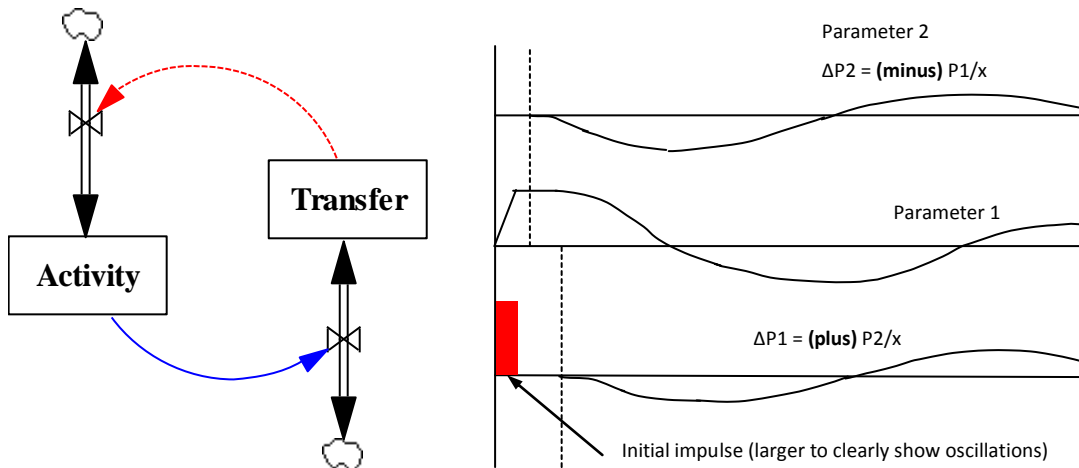
Figure 20: Self-correcting 1st order feedback

An important difference between SF and SC is amplitude of oscillation. SF will over-shoot when returning to the starting level, but only at low amplitude (Fig. 18). The SC parameters actively move in opposition and so experience significantly higher oscillations. SF tends to immediately dampen any change, whereas SC acts like a spring taking longer to return to its original state. Only SC (grey) and SR (blue) are shown in the feedback model (Fig. 21) but SF remains in effect.

5.6.3   Interpreting the Feedback Model

The collaboration model has in total five SR and five SC, with the addition of four stabilising SF. However, Identity uniquely has one less SR, one more SC and no SF. The three SC will superimpose and combined with the loss of SF dampening produce higher amplitude oscillations. If the remainder of collaboration parameters have recently changed, Identity oscillates higher and lower. In addition, if Activity has undergone substantial change, SR will force a temporary shift in Identity in addition to the peak. In the longer term, oscillations will dissipate and Identity will once again be governed by the summation of impacts.

The remaining parameters are arranged in a central ring of SR feedback. A change to one of these parameters will circulate around the loop in both directions, creating a reinforcing 'meta-feedback.' Combatting this are two cross-wise SC feedbacks, but there are twice as

many SR feedbacks as SC. The four SF pathways reduce the likelihood of infinite growth or diminution, although both are possible and equally destructive[37]. The four parameters will tend to rise and fall synchronously in wave patterns created by the interaction of SC and SR and their respective response delays. Due to SF dampening these will however be of lower amplitude than oscillations on Identity.
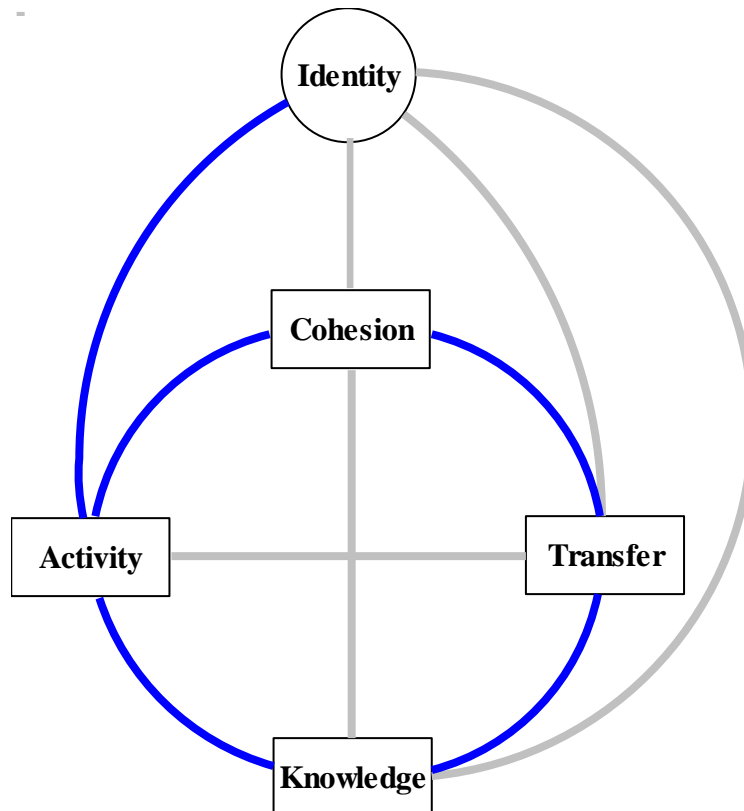
Figure 21: 1st Order Feedback Collaboration Model

Yet alongside its disadvantages Identity has use. The central ring parameters are inherently difficult to deliberately raise (or lower) due to their SF and SC feedbacks. An analogy is that Identity has less mass (inertia) so takes less effort to move. Identity connects to the central via Activity, and uses SR to 'get the ball rolling'.

For example, introducing new technology or systems requires a short-term increase in Knowledge and Transfer to enable understanding before previous approaches can be phased out. Identity is disrupted as people associate themselves to different roles, with ensuing achievement or failure affecting self-confidence. An inspiring leader will help those struggling push through this initial stage, perhaps moving those with static Identity to positions better-

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[37] 'Superhuman' or 'subhuman' feats lead to burnout and frustration, damaging collaboration whose members move outside the SCARF domains and into the exogenous realms of exhaustion and anger respectively.

reflecting their disposition. A leader with dynamic Identity will be able to show confidence as they experience less personal discomfort, inspiring those members with static Identity to tolerate their own, more-severe, distress. Entrepreneurial leadership is exogenous to the model, but allows Identity to be artificially raised. Identity can then drive innovation through short-term[38] increase in member performance, initially via SR with Activity.

5.6.4 Early Induction Proven?

Feedback analysis has shown that the model is stable over the long term, but Identity can experience instability in the short term. Innovation is difficult to implement, and requires extraordinary measures, supporting the early induction (Collaboration is dominated by stability). Within the remit of these early findings, it seems wise to pay attention to fostering dynamic Identity in the form of resiliency through stable parenting and diverse opportunities for collaboration. The former is a question of social policy, but the latter can be assisted by government establishing opportunities for citizen collaboration. With an eye to crafting policy achieving such objectives, attention is now turned to cases of successful innovation.

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[38] Temporary improvement in performance (§6.1.1) will be differentiated from sustained (§6.1.2) and permanent (§6.1.3).

Over the past decade, professionals — lawyers, regulators and legislators — have inserted themselves into more and more economic realms. The princes are perfectly at home amid these tax breaks, low-interest loans and public-private partnerships. They went to the same schools as the professionals and speak the same language. The grinds try to stay far away and regard the interlocking network of corporate-government schmoozing with undisguised contempt. The upshot is that we have an economy that is inching toward recovery but that is not creating much in the way of new innovations and new jobs. It's not that the overall labour markets are shrinking. It's just that very few grinds are bringing new ideas to scale and hiring workers to enact their us-against-the-world schemes (105).

Chapter 6.   Evidence

This chapter moves from simulation into real instances of collaboration. Three forms of innovation are examined for compatibility with the collaboration model. Before this, money and innovation are reconsidered in light of the collaboration model, allowing a broadening of innovation's definition to reflect theoretical progress.

6.1   Reconceptualisations

Chapter one stated the common conception that innovation is delivery of new products, services and processes to market. However this may be overly-simplistic and innovation can be more usefully seen as change in behaviour. With financial incentive commonly (§A.2) seen as the only driver of innovation, money's role in collaboration also deserves re-examination.

6.1.1   Money and Collaboration

A dearth of Australian venture capital (106) has forced entrepreneurs offshore. A lack of access to money is clearly demonstrated by the high number of Australians in California's Silicon Valley, causing them to be termed the 'Aussie Mafia' (107). With sixty five start-up companies run by Australians, it represents the largest (relative to population) expatriate intrusion onto the world's most fertile innovation soil. While money often makes the difference between innovation success and failure, the collaboration model makes no mention of it. How can this be reconciled?

In the business world, innovation and money are often linked, but not inextricably. For example the open-source software movement consists of highly-skilled, otherwise-employed professionals devoting time writing software that is given away (108). Distributed download 'pirates' spend time and risk punishment uploading media for multitudes they do not know

nor receive gratitude from. An entrepreneur seeks venture capital not only for finance, but also the contacts and expertise that investors can access[39].

Generally speaking, money brings people together and makes things happen. It can pay for people's time, relieving the intrusion of other tasks. In many cultures money is used as compensation; from purchase of flowers for minor transgressions to paying 'blood money' for felonies up to and including murder. Money can buy expertise and knowledge, through purchasing books, conference attendance or hiring a consultant. Money can buy training, both to learn and to teach, and this is expense is one reason why companies prefer to hire those already experienced. Money can also buy emotional investment in a role, not only as a promise for future reward, but as recognition for dedication made. A wage addresses all such aspects of collaboration, and when people feel their contribution is not appreciated, a salary increase may be required to prevent their leaving.

When reward leads to a decrease in performance, money has reduced 'intrinsic motivation' (109). For example, money can undermine the self-image of a person on a charitable task (110). Pink (77) states that "money needs to be taken off the table" once pay is adequate for participation as further intrusion of money is unwelcome. Money is important in maintaining functional collaboration, however imprudent incentive structures can become detrimental. An example can be seen in high executive pay correlating to low company stock price (111).

Ulterior motives or conflicts of interest will cause behaviour changes and trigger the approach-avoid response of others, damaging collaboration. When executive performance is not linked to collective success, workers feel unfairly treated and withdraw effort (112 p. 189). For this reason it is inadvisable to allow 'independent' remuneration consultants (113) to recommend remuneration packages as if executive brilliance alone ensured success, but also because executives themselves become divorced from the company. Collective success does not occur purely via individual heroism, however well-paid, and money poorly targeted will lead to undesirable behaviour such as collusion between boardrooms (§A.2). Yet while money can be damaging, rewards are highly effective when properly designed (114). In summary, finance is valuable when used in support of collaboration, but can equally damage it, and does not constitute a parameter people dependable respond to. Depending upon how innovation is defined, collaboration can achieve it with or without money.

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[39] This was discovered in the course of undertaking original interviews.

6.1.1 Impulse Innovation

The feedback model (§5.5.3) demonstrated that sudden change to collaboration caused oscillations in Identity. Yet the introduction of new technology or processes implies change to parameters as members learn how to utilise it. Removal of technology or processes is the polar opposite, but identical oscillations on Identity will occur.

As set out in Powering Ideas (2), technology and processes are core to what policy-makers understand innovation to be (§A.1). Whether technology is externally adopted or internally generated, change to collaboration parameters is quick. The resulting oscillations of Identity manifest in collaboration members' understanding of themselves amid permanent alteration to the collaboration's function. Since these occur from sudden, impulse changes, it is known as *impulse innovation*.

As a result of unquestioning acquiescence to tradition (§3.1.1), rigid hierarchies of ancient cultures were rarely challenged (115), and dynamic Identity unlikely to be required. Dynamic Identity may therefore be a relatively new evolutionary phenomenon.

6.1.2 Emergent Innovation

Creation of technology implies longer term improvement of members of a design team. Like a sports-person in competition exceeding their personal best, an engineer can exceed expectations when part of a ground-breaking team. Recent thinking sees innovation as change in behaviour of consumers, but consumption a weak form of collaboration.

> *Innovation is when you introduce a new idea or concept that results in a sustained change in behaviour [because] behaviour change is going to create the economic value that you're looking for (116).*

It seems collaboration aids survival partly because it allows better individual performance. This broadens innovation into an emergent property of collaboration rather than just short-term impulse change. Sustained elevation of collaboration member performance above their potential (§4.1.1) is known as *emergent innovation*.

People can respond favourably to a collective endeavour, but they can also be suppressed by it. Communism was a study of both extremes; many collective farms worked well initially (117) but production faltered when certain people took advantage of an anarchic situation[40]. Individual potential didn't change, but overall output dropped, indicating that emergent

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[40] Similar abuses of power are evident in 'hippie communes' absent any political commissars (230).

innovation was negative. In this situation, improperly designed incentives reduced collaborative performance and thereby, according to the emergent definition, innovation.

6.1.3 Quotient Innovation

As communism continued, their population experienced a miasma of collective loss of hope and incentive. Such conditions lead to a permanent lowering of potential, exemplified by North Korean refugees unable to interact with their Southern cousins (118). Such longer-term change is a third type of innovation, where a population can increase or lower its individual potential. As an example, the internet age has seen a permanent increase in ability to multi-task but lower attention spans (119). This would indicate higher average potential Transfer, since lower information rates are uncomfortable and cause loss of concentration (§5.6.1) or additional channels to be sought. National economic performance is strongly correlated to education attainment (120). In deference to the Intelligence Quotient test, which ironically now averages one hundred and ten (121), permanent change to potential is known as *quotient innovation*.

There is currently no statistical data available for the collaboration parameters, but three instances allow examination of innovation's effect on people. As demonstrated in the following timeframes: Silicon Valley is evidence of impulse innovation, Open Innovation, emergent and Street University, quotient.

6.2   Evidentiary Instances

The first instance examined is Silicon Valley in California, and specifically in contrast with Route 128 in Boston. The second is a theory called Open Innovation that encourages businesses to use formal collaboration around Intellection Property [IP] to innovate. The third is a community venture known as Street University that helps young people at risk. With the intent of later formulating policy, each is investigated for general consistency with the collaboration model.

6.2.1   Silicon Valley

Silicon Valley has its roots in the 19th century and Stanford University, but did not come to prominence as a technology hub until the 1970's (122). Over the subsequent three decades increasingly unrealistic stock prices for the Valley's internet-based ventures led to bursting of the 'dot-com' bubble in 2000. Today Silicon Valley has one third of US venture capital invested (123) and hosts three of the richest ten US counties (124).

Prior to the dot com bubble, academics studied why Silicon Valley succeeded so uniquely. They focussed on the dense, flexible networks of entrepreneurs, engineers, venture capitalists and associated services (125). Afterwards the focus became more 'exceptionalist,' claiming Silicon Valley was unique because of regional (126) and other differences that could not be duplicated elsewhere, some even criticising the wealth generated.

> *Like an ebb tide that leaves little behind save rotting seaweed and dead fish, the national obsession with all things Silicon Valley has drained away, replaced by a grim fixation on Enronitis and Jack Welch's divorce. (127)*

Early theoretical incomprehension was evident in the Korean version (128) founded by Silicon Valley's 'father' (129) in 1971. While remaining entwined in the Valley's companies and culture, Terman attempted four replications; three in the US and one in Korea (130). Only Korea was deemed initially successful, but has since become a normal university campus (131), with students who prefer employment over entrepreneurship (132).

When compared to the Valley, Route 128 is indicted (133). Both had information technology companies with similar overall market share and strong links to a celebrated engineering university. Nevertheless deeper differences remain stark, with Route 128 firms characterised by stable workforces experiencing little social or technical interaction between each other.

> *The available data do not support a regional turnaround ... [but] even if the data do not indicate recovery, is there other evidence that Route 128 is reinventing itself? Layoffs at the minicomputer firms have spawned a new generation of companies, many of which are rejecting the management models of their predecessors. ...Chipcom's founders assiduously avoided vertical integration and maintained open corporate boundaries. Yet as with the region's other start-ups, the question remains whether even enlightened firms like Chipcom can compete [with Silicon Valley] without the advantages of a supportive environment, particularly when their competitors draw on an industrial infrastructure and culture that both demands and facilitates rapid change, openness and learning. (134 p. vii)*

By contrast, the Valley is marked by a changeable corporate landscape with dense interconnection and transfer of employees. Employees of Route 128 companies remain in situ for decades, while those in Silicon Valley often leave within a year or two, either to take up a position elsewhere or start their own company (135 p. 28).

Another thematic differentiation repeated in the research is a dedication to invention rather than employers. In the Valley, stories of success and failure are shared between employees of different companies, and the latest discovery quickly becomes common knowledge. Competitors routinely ask one another for assistance with a technical problem, and answers are given. A microcosm of this mentality was the 'Homebrew Computer Club' created as a social gathering of like-minded computer fanatics in the mid-70s.

The theme of the club was "Give to help others." Each session began with a "mapping period," when people would get up one by one and speak about some item of interest, a rumour, and has a discussion. Somebody would say, "I've got a new part," or somebody else would say he had some new data or ask if anybody had a certain kind of teletype. During the "random access period" that followed, you would wander outside and find people trading devices or information and helping each other. (136)

In sharing their knowledge without competitive or legal impediment, the club spawned some of the great innovative technology companies of the 21st century (137). Collaboration that created these companies continued in the spaces between them. Employees who left one company joined another almost immediately, but remained in contact with previous colleagues. Venture capitalists as ex-entrepreneurs advised new entrepreneurs, then facilitated contact with legal and accountancy services.

California's non-enforcement of 'do not compete' contracts (138) allowed easier movement of employees. Engineers were routinely awarded stock options, a rare occurrence in Route 128, which gave an incentive to not betray an employer upon leaving. Considering engineers' long hours and high burn-out rate, leaving and starting elsewhere was often best for both the employee (139) and eventually the company itself. For example, employees who understood the needs of previous employers formed a network of specialised services.

The same job of bringing a new workstation to market takes two times as long in the East coast and many more people than it does here. In Maynard, I had to do everything inside the company. Here I can rely on the other companies in Silicon Valley. It's easier and cheaper for me to rely on the little companies in Silicon Valley to take care of the things I need, and it forces them to compete and be more efficient. At DEC, the commitment to internal supply and the familial environment means that bad people don't get cut off. I had to depend on all sorts of inefficient people back at DEC East. (140 p. 56)

As a result of the importance placed upon their position, Route 128 employees tend to be risk-averse. Decisions requiring approval from layers of management, with failed projects forever tainting careers (141). When Route 128 companies began failing, employees transplanted to the Valley had sufficient technical skills, but their indecisiveness and conservatism ill-suited an anarchic environment (135 p. 34).

Risk taking is core to entrepreneurship, requiring belief to be placed in an evolving venture and management of ensuing instability (142 p. 199). Route 128 employees were accustomed to stable environments, but some adapted well regardless.

Describing his years with the DEC engineering and development group in Palo Alto, DeNucci said: "We had an immense amount of autonomy, and we cherished the distance from home base, from the "puzzle palace," and from the "corridor warriors" and all the endless meetings. It was an idyllic situation, a group of exceptionally talented people who were well connected to Stanford and to the Silicon Valley

networks. People would come out from Maynard [Massachusetts] and say "this feels like a different company." The longer they stayed, the more astounded they were."
(140 p. 55)

Silicon Valley represents a symbiotic ecosystem that recycles entrepreneurs and employees into new growth. With the dot-com bubble now a decade past, the Valley demonstrates its continued viability by pushing against the constraints of geography (143) and planning laws (144). Such vibrancy indicates the importance of collaboration between businesses but also, as discussed now, within existing businesses (145).

6.2.2   Open Innovation

In a globalised market, arrival of better or cheaper alternatives can sweep away established companies. Until becoming their victim, 'Not Invented Here' syndrome (55 p. 23) biases companies against externally-sourced ideas (146). Yahoo was the email and search behemoth of the 90's, but is now struggling for relevance. Google demonstrated to Yahoo that a simple, uncluttered search engine was preferred to a hierarchy of links interlaced with advertisements (147). Open Innovation hopes to show businesses how to avoid this occurrence, and the similar tendency to ignore domestic invention (I→K). Kodak's bankruptcy resulted from the advent of digital cameras, a technology that one of their engineers initially discovered but competitors embraced (148).

While not yet an explicit theory (149) *Open Innovation* makes extensive anecdotal recommendations (150) and Henry Chesbrough (151) dominates the field. Chesbrough originally worked within IT start-ups but then moved to advising:

> *[L]eading companies about the benefits of greater openness, including IBM, Proctor & Gamble, 3M, Unilever, Philips, Genetech, General Mills, Kimberley Clark, Intel, Hewlett-Packard, EMC, Dell, Microsoft, SAP and Xerox. (55 p. 257).*

Chesbrough (55) advises companies to lead market upheaval by remaining vigilant for market threats, and positioning the company to avoid them. Cooperation with customers and suppliers provides information on future market directions. The goal is a vertically and horizontally integrated conglomerate that remains adaptive. Commercial and informational relationships lead to formal agreements around common use, and preventing disclosure, of IP. This then creates opportunities to sell or license unused IP within the conglomerate and so liberate value. Collaborating inside IP arrangements (152) is a different perspective to the Valley's adaptive ecosystem.

> *IP is now managed in a variety of ways beyond revenue generation. Patent mapping is used both to manage risk and to identify potential reward within current and possible future markets. It also helps identify potential new businesses that might leverage the*

IP of the company, using that IP to offer an entry ticket to new businesses into the company. Alternatively, IP may provide a consolation prize for the company, which it is exiting old businesses. IP may help define the means by which risks and rewards are shared with key partners. (55 p. 129)

Open Innovation is addressing problems that Route 128 companies have historically faced constrained employee ability and risk-taking (153). A conservative company will retain even underperforming employees since there is no recognition for, or expectation of, performance beyond individual potential. Consistent with the concept of emergent innovation, Chesbrough (2006) recommends that companies enable internal collaboration so that projects founded in the R&D department are engineered in production and thence sold in marketing. Employees not challenged to improve their potential make the company overall less competitive, but a flexible conglomerate provides internal entrepreneurial opportunities.

At its zenith, Chesbrough sees a 'Type 6' company as the most "IP Enabled" (55 p. 126). A Type 6 company interconnects its business model with suppliers and customers while external partners share technical and financial risks and rewards of innovation. It is instructed to collaborate with "key suppliers and customers [who] become business partners, entering into relationships" (55 p. 127) that tolerate risk through a "commitment to experimentation with one or more business model variants, and a willingness to invest some amount of funds and management attention to explore alternative ways to profit from innovation" (55 p. 126). Entrepreneurship is embedded in the value chain by foisting platform technologies upon partners, creating a venture within a venture.

"One important device… [is to] establish its technologies as the basis for a platform of innovation for that value chain … attract[ing] other companies into its business by the tools, standards, IP, and other know-how … for these supporting players to successfully implement the platform. This platform not only coordinates internal R&D with external R&D toward desired business objectives; it also shapes the future direction of that coordination. It further extends coordination beyond the value chain to the surrounding value network or ecosystem in which the investments of third parties add additional value to the platform itself." (55 p. 128)

Complex reconfigurations require expert management of existing personnel and formalised collaborations. Given the expense of good managers and other professionals, it is no surprise that only the largest companies can achieve Type 6 status. Smaller companies simply cannot afford the array of lawyers, facilitators and managers required when conglomerates execute IP-based collaborations between their constituent companies. In reducing these costs Chesbrough draws hope from new mechanisms[41] supplying professional IP services.

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[41] InncCentive, NineSigma, Big Idea Group, InnovationXchange, SSIPEX, Ocean Tomo (55 p. 162)

Arrangements such as Australia's InnovationXchange artificially construct a Type 6 conglomerate using Trusted Intermediaries (TIs) to interface between companies. By developing a deep understanding of their respective companies, and then consulting with other TIs, mutually beneficial opportunities such as cross-license, joint venture or consultancy are identified. Some opportunities found by TIs were between businesses whose executives met socially but due to IP considerations did not share knowledge.

An unanticipated advantage of TIs has been speed of decision making (55 p. 154). Unable to take advantage of IP but with delegated authority to disclose, agreements require days rather than months. Such speed is required by natural collaboration where decisions can be synchronised to approach-avoid responses, which occurs in spontaneous communication of Silicon Valley employees between companies.

Maintaining competitiveness in turbulent markets requires collaboration. This however is made both costly and awkward, not only by the insular Route 128 mentality, but by IP frameworks. Far from 1970's Silicon Valley where patents could be quickly raised, innovation today faces accumulated obstacles. Interlocking patent 'walls' prevent external competition yet slow internal collaboration. Such impediments will be addressed later but the research now moves to quotient innovation in the context of homeless youth.

6.2.3   Street University

Street University began in 2006 (154) to place at-risk youth on a path away from crime and welfare dependence. The name was a deliberate ploy communicating its purpose to young people, but also allowing pride (155) in an institution designed for them. Sydney's Street University was built in a donated warehouse, with another subsequently launched in Australia and a further two planned. The world is paying attention, including visiting music artists and a DELL executive who made a substantial donation upon hearing co-founder Matt Noffs. Since 2006, there have been roughly 13,000 participants per year. The cost is around $100 each per annum, as compared to $12,000 for counselling, $70,000 for juvenile detention (156) or $200,000 for drug court (157).

As Noffs states, living on the street has its own survival skillset. While criminal gangs are undesirable, their behaviour nevertheless conforms to the collaboration model (158). Successful gangs are led by skilled entrepreneurs who evade police, serve customers and negate competitors. The philosophy of the Street University is to respect and incorporate these backgrounds into new pathways, such as expressionistic art forms. An undesirable past

informs and strengthens new endeavours, allowing permanent improvement in potential and thereby quotient innovation.

Street University is guided by the philosophy of "Hook, Brake, Crane and Train" (156). The hidden nature of the building makes entry special, combining with endorsements and visits from artists to 'Hook' young people. 'Brake' attempts to halt damaging lifestyles by linking people with housing or mental health services, or offering emergency accommodation on the premises. 'Crane' then drops the young person into a course or program allowing their self-expression. Professionals volunteer their time to run workshops and the Street University boasts a mixing and recording studio, as well as library and basketball courts. Finally 'Train' provides access to vocational or graduate courses, or even launching a venture, via mentoring and assistance with applications. A critical aspect is the young person focussing on their personal goals while ignoring social expectations unappreciative of their singular talents and experiences. Due to a well-designed system, Matt's presence is no longer required, indicating an anarchic collaboration suits these particular young people (155).

The cost savings are impressive, but so are the individual stories. For four years co-founder Naomi Noffs coached an Afghan refugee who arrived with no education, but has recently been accepted to study medicine (156). A young Indian is now programme coordinator at the Street University; recording music, conducting media interviews and looking forward to a political career (159). Another graduate has launched a business producing own-label shirts. However most significant is many thousands onto a productive path, and police note a marked drop in local crime (155). In summary, the Street University provides a flexible framework for collaboration that grows long-term potential.

6.2.4   Circumstantial Evidence?

These three instances are evidence that innovation requires behavioural change, which occurs in three timeframes. Silicon Valley enmeshes collaboration between companies to make impulse innovation expected and well-managed. Open Innovation attempts to provide emergent innovation using formal agreements supported by patent arrangements, and avoid the destruction wrought by unexpected market shifts. Street University accomplishes the most fundamental behaviour change with tellingly few resources, showing that well-designed collaboration can deliver innovation without extensive finance.

It occurs to me that the Obama administration has done a number of (widely neglected) things that scramble the conventional categories and that are good policy besides. The administration has championed some potentially revolutionary education reforms. It has significantly increased investments in basic research. It has promoted energy innovation and helped entrepreneurs find new battery technologies. It has invested in infrastructure — not only roads and bridges, but also information-age infrastructure like the broadband spectrum. These accomplishments aren't big government versus small government; they're using government to help set a context for private sector risk-taking and community initiative (160).

Chapter 7.   Policy

This chapter takes Chapter five's endorsement of the parameters Chapter six's three evidentiary instances and addresses Chapter one's ultimate aim: coherent government policy. First however it must be established what government should *not* do.

7.1   Leadership Roles

It has been established that change within collaboration is atypical (§5.6.4), and therefore to enact requires leadership. The collaboration parameters provide insight on leadership roles that can respectively optimise them.

7.1.1   Facilitators optimise Cohesion

The facilitator's role is mediating and structuring cooperation allowing access to resources and people. Terman, Chesbrough and Noffs were facilitators of their respective collaborations. Since disclosure is trusted and their judgement of others relied upon, the facilitator is a custodian and source of Cohesion. The most effective facilitators interviewed for this research were not extroverted, but rather quietly confident, selfless and thoughtful. Introverts need time away from others (161) which provides time for reflection, and identification of advantageous opportunities; as the TIs' accomplish. Barack Obama is cited as an introvert who empowers those around him, but has difficulty inspiring an agenda (160) (161).

7.1.2   Entrepreneurs optimise Identity

Dynamic Identity has been previously discussed (§4.5), and entrepreneurs promoted as the ideal. Whereas facilitators are a neutral party, entrepreneurs use Identity to push change and can manage ensuing instability. They optimise Identity by not allowing personal discomfort to show, and by effectively responding to demands of collaboration, inspiring others to do the

same. Being confident of their own ability, the extroverted entrepreneur can take risks: "If we need someone to take charge they will take charge, and they will be less afraid of falling on their face" (162).

7.1.3 Experts optimise Transfer

Optimising Transfer requires collective confidence in the veracity of Knowledge. Academic journals guarantee dependable Transfer through expert editorship. Not only are experts capable of detecting erroneous information, they have an intrinsic motivation to remove false knowledge so their own position[42] is not questioned. In addition, experts can monitor refusal to Transfer if made aware of the transmitter's frustration at not being listened to, or the receiver's frustration of not being responded to. Experts can validate accuracy and monitor behaviour so that Transfer within collaboration is optimised.

7.1.4 Planners optimise Activity

Workflow optimisation is the traditional preserve of management in planning and coordinating tasks and resources. This role is usually termed project management, and requires those oriented to detail and able to communicate plans, which can make women a good, though under-utilised, choice (163). Planning also has elements of strategy which is often a male domain since it requires dispassionate calculation of future probabilities, and is perhaps why stock market analysts are most often male.

7.1.5 Consultants optimise Knowledge

A university degree teaches not only information, but how to find it, and optimal access to Knowledge requires categorisation. External consultants can dispassionately design categorisation systems unaffected by emotional attachment to past arrangements. Knowledge can be found without permission of gate-keepers or guidance of legacy personnel[43].

As a comparative example, Google has become dominant because its algorithm provides relevant search results. However, not all knowledge can be defined with words, and human expertise cannot be tracked by Google. Google rankings are dynamic, but a business needs to track knowledge on a longer term basis, not only for maintaining project histories, but also legal requirements of record keeping. Google uses aggregation to provide a ranking of likely relevance, but in most businesses there are insufficient searches to build statistical ranks. This

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[42] This can create difficulty with innovation; and is why new knowledge may require fresh collaboration.
[43] Legacy personnel possess an internal categorisation system developed over long experience but unavailable to others.

means a document not often accessed is forgotten. Even limiting Knowledge to documents, collaboration requires a directly-implemented tree or 'tag' categorisation method.

7.2 Government Oversight

This research proposes that government cannot assume collaboration leadership roles, but does have an obligation to promote collaboration. In first establishing conflicts of interest with leadership roles, it is remembered that Transfer requires two *people*, and not organisations or departments (§2.1).

7.2.1 Not as Collaboration Leaders

It is legitimate to claim that whenever government actors attempt participation as collaboration members, distortion arises. This includes acting as investor when the government uses public monies to fund a commercial or research venture. Venture capitalists will typically act as facilitators, but governments cannot as it would place the government in a position of supplying money without the capacity of undertaking a leadership or membership role. For this reason, problems are seen when a government buys military equipment. They are a customer without the ability to act as a collaboration member, making cost blow-outs commonplace since direct action is not taken by public servants without a personal interest in outcomes.

While public servants can lead change in their department, they cannot be private-sector entrepreneurs without personally investing public monies. Doing so creates a conflict of interest with their public responsibility to equitably apply legislation (164), and otherwise leads to undesirable outcomes (165). Government cannot facilitate[44] since they are not free agents able to preferentially refer people or keep confidences that could betray their official duties (166). Knowledge quickly loses its currency, and in anticipation of eventually returning to employment, experts that have become public servants tend to act in favour of their previous employer[45], with disastrous consequences[46]. Governments cannot become involved in planning with a particular company because it may involve future strategic manoeuvres against competitors and is therefore a conflict of interest. Government cannot design unique categorisation systems since it may involve commercially-confidential knowledge of a

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[44] The successful NCRIS program used academic facilitators (§A.4) and reveals that, even when public money is spent; such a position should be independent of government.

[45] It is anecdotally widely-held that academics on grant-awarding committees (NHMRC, ARC) make decisions to fund academics and research groups they have links with (10).

[46] Japan's TEPCO (219) and America's Goldman Sachs (218) have a 'revolving door' relationship with government regulators that contributed to global disasters.

company. Nation-wide categorisation systems have been attempted in many places, but become unavoidably cumbersome and so are rarely used outside government-associated endeavours (167).

If government were to allow their public servants to participate, they must give license to do so freely or else risk distorting their behaviour. Distorted behaviour triggers other participants' approach-avoid response, causing collaboration break-down that requires money (§6.1.1) to alleviate. It is however impossible to give free license without contravening principles of objectivity and transparency underlying good governance.

7.2.2 Dual Objectives

If government is not able to assume any of the five leadership roles, what should it do? Given government represents the interests of all citizens, its natural task is ensuring functional collaboration to allow citizens opportunity to achieve all three timeframes of innovation. Achieving this requires collaborations to be inclusive and viable rather than elite or fraudulent.

When groups lose touch with the remainder of society, they tend to have disregard[47] for its fate. When people are wealthy and isolated, they become fearful wealth will be taken by the poor, or by proxy the government. When people are poor and isolated, they become distrustful of the power of the wealthy, or by proxy the government (168). These suspicions create impediments to respectful and factual debate, and are the reason why an educated middle class is important for economic and social progress.

Once arisen, fracturing of society is difficult to treat as generations become inculcated in castes (§4.5.1). The antidote is collaboration across social strata allowing meaningful contribution to a common future. As the Australian Indigenous Mentoring Experience [AIME] has shown, the rich can gain valuable perspective from collaborating with the poor.

> *I guess it's like reverse mentoring, you know. I had stereotypes from country friends sometimes that, you know, Indigenous people were troublemakers - I'd heard all sorts of things. There's nothing more real than two people getting to know each other and putting aside like any previous conceptions of what issues they may be facing - just being, like, people. (169)*

In terms of the national interest, any emergent collaboration will help its members achieve beyond their potential, especially if given leadership roles. Even the most hierarchical

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[47] While appearing 'generous,' philanthropic societies and 'balls' are anathema to universal access since they become a mark not only of differentiation but of moral superiority and defence of low taxation.

organisation will have opportunities to lead that can be taken on initiative (§4.3). Experience assists in knowing when and how such opportunities should be taken. For example, entrepreneurs given practice at collaborating are provided not only multiple sources of Identity, but improved recognition of correct application of Identity in different situations, which is the crux of leadership for this parameter. America benefits greatly from its pool of 'serial entrepreneurs,' many of whom initially failed, but were supported in later attempts.

7.3 Recommended Policies

To promote healthy collaboration, audit of leadership forms the centrepiece of the first policy of tax offsetting membership fees to create a nation-wide Silicon Valley. The next policy is reduction of IP costs inspired by Open Innovation. Then a recommendation that the public are given vouchers that they can use to fund ventures such as Street University.

7.3.1 Collaboration Tax Offsets

At the recommendation of the Productivity Commission (10), the 2008 Australian government extended tax-offsets for business R&D. While complex to implement (170) and open to abuse (171) tax offsets remain preferable to grants since government is not itself disbursing funds, and so taking a leadership role.

> *There have been many careful empirical studies of the efficacy of the corporate R&D tax credit. Most studies find that the credit is effective in the sense that each dollar of foregone tax revenue causes businesses to invest at least an additional dollar in R&D. In other words, the credit stimulates at least as much R&D activity as a direct subsidy. And unlike a subsidy, which is usually linked to a particular kind of R&D related to a specific national goal, the credit allows businesses to select projects on the basis of the anticipated returns from incremental research dollars. (172 p. 2)*

It has been established that innovation is qualitative, meaning claims for R&D tax offsets require honest admission rather than being amenable to measurement. Since the entire firm has an interest in financial assistance, neither executives nor employees can be relied upon to report reliably. An alternative is to provide tax credits directly to individuals, using citizen's personal satisfaction as arbiter of validity.

A counter-precedent is trade unions, whose membership dues are entirely tax-deductible. Unions are known to resist innovation due to its unwelcome disruption on their membership (fee) base. For the same reason, unions discourage employee movement between companies but rather prefer workers to remain in situ (173), even in the face of changing market conditions. Unions do not welcome flexible bargaining that allow inclusion of share options, but instead desire collective rates of pay, which centralise and demonstrate their power.

Yet each industry is generally represented by a single union (174), meaning the worker's only alternative is not being unionised. This may be acceptable for highly-skilled professionals, but not low-skilled workers with less bargaining power[48]. In any case, un-unionised workers are disallowed in many workplaces under threat of strike. Those same unions are renowned for abuse of their power; delaying projects and bullying businesses[49]. Bosses of low-skilled unions also tend to use their position (and member's fees) for personal gain (175). Specifically in Australian politics, tight links between low-skill unions and the right faction of the Australian Labor party (176) encourage policy conservatism[50] (177). Since all five roles require intelligence, it is unfortunate but not unexpected that low-skill membership bases give rise to poor leadership.

To remedy these, the author proposes for unions to become one type among many accredited 'collaborations'. While still performing the function of unions, lower barriers to entry can give rise to multiple unions per industry, allowing pro-innovation options. A company could negotiate employment flexible contracts but those paying too little would see workers move to other unions. An important conjoint policy would be more generous welfare, and without penalty for leaving employment. Regardless of its generosity, the availability of better jobs in a dynamic ecosystem should see fewer welfare recipients.

Collaboration audit requires investigation of leadership: entrepreneurs who embrace change, facilitators that enable relationships, competent experts, active planners and effective consultants. Each leader should be able to produce physical or anecdotal evidence of their contribution. An entrepreneur will have introduced new approaches, and then made members feel comfortable in their adoption. A facilitator introduces members to one another or inducted new members. An expert applies their expertise, such as assessing a worker as competent for a position. A planner can show plans made, budgets delivered and strategies executed. A consultant can point to categorisation systems in use.

None of these are quantitatively assessable, but each is nevertheless an objective indicator of leadership efficacy. In assessing them, the public auditor does not need to be expert in the specific collaboration but instead can rely upon intelligent judgement amid data from physical evidence and member's testimony. Since it is their time and opportunity being wasted,

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[48] Rather than unions, Silicon Valley has inter-firm 'caucuses' to protect minorities in changeable workplaces (222).
[49] To introduce accountability into the Australian building industry (220) the Australian Building and Construction Commission was created by a Liberal government, but has recently been dismantled (221) due to union pressure on a Labor government.
[50] In the author's view this explains Australia's social conservatism compared to Nordic countries that similarly have small populations, are unblighted by war and have gained economic wealth post WWII.

members will self-report poor leadership or confess when asked. If investigation finds the collaboration is not serving members, it is disendorsed and membership fees returned to consolidated revenue[51]. This is a low-stakes investment where only leaders lose income and members can go elsewhere, or else create a new collaboration and lead it themselves. Oversight in this fashion promotes an environment where members can achieve their potential by choosing to belong, and having many options of, collaborations that suit them.

Tax offset of membership fees effectively subsidises administration costs of collaboration. It expensively uses citizens for primary oversight, promoting an ecosystem reminiscent of Silicon Valley. The opportunity to become involved would draw investors and inventors while employers can recruit staff in person, replacing the formulaic tedium of written applications. Training providers would become involved to mould courses that fit changing needs. Leaders wishing to form their own collaboration have a guaranteed income stream should they attract members.

In Australian, payment of collaboration membership fees would ideally occur via the Australian Taxation Office [ATO]. Collaborations nominate their membership fee level, and when a member registers, the amount is removed from their taxes and credited to the collaboration. In order that people valued their fees, and did not expose the government to excessive expenditure, there would be a per-person cap. Those paying fees from their own pocket without tax subsidy would not contribute to their cap, but still be registered in order to identify criminality[52]. A register of collaborations, and their specialisation, would be publicly viewable; and similar to company annual reports, audit data published.

The Collaboration Tax Offset policy enables people to mix and thereby learn new things. Equity of entrance and treatment is guaranteed by subsidising membership fees and auditing leadership respectively. As Silicon Valley has shown, such collaborations assist business innovation, and in Australia's case, possibly union relevance (178).

7.3.2 Reduced Patent Terms

Open Innovation contrasts the 'biological' ideal of Silicon Valley with Chesbrough's response to patent law and corporate conservatism. Chesbrough makes a brave case for collaborative

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[51] Collaborations being formed for tax avoidance and/or personal gain would cause people to be banned from leadership positions, and perhaps prosecuted for fraud.
[52] Collaborations created for the purpose of tax fraud would be discovered by various means, such as by members who found no worthwhile activity being undertaken. Collaborations that refused membership to such people could also be reported.

openness, but admits that his remedies are unsuitable for smaller companies unable to afford patents and lawyers, or to influence suppliers and customers.

> *To be fair, there are advantages to the type 1 business model. First and foremost, the type 1 model is by far the lowest cost model. This model reduces the cost to the firm entering into a new market since it requires no money to be spent on expensive items such as innovation. (55 p. 112)*

Such inequality of participation provides justification for government intervention. That a small business is less able to innovate because of prohibitive cost fragments society. Innovation requires functional collaboration with well-designed incentives (§6.1.1), which is why the previous policy subsidises and audits leadership. The problem of patents however requires a different solution.

Originally, patents gave inventors time to recoup capital investment by providing a monopoly period. The world has changed greatly since the 17th century when an anti-fouling patent (179) gave England a critical advantage against French warships. Patents were also a permanent record that preserved knowledge in case of inventor's death. Before ubiquitous university and corporate R&D, lone inventors were valuable sources of technology. As a result of this philosophy, patents today can be viewed online for free, and patent 'walls' are necessary to fully protect ideas (180). Regardless, China and similar nations illegally and systematically copy patented inventions. At the same time, they use their economic power to buy patents that suppress innovation elsewhere (181); a practise on a smaller scale known as trolling (55 p. 79). In addition to aiding abuse of patent law, centralised invention disclosure given modern telecommunications is unnecessary.

The solution however is not changing disclosure rules, but reducing the value of patents and so reward for their abuse (182). While previously few inventions were sold internationally, a twenty year monopoly to world markets is now unjustifiably lucrative[53]. Rapid prototyping, computerised design and highly-integrated production systems (183) reduce time and cost to market. Patents today undermine innovation by warranting huge legal[54] and administrative[55] costs protecting the monopoly rights they grant. IP suits are the most expensive court case and some patent holders do not have the resources to defend them. Governments receive patent fees of thousands of dollars per year per country, and indeed link them to awarding of research grants. Ensuing patent upkeep is funded by universities, and therefore the taxpayer,

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[53] Patents are warranted for pharmaceuticals given the high cost of lengthy human trials.
[54] It costs an average of $500,000 per claim to defend patents in court (225) and a patent typically has many claims.
[55] A world-wide patent will cost $500,000 in license and drafting fees over its term (226).

but often 'warehoused' by academics and never actually commercialised (184). Yet the illusory promise of quantifiable innovation (185) embodied in measurable patent numbers continues to attract financial investment (186) from the tax payer.

Innovation has become the arena of large corporations inherently deriving benefit from the status quo. Chesbrough's solution of building vertically and horizontally integrated conglomerates will strengthen these corporations, but at the price of smaller players and eventually innovation itself. With their patents impeding competitive threats, corporations can gradually contract their operations to maximise profit without threat from elsewhere. As the global financial crisis has shown, corporates survive when the surrounding economy is moribund, although there comes a point where a severe downturn begins to hurt (187). In a very real sense, patent law threatens a return to feudalism, with all its concomitant problems of wealth concentrated, innovation prevented and eventually impoverishment for all.

Large corporations are effectively exclusive clubs closed to the majority of society[56], with even Silicon Valley now seeing a concentration of executive power (153). This contradicts the principle of universal access, but by reducing the lifespan and therefore value of patents; smaller businesses will more readily compete. Collaboration tax offsets initially creates vehicles while reduction of patent terms allows subsequent growth with less-costly or expired IP. This research recommends reducing patent terms from twenty years to five[57].

7.3.3 Collaboration Vouchers

Considering the effectiveness of the Street University in permanently changing futures, government is behoved to encourage similar experiments. Yet as found in the analysis of Powering Ideas (§A), deliberate funding is prone to politics and a requirement for metrics that may not be evident for some years. The fact that Street University attracts young people indicates that people can be trusted to know which collaborative opportunities will benefit them. Not being themselves homeless youth, public servants are not in a position to know where to direct funds, nor assume a leadership role once they do.

Rather than the government announcing grants for welfare programs, the unemployed should be supplied vouchers to spend on membership to preferred collaborations. This policy would work seamlessly with tax offsets, even imposing the same limit on spending. Members funded by voucher are not discriminated against since the ATO would not inform the collaboration

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[56] Consumption is only collaboration in the sense of indirect knowledge transfer from product designers.
[57] Existing patent terms currently reduced in ratio with their remaining life.

how payment was made. This allows for true equity of access to collaboration, and thereby opportunities to meet employers, trainers and investors. It is certainly likely to be more cost-effective than the current approach.

> *Those Job network providers who operate for profit training businesses (often associated with secretarial or administrative training or colleges offering VET diplomas) will often steer clients into their own courses, even if inappropriate for their needs, or if a more appropriate course is available at a TAFE or a competitor institution, thus again preventing competition and responsiveness to clients, and artificially subsidising their own profit making businesses at the expense of others which are not aligned with Job network providers. There is a place for contestability and tailored assistance in employment services, but the current model provides job seekers – and the broader community – with a poor return for the limited investment we make. (188)*

Giving the unemployed buying power towards building their own future does not require a vast bureaucracy or a time-consuming grant application. Similar to the recently arisen but hugely-popular 'crowd sourcing' phenomenon, collaboration vouchers rely upon people participating in their own solution, and superior collaborations surviving their competition.

> *Talk of crowdfunding as a short-lived fad has largely ceased, as evidence mounts that lots of people value personal engagement with projects they help to finance. "People increasingly want humanity with their technology," says Caterina Fake, an early investor in Kickstarter. Hitherto people have opened their wallets for three main reasons: "caring about the person or company; wanting the product; or being part of a community," says Slava Rubin, a founder of Indiegogo. Adding profit as a motive will bring fresh challenges. (189)*

Crowd sourcing and collaboration subsidy are both policy implementation devolved to the citizen, which is appropriate given the ethical hazard of government imposing solutions (§A.3).

7.3.4   Freedom from Government

This chapter has developed policy consistent with the collaboration model based upon three instances of successful innovation. At the same time, it has avoided the hazard of government intervention where public servants are unable to assume collaboration leadership roles. An alternative is extensive outsourcing, currently delivering cost-effective services for one American town (190). Another is 'social bonds' that only pay investors upon delivery of measurable social outcomes, such as reduced recidivism (191). These solutions would be assisted by an ecosystem of collaboration producing socially and economically-beneficial ventures to undertake services currently monopolised by the government.   The most successful of these would be effective at all three timeframes of innovation.

We could be in for a long, slow decade. There's a confluence of forces that are probably going to retard economic vitality. Consumers are still overindebted, and it will take years of curtailed spending before households are back on a sustainable path. Federal and state governments also will have to pull back. Labor markets were ill before the recession and are worse now.

Our trading partners in Europe and Japan are stagnant or in peril. Banks in this country are not lending to small businesses and banks elsewhere have huge write-downs to endure. The psychological war between business and the Obama administration also is taking a toll. Business types think the administration is stuffed with clueless professors. Some administration officials think corporate honchos are free-market hypocrites prowling for corporate welfare (192).

Chapter 8.   Conclusion

The above Brooks quote circa June 2010 has proven remarkably prescient. Amid an ongoing recession, the world remains in the grip of vast uncertainty over policy direction. Is a 'European' standard of living and approach to welfare viable? How is a Western economy stimulated when capital will fly to where taxes and wages are lowest? Effectively-bankrupt nations are hostage to investors unwilling to buy their debt unless at an unaffordable premium (193). A bloated, speculative 'vampire squid' financial sector is 'too big to fail' (194) (195) but refuses to loan money to business because of stagnant demand as a result of an economy they wrecked. Growth a valuable commodity, and in a time of expensive Keynesian stimulus packages and disastrous Hayekian austerity programs, China offers rare hope. Before explaining how this research sheds light in China's success, research progress to date is summarised.

8.1   Thesis Summary

Chapter one began by introducing innovation via critique of a government report (§A). In establishing its inconsistent, non-theoretical rationale, the case for an alternative was made. Chapter two discussed alternatives: from other reports, other theorists and the author. None were found to be sufficient, with complexity of the problem-space at true fault.

Chapter three designed a method to overcome qualitative complexity using System Dynamics and Control Theory and Critical Thinking. Theory was built within an iterative recursive framework using abduction, induction and deduction. Chapter four explained the resulting collaboration model using the structure assessment test.

Chapter five used the SCARF approach-avoid model to understand captive, selective and novel engagement within tribe, village and town contexts respectively. Examination then moved further back into evolutionary history to understand how mammals collaborated, and in what way different to humans. Speech and cognition were most obvious, with psychopaths being an example of functional specialisation that disregarded empathy. Partial display of parameters in mammals gave weight to the conclusion that cooperative life prospers when the parameters are expressed by the group rather than necessarily in all individuals.

In the final stage of Chapter five, feedback analysis showed a systemic bias towards stability; or lack of innovation. If the collaboration parameters were changed quickly, members' Identity was subject to potentially-uncomfortable oscillations. This highlighted the importance of resilient individuals with good parenting and wide exposure to diverse sources of confidence. Without such individuals, collaboration remained moribund and conservative as change was avoided. This showed that innovation indeed requires atypical effort, and would have historically not occurred without survival pressures.

Chapter six saw reconceptualisations of innovation, delinking money and inserting the idea of behavioural change. Impulse innovation was approximated to an addition of new technology or processes. Emergent was so-called because innovation is an emergent property of cooperation allowing individual performance above their ostensible potential. Quotient innovation is permanent improvement to potential named after the ubiquitous IQ test.

In seeking support for the collaboration model, evidentiary instances were chosen for their reflection of the three innovation timeframes. Silicon Valley is notable for impulse innovation and Street University for quotient innovation. Open Innovation is a recipe for overcoming a patent system that discourages change, combining with inherent conservatism of large organisations that fails to build employee potential and thereby emergent innovation. Establishing an evidentiary link to innovation timeframes clears the path for policy recommendations combining them with the collaboration model.

Chapter seven aims for policy coherence by first understanding that government cannot directly participate in collaboration. Each of the parameters was found to correspond to a leadership role that government experienced a conflict in undertaking. Government's role is rather ensuring universal opportunity and promoting social cohesion. Within this remit, collaboration tax offsets, reduced patent terms and collaboration vouchers are suggested. The first and last create an ecosystem of collaboration while the second reduces impediments to

innovation for firms both small and large; the former by reducing patent costs, the latter by increasing competition.

8.2   Observations

The adage 'it takes a village to raise a child' implies that multiple influences are necessary for resilience (196). High rates of mental illness and suicide are seen in societies characterised by broken marriages and internal migration (197) as well as income inequality (198). Post WWII, social impacts of mobile, fragmented communities with associated family disruption are only becoming evident some sixty years later.

While the Cultural Revolution killed millions, it preserved the integrity of villages while removing a caste of hereditary land owners. When restrictions to private ownership were removed in the 80's, these former peasants became the foundation of economic growth (183). Today, China's dynamic and flexible low cost economy supplies the world's consumer goods. As factories and indeed entire cities rise seemingly overnight, impulse innovation is evident. As an agricultural peasant class are given undreamt of opportunities to accumulate wealth in factory jobs, emergent innovation is seen. As China invests vast sums in educating her young people, quotient innovation is apparent. By innovating across the spectrum of timeframes, China is doing what the developed world has forgotten how to. This success is however being increasingly undermined by the corruption that unavoidably results from an opaque, non-representative system of government.

Western growth is anaemic because institutions and populations have become moribund. Innovation is impossible when the rich use the status quo to get richer, and leave the poor to fight for the spoils. There is no 'trickle down economy;' only the meagre bribe of low wages and welfare that removes personal responsibility from the rich and poor respectively. Absent revolution, the masses have little power, but this research offers hope that they may be enfranchised to grow their future, and so our collective wealth, without the dramatic upheaval seen in the Cultural Revolution.

8.3   Future Work

The author sees three fertile directions for future work, the first being introduction of the collaboration model to specific locales using principles of *Action Research* (199). With application of theory being the objective, educational material would be prepared for collaboration members and leaders. Implementation would occur as they see fit, with outcomes monitored (200) as suggested by audit recommendations (§7.3.1).

The second direction is further exploration of leadership roles, perhaps comparing optimisation of specific impacts with existing management theory. Each of the leadership roles are specialised, and could provide fertile grounds for focussed attention in partnership with relevant theorists.

A third direction is computer simulation of the collaboration model to replicate macro economic and social behaviour. Assistance would be required to identify data, and to undertake simulation. Given the novelty of this research, it may shed light on certain historical mysteries: for example, most economists predicted China would not survive the 2008 crisis given collapsing exports (201).

A distinctive name for this research would be beneficial, and it is henceforth as CEISYS Theory. *CEISYS* (pronounced *sigh-sis*) is an acronym for Collaborative Entrepreneurial Innovation System[58].

8.4   Closing Comments

It was argued in Chapters one and two that fostering innovation remains a mystery to both policy makers and theorists. Defining money within the narrow bounds of transactable goods and services poses difficulties reconciling economic liberal philosophy with the social undesirability of wealth disparity. Unavoidably, if accumulating monetary wealth is the sole arbiter of personal success, those possessing more will use their relative buying power to further improve their position. If however money becomes secondary to participation in collaboration, individual success is not dictated wealth but by agency. Holding highly-paid rank in a monolithic institution would be less of a badge of honour compared to creating its replacement. While admittedly utopian, such a perspective has allowed both theoretical rigor and pragmatic application of policy around innovation.

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[58] Feedback on this research is welcomed by the author at www.ceisys.com.

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Appendix A: Critique of Powering Ideas

Powering Ideas (2) henceforth 'the report' represents state-of-the-art of Australian policy-making around innovation. Section one presents advantages of innovation and establishes collaboration as its precursor. Section two blames various 'market failures' for a lack of innovation that obliges government to apply financial remedies. Section three examines how the government applies these incentives, such as coordinating between state and federal committees. Section four demonstrates that three previous policy successes run counter to recommendations made by the report. The report is heavily referenced and quotes are reproduced for the reader's convenience.

A.1   Innovation Defined

The form of innovation intended by the report is new products and services but broader advantages are also recognised.

> *Economically, innovation delivers productivity growth and business profitability, which allows participation in newly-arising world markets. This occurs through "[making companies] more competitive by enabling them to differentiate their products and services, target niche markets at home and abroad, and participate effectively in global supply chains." (2 p. 43)*

> *Socially, innovation allows us to maintain our standard of living through wealth generation, address pressing social and environmental challenges, while also creating "better products and services, higher levels of comfort and security, richer experiences, and new forms of social engagement." (2 p. 13)*

> *Innovation-based collaboration has benefits for the individuals involved, increasing their ability to "absorb new knowledge, recruit new people, and develop new skills." (2 p. 60)*

> *Regarding the wider research and other systemic outcomes, "Collaboration stretches our research dollars further, spreads risk, favours serendipity, propagates skills, and builds critical mass." (2 p. 8)*

To expand the final point, while collaboration is seen as an enabler of innovation, informal relationships are of most value.

> *Firms in the United States and the United Kingdom regard informal contacts as the most important type of university-industry interaction contributing to innovation, ahead of graduate employment, research publications and technology licensing… Successful Australian innovators identify collaboration as a key value. International evidence confirms that collaboration is a bigger influence on business performance than strategic orientation or the opportunities inherent in the market environment. IBM's global chief executive officer survey found that, "Extensive collaborators outperformed the competition in terms of both revenue growth and average operating*

margin." If anything, collaboration is even more important for smaller firms (2 pp. 60-61)

There are many mechanisms by which collaboration assists business growth and profit.

...enables [a company] to reduce costs by eliminating duplication, achieving economies of scale, and democratising access to expensive infrastructure. It spreads the risks and maximises the rewards associated with innovation (2 p. 60).

The report cites US manufacturers collaborating with universities who will experience the greatest benefit of collaboration.

[L]arge firms acting on their own account for a much smaller share of award-winning innovations, while innovations stemming from collaborations with [company] spin-offs from universities and federal laboratories make up a much larger share (2 p. 61).

As a result Australia should "...increase the level of collaboration between public researchers and private industry [since] we rank last in the OECD on this measure" (2 p. 8) but "[t]he number of small and medium-sized firms doing research and development remains low, and innovative businesses are still the exception rather than the rule" (2 p. 23).

A.2   Market Failure

Market failure is ongoing failure of the market to supply a demand, and from the perspective of the report there are a number of reasons why markets fail to innovate.

...ground-breaking innovation [that] requires sustained commitment, sometimes for decades. Translating new ideas into money-making products and services takes staying power. It requires an innovation system that offers an unbroken path from vision to realisation. The market alone can't deliver this, and governments have a responsibility to step in where markets fail. It is their job to plug gaps in the system through which ideas might be lost. (2 p. 3)

Exactly what the government can do is not always clear. Innovation is "complex and risky. Everything is interconnected. The success of measures … may depend on whether firms can get the researchers or the venture capital they need" (2 p. 27) and even while "market gives business powerful incentives to innovate [the] signals it transmits to individual firms are often weak, mixed, and disconnected from the here and now" (2 p. 43) In the face of these complexities, the government's major weapon is financial assistance.

The passage from experimental development to commercialisation is so treacherous that high-tech start-ups call it the valley of death. The global financial crisis has made this valley considerably wider. Australian Government programs that respond to this market failure include Commercialising Emerging Technologies (COMET) and venture capital vehicles such as the Innovation Investment Fund. (2 p. 47)

The 2008 global financial crisis was a market failure of bankers and speculators seeking short term profit rather than long term innovation that takes a "…sustained commitment,

sometimes for decades" (2 p. 3). Government can encourage longer planning horizons by fostering economic stability and reducing trade barriers, but also providing direct funding to private and public R&D.

> *The OECD has suggested that the best way to promote innovation is by providing stable economic conditions and low interest rates; reducing anti-competitive regulation; increasing the availability of internal and external finance; expanding public research; providing fiscal incentives; and being open to foreign R&D (2 p. 43).*

Even in an economy boasting over twenty years of growth, Australia's cultural aversion to risk (202) manifests as unwillingness to exploit innovative opportunities.

> *The culture and management of Australian organisations lags behind the world's best in other areas as well. A survey of manufacturing firms found that "while there is evidence of manufacturers engaging in some innovative business practices, especially towards achieving production efficiencies, they generally fail to appreciate and employ innovation as a decisive competitive strategy (2 p. 23).*

Theoretically, companies that innovate should out-compete those that do not. Innovation via market competition is hampered by company executives colluding across boardrooms to protect cherished positions (203) and exorbitant remuneration.

> *If you're Fidelity, the huge mutual fund, are you really going to criticise a CEO of X company for making an obscene level of pay when you yourself are making an obscene level of pay? Because you have this problem of everybody being co-opted (204).*

Rather than executive irresponsibility, the report blames "asymmetry of information."

> *The main impediment to venture capital markets working effectively is the asymmetry of information between the firm and financial institutions, which cannot accurately gauge the likely success of a project. For want of better knowledge, the institutions do not invest (2 p. 48).*

While short-sighted executives (205) are synonymous with corporate failure[59], employees at all levels are important for successful innovation. This author believes that unfair dismissal laws penalise innovative companies by keeping their unproductive workers employed (206) with the countervailing implication that bad companies are 'propped up' by good workers because positions at better companies remain unavailable (207). The report believes that poor workers should ideally not exist, and that the education system bears responsibility.

> *Australia's education and training system does not pay enough attention to the skills required for innovation. Employers complain that they have difficulty recruiting workers with these "soft" skills, which include the ability to solve problems, communicate effectively, and work in teams (2 p. 23).*

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[59] Two very recent illustrative examples are CEOs of Sydney Morning Herald (223) and Glencore (224).

A specific example cited by the report are research students not having 'soft' skills for multi-disciplinary teams, making them less useful for both research and employment.

> *Concern has also been expressed about the lack of clear career paths for research students, and the training system's failure to teach them skills that will make them attractive to private sector employers, and equip them to do collaborative, multidisciplinary research (2 p. 37).*

Performance will suffer when teamwork is poor, even assuming the technical skills exist and management is proactive.

> *Making innovation work requires a workforce with sophisticated skills of all kinds — including leadership and management skills. It also requires cooperative workplaces in which creativity is encouraged. Few organisations command all the skills needed to innovate successfully on their own. They must network and collaborate — locally and globally. Innovation happens because organisations mobilise resources to make it happen; it happens because they invest in innovative capacity. How much they invest is influenced by the opportunities and incentives available to them (2 p. 17).*

The report neatly divides this complex landscape into 'opportunities' controlled by the market (including education §A.4) and 'incentives' offered by the government, which must have "explicit goals."

> *Australian Government support for business innovation must […] target firms of all sizes and in all sectors. It must recognise the complexity of the innovation process and the different forms innovation can take. Above all, it must be responsible. To justify the community's investment, all programs and incentives must achieve explicit goals that can be measured against **objective benchmarks**, they must induce business to do more than it would have done without public support, and they must have no adverse effects (2 p. 59). [Author's bold]*

Given the admitted uncertainty and complexity of innovation, one wonders what "objective benchmarks" might be, and how they are designed. In the absence of coherent theory, the report advances 'Priorities' to promote innovation, one of which concerns government, and within this a set of 'Principles' of government intervention.

A.3   Priorities and Principles

The report proposes seven Priorities (2 p. 4) to promote innovation. Priorities one and two fund "high quality research" and "skilled researchers" while Priority three "fosters industries of the future." Priority four aims to increase "dissemination of new technologies, processes and ideas, with a particular focus on [SMEs]." Priority five is to encourage "a culture of collaboration within the research sector and between universities and industry." Priority six would like to see "…more international collaborations on research and development." Priority seven concerns improvement in "policy development and service delivery" around government intervention in the market.

The government will streamline and strengthen administration to "make it better at targeting national priorities, coordinating the activities of different governments, and measuring performance" (2 p. 27). Federally, the intent is to "continue to increase cooperation and coordination between Commonwealth agencies. Its aim is to minimise duplication, build critical mass, and promote cross-disciplinary understanding" (2 p. 28) in order to rectify the circumstance where:

> *Governments in Australia run some 155 programs to support business innovation —*
> *forty-five administered by the Commonwealth and 110 by the states and territories.*
> *The Review of the National Innovation System and others have argued that this*
> *proliferation is confusing and inefficient (2 p. 29).*

To address this "proliferation" of grant programs, the report recommends that policy coordination is streamlined via three individually-tasked committees[60], combined with as-required meetings of federal, state and territory ministers. Currently, any of these forums can make decisions pertaining to the system, with no guarantee of consistency. A suggested way to provide uniformity and rigour is through the Prime Minister's Science, Engineering and Innovation Council[61]:

> *Under the leadership of the Chief Scientist, the council provides advice on technical,*
> *economic, environmental and social aspects of science and technology; helps keep*
> *Australia's research and innovation priorities up-to-date; and raises community*
> *awareness. Most importantly, it is establishing formal structures to look over the*
> *horizon and provide the strategic foresight needed to support long-term, whole-of-*
> *government policy development (2 p. 28).*

Additionally, the (renamed) Coordination Committee on Innovation will be given expanded cross-portfolio coordination responsibilities:

> *As well as improving the coordination of policies and programs, [the committee] will*
> *coordinate advice on cross-portfolio innovation matters; gather and disseminate*
> *information on local and international innovation trends; coordinate cross-portfolio*
> *input to international forums and programs; and report on the implementation of*
> *Australia's inno*vation and research priorities *(2 p. 28).*

The third committee involved in coordination is the Advisory Council on Innovation and it has been tasked with "securing national agreement on a set of principles for innovation program design."

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[60] Prime Minister's Science, Engineering and Innovation Council, an expert group which advises the Australian Government on science and innovation; Commonwealth, State and Territory Advisory Council on Innovation, a committee of officials responsible for intergovernmental coordination; and a committee of officials responsible for coordinating Commonwealth agencies.

[61] The Standing Committee on Science and Innovation (9) previously recommended that the minister of DIISR be given signing authority over all legislation pertaining to innovation, but this was not included in the report.

Once agreement has been reached [on the set of principles], all governments will be asked to assess existing and proposed programs against these principles. The Commonwealth will also join with the states and territories in examining the feasibility of developing a new portal that will enable firms to access all Australian business innovation programs in one place (2 p. 29).

These principles are intended to act as a guide for policy development, with the suggested first draft being:

1. *the rationale for intervention and the role of government should be clearly identified*

2. *that each intervention should support the development and effectiveness of the national innovation system as a whole*

3. *that interventions should reflect and respond to demand-side needs and priorities*

4. *that the best-placed jurisdiction should be responsible for design and delivery*

5. *that innovation risk should be assessed, accepted, and incorporated into the design (2 p. 27)*

Without theory, the Principles are necessary to provide guidance in a complex landscape. They ask policy makers to use common sense, sound information and to not shy away from complexity. They do not however explain how innovation works and how policy can explicitly encourage it. It is revealing that final version of the Principles remains to be agreed upon, similar to a peace treaty. Theory does not arise from the pragmatic agreement of stakeholders, however wise and well-intentioned.

Being non-theoretical, the Principles attempt to find safety in generality. Unfortunately, when generality becomes vagueness, there is no guidance for specific policy. To compensate for a lack of theoretical foresight, the report recommends hindsight, or in other words "accountability."

The Australian Government has a duty to measure the impact of specific innovation initiatives and the performance of the system as a whole. This is the only way to be sure that policies are working and resources are being put to the best possible use. Indicator analysis, scorecards, and case studies are all commonly used for this purpose, but they only tell part of the story. Econometric analysis has the potential to tell us much more about how well the system is doing. So do studies linking innovation data to statistics of other kinds — financial, administrative, environmental, social and so on. The Australian Government will work to collect better data on innovation and develop new, more sophisticated analytical capabilities. It will also produce an annual report on the performance of the national innovation system. The report will identify new opportunities and challenges, and provide regular updates on implementation of the National Innovation Priorities (2 p. 29).

In placing reliance upon accountability for innovation programs, two problems arise. Innovation is by its very nature novel, which renders pre-ordained measures problematic. How can a risky venture be invested in when its uncertain nature renders early, firm decisions

on output metrics illogical? Certainly Principle five warns against allowing the uncertainty of innovation to excuse inaction, seemingly contradicting a stipulation for "objective benchmarks."

Also, some critical aspects of innovation, such as informal collaboration, are resistant to quantitative assessment. Government relies upon numerical (typically financial) accountability to measure progress so that over time policy can improve. Yet if important aspects cannot be counted, successful policies may not be evident, especially given the timeframe of innovation (decades) compared to election cycles (years).

The alternative to policy evolution is identifying theory from which both policy and its accompanying accountability can arise. The complexity of innovation renders any linking of past inputs and future outcomes disputable. Selection of the fittest requires qualitative objectivity and assessment over long time horizons, yet a politicised environment corrupts this process as the following examples demonstrate.

A.4   Failure to Learn

Three policies from the report are compared against known successes and stated principles, with the aim to highlight unsound application of vague ideals open to political interpretation. The first rejects a working approach by replacing a facilitator with a committee. The second starves a notably successful idea with poor funding. The third demonstrates a hypocritical attitude to collaboration, and the skills required.

The previous government's *National Collaborative Research Infrastructure Strategy* (NCRIS) built large-scale scientific infrastructure, access to which was shared amongst researchers in the field. The original manifestation, circa 2007, had a facilitator chosen from amongst researchers in each field and tasked with finding agreement amongst the field as to the type and location of equipment to be purchased. Views from throughout the scientific community were gathered that allowed a decision to be eventually made.

It was a highly-successful program, notwithstanding concerns around potential conflicts of interest (208). These arose as a result of the facilitator originating from the ranks of active researchers, providing an incentive to favour the 'home team.' No complaints eventuated however, and the program was applauded for spending public monies in an equitable and efficient fashion. Conversely the report promotes an incarnation of NCRIS led by the National Research Infrastructure Committee rather than individual facilitators. There is no reason

supplied for making this change, and none of the Principles offer guidance. It seems to be an instance of political considerations overriding objective evidence.

Some years ago CSIRO instigated an 'Engagement Centre' through which small to medium enterprises (SMEs) could form relationships with scientists. Their 'Engagement Managers' facilitated the negotiation of consultancies, contract research, licensing, partnerships and co-investments. The government has recognised the success of this model and broadened it into a nation-wide system of centres, advisors and facilitators; collectively known as *Enterprise Connect*. Enterprise Connect primarily provides business advisors to SMEs, with the further potential to award small grants ($20k) to hire a consultant.

There was an experimental program established by Enterprise Connect in Adelaide using local ex-CSIRO Engagement Managers to explicitly connect supply chains and make optimum use of industrial capacity. However, with only limited coordination between the relatively few advisors (86 nation-wide[62]) time constraints make facilitation of business collaboration a luxury. This contradicts expansive claims made by the report that "by reducing the cost of finding, acquiring and adapting information, and by strengthening links between small firms and other actors in the innovation system" (2 p. 49) it has "dramatically increased Australia's investment in skills and education, and created new instruments for accelerating innovation across the economy, most notably Enterprise Connect" (2 p. 44).

If Adelaide's program was properly funded at a national level, it would be more likely to achieve the above claims. Yet at the time of writing there exists only approximately 100 business advisors, with 20 funded by industry (209). In the interim, new funding has primarily been directed towards project grants (210) of the type that have experienced trouble[63] in the recent past (211). A tendency for electorally-impressive announcements rather than pragmatic policy is understandable but nevertheless disappointing, and continues with the multi-billion dollar *Building Education Revolution (BER)*:

> *...preparing young Australians for the future by giving them the skills they will need to participate fully in a knowledge-based economy and a democratic society. A national curriculum in the seven key learning areas - English, mathematics, science, history, geography, languages, and creative arts - will be implemented in 2011. It is particularly important that we build technology skills - as the Commonwealth is doing through the National Secondary School Computer Fund and related initiatives. It is*

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[62] Telephone interview with an Enterprise Connect advisor 3rd June, 2010.
[63] Three large solar projects were scrapped and re-tendered after failing to meet milestones due to lack of cooperation from large fossil fuel energy companies that should have been grounds for a renegotiation of terms.

equally important that we reverse the historic decline in the study of science and maths (2 p. 40).

BER focuses exclusively upon traditional learning outcomes with inclusion of technology skills. Activities that might improve student's interaction are neither suggested, nor further investigated. This is a huge discrepancy between claimed market failure and suggested remedial policy.

> *To ensure that Australia continues to have the right innovation priorities and that we are pursuing them in the right way, we must continuously evaluate our policies and measure our performance. This will tell us what's working, what isn't, and what we can improve. Given the growing complexity of the innovation process, we also need to ensure that the national innovation system is governed effectively (2 p. 9).*

How is a student's capacity to interact and form relationships measured? Not easy to answer, yet by placing emphasis on post-hoc accountability rather than theoretically-sound policy, the question is avoided, or rather left to 'the market.' Collectively, these three policies reveal how a lack of theory leads to poor outcomes, which this research will attempt to remedy.

Appendix B: Iterative Theory Building

System Dynamics and Grounded Theory are the foundation of the qualitative methodology adopted by this research.

B.1   System Dynamics

With its origin in electrical engineering, System Dynamics (34) is founded upon control theory and non-linear dynamics, meaning there is rigorous mathematical foundation to the theory developed.

B.1.1   System Dynamics Elements

System dynamics has four elements; accumulating variables (stocks), the rate of their change (flow), non-accumulating variables (variable) and the relationships (impacts) between them. These constitute the algebraic elements of integration, differentiation and operation respectively (Fig. 22).
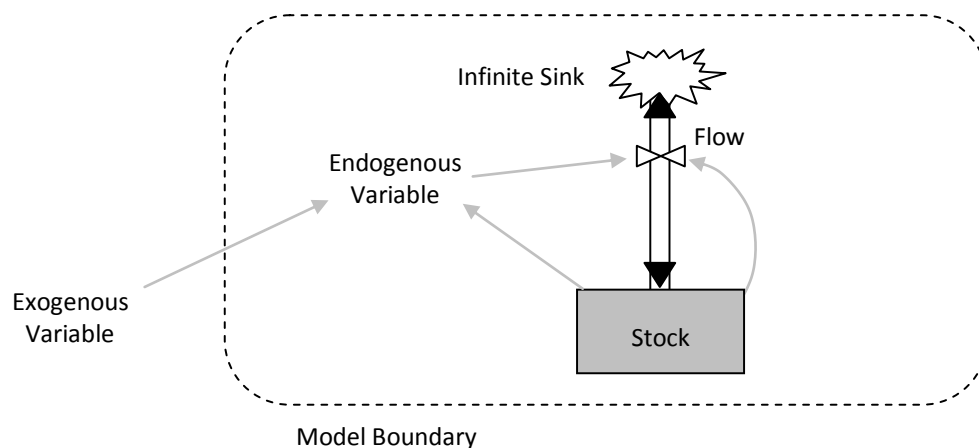

Figure 22: System Dynamics components

Stocks are an aggregate of homogeneous elements whose rate of accumulation the relevant flow regulates. Stocks capture the tendency for aspects of systems to accumulate. Conceptually, a stock is reminiscent of a bathtub filling with water, where the volume of water at any one time is the level of the stock, while the rate that water is pouring out of the tap is the flow. Variables are simply an instantaneous calculation based upon their inputs at the particular time.

A stock is only changed through a flow, while a variable is affected instantaneously by their inputs, which may be either stocks or other variables. A flow is also a variable, but tradition

dictates that they not have any impact bar on the stock they are 'emptying' or 'filling' (similar to a bathtub).

A subsystem diagram shows the overall architecture of a model, conveying information on the boundary and level of aggregation (Fig.18). It may be also noted that System Dynamics typically employs single-directional flows (the filled black triangle), but this research uses dual-directional flows. This is just as mathematically rigorous, since it effectively adds (or minuses) one direction to (from) another, but makes presentation less cluttered.
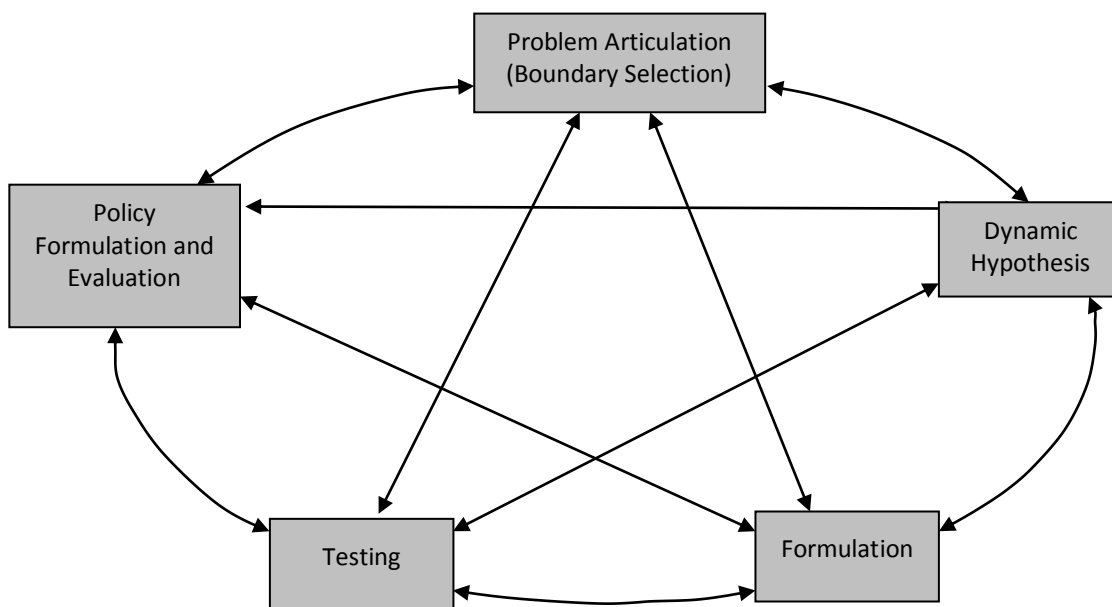
A.1.2 System Dynamics Iteration

Figure 23: System Dynamics Iteration (34 p. 87)

	Step	Activity
Problem Articulation	Theme selection	What is the problem? Why is it a problem?
	Key variables	What are the key variables and concepts to consider?
	Time horizon	How far in the future should we consider? How far back in the past lie the roots of the problem?
	Dynamic problem definition (reference modes)	What is the historical behaviour of the key concepts and variables? What might their behaviour be in the future?

Formulation of Dynamic Hypotheses	Initial hypothesis generation	What are current theories of the problematic behaviour?
	Endogenous focus	Formulate a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure?
	Mapping	Develop maps of casual structure based on initial hypotheses, key variables, reference modes, and other available data, using tools such as a stock and flow map;
Formulation of Simulation Model	Specification	- of structure, decision rules
	Estimation	- of parameters, behavioural relationships and initial conditions.
	Tests	- for consistency with the purpose and boundary
Testing	Comparison to reference modes	Does the model reproduce the problem behaviour adequately for your purpose?
	Robustness under extreme conditions	Does the model behave realistically when stressed by extreme conditions?
	Sensitivity	How does the model behave given uncertainty in parameters, initial conditions, model boundary and aggregation?
Policy Design and Evaluation	Scenario specification	What environmental conditions might arise
	Policy design	What new decision rules, strategies and structures might be tried in the real world? How can they be represented in the model?
	"What if…" analysis	What are the effects of the policies?
	Sensitivity analysis	How robust are the policy recommendations under different scenarios and given uncertainties?
	Interactions of policies	Do the policies interact? Are there synergies or compensatory responses?

Table 2: Theory development process for system dynamics (34 p. B.2)

B.2 Grounded Theory

Grounded Theory is a methodology allows development of new theory where the existing is insufficient. Starting from a completely blank slate, new theory is:

> *…inductively derived from the study of the phenomenon it represents. That is, discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis, and theory should stand in reciprocal relationship with each other. One does not begin with a theory, and then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge. (35 p. 23)*

While induction provides for utilisation of data, and is the first step undertaken, deduction and abduction are also critical. Induction is employed to build models from data, while deduction then extends and checks the models for internal consistency. Abduction is also employed to check the model against data, and where the match is imperfect, alterations are prompted.

B.2.1 Grounded Theory Elements

Grounded theory has three elements; *concepts*, *categories* and *propositions* (Fig. 20). Concepts are units of analysis arising from data, effectively smaller pieces that do not appear to encapsulate others. These are the initial result of induction, and unlikely to represent fundamental components at the outset. When the data suggests that categories should be grouped together, Grounded Theory terms them categories (System Dynamics: constructs). They are more abstract and less reminiscent of raw data, and inductions made concerning them. The third element of grounded theory are propositions (System Dynamics: impacts) indicating the relationship between a category and its concepts, as well as between concepts themselves (Fig. 24).
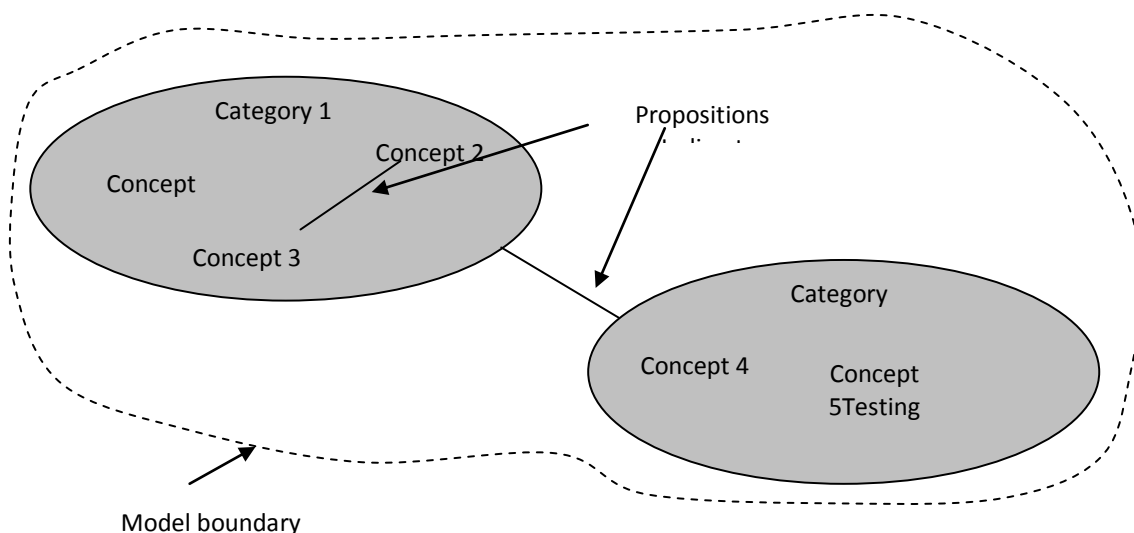

Figure 24: Operational elements of Grounded Theory

Propositions are deductions as they must be logically consistent with the construct (category or concept) on either end. Creation of concepts requires induction as they are derived straight from data. Categories are abductions since amalgamating concepts requires an inspired leap. Categories are where the real advance in theory occurs, but deduction and induction are essential to the process.

Open coding is identifying concepts from data (induction) and categories to group concepts (abduction). Both axial and selective coding use deduction, the former gives propositions between concepts and the latter propositions between categories. Collectively these give rise to a theoretical framework.

B.2.2   Grounded Theory Iteration

Five analytic (and not strictly sequential) phases of grounded theory building are identified: Theoretical Sampling, Data collection, Data Ordering, Data Analysis and Theory Development. It is intended that they form a template for the subsequent discussion which moves from a normative or prescriptive account of recommended activities to a descriptive account of how these prescriptions were applied in the study (Fig. 25).
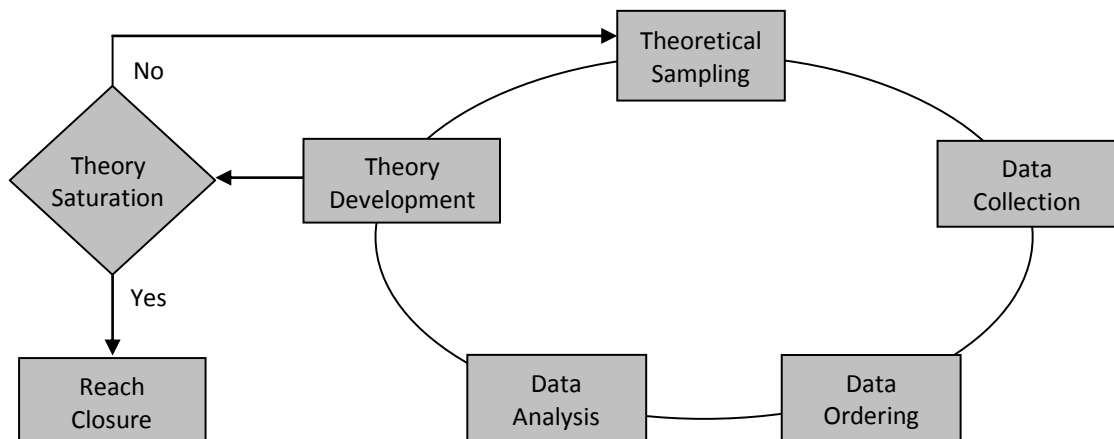

Figure 25: Grounded Theory Iteration

	Step	Activity	Rationale
Theoretical Sampling	Review of technical literature	Definition of research question	Focuses efforts
		Definition of a priori constructs	Constrains irrelevant variation and sharpens external validity
	Selecting cases	Theoretical, not random, sampling	Focuses efforts on theoretically useful cases (e. g. , those that test and/or extend theory)
Data Collection	Develop rigorous data collection protocol	Create case study database Employ multiple data collection methods Qualitative and quantitative data	Increases reliability Increases construct validity Strengthens grounding of theory by triangulation of evidence - enhances internal validity Synergistic view of evidence
	Entering the field	Overlap data collection and analysis Flexible and opportunistic data collection methods	Speeds analysis and reveals helpful adjustments to data collection Allows investigators to take advantage of emergent themes and unique case features
Data Ordering	Data ordering	Arraying events chronologically	Facilitates easier data analysis. Allows examination of processes
Data Analysis	Analysing data relating to the first case	Use open coding Use axial coding Use selective coding	Develop concepts, categories and properties Develop connections between a category and its sub-categories Integrate categories to build theoretical framework All forms of coding enhance internal validity

	Theoretical sampling	Literal and theoretical replication across cases	Confirms, extends, and sharpens theoretical framework
	Reaching closure	Theoretical saturation when possible	Ends process when marginal improvement becomes small
Theory Development	Compare emergent theory with extant literature	Comparisons with conflicting frameworks	Improves construct definitions, and therefore internal validity
		Comparisons with similar frameworks	Improves external validity by establishing the domain to which the study's findings can be generalised

Table 3: Grounded theory research phases