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WHITE SPACES INNOVATION IN SWEDEN

INNOVATION POLICY FOR EXPLORING THE ADJACENT POSSIBLE

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REGION SKÅNE

TILLVÄXTVERKET
SWEDISH AGENCY FOR ECONOMIC AND REGIONAL GROWTH

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White Spaces Innovation in Sweden

Innovation policy for exploring the adjacent possible

by

Phil Cooke & Arne Eriksson

Foreword

How a future cluster strategy can or should be formed is an issue under discussion in various cluster initiatives and regions. It is also being examined in VINNOVA's VINNVÄXT programme and the cluster programme of the Swedish Agency for Economic and Regional Growth - Tillväxtverket.

One question focuses on the appearance of so-called innovation platforms as the next developmental phase, due to the way in which innovations increasingly appear at the interface between different clusters and innovative milieus.

Evaluations and monitoring of cluster programmes show that the partnership between various clusters should be an important ingredient of inventiveness and market innovation. Region Skåne, VINNOVA's VINNVÄXT programme and the Swedish Agency for Economic and Regional Growth discussed the prospects for this during 2010 and decided to look into these issues in more depth (theoretically as well as empirically) in a joint learning project during 2011.

The empirical elucidation was mostly in the form of interviews with cluster leaders, regional representatives etc. and through joint workshops to test and apply theoretical bases. An ongoing issue in the work has been how the "grand challenges" can become a source of strategic growth for Swedish cluster initiatives.

All areas of the project were implemented by the report authors: Professor Philip Cooke from Cardiff University and Arne Eriksson (consultant).

The type of horizontal innovation upon which this report focuses assumes a well-developed capacity for interdisciplinary partnerships. A central part of the project was evaluation and testing of methods for this. Amongst their conclusions, the authors highlight the importance of governmental actors being involved in the innovation processes, but also that this should be allied with a requirement for more sustainable strategy and joint development design.

The authors are responsible for the content and conclusions of the report.

Region Skåne, the VINNVÄXT programme and the Swedish Agency for Economic and Regional Growth would like to extend their grateful thanks to everyone who participated in the interviews and workshops and not least of all to Arne Eriksson and Philip Cooke. You helped to perfect both the work and its conclusions. Thank you!

August 2011

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Om projektet och rapporten

Den här rapporten redovisar en studie som är en vidareföring av tidigare arbete för bl.a. VINNOVA om plattformspolicy, se The Matrix (VINNOVA Report VR 2010:10). Ansvariga forskare är professor Phil Cooke från Cardiff University och Arne Eriksson, Arne Eriksson Konsult som båda var för sig och tillsammans arbetat med innovationspolitiska frågor under lång tid.

Bakom projektet står Tillväxtverket, VINNOVA och Region Skåne. Arbetet inleddes i slutet av november och arbetet med rapporten slutfördes vid utgången av juni månad i år. Studien och dess policyslutsatser behandlades vid ett seminarium den 2 september 2011.

Huvudfrågan är om och hur svenska kluster(initiativ) ser s.k. stora sociala utmaningar som klimat, energi, åldrande som innovationsdrivande och grund för strategisk tillväxt och vilka ansatser och metoder som kan användas för att transformera sådana utmaningar till affärsmöjligheter i gränsområden (vita fält, strukturella hål) mellan kluster och genom ”horisontellt” klustersamarbete.

Studiens utgångspunkter, syfte och genomförande

Utgångspunkter och syfte

Projektet har tre utgångspunkter. Den första är att innovation i växande grad sker genom gränsöverskridande samarbete mellan discipliner, kluster och kompetenser. I litteraturen används begrepp som överbryggning av *strukturella hål*, identifiering av *vita fält* och eller utforskning av *blåa oceaner* för att beskriva detta. Det horisontella och gränsöverskridande förhållningssättet motsvaras i policytermer av s.k. plattformspolicy som söker utveckla metoder för att åstadkomma flera saker. En är metoder för att blottlägga beroenden mellan företag/kluster som han hänföras till t.ex. teknologiska samband. Sådana beroenden är betydelsefulla eftersom samarbete ofta handlar om att bygga gemensamma förmågor med bas i kompletterande men relaterade kompetens- och kunskapsområden. En annan är att finna metoder för företag/kluster att utveckla koncept, nya produkter, tjänster och system som är nya och/eller unika. I projektet sammanfattas detta under benämningen designtänkande. En tredje är metoder för ledning av nätverkssamarbete och orkestrering av sådant.

Den andra utgångspunkten är att som i EUs program för Innovation Union betona betydelsen av stora samhällsutmaningar som drivkraft för innovation. Vår idé är att plattformspolicy är en förutsättning för att lyckas med detta. Skälet är att denna sorts

innovationer ofta är radikala och systemförändrande och möjliggörs av en policy som verkar både via regler, marknadsskapande insatser som innovationsupphandling, visst forskningsstöd och utbudspåverkande insatser som kapitalförsörjning, utbildning men slutligen även sådana insatser som är mer renodlat systemiska till sin natur som stöd nätverksbildning och relationsskapande. Med andra ord lyfter sådan policy fram betydelsen av en blandning av stödjande åtgärder (policy mix) med grund i att policy inte enbart kan grundas på marknadsmisslyckanden utan att även åtgärder som motiveras av brister avseende relationer och interaktion mellan aktörer inom och mellan ”delsystem” måste ingå i blandningen.

Den tredje utgångspunkten är att många kluster(initiativ) nu nått en sådan mognad att ”sanningens minut” står för dörren när fortsatt utveckling förutsätter att de har förmåga till strategisk tillväxt. Detta betonas t.ex i senaste utvärderingen av VINNVÄXT.

De här utgångspunkterna ska ses i ljuset av att syftet med det här projektet är att undersöka i vilken omfattning som strategisk tillväxt i svenska kluster kan ske genom innovationssamarbete mellan kluster för att driva fram innovationer med stora samhällsutmaningar i fokus där designtänkande är ett sätt att göra dem handlingsbara.

Designtänkande bygger på att utveckla koncept och gestalta sådana i form av prototyper som allteftersom blir med detaljerade. Designprocessen är iterativ. Den skiljer sig från projektarbete och andra undersökningsansatser som förutsätter att problem är väldefinierade och att lösningar kan uppnås genom uppdelning av problemet olika delar eller projekt. Någon har sagt att designprocesser ställer frågan om vad som skulle kunna vara. Svaret på en sådan fråga förutsätter gestaltning och föreställning om mönster och helheter som tolkas och förtydligas för att till slut nå den konkretion som tillåter att helhetens delar kan omvandlas till ritningar och moduler. Användning av designtänkande är särskilt viktigt när problem är mångtydiga och/eller när de involverar många olika aktörer som var och en har sin tolkning av vad som skulle kunna vara. Designprocessen tillåter att olika perspektiv bryts samtidigt metodiken att arbeta med prototyper (helheter) visualiserar föremålet för konversationen. Prototypen fyller funktionen som s.k. gränsobjekt och kan därmed tillåta kommunikation mellan personer med olika expertis, språk och begrepp.

Genomförande

Arbetsprocessen i projektet har varit en kombination av utveckling av ett analytiskt ramverk med bas i komplexitetsteori och dess tillämpning som tolkningsram för intervjuer med 15 klusterledare samt tre regionutvecklare. Syftet med intervjuerna var att få information om vilken betydelse som samhällsutmaningar har haft och bedöms få framöver för kluster i Sverige och i anknytning till detta i vilken omfattning samhällsutmaningar lett eller förväntas leda till innovationssamarbete mellan olika kluster. En redovisning av intervjuerna finns i kapitel 3. Vi kunde identifiera ett antal klustersamarbeten med bäring på samhällsutmaningar. Till en del sker sådana samarbeten i ett regionalt sammanhang och i andra har VINNVÄXT eller Tillväxtverkets nationella klusterpro-

gram fungerat som kontaktskapare mellan kluster i olika delar av landet. Vi kunde också konstatera att det utvecklats olika angreppssätt i regionerna där vi genomfört intervjuer. Region Skåne har definierat personlig hälsa och uthålliga städer som samhällsutmaningar för innovationssamarbete och har även ett uttalat fokus på s.k. vita fält. I Västragötalandsregionen används stora investeringar i fysisk infrastruktur eller i forskningsinfrastruktur som s.k. ikonprojekt för kraftsamling kring samhällsutmaningar.

Vi har också vid två workshops prövat att tillämpa designtänkande på samhällsutmaningar med ett trettiotal deltagare vid båda tillfällena. Det andra tillfället var i Malmö den 14-15 April med deltagande av bl.a. professor Roberto Verganti som är en ledande förespråkare för designtänkande. Moderator för den workshopen var Tom Inns som är designprofessor i Dundee. Bl.a. har ett samarbete om diabetes sprungit fram ur dessa möten.

Metodologisk ansats

På grund av att samhällsutmaningar liksom innovation är komplexa fenomen har vi förankrat vår studie i komplexitetsteori som i ökande omfattning används för att analysera komplexa sociala system från att tidigare ha utvecklats för analyser av naturliga och biologiska system. I litteratur om samhällsutmaningar och innovation används på engelska begreppet ”wicked” om båda. Ordet har betydelsen dum, elak,ond, konstig på svenska. Innebörden är att det är problem som inte har någon entydig lösning. De är ostrukturerade och innehåller en uppsättning utmaningar och restriktioner som låser varandra. Sådana problem och sökandet efter lösningar på dem involverar många aktörer med olika intressen. Lösningar är inte rätt eller fel utan bättre eller sämre. Det betyder att vi här har att göra med frågor där orsak och verkan inte är enkel att förstå och i konsekvens med detta är kontroll och utvärdering svår. Därmed är det stora likheter när det gäller förutsättningarna för analyser av konstiga (wicked) frågor och för analyser av komplexa adaptiva system.

Vår grundföreställning är att en förnyelse och vidareutveckling av en regional utvecklingsmodell måste ta sin utgångspunkt i att utnyttja den innovationspotential som erbjuds av gränsöverskridande, horisontell interaktion mellan olika sektorer och kluster inom ramen för regionala och/eller nationella innovationssystem. Komplexitetsteorin innehåller ett par begrepp som redan använts i innovationssammanhang nämligen system och stigberoende. Vi talar om *öppna system* i vilka innovationer uppstår genom interaktioner mellan aktörer i olika ”delsystem” som kluster och företagsnätverk. Tidigare erfarenheter spelar roll t.ex genom rutiner om hur beslut ska fattas. Denna *evolutionära ansats* har varit viktig för mycket innovationsforskning redan tidigare och ingår också som en del i komplexitetsteorin. En viktig poäng är att *interaktion* sker på basis av *självorganisering* mellan parter som har samma mål, som möter samma restriktioner eller som har kompletterande kompetenser.

Hänsynstagandet till komplexitet påkallar nya verktyg men även nya förhållningssätt till policy. Viktiga frågor att behandla från ett komplexitetsperspektivet är följande:

- varför variation och blandning av perspektiv och kompetenser är viktig och varför specialisering ur ett innovationsperspektiv bör behandlas med försiktighet även om specialisering har sin roll i senare skeden av en värdeskapande process
- hur interaktion sker inom och mellan nivåer i inneslutande hierarkier med självorganisering som princip och betydelsen av gränser och restriktioner som hinder men även som drivkraft till förnyelse
- vilka konsekvenserna är av evolutionär och icke linjär förändring illustrerad genom begrepp som emergens och attraktorer

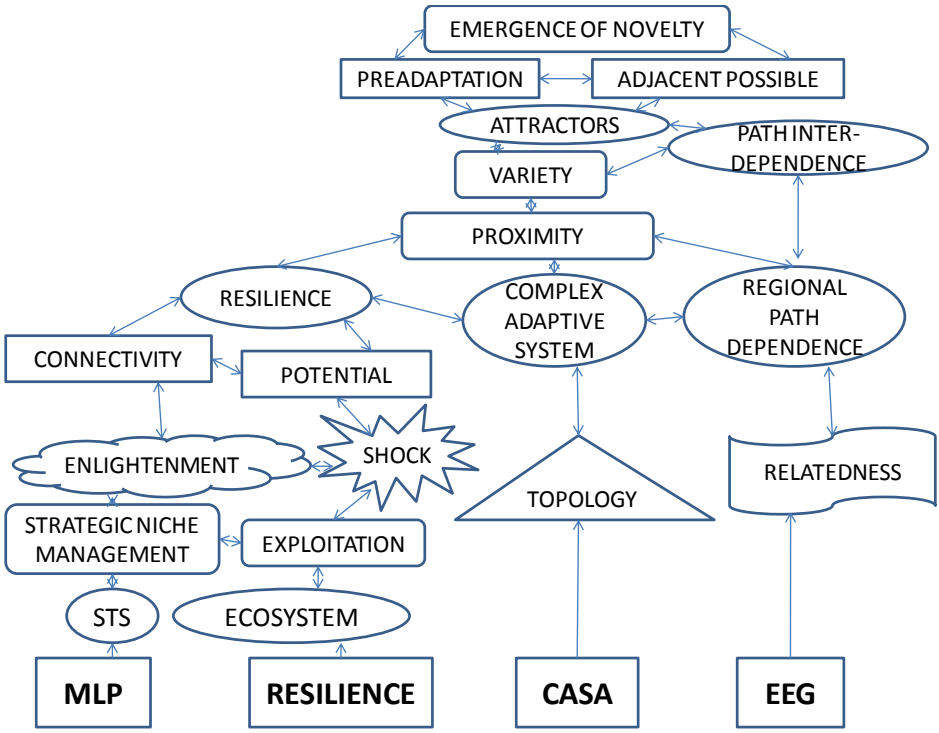
Våra olika modellansatser beskrivs i figur 1 (som även ingår i rapporten som figur 3.3). Figuren ska läsas nerifrån och upp. Längst ner i figuren anges fyra olika ansatser som influerat vår analys. Två av de här är vanliga i innovationsforskningen nämligen den flernivåmodell - MLP- som visas längst till vänster i figuren och den evolutionära modell – EEG - som geografer tillämpar och som finns längst till höger. Mellan dem finns två modellansatser med bas i komplexitetsteori. Den första av en modell som studerar robusta system och uthållig förändring där begreppet resiliens är centralt. Den andra är modeller om komplexa adaptiva system. De fyra modellerna skiljer sig åt genom att flernivåmodellen och resiliensmodellen båda är en slags makromodeller medan de två andra studerar förändring ur ett mikroperspektiv.

Överst i figuren anges hur förnyelse och innovation uppkommer på två olika sätt nämligen genom att känd kunskap och känd teknik inom ett område ”invaderar” en annan bransch eller ett nytt tillämpningsområde. Detta är preadaptation. Innovation i gränsområden kan även uppkomma ur kunskap som är nära eller angränsande (the adjacent possible) som är ett okänt vitt fält med hög innovationspotential och möjligen kännetecknat av hög osäkerhet. Detta begrepp har sitt ursprung hos den amerikanske evolutionsbiologen Stuart Kaufmann. Vad som ligger inom räckhåll beror både av sökfärdigheter hos aktörer och av omgivningen. Den amerikanske författaren Steven Johnson hävdar i en bok att merparten av innovationer är exempel på denna typ av innovation. Gemensamt är att resultatet av de processer som sker i komplexa system inte kan förutses i detalj.

I centrum för flernivåmodellen står frågan om strukturell förändring. Analysen innefattar tre centrala begrepp nämligen nisch, regim och landskap som avser olika nivåer och tillsammans avgränsar socio-tekniska system (STS). Utgångspunkten är att teknologi tillsammans med marknadsförhållanden och regleringar gör att ekonomisk utveckling upprätthålls inom ramen för regimer som är svåra att förändra. Regimer blockerar förändring och låser utvecklingsförlopp. Inom regimer utbildas s.k. dominant logik som med ett komplexitetsbegrepp verkar som attraktor. Argumentet är att denna attraktor är så stark att förnyelse inom nya nischer inte kan ske utan att det skapas en skyddad om-

givning för experiment. Reglering, teknikupphandling etc. är exempel på hur nischer kan etableras. Landskapsbegreppet anger möjligheter eller begränsningar som följer av lagstiftning och andra institutionella förhållanden av långsiktig och långsamt föränderlig natur. De olika nivåerna interagerar med varandra. Den här modellen har i Nederländerna översatts till en policyansats som kallas Strategisk Nischutveckling (Strategic Niche Management).

Figur 1 Syntes av regionala innovationsperspektiv och processer



Källa: Centre for Advanced Studies, Cardiff University

Ett annat slags makrosammanhang ges av forskningen om resiliens som prövar lärdomar om ekosystem på sociala system. Resiliens står för att system är robusta och kan klara chocker och störningar som de utsätts för. Ett robust system kan fånga upp störningar genom att det innehåller variation och nätverk med hög konnektivitet.

Till höger i figuren finns två mer mikroansatser nämligen komplexa adaptiva system (CASA) och Evolutionär Ekonomisk Geografi (EEG). I dessa system påverkas regionala innovationsprocesser av beroende (relatedness) när det gäller EEG och av topologi när det gäller CASA där systemanpassning sker genom förflyttning i ett landskap med många lokala bergstoppar. I evolutionär geografi förekommer som nämnts ovan stigberoende men möjliggörs även i vissa situationer passager mellan regimer som tillåter

innovation i gränsområdena mellan. Då kan innovation uppstå genom att befintlig kunskap och/eller teknologi används på nytt sätt eller i en ny bransch (preadaptation).

Den grundläggande tankefiguren i CASA är landskap med berg och dalgångar vars bredd och höjd varierar. Bergen skiljer utvecklingsbanor åt. Stabilitet ges av attraktorer som ”drar” aktivitet mot dalgångarnas botten. Det finns en speciell sorts attraktor som kallas för mystiska attraktorer (eng. strange attractors) som är särskilt intressanta eftersom de förmår hålla system i balans trots stora rörelser i alla riktningar hos agenterna i det. Förändring av att aktörer ger sig ut på s.k. ”adaptive walks” upp längs bergsidan. Ser vi horisontell innovation ur detta perspektiv handlar det således både om att utrusta aktörer så att de är rustade för bergsklättring och att möjligen också påverka hur förbindelser mellan dalgångar kan förbättras. Det hör också till den här metaforen att systemen utsätts för externa chocker som kan förändra deras utseende. Det kan vara s.k. genombrottsteknologier eller snabba värderingsförändringar eller kraftig kollektiv resursmobilisering till följd av t.ex. stora samhällsutmaningar.

I sociala system med mänskligt deltagande måste också tas hänsyn till att vi kan lära och kommunicera genom språket.

Resultat och policykonsekvenser

Se det regionala utvecklingsproblemet på ett nytt sätt

Det finns enligt vår mening ett betydande värde i att använda teorin om komplexa adaptiva system för att ändra tolkningsramen om regionala utvecklingsproblem. Det är t.ex. klart att emergens, dvs. innovation baserad på interaktion och kraftfulla och stabiliserande mystiska attraktorer, hindras där relationer och komplementära beroenden är outvecklade och där kluster är få med stora avstånd mellan dem. En ytterligare dimension av en ny tolkningsram är att det finns mycket att vinna på att anlägga ett horisontellt perspektiv på kunskapsflöden snarare än smart specialisering om fokus är innovation. Vi har visat i studien att ledande företag och kluster i samklang med utvecklingsorganisationer redan drar nytta av korsbefruktning mellan kluster för att utforska affärsmöjligheter där gemensamma visioner och strategier fungerar som mystiska attraktorer.

Det räcker dock inte med komplexitetsteori

En andra slutsats är komplexitetsteorin inte är tillräcklig som en ledstjärna för regional teori och praktik. Skälet är att den inte är handlingsinriktad i praktisk mening även om idén om utforskandet av ”det intilliggande möjliga” ger en allmän anvisning. Den analys vi redovisat och det försök vi gjort visar att designtänkande kan vara ett steg på vägen för att fylla denna brist.

Komplexitetsteori inte helt förenlig med nuvarande modell för policyutformning och styrning

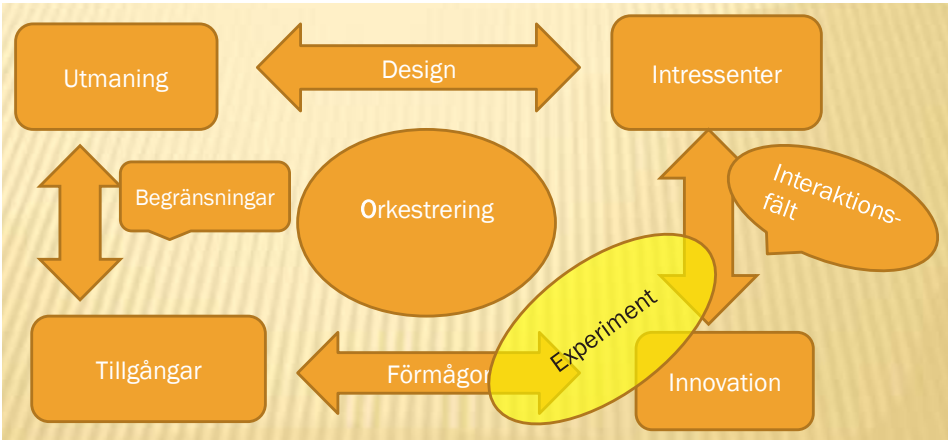
Policyutformning sker i Sverige inom ramen för en enhetlig styrmodell gemensam för alla politikområden. Den är tänkt för styrning av offentlig produktion av tjänster; således en produktionsstyrningsmodell. Som sådan är den uppbyggd kring tydliga mål, oftast en föreställning om klart samband mellan orsak (insats) och verkan. Effektlogik är VINNOVAs begrepp för detta. Kontroll och utvärderingsbarhet är andra viktiga styrningsaspekter. Komplexa system fungerar på annat sätt som vi visat och innovationer och innovationspolitik utspelas i sådana system. Det visar sig i att många oförutsedda resultat uppstår samtidigt som de avsedda resultaten blir mer begränsade än förväntat. I värsta fall kan detta utlösa en ond spiral därför att bristande måluppfyllelse leder till än tydligare mål och avgränsade projekt med ytterligare förstärkt utvärdering och kontroll osv. Bidragande är här också medialiseringen som förstärker inslaget av förenkling. Det senare är ett fenomen som är av särskilt betydelse för utvecklingsfrågor och framtidsinriktad politik som innovationspolitik som sällan uppfyller en medialiserad omgivnings behov av händelse- och nyhetsdriven dramaturgi.

En policymodell byggd på designtänkande och förbättrad förmåga att hantera komplexitet

När det gäller samhällsutmaningar handlar policyutformning om att hitta sätt att göra en sådan utmaning handlingsbar på ett sätt som tillåter och inbjuder till horisontellt samarbete mellan olika typer av aktörer. Men det gäller samtidigt att ta hänsyn till de begränsningar som nuvarande resurser och förmågor innebär. Figur 2 (vilken även finns som figur 5.5 i rapporten) visar en enkel modell för detta som utgår från att det finns ett behov av ”mjuk” styrning eller orkestrering. Grundantagandet är att en samhällsutmaning är så komplex och innehåller så många handlingsmöjligheter att den ger goda förutsättningar för den typ av horisontell innovation som rapporten behandlar. Förutsättningen för att denna potential utnyttjas är att applicera designtänkande som i en successiv process av tolkning och prototyper leder till en eller flera tolkningar som blir en gemensam fråga eller ”plattform” för olika konstellationer av aktörer. Detta visas i figuren av pilen mellan Utmaning och Intressent. Det framgick i kapitel att designtänkande som förhållningssätt och arbetsmetod fungerar för detta syfte. Den typiska designmetoden är att använda visualisering eller prototyper som gestaltar en helhet som med gradvis förädling kan t.ex modulariseras och därmed bli en handlingsbar utmaning för en konstellation av aktörer medan andra grupperingar ägnar sig åt andra aspekter av den gemensamma frågan. Poängen är att många idéer, perspektiv och begränsningar sammanfogas till en helhet tydliggör beroenden och gemensamma intressen men som därefter också ges sin ”lokala” mening som allteftersom får tydligare skärpa och detaljerad utformning. Med ett begrepp från kommunikationsteori kan man saga att visualiseringar och protoyper fungerar som gränsobjekt som tillåter utbyte över gränser men med lokal variation i betydelse. Med hänvisning till analysen i kapitel 4 handlar detta också om

etablera sådana gränsobjekt som "mystiska attraktorer". Men detta förutsätter att det finns interaktionsfält där sådana kan utöva "dragningskraft" på olika konstellationer.

Figur 2 Orkestrering och samhällsutmaningar



Detta för över till förbindelsen mellan Intressenter och Innovation. Designprocessen identifierar handlingsbara utmaningar och intressentgrupper. Uthålliga städer kan t.ex handla om vatten, energi, transporter och även sammanlänkningar av dessa delområden. Med Interaktionsfält avses sådana intressentgrupper. De kan ingå i kluster, nätverk och andra slags konstellationer. Begreppet interaktionsfält avgränsar således olika slags grupperingar som är ekonomiskt rationella och meningsgivande för aktörer att delta i. I den process som skisserats skapas förutsättningar för att sådana grupperingar kan interagera inom sig själva men även med andra grupperingar med komplementär kompetens. Benämningen har valts för att betona att ökad konnektivitet är av vital betydelse för horisontell innovation där innovation förväntas uppstå genom kombination av resurser och förmågor från olika "regimer".

Designprocessen avser att via sammankopplingen mellan aktörer, frågor och sammanhang ge uttryck för olika konstellationers svar på frågan om vad som skulle kunna vara möjligt? För att detta ska bli avsikter måste hänsyn tas till de begränsningar som tillgänglig kunskap, resurser och förmågor innebär men också hur samarbete och "samspecialisering" och investeringar kan användas för att mildra eller undanröja sådana begränsningar. Innovation uppkommer sålunda genom kombinationen av utforskning av "vita fält" och säkerställandet av de förmågor som behövs för att fylla ut dem.

Policy kan spela roll genom "mjuk styrning" för att vara inspiratör för designtänkande, genom att etablera interaktionsfält och genom att vara en aktör och medlare när det gäller att hantera restriktioner samt slutligen eventuellt som finansiär när det gäller investeringar i nya förmågor som är nödvändiga för att genomföra experiment.

Dra nytta av lärdomar om designtänkande avseende samhällsutmaningar i pågående utveckling av innovationsstrategier nationellt och regionalt.

Variation är ett nyckelord för den typ av innovation som den här rapporten handlar. Men en variation av influenser i tillblivelseprocessen måste också ha en motsvarighet när det gäller variation i uppsättningen instrument och aktörer som stödjer sådana processer. Man talar internationellt om s.k. policy mix. I ett svenskt perspektiv innefattar en sådan policyprocess såväl ministerier som utvecklingsorganisationer och myndigheter på såväl nationell som regional och lokal nivå. Att skapa en blandning eller en repertoar av insatser som kan aktiveras för olika situationer förutsätter samarbete mellan många offentliga organisationer. Erfarenhetsmässigt har sådant samarbete over sektorsgränser varit svårt att etablera. Vi menar att designtänkande även kan användas i ett sådant sammanhang och föreslår ett utvecklings- och träningsprogram avseende Policydesign för utmaningsdriven innovation.

1 The research project

1.1 The research issues

This report documents a multi-client research project to investigate the subject of Innovation Platforms as the next phase in the evolution of Regional Innovation Policy. Those development agencies with responsibilities for supporting and promoting innovation at the leading edge have begun to recognise a basic truth about contemporary business innovation. This is that fruitful innovation interactions increasingly occur at interfaces between diverse firms, sectors, and even clusters. This offers national and regional development agencies a new, catalytic role in stimulating regional innovation. This occurs through shaping innovation platforms that can enable cross-fertilisation between clusters and tackling complex social innovation challenges like climate change, ageing, and sustainable cities to name a few.

The study builds on earlier work on Platform Policy for VINNOVA reported in *The Matrix – Post Cluster Innovation Policy and Regional Policy in Transition* (VINNOVA Report VR 2010:10). The most recent evaluation of the VINNVÄXT program has also been of influence in its recommendation for strategic growth through the identification of needs or markets to target, on the one hand and on the other, to possess the necessary capabilities to serve those markets in an efficient way.

This proposal grows from a perception that traditional sector and cluster policies have reached a point in their evolution where significant growth or employment gains are less forthcoming than previously thought likely or experienced. Three reasons help explain this. First, economic context is important and in a general downturn of the severity of the present one, conditions for sector or cluster growth are not good. Second, more directly, it is widely known that risk-finance for established and particularly new business ventures has all but dried-up due to cautionary investor practices. Finally, the model of vertically drilling down in relatively narrow fields, even involving partnership with similar overseas initiatives, may need refreshing. *Fundamentally, our belief is that refreshment and expansion of a relevant development model comes from discovering the innovative potential of horizontal interactions among different sectors or clusters.* Importantly, this commences a new evolutionary policy cycle that begins by focusing on innovation opportunities in regional and national geographical proximity before scanning the globe for knowledge advantages.

It is clear that this is a new and exciting avenue for national innovation and regional development agencies to understand and consider as a possible tool-set in their armoury of developmental instruments. It is not only an issue of adding new tools. Innovation policy also increasingly has to be relevant for designing and implementing policy in

very complex environments at the same time as innovation in itself can be seen as a 'wicked' issue. This means policy and practice can have negative 'unanticipated consequences' requiring both experimentation and retro-fitting skills to resolve. We claim this calls for a new policy mindset as well as a changed toolset. We have therefore adopted an analytic framework influenced by *complexity* thinking to illuminate central issues like:

- why variety is important, and 'smart specialisation' to be treated with caution
- how micro-macro level interaction takes place in nested hierarchies, and
- assessing consequences of evolutionary and non-linear change.

Framing the analysis in this type of context also affects the way policy might be perceived. An example is the notion of "wickedness" which is not easily compatible with the present 'steering' model in innovation policy. As in other policy fields 'steering' assumes that policy problems are clearly defined, decomposable and based on a control perspective. So we have also made an effort to translate this complexity thinking into the policy domain.

1.2 Strategic growth by turning Grand Challenges into business opportunities

Both the OECD and the EU in their respective innovation strategies attach a great deal of importance to global and social challenges as drivers for innovation and growth. In the EU communication regarding the Innovation Union the issue is presented as follows:

> *"Focusing on innovations that address the major societal challenges identified in* ***Europe 2020,*** *strengthening our leadership in key technologies, reaping the potential these markets offer for innovative businesses, and enhancing EU competitiveness. Innovation must become a key element in EU policies and the EU must use the strong potential of the public sector in areas such as energy and water, health, public transport and education, to bring new solutions to the market."*

In this project we will link Grand Challenges with the idea of strategic growth for clusters in VINNVÄXT, the National Cluster Program run by Tillväxtverket and the clusters in Skåne. Our premise is that turning Grand Challenges into business opportunities will call for transversal (cross-cluster) innovation which in turn will lead to a need to understand issues related to boundary crossing, bridging of interfaces and also a demand for tools to facilitate and/or orchestrate transversal innovation. We believe that 'design thinking' is an approach to test in this context. Transversal innovation also has to build on interdependencies of different sorts between companies and clusters. *Related variety* is an enabler and a constraint for transversal innovation because it is both the

basis for novel knowledge recombinations and an influence on innovative path dependence. It is interesting to see that in many countries this has put city-regions in a central position as test beds and innovation orchestrators. A strategic issue for the design of Grand Challenge initiatives is to organise a process that explores the value-creating opportunities related to Grand Challenges or the uncontested market spaces between clusters ('white spaces'). Exploring the market potential of Grand Challenges requires foresight and also design of a foresight process that enables cross-cultural knowledge exchange among enterprises. The assessment of potential is to a large extent conditioned by present capabilities. New capabilities are developed through reconfiguration of existing expertise and through investment in research and other forms of expertise. Relatedness is a keyword in terms of lateral interaction among firms and clusters. As far as Grand Challenges or system innovation is concerned this process is also a mix of top-down and bottom-up (the multi-level perspective; MLP). It is also a process that involves business, knowledge providers and public agencies.

1.3 The implementation of the project

Objective

The objective of the study was to present and to some extent test methods to make Grand Challenges actionable in an innovation system context. On the one hand this requires methods to identify new uncontested market spaces – structural holes, white fields or spaces, otherwise also known as 'blue oceans' of market opportunity but little competition. On the other it also requires methods that make it possible to take existing capabilities into account as enablers and constraints.

Work process

The work process followed began with an overview of what has been elsewhere related to Grand Challenges and what approaches and methods were utilised. The purpose of that was to get an initial idea of how to frame Grand Challenges from an action perspective. By actionable we here mean that it is possible to mobilise a group of stakeholders and "interpreters" that are prepared to participate in a design discourse starting from the initial framing of the issue. Absorptive capacity for knowledge spillovers at cluster interfaces (transversality) should be optimal. A too broad framing will probably result in a situation where too few will feel a sufficient sense of urgency and if it is too narrowly defined we face the risk of missing the transversal perspective. The second path taken was to learn by interacting with individual clusters and stakeholders in the VINNVÄXT program, Tillväxtverket's cluster program and in Region Skåne. In this approach the starting point was to ask what strategic growth means, which Grand Challenges have a place in this context, and how they are mobilised. We conducted interviews with 15 clusters and received secondary information from others which means that we have information from most of the more "mature" cluster initiatives in Sweden. In addition

we have also interviewed three regional development agencies namely, Region Skåne, Ostsam and Västragötlandsregionen.

The notion of a design discourse is picked up from Roberto Verganti´s book Design-Driven Innovation. In this, 'design' is a collective process of 'creative reasoning' to explore the unknown, or what complexity theory calls the 'adjacent possible'.The "Design Direction Workshop" plays a central role in this discourse. We arranged two such workshops to test the idea of applying design thinking in making Grand Challenges actionable. The purpose of the first workshop, planned to early March 2011, was to let those people we met during our interviews discuss together our initial framing of the topics of common interest. The second workshop was a two-day event in Malmö, April 13-14 where the first day had presentations by Roberto Verganti on Grand Challenges as Sources of Innovation of Meaning, and by Phil Cooke presenting our analytical 'complexity' framework and results from the interviews. These analytically oriented presentations were contrasted with short interventions from cluster managers telling their stories with relevance to Grand Challenges and Cross Cluster collaboration. The second day was a series of practical design workshops involving application of Design thinking and moderated by professor Tom Inns of Dundee University, UK. He has also documented the workshop and this documentation is available by contact with Arne Eriksson, arne@aek.nu.

The project started in November 2010 ended in June 2011.

Researchers

The research in question was led by Phil Cooke and Arne Eriksson who were both responsible for preparing research instruments and schedules. Interviews were conducted by Phil Cooke and Arne Eriksson based on a jointly-designed semi-structured interview support instrument.

1.4 Outline of the report

The core of the report is in chapters 3 and 4 where the interviews we have done are set into an evolutionary analytical framework (chapter 3) followed by an analysis of transversal innovation and regional change as enabled by variety and constrained by path dependencies and emergent path-interdependencies. Chapter 2 gives an overview of complexity thinking and policy conclusions are presented in chapter 5.

2 Grand Challenges and Cross Cluster Innovation in a Complexity Context

2.1 What is Complexity?

What does it mean to refer to complexity in a study of Grand Challenges and Cross Cluster Innovation? As an indication, recent evidence of the growing importance of complexity can be found in an IBM survey from 2010. The biennial IBM Global CEO Study featured interviews with 1,541 CEOs, general managers, and senior public sector leaders from 60 countries and 33 industries worldwide. Eight in 10 CEOs, the survey found, expect their environment to grow more complex, while only 49 percent believe their organizations are equipped to deal with it. According to IBM this factor represented the largest leadership challenge identified in eight years of research.

There is an important issue involved in the process of transforming Grand Challenges into actionable grand potentials that has to do with the inherent "wickedness" of grand challenges, or their unanticipated consequences and problems arising. For instance, biofuels moderate greenhouse gas but cause food price hikes and riots in poor countries if incentive policy is too simplistic. In recent years there has been an increased interest in what 'wickedness' means and how it should be dealt with from viewpoints in business strategy, policy making and in respect of regional, national and business innovation. The very basic argument is that a Grand Challenge seen as a wicked problem cannot be made actionable by using normal procedures in business and in policy of reducing problem complexity by successively breaking it down into smaller sub-problems that can be acted on. So, why is that?

Wicked problems aren´t merely harder or more complex than hard problems. They don´t just involve more factors and stakeholders. They don´t just take us longer to solve. Analytical thinking alone, no matter how skilfully applied, isn´t going to generate an answer to a wicked problem. In an important article from 1967, C West Churchman described them as:

> *"a class of social systems problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing".*

In other words, wicked problems are ill-defined and unique in their causes, character, and solution if there is one.

In a recent report from the Australian Government (2007) discussing wicked problems from a public policy perspective their properties are stated in the following nine points:

- Wicked problems are difficult to clearly define
- Wicked problems have many interdependencies and are often multi-causal
- Attempts to address wicked problems often lead to unforeseen consequences
- Wicked problems are often not stable
- Wicked problems have no clear solution
- Wicked problems are socially complex
- Wicked problems hardly ever sit conveniently with the responsibility of any one organisation
- Wicked problems involve changing behaviour
- Some wicked problems are characterised by chronic policy failure

Wicked issues reflect prevailing and increasing social complexity, a key feature of socio-economic evolution. There are other forms of complexity as well. Innovation can also be treated as a wicked problem and especially so if we talk about innovation to address grand societal challenges because then innovation is expected to have system-wide effects.

Complexity arises from the inter-relationship, inter-action and inter-connectivity of elements within a system and between a system and its environment. Murray Gell-Mann ["Complexity Vol. 1, No.5, 1995/96] traces the meaning to the root of the word. *Plexus* means braided or entwined, from which is derived *complexus* meaning braided together, and the English word "complex" is derived from the Latin. Complexity is therefore associated with the intricate inter-twining or inter-connectivity of elements within a system and between a system and its environment.

Another way of saying this is that complexity has to do with independence and interdependence and from that perspective complexity is becoming of greater interest since organizations, policy areas, the economy and society at large have to face increasing complexity. From an economic perspective independence is manifested in an ongoing specialisation and a search for uniqueness in terms of what products and services to market. However, in a globalised world, *interdependence* is manifested in terms like value nets, 'open innovation' and more broadly in social capital and relationships. From the complexity perspective, the greater the variety in any complex adaptive system, the greater the opportunity for novelty or innovation arising from knowledge recombinations. Hence, independence and specialisation are, from this perspective, sub-optimal.

Complexity however does not argue for ever increasing interconnectivity, for high connectivity implies a high degree of interdependence. This constrained ('zero-sum') approach means that the greater the dependence between related systems or entities the

greater the perturbation or disturbance of a move or action by any one entity on all the other related entities. Such a high degree of dependence rarely has beneficial effects throughout the whole ecosystem. Degree of connectivity is also associated with the quantity of information which flows between the connected entities and it may be argued that the higher the connectivity the greater the exchange of information. Yet, a very high rate in the flow of information is again found to be deleterious as it tends to push the system towards instability (Mitleton-Kelly).

Thus we prefer a more 'positive-sum' perspective. Accordingly, in full awareness of the above points the term 'complexity' will be used within this report to refer to the theories of complexity as applied to complex adaptive systems (CASA; Fig. 3.3). These are dynamic systems able to adapt and change within, or as part of, a changing environment. It is important however to note that there is no dichotomy between a system and its environment in the sense that a system always *adapts to* a changing environment. The notion to be explored is rather that of a system *closely linked with* all other related systems making up an ecosystem. Within such a context change needs to be seen in terms of *co-evolution with* all other related systems, rather than as *adaptation to* a separate and distinct environment.

It is the notion of co-evolution *with*, which will be examined in relation to the 'innovation process' within the context of a co-evolving 'social ecosystem'. If the innovation process of any one organisation is seen as distinct and separate from all related businesses, which include suppliers, buyers and competitors, then strategy will always be seen as a 'response to' the actions and decisions of those other entities. But if strategy (interpreted in this context as actions and decisions affecting the organisation and direction of the firm) is seen as a co-evolving process, then the perspective changes, and each firm is seen as *a fully participating agent that both influences and is influenced by the social ecosystem* made up of all related businesses, consumers and legislative bodies.

2.2 Coping with complexity

Boisot and Child (1999) argue that complex adaptive systems generally choose one of two responses to the complexity that confronts them. A complexity reduction response involves developing a single representation of the variety in the environment and developing a singular adaptive response. Organizations that attempt to reduce complexity emphasize codification (specifying categories to which data are assigned) and abstraction (limiting the number of categories that need to be considered in the first place). Thus, managerial responses to complexity based on codification and abstraction would include minimizing the number of goals and strategic activities to be considered, formalizing and centralizing structural/decision making patterns, and minimizing the number of interactions/connections necessary for decision making. This is in short to follow a reductionist path. This approach is transaction oriented and builds on sharing codes.

Order is seen as a kind of balance or equilibrium and the pursuit of equilibrium has long been a goal of traditional management. In fact, good managers are often judged as those who achieve stability and balance in a system, and are able to minimize sudden and unexpected changes (anticipating 'wickedness' capability'). Traditional approaches to orderly management have been based on the idea that the world is knowable, because it is a kind of mechanical system in which identifiable forces and fundamental laws of motion are in operation. Good managers in such systems arm themselves with knowledge of cause and effect and over time can come to understand the forces and laws they perceive at work in the system. This knowledge enables managers to achieve predictability, order and control in their organizations. Predictable stability becomes ``normal'' and change is seen to ``punctuate'' the equilibrium as a radical departure from normal.

A complexity absorption response to environmental complexity, on the other hand, involves holding multiple and conflicting portrayals of the variety in the environment. Managerial responses to complexity from the absorption perspective would include the development of multiple and sometimes conflicting goals, recognising the importance of a variety of strategic activities, more informal and decentralized structural/decision making patterns, and a wide variety of interactions and connections for decision making. This would be to apply *abductive* logic (i.e. creative rather than deductive or inductive reasoning). This is design thinking in Martin's (2009) language, or applying an entrepreneurial response to use Boisot & McMillan's (2007) language. This approach also has a need for co-construction or innovation of meaning (e.g. use of metaphors, analogies and narrative) since the cognitive dimension is very important together with dialogue, discourse and learning to reach shared meaning.

Weick (1995) describes 'sensemaking as arguing' and encourages managers to recognize the 'divergent, antagonistic, imbalanced forces' that are woven throughout the process of sensemaking. When managers try to impose order and eliminate ambiguity it is because ambiguity is seen as a form of ignorance and acknowledging ignorance brings out insecurities. Such insecurities are traditionally dealt with by acquiring information. However, if ambiguity is viewed as confusion that occurs because of multiple interpretations then it is a condition that improves when individuals work together to construct new meanings (Weick, 1995). Insecurities are reduced not merely with information but with information interpreted through a social process. Finally, disorder can be seen as something to be eliminated, avoided and prevented. These concerns are evident in the rationale for the EU's advocacy of 'smart specialisation' faced with a perceived EU innovation space characterised by: unrestricted competition, diversity, fragmentation and policy overlap (Foray, 2009). Alternatively, it can be accepted, if not celebrated, as an opportunity for new growth. Change does not occur without a shock to the current order.

2.3 Properties of complex dynamic systems

Variety

Variety, Constraint and the Law of Requisite Variety is the title of a very influential article by Ross Ashby published in 1968. The analysis in the paper has come be referred to as Ashby´s law. Ashby is also the author of another classic paper, namely Principles of Self-Organizing Systems published 6 years earlier. He was a systems thinker or a cybernetician. The three concepts mentioned in these two articles- variety, constraints and self-organisation- are also central concepts in today´s complexity thinking and we also use them in this report.

Like most early cyberneticians, Ashby´s work was shaped by information theory as formulated by Shannon (1948) and Shannon & Weaver (1963). Rather than focusing on communication per se as Shannon & Weaver were, Ashby was more interested in how variety could provide insight into a system´s capacity for regulation, i.e. its means for keeping itself intact in the face of disturbances. Variety was conceived around the notions surprise and difference. Ashby´s perspective was to study how chaos could be avoided. Later on another issue came to the fore, namely how variety might be amplified to avoid the kind of strict order that does not allow innovation. This has expanded into *emergence* which in regard to the production of macro-level structures represents the inverse of regulation through the amplification of micro-level diversity.

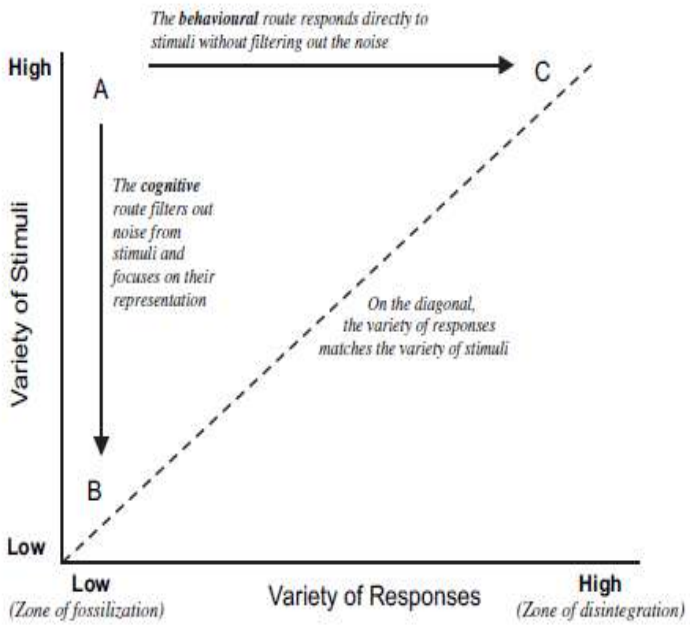
The issue of balance leads us back to the question raised by Ashby's law of requisite variety. How much variety is actually requisite?

Does every instance of variety call for a response? We can illustrate the nature of the issue by means of a diagram that presents Ashby's Law in a graphic form (see figure 2.1). The vertical axis of the diagram measures the variety of the stimuli to which a system is subjected. The horizontal axis measures the variety of the responses available to the system. Ashby's law locates adaptive responses on or below the diagonal in the diagram e i.e. *the variety of a response at least matches the variety of the stimulus* that provoked it. In a regime of high variety stimuli, the sheer variety of responses that appears to be required might well lead to the disintegration of the system. At the other extreme, a system with little or no variety in its responses eventually fossilizes or gets selected out.

The challenge for any living system, then, is according to Boisot (2007) to navigate between the twin threats of disintegration and unresponsiveness. Living systems endowed with cognitive capacities, however, have successfully evolved responses to *representations* triggered by the stimuli rather than to the stimuli themselves, that is, they draw on prior knowledge of the stimuli to filter out those elements of stimulus variety that constitute 'noise', concentrating their response on the much smaller variety of information bearing stimuli that remain. In Figure 2.1 this more 'cognitive' strategy is indicated by the line AB. In contrast with the horizontal line AC, it does not attempt to

match the variety of a given set of stimuli on a one-to-one basis with a given set of responses. Rather, through a filtering and interpretive process, it reduces the variety of the response called for by reducing the number of stimuli that it actually *needs* to respond to. Data are filtered and interpreted in ways that are unique for each of us. These differences are crucial for problem solving, variety generation and innovation since they create possibilities for creative tension and complementarily. This is important from an innovation point of view because it means that the same bits of information have different meanings for us as information processing agents. The formative aspects are valid not only as personal attributes but also how they might be contested and influenced by interaction with other persons in the framing of shared problems. In a broader sense and especially in a dynamic perspective the formative aspects also have to take into account the mutual relationship between personal cognitive and perceptual filters and values or culture. This becomes very clear in Roberto Vergantis book Design-Driven Innovation when talks about innovation of meanings but the relationship is also reflected in Storpers (1997) notion of conventional-relational assets.

Figure 2.1 Illustration of Ashby´s law



Source: Boisot (2007)

The reason for stressing and showing the formative layer is an acknowledgement of the decisive importance diversity of perspectives, heuristics, interpretations and predictive models have for innovation (Page (2007). For Page diversity is cognitive differences that concern perspectives, interpretations, heuristics and predictive models.

The first framework captures the idea that people have diverse *perspectives.* Informally speaking, perspectives represent solutions to a problem. When we say that people have diverse perspectives, we mean that they see or envision the set of possibilities differently. Perspectives embed knowledge: what we know is a function of how we represent things. Perspectives provide one framework for how people see the world differently. A second framework, interpretations, highlights the different categories people use to classify events, outcomes, and situations according to Page. For example, one financial analyst might categorize companies by their equity value, while another might categorize them by industry. One voter might categorize politicians after what party they represent. Another might categorize them based on which part of the country they represent. Informally speaking, interpretations lump things together. A third framework captures the different tools people use to solve problems. These are called heuristics. These can range in sophistication from simple rules of thumb to sophisticated analytic techniques. Heuristics must be applied with respect to a particular representation of a problem, a perspective, so Page often speaks of perspective/heuristic pairs. Heuristics also play an important role in Martin´s Knowledge Funnel. Because people often apply heuristics in combination, a person who knows two heuristics often knows three - the third being the combination of the first two. Often these combined heuristics prove far more powerful than the individual heuristics that form them. The fourth framework for capturing cognitive diversity, predictive models, describes casual relationships between objects or events. Predictive models serve as a shorthand to make sense of the world. The combination of perspectives, interpretations, heuristics, and predictive models, create cognitive toolboxes that are helpful in dealing with the trade-offs that Ashby point to. It should also be noted that predictions in a complexity setting refers to predictions about system wide patterns whereas detailed predictions of behaviour are not possible.

Constraints

Constraints play a role in complex adaptive system since they are often perceived as nested hierarchies. One of the most debated issues in the literature is whether causation in these systems is about bottom-up self organization beyond control from outside and from above. *Emergence* is a concept that follows from self-organisation and interaction between parts of system. In some explanations of emergence it is interpreted as an impossibility to predict the outcome(s) of interaction. Of course this is at odds with idea of policy making as purposeful intervention coupled with a presumption of a causal link between activities and outcomes (predictability). From a physicist's perspective anything but upward causation is impossible because top-down causation would mean that a system is overdetermined. Other researchers take their starting point in the fact that complex adaptive systems are nested self-organising networks of agents. This means that they are hierarchic and that especially in social systems with human to human interaction there is also a possibility of social or downward causation. The stance taken to

this micro-macro relationship is of practical importance since it determines the role of intentionality and governance in a complex social system.

In practical innovation policy terms this can be exemplified by analyses being done in relation to Strategic Niche Management and Multi Level Governance. In that Dutch school of research on transition (e.g. from a hydrocarbons to a post-hydrocarbons socio-technical 'landscape') a distinction is being made between landscapes, regimes and niches in a nested system of self-organisation that is constrained and/or enabled between levels (MLP – multi-level perspective). History/time constrains the development of regimes via path-dependencies being reflected in a dominant logic (that acts as an 'at-tractor' between them). Slowly changing cultural patterns, regulation and institutional conditions enable/constrain change of regimes and the way niches are developed. And over time changed practice affects institutions and culture and changes the landscape. An example is the way shipyards now house creative industry and its incubators. This is because the requirements of the former – waterfronts, grand office spaces – act as ('strange') attractors to the design-driven 'urban pioneer' and 'creative edge' ethic of the creative 'socio-cultural regime'. Independent path dependencies have become path interdependencies. Rents are also low and subsidies available, which helps 'protect the niche'.

However it is important to note that hierarchy does not have same connotation of top-down control in complexity analysis as in everyday language. Neologisms like heterarchy and panarchy (Gunderson & Holling, 2002) have been suggested instead of hierarchy to allow inter-level causal relations to flow in both directions, part to whole (bottom-up) and whole to part (top-down). By delimiting the parts´ initial repertoire of behaviour, the structured whole in which the elements are suddenly embedded also redefines them. They are now something they were not before, nodes in a network, components of a system. This may mean that they might be restricted compared to being independent. The evolutionary advantage is that the system can reach states that the independent parts cannot. This is the point when the term *co-specialisation* is used in relation to dynamic capabilities of clusters and business ecosystems.

Evolution

Thinking about complexity has evolved from the study of natural systems or biological systems to social systems. Along this path it has picked up influences from systems thinking by reference to Ashby. In a similar way evolutionary thinking has been influential in framing the issue of the survival and development of systems as a question of evolutionary fitness between the system and its environment. This means that defining the boundary between a system and its environment is very important unless the system is truly universally defined both for analytical purposes and for systemic intervention.

The analysis of fitness is seen as an optimization problem and the solution to this problem is dependent on the topology of a fitness landscape. Fitness landscapes are often conceived of as ranges of mountains. There exist local peaks (points from which all

paths are downhill, i.e. to lower fitness) and valleys (regions from which most paths lead uphill). A fitness landscape with many local peaks surrounded by deep valleys is called rugged. The Dolomites is a good illustration of the topology.

A useful way of visualizing this is as ontogenetic landscapes depicting a "series of changes of relative stability and instability" over time (Thelen & Smith, 1994). Figure 2. If a system accessed every point or region in change over time with the same frequency as every other (that is, randomly), its ontogenetic landscape would be smooth and flat. A completely flat, smooth initial landscape would portray an object with no propensities or dispositions; that is, with no attractors. It would describe a "system" with no identity, a logical impossibility. The deeper the valley, the greater the propensity of its being visited and the stronger the entrainment that its attractor represents.

Ontogenetic landscapes are constantly modified, dynamical portraits of the interactions between a system and its environment over time: they capture, in short, a time-lapse portrait of individual systems. Attractors embody the system's current control parameters (its self-organized controls), which have been constructed and continue to be modified as a result of the persistent interactions between the dynamical system and its environment.

Attractors can be of several kinds. Of special interest for our purposes are those called strange attractors. All attractors represent characteristic behaviours or states that tend to draw the system toward themselves, but strange attractors are "thick" (Juarrero, 2002) allowing individual behaviours to fluctuate so widely that even though captured by the attractor´s basin they appear unique. Strange attractors describe ordered global patterns with such a high degree of local fluctuations, that is, that individual trajectories appear random. Complex adaptive systems are often characterized by strange attractors. The strange attractors of seemingly "chaotic" phenomena are therefore often not chaotic at all. Such intricate behaviour patterns are evidence of highly complex dynamic organisation. This is essential if innovation processes are to be thoroughly understood as 're-combinations' of knowledge, new and old.

Quantitative research has articulated the strange attractors that shape a variety of dynamical human systems. Such quantitative analysis requires that the systems incorporate a small number of deterministic variables (dimensions). If the dimensionality of the system is too high (the commonly-used limit is eight variables), the system is considered to be random because the pattern cannot be discerned by current manipulative practices and analytical algorithms. Qualitatively, however, the strange attractor has been used as a metaphor to describe highly complex, but patterned, behavior in human systems. Whenever the behavior of the system is bounded, includes infinite freedom within the bounds, and generates coherent patterns over time, the human system can be metaphorically described as a strange attractor regime. Examples of human system aspects that fit this qualitative description include organizational culture, patterns of professional practice, or the behaviors of firms within a given industry. In each case,

individual agents work within accepted boundaries in accord with patterns of behavior that are supported by the rest of the system in complex and nonlinear ways.

Figure 2.2 Illustration of a rugged fitness landscape

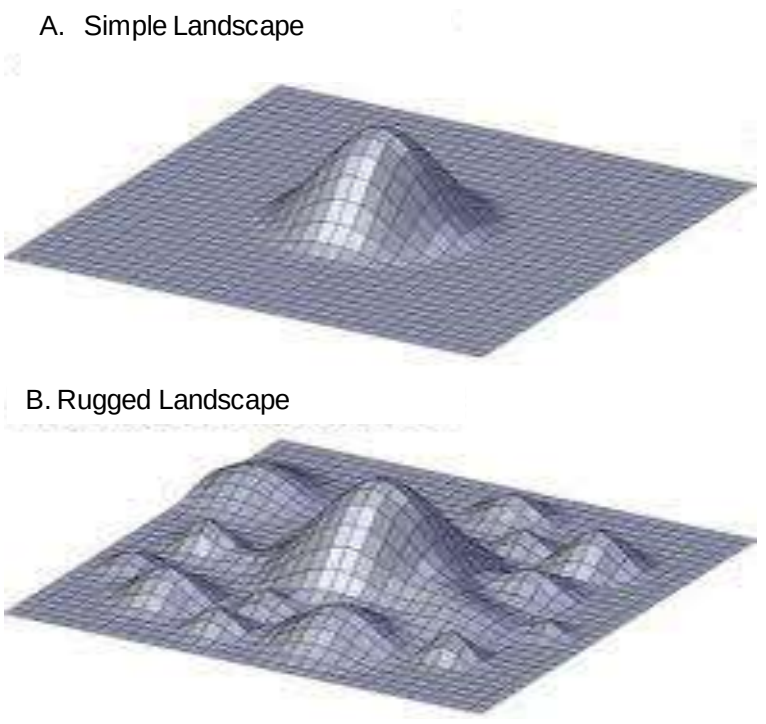
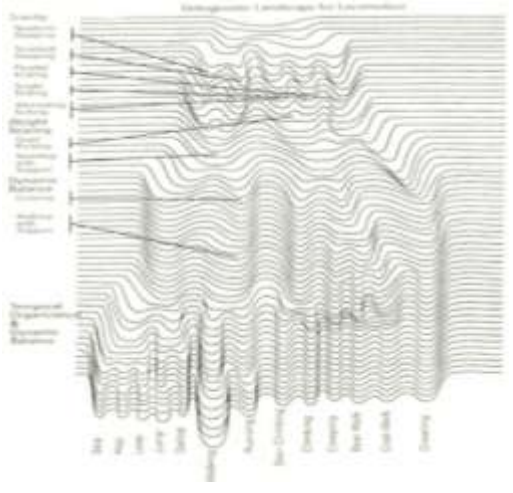


Figure 2.3 Ontogenic landscape for locomotion

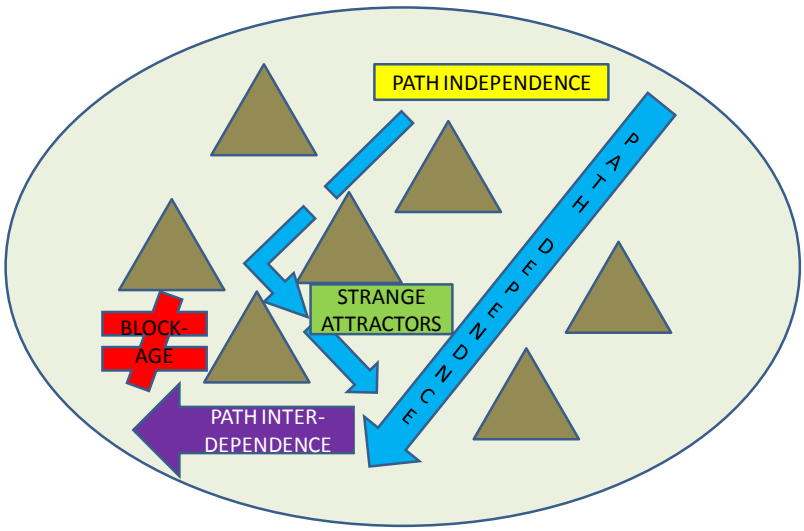


To give this a bit more concreteness we can return to the example of Strategic Niche Management. The valleys represent regimes where each regime has its dominant logic as attractor. Change in this system requires adaptive walks up the slope of the valley to improve fitness and/or a catastrophe that changes the whole landscape. The first type of change is what developing niches means whereas the catastrophe might be a major technological breakthrough that changes the terrain radically and opens paths between valleys. Stuart Kauffman (1995) developed a much used optimization model called the NK-model to study which type of solutions these adaptive walks may lead to. One important feature of this model is that with increasing complexity it is difficult to reach global optima so the search is often around local optima. Proximity reduces complexity.

Strategic niche management is based on the assumption that breakaway from the dominant logic is not possible without designing protected spaces for niches to develop. The success of such a strategy is dependent on whether the valley (basin of attraction) is broad enough to give room for niches i.e. local peaks in the landscape.

The figure 2.2 shows clearly that there are local peaks in the landscape where an agent can get stuck. This is a reason why Stuart Kauffman (2008) coined the term *the adjacent possible* to describe where solutions may be found. This concept has been used by Steven Johnson in a study of innovation that is referred in chapter 4. The point here is that adjacent possible is given partly by the capabilities of the searching agent but also by the environment. It might be that time is not ripe for an invention to become an innovation. Conversely one might assume that strange attactors like culture or social capital can be more or less enabling for innovative cross-fertilisation because there are strange attractors of meaning.

Figure 2.4 Complex Adaptive System Topology for Innovation



Source: Centre for Advanced Studies

2.4 Why human complex systems are different

Human systems are different from natural and biological because they are reflexive which means that we can learn. The major differentiator is that humans can communicate by the use of language which has been described as involving the coordination of the coordination of actions (Maturana and Varela (1980). Language can itself be seen as complex adaptive system but language and the communication and interaction it allows affect interplay between micro-macro levels in other systems. Humans are cognitive agents set out to pursue purposeful action, i.e. action or intervention based on intentions individually and collectively. Here we should note Midgely´s (2000) suggestion that if intervention is purposeful action by an agent to create change, then systemic intervention is purposeful action by an agent to create change in relation to reflection on boundaries. What he means is that there is a need for agents to reflect critically upon, and make choices between, boundaries. Boundaries define both what issues are to be included, excluded or marginalized in analyses, and who is to be consulted or involved (the two are obviously linked, as different agents will have different concerns). Because of the 'who' question, issues of power and participation are unavoidable in systemic intervention.

Language is important from an innovation point of view which has to do with character of the "knowledge boundaries" that have to be crossed. These are referred to in communications theory as syntactic, semantic and pragmatic boundaries and the higher the novelty the more a need to be able communicate across the two latter categories of boundaries (Star (1989), Carlile (2004) by making use of boundary objects. These in turn allows for complexity absorption (Boisot & Child, 1999). This is not the place to expand further on these topics. They are mentioned because they may play an important role in coordination and sensemaking in the generative phases of ideas and concepts.

The issue of intent and the consequences thereof make the issue of how boundaries are defined of interest. The more universally a system is defined the less influence of individual and perhaps even collective action.

It is clear that in order to be recognisable as such, a system must be bounded in some way. But as Cilliers (2001) says, as soon as one tries to be specific about the boundaries of a system, a number of difficulties become apparent. For example, it seems uncontroversial to claim that one has to be able to recognise what belongs to a specific system, and what does not. But complex systems are open systems where the relationships amongst the components of the system are usually more important than the components themselves. Since there are also relationships with the environment, specifying clearly where a boundary could be is not obvious. Cilliers suggest that we should think of boundary as something that constitutes that which is bounded in order to see the boundary as something enabling rather than as confining.

As an illustration of this logic he presents the example of the eardrum. It forms the boundary between the inner and the outer ear, but at the same time, it exists in order to

let the sound waves through. As a matter of fact, if it was not there, the sound waves would not be able to get through at all! If the boundary is seen as an interface or membrane participating in constituting the system, we will be more concerned with the margins of the system, and perhaps less with what appears to be central. A second boundary issue concerns the "place" of the boundary. The propensity we have towards visual metaphors inclines us to think in spatial terms. A system is therefore often visualised as something contiguous in space. This tendency is reinforced by the prevalence of biological examples of complex systems. We think of systems in an "organic" way. Social systems are obviously not limited in the same way. Parts of the system may exist in totally different spatial locations. This may be exemplified by clusters as geographically defined systems and at the same inhabited by actors belonging to different social worlds or systems where the overlaps between these different kind of boundaries constitute much of the governance issues related to horizontal innovation. And there is a discussion on boundaries there as well, especially if we include the cognitive and social aspects in the governance discussion which was mentioned above.

3 Resilience, Innovative 'White Spaces' & Cluster-Platforms in Swedish Regions

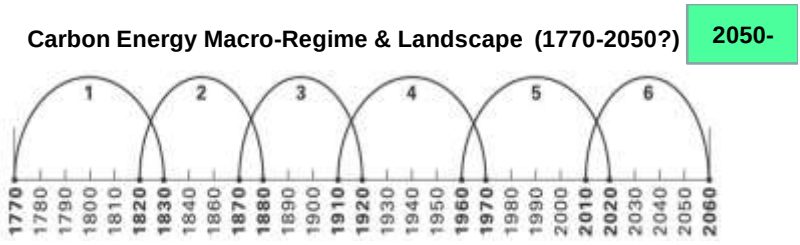
3.1 Introduction

Configuring the previous scene-setting exercise, we are convinced that the newest and most fruitful insights into our understanding of innovation processes come where understanding is informed by one of four complementary theoretical perspectives. These are, respectively: the Multi-level Perspective on Co-evolution (MLP); the Resilience or Panarchy perspective; Complexity Theory; and Evolutionary Economic Geography (EEG). These are eventually combined into a new synthesis to assist advanced understanding of the role of transversality and proximity in contemporary innovation processes (Fig. 3.3).To recap, the multi-level perspective (MLP) on co-evolutionary transition is a comparatively simple but nevertheless useful perspective from the Netherlands addressed principally at the eco-innovation sphere where some thirty-two industrial sub-fields were selected for special attention in relation to their eco-innovation potential. Policy-makers worked over a number of years with eco- innovation academics to develop a three-tier macro-perspective on transition and the co-evolution of socio-political and economic sub- systems (socio-technical systems; STS) that define the needs driving eco-innovation (see, for example, Kemp, 2002; Geels, 2004; 2006). One of the important observations is that the challenge posed by the need to control human-centred global warming demands innovation of a far higher systems order than any preceding 'technological paradigm' in the world's industrial history (Fig.3.1). This is because all preceding 'long waves' of transformative, radical technological innovation from mechanisation through the railroadisation, electrification, motorisation, and informatisation paradigms of global society, occurred under a macro-regime or 'landscape' of reliance upon fossil fuels. Now the macro-regime and whatever future technological paradigms emerge over time in the future should be set in a 'post-hydrocarbon landscape'.

Related to MLP is a richer and more integrated nature-society perspective on co-evolutionary transition known as 'Panarchy' or the 'Resilience' approach (Gunderson & Holling, 2002; Folke, 2006). Panarchy is a framework to account for the dual characteristics of all complex adaptive systems – stability and change. It shows how economic growth and human development depend on ecosystems and institutions, and how they interact. It arose from observation of failed attempts to manage regional ecosystems that

often culminated in their degradation because of linear management efforts focused on a single variable, usually economic. By contrast, it demonstrates and models a multi-scalar adaptive cycle that promotes eco-innovation alongside an MLP for institutional intervention in the process. Third, relatedly and concerned with complexity in adaptive systems of any kind, not especially ecosystems or economic systems, is Complexity Theory. This forms a bridge with the final approach to be outlined, namely Evolutionary Economic Geography because of two of its key evolutionary insights, namely 'Preadaptation' and the 'Adjacent Possible'. These explain innovation (in this case, eco-innovation) in terms of fitting an unforeseen potential with the 'adjacent possible' application (Kauffman, 2008). *Preadaptation* takes already existing innovations from one industry setting and adapts them for wholly different industry solutions.

Figure 3.1 The Waveform Evolution of Carobonised Capitalism (1770-2050?)



Long Wave	Mechan-isation	Railroad-isation	Electri-fication	Motoris-ation	Informa-tisation	Neuro-nanobio
Time Period	1770-1830	1820-1880	1870-1920	1910-1970	1960-2020	2010-2060
New Inputs	Water Power	Steam Power	Electric Power	Oil	Micro-processor	Biochip, Brain Imaging
Driving Industry	Textiles	Rail-ways	Electri-city	Automo-tive	Micro-computers	Nano-biotechnology
New Industry	Canals, Cotton Mills	Steam-ship,Tel-egraph	Motors, Power tools	Aero-space	Soft-ware,	Neuro-therano stics

Source: Based on Lynch, Z. www.neurosociety.com

The *Adjacent Possible* is a search process that seeks novel solutions, many being incremental innovations, relatively close to the existing state of the art. Such novelty becomes radical innovation when the knowledge recombination search swiftly reveals numerous related innovation possibilities and potentials. Complexity theory contains many more interesting and relevant concepts, some of which are shared with the other three approaches to be discussed. For example, it presumes complex adaptive economic

systems display: dispersed interaction e.g. regionally specialised *knowledge* domains; absence of a global controller (self-managing adaptive systems); cross-cutting hierarchical organisation (e.g. multiple economic governance jurisdictions, including MLP); continual adaptation; permanent innovation; and 'far-from-equilibrium' (prone to crises) system dynamics (Arthur, Durlauf & Lane, 1997). Nevertheless, broadly-speaking, although there are historic exceptions, discussed by the likes of Diamond (2005), economic and other systems have the self-adapting capabilities of 'resilience' although time-scales that are quite lengthy, as also recognised in the MLP approach. It is further argued by Holland (1995) that the non-linearity and variety (diversity) of complex adaptive systems generates path dependence. This means 'regional regimes' of interaction facilitate innovation as the system evolves, allowing qualitative shifts in system dynamics (e.g. hydrocarbons to a post-hydrocarbons macro-regime or 'landscape').

Table 3.1 Theoretical Perspectives on Multi-Level Regional Innovation System Interactions

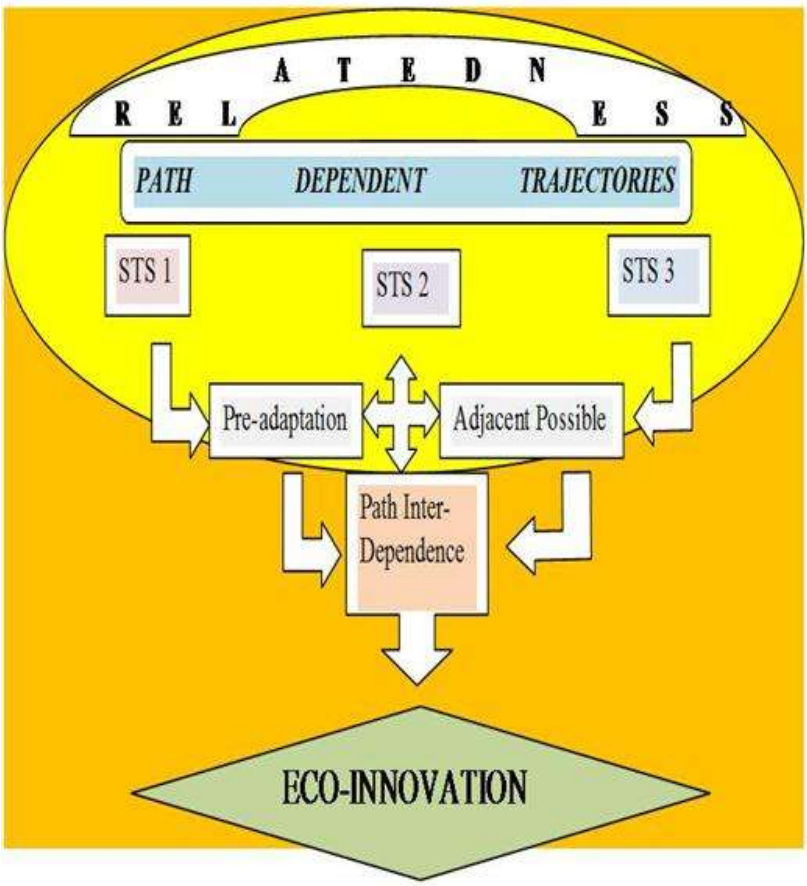
Theoretical Approach	Key Innovation Characteristics
Co-evolutionary, Multi-level Perspective	Non-Cyclical Scalar Relationships Socio-technical Systems (STS) - Interactive Strategic Niche Management
Panarchy	Multi-level Interactions (Cyclical) Potential (High Variety) Connectedness (Robust Endogenous Institutions) Resilience (Resistance to De-stabilisation; Renewal)
Complexity Theory	Preadaptation/Exaptation Cognitive Reversal Borrowing Searching Adjacent Possible
Evolutionary Economic Geography	Path Dependence/Path Inter-dependence Relatedness/Transversality Proximity

Source: Centre for Advanced Studies, Cardiff University

This leads, fourth, to a brief introduction to key insights of relevance to this analysis coming from evolutionary economic geography (EEG; Frenken et al., 2007). Taking two key concepts from spatial economics and technological history it finds particular utility in the idea of 'relatedness', on the one hand, and path dependence, on the other. Relatedness arises from research into regional economic growth where it is found that economies with 'related variety' among industries perform better than those without it. This is called the 'proximity' effect superseding the 'portfolio' effect from the viewpoint of industrial structure. More related variety means more lateral 'absorptive capacity' from related 'knowledge spillovers'. These can enhance the innovation potential of regions and EEG research goes further into this relationship and, as indicated, finds the element of 'relatedness' within the required variety to be the independent variable. Moving on, 'path dependence' at the regional level can explain stability but also system

stagnation and inertia (Martin & Sunley, 2010). However in contexts such as that of a regional economy with related variety, path *interdependence* can be envisaged where two or more economic trajectories may intersect in regional space (Fig. 2.2), conceivably producing unforeseen innovations from their 'revealed related variety' or *ex post* relatedness. As the case material to be discussed below shows, much innovation is of this speciation or mutation kind.

Figure 3.2 Eco-innovation of STS Path-Interdependence

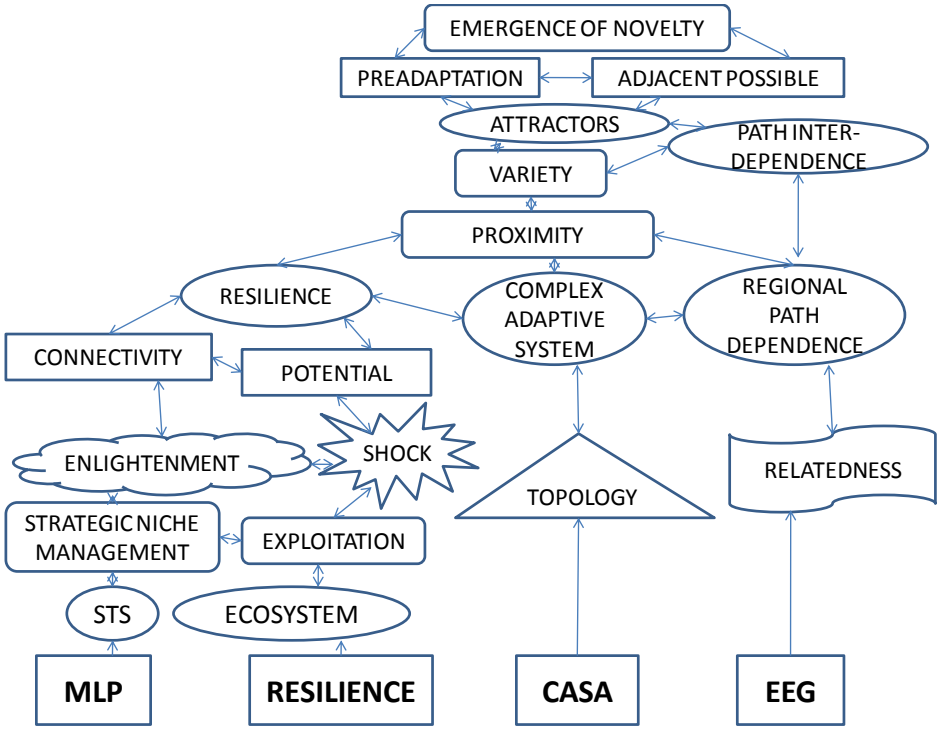


Source: Centre for Advanced Studies, Cardiff University

Recent research on 'innovation biographies' shows this also happens globally among distinctive 'transition regions' (Cooke, 2010).Table 3.1 lists the important elements from the foregoing review before these are marshalled into a partial (Fig. 3.2) and general (Fig. 3.3) conceptual model of the processes whereby regions may be stimulated or blocked by the dominant (national) socio-technical systems of consequence to the key Research, Development & Innovation (RDI) fields. Equally, there will be interest in

the extent enlightened national institutional frameworks have stimulated regional innovation. As is evident, while the four theoretical perspectives are distinctive, they all adhere to broadly evolutionary principles, so there is a degree of overlap and associated redundancy. For example both the MLP and panarchy have clear multi-scalar structures. The cyclical nature of panarchy makes it richer and more relevant to a dynamic perspective and its emphases on potential (high variety), connectedness (institutional or regime robustness) and resilience (capability to resist shocks and exercise renewal /innovation) are central to the analysis. Nevertheless, the concepts of STS and strategic niche management are even more directly appropriate for innovation and eco-innovation analysis. Similarly, the complexity theory identification of preadaptation and the adjacent possible explains processes by which innovation proceeds through knowledge recombinations related to proximate and non-proximate path-interdependence and relatedness. These are highly complementary concepts of significance to the explanation of 'value variety'. This means recognising both the value of variety for innovation and economic development, and that policy should value this fact.

Figure 3.3 Synthesis Framework of Regional Innovation Perspectives and Processses



Source: Centre for Advanced Studies, Cardiff University

Accordingly, these largely complementary concepts may be arranged in the form of a conceptual model of innovation which is subsequently tailored to the analysis of comparative empirical case material to estimate the relative importance of regional-national interactions and determinations for eco-innovation. This partial model is provided in Fig. 3.2 while the general synthesis is found in Fig. 3.3. In the innovative territorial core of Fig. 3.2 are path dependent socio- technical systems (STS), namely regional industry paradigms and their associated socio-technical regimes. Where these display relatedness, the triggering factors of pre-adaptation in one or other STS and/or the search and selection process for the 'adjacent possible' causes path inter-dependence of technologies (artifacts and/or organisations). Under the impetus of an initial shock to economic activity, resilient knowledge recombinations resulting in innovation occur. The adaptive regional innovation system is open and there are several multi-scalar links through networks to higher and lower governance or industry organisation levels as well as to relevant STSs elsewhere.

Occurring in Fig. 3.3, reading from the bottom of the diagram to the top is the following. First, the MLP and Resilience perspectives are revealed as providing macro-contexts for the more micro- complex adaptive systems approach (CASA) and EEG approaches. Thus a socio-technical system is equivalent to an industry 'ecosystem' including its social as well as economic elements. Change occurs gradually ('enlightenment' - MLP) or as a response to 'shock' to the system in the resilience perspective. How this occurs is explained in resilience theory in terms of the system's 'potential' or variety and its 'connectivity' or governance and networking capability. Such an explanation is absent in MLP because of its non-crisis assumption of change. This inclines the schema in Fig. 3.3 over towards the more micro-processes of regional innovation captured by CASA and EEG. Here, their contextuating concepts are 'relatedness' and the 'topology' by which CASA explains system adaptation as vectors of activity combine or recombine to adapt and change (Fig. 2.2). For EEG this involves regional path dependence (e.g. an industry trajectory) diverting into path inter-dependence and the prospect of innovation at cluster or sector and firm interfaces. While for CASA this is an effect of adaptation under conditions of variety in which 'attractors' meet.

EEG has nothing further to say about innovative practices of 'attractors' but complexity science introduces 'preadaptation' or innovation through transferring novelty from an existing application to a wholly new industrial field. An example of this is the application in the Smart Textiles cluster of advanced textile weaves to biomedical innovations such as cardiac grafts. There can also be retro-innovations as practised by GE for cardiac scanners in 'bottom of the pyramid' low value but high demand health markets in developing countries, as described in April, 2011 by Tom Inns in our second design workshop in Malmö. Finally, inter-cluster action may occur by attractors driven to explore the 'adjacent possible,' an unknown 'white space' field with great innovation potential but possibly high uncertainty. An example is paper batteries utilising algae

extracts developed in Sweden by UppsalaBIO. *In Fig. 3.3 we see the most important connective elements summarised in Table 3.1 translated into a general complex regional innovation framework designed to capture the main forces policy-makers need to understand in the foreseeable context of global and local turbulence, transversality and transition out of the multiple crises with which they and their constituents are faced.*

In what follows in the space available, we will first summarise a number of stylised cases of 'value variety' in action in circumstances where regional relatedness is being stimulated by a 'transversality' policy approach to identify regional opportunities for innovation. In this regard, markets do not necessarily show themselves to be 'small and fast' adaptive resilience systems and public-private innovation agencies perform the path-interdependence role. In most of the live examples 'preadaptation' is being exploited, not least because it is easier to spot in the arenas or 'research-based theatres' such innovation intermediaries create (Pässilä, & Oikarinen, 2010). In the more ambitious exemplar, discussed longitudinally (Region Skåne) the adjacent possible is being explored in a variety of ways.

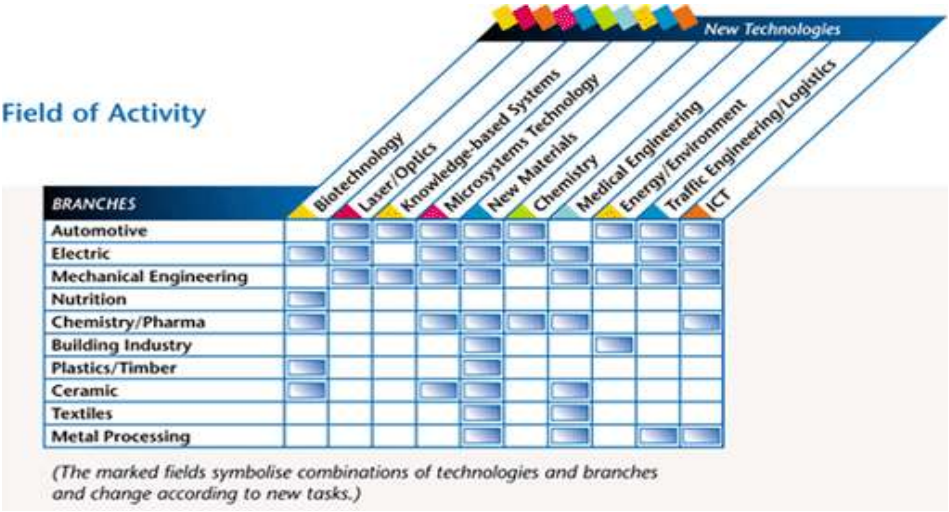
3.2 Preadaptation Exemplars

3.2.1 Bayern Innovativ

Since 1995 such a model is found in Bayern (Bavaria) Germany as summarised below and focused upon the platform-building activities of *Bayern Innovativ* a governance agency for regional development (Fig.3.4) based in Nürnberg. Here the agency identified key industries that were beneficiaries of cluster policy paid for by Bavaria's resource windfall when it sold its share in the regional energy supplier. These were cross-tabulated against key technologies to find the inter-disciplinary and inter- industry innovation potentials of 'related variety' in the regional economy. Many innovations (on average 10%) have ensued from the over 1,000 per year 'conversations' facilitated between neighbouring sectors concerning technological co-operations, applications and resulting innovations. Part of the new platform thinking involved recognition of the importance of enhancing 'preadaptation' among clusters by creating an 'innovation theatre' where innovations from one industry could be shown to representatives of different industries for them to assess the knowledge transfer and recombination potential of specific technology applications.'Storytelling is perceived as a crucial feature if the knowledge cross-fertilisation process. It takes the form of organising occasional large conferences of interest to members from a wide variety of industry sectors and clusters. For these, what is referred to as a 'red thread' narrative is provided such that different actual and potential innovation elements are woven into a coherent narrative. Thus a 'red thread' theme for a conference might be Living Lighter. This would appeal to representatives from agro-food, medical care and technology, automotive and other engineering seeking to reduce content weight of products, energy companies etc. The list is

almost endless. Accordingly, presentations and demonstrations have to be carefully thought about almost as a kind of unfolding dramaturgy or 'research-based theatre' (Pässilä, & Oikarinen, 2010).

Figure 3.4 Bayern Innovativ: Technology Platforms



Source: Bayern Innovativ - http://www.bayern-innovativ.de/ 2009

How does *Bayern Innovativ*'s proactive regional innovation policy work? Fig. 3.4 gives an indication whereby matrix management of potential innovation opportunities at intersections between industries, some having been beneficiaries of earlier cluster programme investments, and technologies occur. These are points where conversations among distinct and by no means obviously neighbouring business sectors are facilitated. Accordingly, where these facilitate personal discussion between experts and customers, sustainable cooperation networks are developed. More than 1,000 new co-operations are initiated annually. Examples of the roughly 10% of marketed innovations arising from these co-operations include:

- *Laser technology* preadapted to beam nanoscale droplets onto microarrays for rapid bioanalysis
- *Mechatronic systems* for car engine management that have been transferred to bus steering systems
- *Portable fuel cells* that have been preadapted in automotive electronics
- *Plastic injection moulding* processes from button manufacturing which have been preadapted in automotive plastic components
- *A logistics and transport* company that has secured a contract with one of the world´s largest Internet suppliers

- *A technical textile producer* preadapted an automotive nanotechnology fabric to innovate in the field of medical uniforms.

Hence, *Bayern Innovativ* (BI) initiates business-driven project co-operations across disciplines and branches, taking into account the latest results from the scientific community. Over the past decade the agency has forged new pathways and created a portfolio of cooperation platforms and networks that have generated an extended, sustainable network structure. Both the platforms and the networks are in demand at regional, national and international levels.

3.2.2 EcoPlus: Lower Austria

It is worth noting that this approach may have been pioneered in parallel in Upper Austria where in 1997 a *Technology Policy Matrix* cluster programme was first implemented. Unlike the BI approach that in Lower Austria is thematically formed into a matrix policy structure by infusing each member cluster with the common goal of enhancing 'sustainability'. There are nowadays five key clusters evolving and receiving support around the theme of eco-innovation. These are, respectively:

Green Building – this is the economic hub of a network of ecologically aware firms in the region's green construction industry. The cluster team includes architects, energy experts, building and interior design professionals. The cluster is coalescing towards energy and environmental technology fields

- *Automotives* – companies are supported in; internationalisation, qualification and co-operation with research facilities.
- *Food Cluster* – supporting the regional food industry, from farm to fork. Food quality, safety, organic and regional products are supported and promoted.
- *Logistics* - this involves shippers, transporters, and logistics services to enhance transport bundling, reduction of empty journeys and more efficient transport and shipping.
- *Plastics* – an inter-regional cluster also involving the Salzburg region. This seeks innovation adjacencies in the development of bioplastics and fibre composites (biofibres). Expansion into medical technology and recycling is planned.

Finally, a further variation on matrix or transverse innovation methodology has been long- practised in Värmland region, Sweden.

3.2.3 Region Värmland's Packaging Arena

This is a user-driven and design-driven innovation platform model which is highly attuned to 'transversality' and empowering local small and medium-sized enterprise platforms to secure strong positions as innovative suppliers to global packaging users. In this respect it is one of the more interesting post-cluster complexes. It is the Swedish

region of Värmland, home to the Packaging Arena – a complex cluster of packaging, paper, engineering, food and graphics firms that are indispensable for the MNCs they supply, including in Asian markets. The Packaging Arena is a functioning cluster of 45 members that supplies services ranging from Guidance & Process support, to Consumer Testing, to Innovation Support. A strength is its engagement with Consumer, Paper and Graphics research at Karlstad University and Broby College of Cross Media in Sunne. The Packaging Arena is one of many clusters operating in the Värmland regional innovation system. Importantly this displays considerable relatedness among the clusters enabling knowledge spillovers and joint working to occur. This aspect of joint working is evident in the Packaging Arena's strategic plan document. The process management team is well-qualified and team members have distinct competence areas that result in the whole group being able to manage sometimes complex work-related tasks. Perhaps uniquely, the Packaging Arena displays a number of related facilities, notably the Packaging Media Lab, the Packaging Greenhouse, DoTank Design Studio, Swedish Flexography Institute and the Graphics Institute at Broby Cross-media College. Consideration is being given to creating an incubator at the downtown Karlstad head office.

The Packaging Arena adopts a modern, conceptualised approach to management. Members are allocated to a Value Star that covers each part of the supplier base. New memberships are encouraged mainly from candidates who offer functions that strengthen the Value Star. The CEO is male but the other seven staff are female, each with a particular sub-unit such as the Japan desk (Japanese national) or the Packaging Media Lab to manage. In this facility eye-tracking analysis is managed, a function which enables consumer eyelines to be tracked when confronted with substantial amounts of visual information as in a supermarket where choices are made over which products to buy. Such consumer information is made available to retail outlets who utilize the Packaging Media Lab as a living laboratory for testing out new product displays, for example. The Packaging Greenhouse, by contrast is a place where ideas can be proposed, discussed, analysed and adopted or rejected by members from retailing and the packaging supply chain. Inputs to such ideas sessions are enriched by the presence of representatives of the Service Research Centre at Karlstad University and the Graphics Institute at Sunne. The Japan desk is important because of the close knowledge transfer links established with the Japanese packaging industry. Representatives of the latter are regular visitors to several of the facilities of the Packaging Arena as they are to major trade exhibitions such as TokyoPac.

3.2.4 Region Skåne's White Spaces & Resilience Ambitions (Adjacent Possibilities)

Research starting in the mid-2000s showed cluster strength in this region to be in agro-food production and services, including functional food based on biotechnology applications (health drinks) and organic food (farms, public canteens and restaurants) as well

as conventional mass production using industrialised 'productivist' chemical, pesticide and other conventional control technologies. A once strong but now fading path dependence was on shipbuilding in Malmö but with the closure of the Kockums yard in the 1980s that has led to redundancy and migration of shipyard workers. By early 2010 the western harbour area had been re-invented as a centre of 'cognitive-cultural' and other service industry. Other activity also assiduously promoted by a highly capable regional development agency includes mobile telephony ('Mobile Heights'), electronic security, the Skåne film industry and new media, including computer gaming. An emergent cleantech industry ('Sustainable Hub') and a Systems Resilience initiative ('Training Regions') are also beginning to be visible.

The Skåne region development authorities prioritise cluster-building but also the exploration of value in the so-called 'white spaces' between cluster fields ('adjacent possible') where innovation opportunities are considered to lie. Accordingly, efforts have been successfully made to encourage crossover practices between the film industry (home of the Wallander detective series) and the tourism industry, resulting in a new €60 million 'film tourism' industry centred on Ystad in coastal southern Skåne. This also connects to the hospitality and culinary tourism aspects of the food-tourism platform. Another sphere in which the regime promotes both emergent clustering and transversality is in relation to clean food packaging with projects bringing joint research and testing of starch (from potatoes) as a degradable bioplastic and other variants of clean and reduced packaging. Lead packaging firm Tetrapak is faced with the imperative to innovate as consumer demand for cleaner and less packaging leads to reductions in market demand that resulted in reduction of overseas and domestic employment. The centrally-funded Skåne Food Innovation Network has been a big promoter of functional food technology, receiving €10 million over ten years, to develop it and the food cluster more generally. In 2010 these efforts were met with considerable success when the main health drinks producer Skåne Dairies sold its main ProViva portfolio to French multinational Danone for €50 million. These clusters constitute specific regional STSs in line with the MLP perspective.

Accordingly, Skåne Region is committed to giving greater identity and focus to its established and nascent industries by promoting its cluster policy which targets about eight fields. However, regime management builds upon transversal thinking and practice such as that advanced in Blackwell et al., (2010) about the evident advantages of filling regional 'white spaces' by stimulating the discovery of 'revealed relatedness' and promoting transversal or interface projects and initiatives among clusters. As it stands the clusters are mostly new and rather weak, except for food and film. However, Skåne's position on the Swedish periphery but in a Scandinavian core due to its proximity to Copenhagen, means geographic proximity is important, something recognised in the status of the international Medicon Valley life science cluster between Skåne and the Danish capital.

The Skåne Food Innovation Network

Re-researching the regional innovation system in early 2011, the following had evolved. First, regarding the regional food cluster (SFIN) and its evolving strategy (regional paradigm and regime or STS), this had confronted the future shock of the ending of its core funding from Sweden's central innovation agency by re-framing its trajectory. This involved three new initiatives. First SFIN's core concept had shifted significantly in perceiving opportunity in an 'adjacent possible' evolution as the regional innovation network selling and supplying innovation and entrepreneurship services to all regional clusters. Thus it would sit, close to market, beneath the regional economic development agency and the regional administration more generally. This advisory and consultancy function would grow out of capabilities developed over a ten year period in managing both a complex food cluster and building 'relatedness' bridges to different regional and supra-regional (Baltic Sea Region) clusters and global networks with other food clusters. Second, and to assist this process, a multi-level perspective had been embarked upon involving lobbying central government ministries and politicians to raise standards by changing regulations and helping create new food innovation opportunities. The aim is no less than re-invention of the public procurement process, moving it away from an ingredients-led to a meal experience-led approach. One example of this concerned 'Food for the Elderly' whereby better quality would be required from rules and expectations regarding food from the health and social security authorities for hospitals and care-homes. Having cluster entrepreneurs ready to demonstrate improved service quality to ministers strengthened the lobbying effort. A third aim is to raise innovation among large food companies by getting 'silos and clusters' to co-operate on innovation. This involves creating arenas where innovation demonstrations ('preadaptation') and exploration of innovation structural holes (known in the region as 'white spaces') might occur ('adjacent possible'). Thus 'green' packaging, the 'sustainable hub' cluster, Life Sciences, Media Evolution and Mobile Heights (ICT) would be among innovative contexts introducing and exploring innovation with each other. Accordingly, from the food industry perspective, transversality of this kind would allow SFIN to spearhead a more robust export model, acting 'guerrilla-like' to bring entrepreneurs directly into export markets. In general, this 'T' model as deployed by SFIN works upwards in the food focus (MLP) and outwards in the relatedness dimension, connecting fast-moving entrepreneur systems with slow moving, large corporations to increase innovation and expand global markets.

Mobile Heights

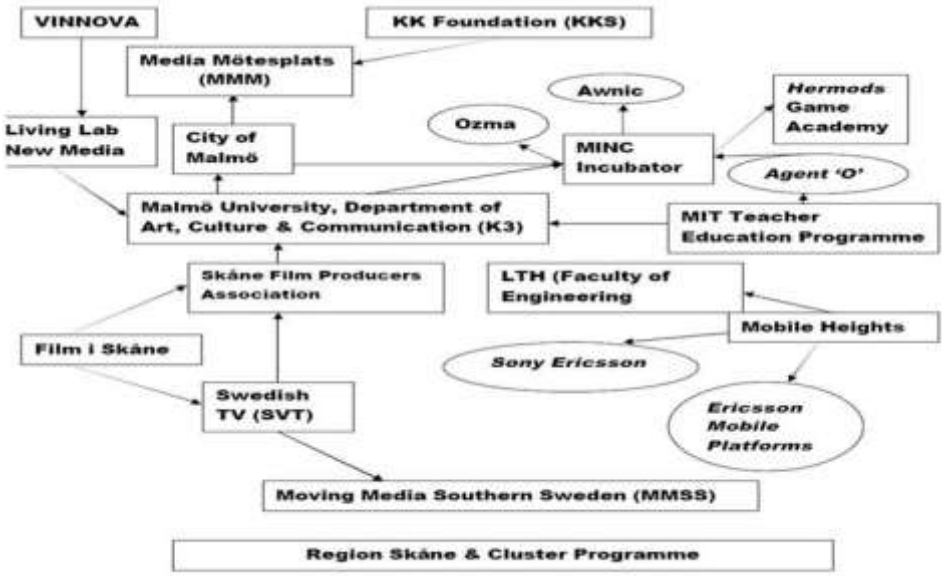
This cluster constitutes a platform of large firms like *Sony Ericsson*, *ST Ericsson*, *Ericsson Group* and *TeliaSonera* and ICT start-ups in incubators and the MH Business Centre. As a cluster it is already well-entrenched in a highly globalised ICT industry. Very rapidly, with major shocks to the hitherto Nordic predominance in mobile telephony, the global market has been invaded and expanded by Asian producers, notably South Korea

and China. Thus the Swedish industry had responded with two action lines: first a lead-firm like *Sony Ericsson* would make decreasing amounts of hardware and instead place its focus upon managing global services, such as selling network services to service suppliers such as, in Scandinavia, *Telenord* and *Telia*, to whom they also sell the extra service of managing the network, *Telia* simply managing billing and cash flow. Accordingly *Telia* had been cutting employment since the mid-2000s and had not filed any patents for two to three years. It was also felt that *ST Ericsson*, the telephony infrastructure arm of the *Ericsson Group* would probably not in the future survive as a stand-alone company. The medium-term key competition for *Sony Ericsson* is seen in Mobile Heights to be Chinese firm *Huawei*, which recently located an office in Lund, Mobile Heights' home base, for the development of basic components for mobile phones. *Huawei* works with everything from base stations to mobile Internet modems and its own telephone handsets. This augments their earlier offices at Kista Science Park in Stockholm and Gothenburg, employing 250 engineers. Some Chinese Internet portals like *Ali Baba* and *Ten Cents* are assessed by Mobile Heights as larger than *Google.* The other keen competitor for the *Ericsson Group* as a leading specialist in mobile telephony infrastructure platforms is San Diego-based *Qualcomm*. Their list of customers includes *Sony Ericsson*, which uses the company's platforms for their Android smartphones. The US firm also located an office in Lund in 2010, seen as partly an effect of increased demand and cutbacks in the telecom sector in Lund that have made hundreds of qualified engineers available. The second resilience strategy being adopted in the industry, very rapidly in Sweden, was the adoption of 'open innovation' whereby IPR is made available to SMEs and start-up businesses for exploitation (Chesbrough, 2003). An early adopter of 'open innovation', the Dutch firm *Philips* had exhausted its unused IPR by outsourcing it to spin-out entrepreneurs as a result of which it had experienced yet another round of employment downsizing. *Sony Ericsson* is now active in a major way in 'open innovation' relationships with innovative start-ups. *Ericsson* has been a classic 'closed innovation' firm but they have ample resources to buy from external suppliers and are actively seeking to contract to or acquire them. That there are quality entrepreneurial firms in the region is testified to by RIM (BlackBerry) acquiring user-interface maker *The Astonishing Tribe* (*TAT*). Also *Polar Rose*, a Malmö startup which built a facial recognition programme that linked into *Facebook* photos, was bought by *Apple* for $29 million, both in late 2010. Other open innovation connections involve Mobile Heights start-ups contracting to *AstraZeneca* in the Life Sciences cluster for remote diagnostics telephony with discussions proceeding on biosensors. From the cluster perspective a key focus is on the MH Business Centre where start-ups are nurtured with enterprise support, contracts and IPR from larger firms. Lateral linkages are also in position with the Media Evolution (*Nordic Game*) and Open Health Alliance clusters nearby and the FPX (Geographical Information Systems) cluster at Gaevle and the Baltic Sea Region cluster partnership.

Media Evolution

This cluster is concentrated upon 'Convergent Media' or what is also known as 'New Media'. It promotes the emergence and growth of start-ups in the relevant fields. Most such new firms have entrepreneur leaders with at least two to three years past experience in larger companies, a minority came from Lund or Malmö University. An example would be Jan-Erik Solem, founder of *Polar Rose* (see above). *Polar Rose* grew out of computer vision research - the analysis of digital images and video - at the Universities of Lund and Malmö. *Polar Rose* entered the Teknopol MH Business Centre in 2004. Teknopol is a tailored business advice agency specialising in start-up activity, notably in regard to the Mobile Heights Business Centre, Cleantech in Sweden initiative, and Life Sciences Business Centre, each of which relates to Region Skåne's cluster-platform programmes. Teknopol is not an incubator but connects to appropriate incubators at IDEON Science Park, Lund. It supplies other high-tech business services like investment, subsidies, customer identification and other enterprise support (see Teknopol account below). *Polar Rose* was given an initial loan of €30,000 as a *Sony-Ericsson* spin-out, to develop academically originated face-recognition software. J-E Solem became the CTO of the company with Danish serial entrepreneur Nikolaj Nyholm as CEO. TAT, (also discussed above) which was recently purchased by Research in Motion, responsible for BlackBerry smartphones, was only set up in 2002. TAT is a UX-UI, i.e. user experience-user interface firm. The UX field has its roots in human factors and ergonomics, which since the late 1940s has been focusing on the interaction between human users, machines and the contextual environments to design systems that address the user's experience. The term also has a more recent connection to user-centred design principles and also incorporates elements from similar user-centred design fields. As with the fields mentioned above, user experience design is a highly multi-disciplinary field, incorporating aspects of psychology, anthropology, sociology, computer science, graphic design, industrial design and cognitive science. Depending on the purpose of the product, UX may also involve content design disciplines such as communication design, instructional design, or game design. The subject matter of the content may also warrant collaboration with a Subject Matter Expert (SME) on planning the UX from various backgrounds in business, government, or private groups. *TAT* is set to enhance the BlackBerry PlayBook and smartphone platform. In 2009 Media Evolution established its own firm *EDCO*.

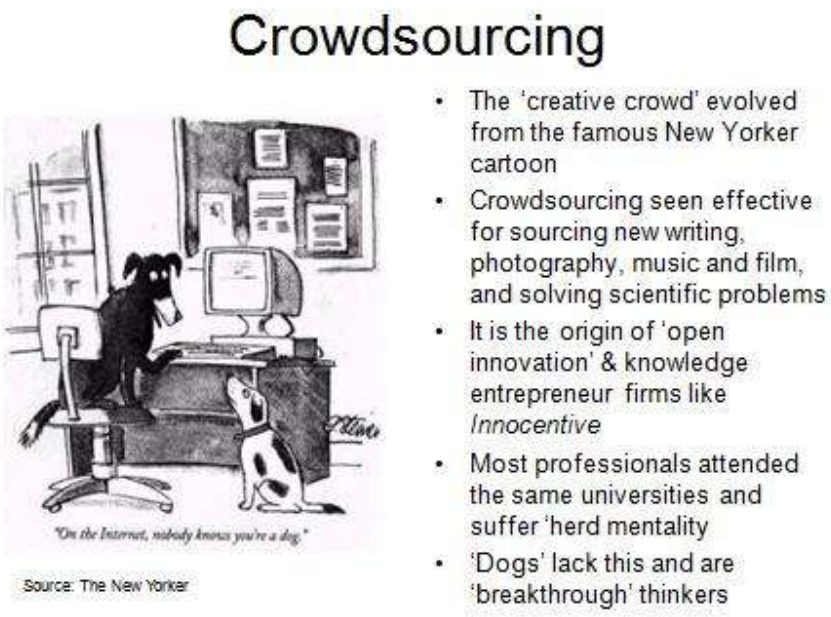
Figure 3.5 Broader Skåne Media Cluster to which Media Evolution EDCO Relates



Source: Centre for Advanced Studies

The principal tasks of EDCO involve interacting with the broader Region Skåne Media Cluster (Fig. 3.5), acting as a conduit of EU Structural Funds allocations through Swedish economic development agency (Tillväxtverket, former Nutek) and also with funding from its national cluster program, connecting Media Evolution's more than one hundred 'convergence-focused' firm members (subscription SEK1-8,000 per year), including Ericsson Multimedia, publishing companies, advertising agencies and a regional bank. These connect to the MINC incubator, Malmö University Living Laboratories, the Nordic Game programme, and the Film i Skåne initiative (Fig. 3.5). The NetPort game business development organisation unites the interests of Karlshamn township, the games industry and Blekinge Institute of Technology, and 'Learning Business', a network of companies involved in media and e-learning. Among the 'shocks' confronting Media Evolution are the ICT corporate downsizing and entrepreneurship issues faced also in Mobile Heights and the rapid emergence of convergence requirements across Sweden's Modern Times Group (MTG) with its multi-channel, satellite and cable demands and changing UX-UI and Internet protocol TV (IPTV) expectations for downloading to iPads, iPhones and other digital devices.

Figure 3.6 Origin of Crowdsourcing

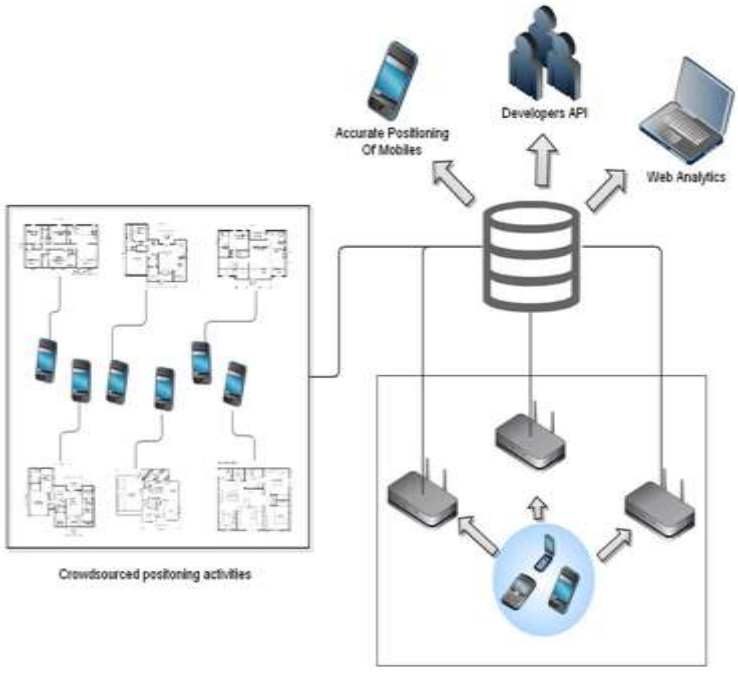


This is increasingly user-interactive with novel social media forms like 'Crowdsourcing' as described in Scott Page's book The Difference (Page, 2007), and even 'Crowdfunding' of anything from film projects to start-ups (Fig. 3.6). Accordingly, Crowdsourcing also indicates the response of 'open innovation' to global, corporate competitive forces impinging upon large Swedish ICT incumbents. A larger shock, like Climate Change causes firms and Media Evolution itself to engage UX thinking with 'experience economy' customers like Exploria, Malmö's incipient (2016) Theme Park & Science Centre with interests in sustainability, environment and in 2014 an Electronic Virtual Park. The process of 'gamification' (serious simulations as well as entertaining computer games) as recognised in disaster management cluster 'Training Regions' is part of the response to such changes. Thus by connecting technologies, new business models and customer interaction Media Evolution aims to promote new, convergent technology to make Skåne 'The Interactive Capital of the World'.

As we have seen in the previous account, **Teknopol** is a business advice agency for start-ups dealing in subsidies and loans of between €30 and 500 thousand. Three ingredients guide advice for entrepreneurs; entrepreneurial skills enhancement; industry collaboration as an early customer base; and new ways of finding finance. Experience shows that having serial entrepreneurs like the one at *Polar Rose* is the optimal asset. Giving them six months on a project after they may have been downsized from *Sony*

Ericsson with redundancy payments can make a twelve-month salary, which with business experience is often sufficient to create a robust business.

Figure 3.7 Qubulus Crowdsourced Indoor Positioning Platform



As noted, there are three cluster strands that Teknopol is active in promoting: Life Sciences; Mobile Heights and Sustainable Hub/Cleantech in Sweden. Building cross-cluster interactions between ICT and pharmaceuticals has worked well, as for example in the case of AstraZeneca's requirement for an ICT solution for its remote diagnostics concept. Other interface projects supported have included digitisation of the regional newspaper and developing on-line loyalty and payment systems for IKEA Bank. Other Life Sciences initiatives involve functional food collaborations around diabetes treatment and metabolism diagnostics again with diabetes treatment to the fore. In relation to renewable energy (Cleantech in Sweden) personal links were developed with *E.ON* which opened doors to their ideas portfolio, with a view to 'open innovation', which was then taken up with a different energy firm *Vattenfall* with main connections at CTO level. Mobile Heights' new business plan (MH 2.0) directs future ICT activities forcefully towards ICT applications emphasising personal health and remote diagnostics and treatment. AstraZeneca gave access to their patient data-base to facilitate development of ICT based clinical testing of new treatments. In ICT *Ericsson*'s soft SIM-card is in development for machine-to-machine interaction (otherwise known as 'Internet-of

Things') in combination with MH entrepreneurs. Other ICT outward innovation links include *Qubulus*, which is a system platform for Indoor Positioning (Fig. 3.7) on which Location Based Services (LBS) can be developed by *Qubulus* or by an application developer community through a shared application programming interface (API). The platform aggregates positioning input from a wide range of proprietary *Qubulus* technologies ranging from web services & mobile apps to hardware installations. By using the best technology to fit the usage and purpose of the customer case *Qubulus* can meet tough demands and solve the problem of indoor positioning. Crowdsourced positioning activities are a focus in designing space syntax for people flows, shopper movements in retail malls, 'product finder' smartphone applications of the kind that Packbridge would like to develop On this Mobile Heights is interacting with Gaevle's FPX GIS/GPS cluster supported by TILLVÄXTVERKET. The overall mantra of Teknopol is that the 'Opposable Mind Grips the Mystery and Grasps the Innovation' (see also Fig. 4.3).

Packbridge

This cluster focuses on packaging innovation, especially for smaller, specialist firms like those engaged in 'local food' markets for whom it is difficult to get innovative packaging that show the values of the company on the package in small volumes. On this, Packbridge works with the Food Academy, a Lund University member of the SFIN regional food network. Packbridge was founded in 2010 and has conducted an industry survey, research review and a database exercise of key actors in the market for their kind of target businesses. In relation to 'shocks' of an environmental nature, the research showed such business customers seek lower cost packaging, think recycling can be important for their markets and factor in energy cost and type much more in their cost and ethical calculations. Alongside the Climate Change, Energy and Sustainable Cities crises, Health demographics influence Packbridge's strategy for its members. Accordingly, as well as SFIN, 'relatedness' to the 'Sustainable Hub' network is important. For example bioplastics have been developed that are liquid-tight, a problem hitherto and these can be introduced to organic product marketing in future. Then, in a food-packaging-cleantech interface with Media Evolution, Packbridge foresees interactive packaging solutions involving mobile telephony for applications ('apps') in respect of payment, provenance, traceability and food recipes rising in importance. In relation to Skåne's Life Sciences cluster and the broader Medicon Valley relation-building is also on the Packbridge agenda. The idea of a 'Food Finder' app was also of interest using GIS/Interior Positioning platforms of a kind that, as noted, already exist as prototypes in the *Qubulus* family of platforms. Crowdsourcing is the key to achieving operability with this concept. This will evolve to the extent Packbridge meets its aspiration of engaging fully with the crowdsourcing platform, for example at the 'Humanist Laboratory' conference at Lund University. Related technologies of relevance in this dimension include nanotechnological surfaces, molecules and barriers in relation to sustainable packaging. Problems such as bacteria in liquids still occur in packaged goods as a

health scare at Ostersund regarding water indicated and in relation to disaster management as when major system failures occur as in Haiti, or over water supply after Northern Ireland's unexpectedly hard winter. A further suggestion is 'disaster stores' for food that starts renewable but when time-expired become biodegradable.

Sustainable Business Hub

The relatedness between this cluster concept and most of the preceding ones is obvious and in many cases has been recognised by the cluster agents and mentioned in the above accounts. The proximate 'shock' that led to the formation of this cluster initiative relates, naturally, to the combination of Climate Change and the Energy Crisis which invokes the strategic concept of Smart, Sustainable Cities in which adaptive infrastructure systems are optimally integrated. There are economic as well as environmental benefits from this approach, which are seen in the business potential of the Middle East and China as well as, nearer home, upgrading the existing infrastructures in the Baltic Sea Region. Technologies like renewable energy and sustainable district heating are cases in point. Sustainable Business Hub (SBHUB) is a membership organisation of 120 global customer and local supplier firms, municipalities and research institutes throughout Sweden but mainly based in Skåne. Their main focus and interest is in commercialisation of Swedish expertise in systems optimisation for renewable energy production, district heating and cooling, recycling and water and waste management. The strongest expertise in SBHUB is water and waste management. However, there are other specialist clusters in the overall sustainable innovation platform. Thus SweHeat is the brandname for energy production and district heating and cooling. VARIM is the industry association for water and water purification and SymbioCity is the organisation promoting waste management. Because SBHUB works with systems optimisation aspects and export promotion, there are major synergies with the systems integration aspirations of the new 'Training Regions' cluster with its focus on infrastructure systems resilience (see next section). Demanding customers driving the SBHUB trajectory forward include Swedish municipalities and cities seeking to exploit scale economies in production and distribution. For example the Skåne city of Helsingborg is a global leader in aspects of 'industrial ecology' whereby its waste management process produces inputs for biogas energy and biofertilizer production.

For example, the Filborna recycling facility (Fig. 3.8) used to transport its biofertilizer, some 35,000 tons, with trucks to farmers – at high transport costs and a considerable impact on the environment. Now the fertilizer is sent to the farms through pipelines. Thus 20,000 square metres of biofertilizer are pumped from the plant to four separate tanks over a radius of 12 kilometres. Each tank is monitored and controlled by the plant's master system. Innovation such as this has stimulated cross-cluster interactions with SFIN (biogas energy optimisation and broader sustainability in the food chain), Packbridge (green packaging) and Mobile Heights (green ICT and transportation). Innovation arising from such interactions ensued at firm-level, including smaller new

entrant businesses as well as more established firms in eco-innovation value chains. Creating arenas for knowledge transfer conferences and workshops around these and related issues is a key function of SBHUB. The shared interest (with 'Training Regions') and understanding of the imperative to improve systems management, integration and resilience is the main field requiring advanced knowledge sharing and practical innovation. A particular interest focuses on hospitals and improving their logistics, energy and waste-recycling in the SymbioCare project being conducted with the Region Skåne health authority.

Figure 3.8 Hälsingborg Piped Biofertilizer

Training Regions

This emergent cluster initiative was founded in December 2010; accordingly this account is programmatic rather than evaluative. It plans an Open Arena, run by logistics specialist company *TR International* charged with identification of needs, solutions, R&D and policy expertise and targets for enhancing infrastructure system resilience in Skåne, Sweden, the Öresund region and internationally, especially where Swedish interests (e.g. business) and capabilities, (e.g. disaster management) are involved. The increasing frequency of disasters in recent years and the scale of damage they bring, pose considerable challenges regarding the development of viable and effective approaches to help mitigate the impacts upon the population and the environment. The new threats faced, from developing technologies, globalisation, and political tensions are increasing. These, together with the risks associated with climate change and threats to collective safety bring about a need for a coordinated approach to research and international collaboration on emergency management. Research leadership is provided by LUCRAM,

Lund University's Centre for Risk Assessment & Management. It hosts four research 'clusters': Cluster for Emergency Response Research (CERR); Cluster for International Disaster Studies (CIDS); Human & Organisational Factors in Risk Management (HOFRIM); and the Leonardo da Vinci Laboratory for Complexity & Systems Thinking. The need for practical rapid response to system crises has been agreed with and supported by the Swedish Export Agency, centrally concerned with global commodity, asset and knowledge flows and structures. Global regions hosting large cities or export economies are highlighted (Fig. 3.9). It is clear that emergencies, crises or disasters in any of the key nodes transceiving key infrastructure flows require optimal resilience. Training Regions' January 2011 business plan focuses on interactions, leaderships and resilience planning and management in relation to such multi-level flow structures, focused upon cities. This perspective echoes a quotation made in 1904 by the famous Scottish town planner Patrick Geddes to the effect that *'….a city is more than a place in space; it is a drama in time….'.*

Figure 3.9 Global Telecommunications Flows, 2010

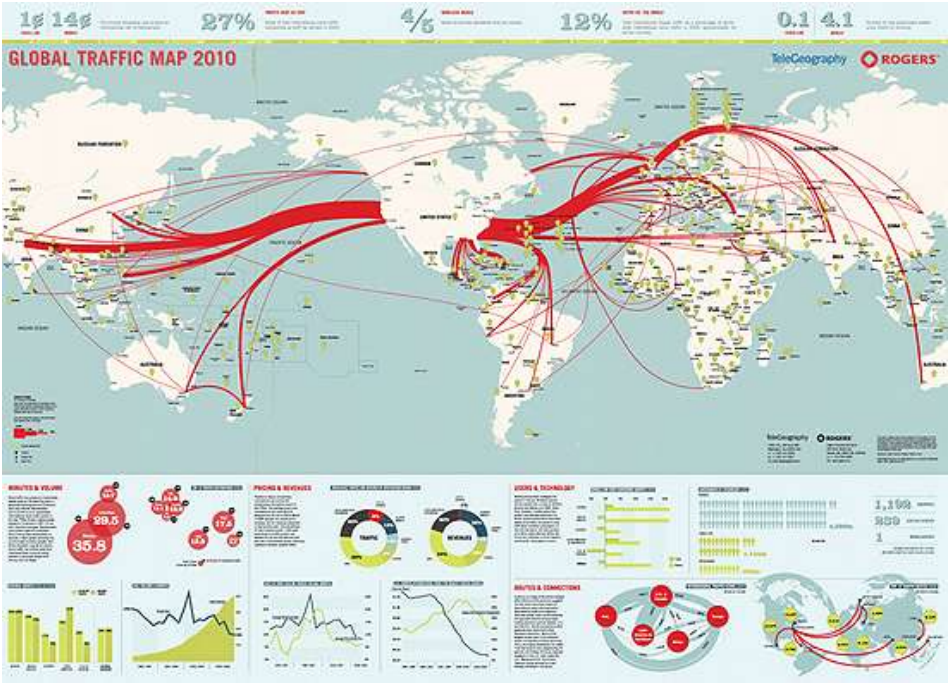


Figure 3.10 Sweco Design for Caofeidian Eco-city, China

Armed with the theory that cities are processes not just geographical spaces, inter-city flows can be disrupted, for example, by bad weather whereby medical staff may not be able to reach hospitals, not because they cannot be helicoptered in, but because they have to look after their children who cannot get to school. Normally municipal services and health services have different interests, systems and services but in emergencies they clearly need to be able to interact resiliently. Accordingly, network interface enhancement is a key instrument to improving system resilience. The inter-operability of Apple PCs and smartphones is useful and accessible to millions and semantic search engines demonstrate improvements in understanding user thoughts and needs. 'Gamification' of learning processes inspired by interfacing of the Tetris Blue Light gaming system kind is also inspirational given it can easily be handled by children. Thus Open Arena will first assemble sixty or so representatives of the Öresund emergency and basic infrastructure services alongside private companies engaged in computer gaming to demonstrate how simulation 'theatre' can assist management, operation and technical solutions to Grand Challenge issues like Climate Change-induced events such as exceptionally bad weather or other emergencies in an optimally resilient manner. 'Gamification' will upgrade typical civil protection training which relies on whiteboards and post-it notes. Training is needed in Vector Command i.e. how leadership is provided in emergencies, especially international ones, where different rules apply. In most countries police have VC status but in Sweden and a few other nearby non-Scandinavian countries (e.g. Russia, Poland) it is the fire brigade that exercises VC until it is established that a crime has been committed, such as terrorism, when the police take over. Some civil protection systems are highly procedurally-driven, others are both more

scientific and flexible. In the London terrorist attacks in 2005 the fire brigade frequently arrived first but hierarchical system 'silos' meant they could not over-ride ambulance service regulations as a consequence of which victims whose lives could have been saved died. A British firefighter receives fifteen weeks' training while in Sweden it is two years of higher education involving preventative as well as rescue recovery, including cognitive skills like pattern recognition and so on.

Accordingly unified command (UC) systems require parameter-mapping, in developing knowledge of managing 'systems of systems'. A priority is to make system information transparent to each Open Arena membership organisation as a basis for developing technical solutions together. Therefore, for Training Regions, which is a pedagogic initiative, methods of learning resilience management among complex systems is a priority. The key Swedish international engineering consultancy *Sweco* won the contract to design the first phase of the new Chinese eco-city of Caofeidian some 200 km southeast of Beijing (Fig. 3.10). Sweco defines the sustainable city or eco-city as a concept for sustainable urban development that can be applied on both a large and small scale. The idea is based on the use of a holistic approach to reduce emissions from entire urban districts. By planning according to the unique conditions of each site and proposing integrated system solutions for energy, transport, waste, landscape design and other factors, is it possible to create virtually climate-neutral cities. Accordingly, designing for resilience is evolving as a *Sweco* niche expertise as it changes its profile from a 'silo-supplier' of specific construction services to a 'platform-supplier' of integrated and sustainable services in multi-functional structures like eco-cities.

3.2.5 Concluding Remarks on Region Skåne's Innovation Platform Model

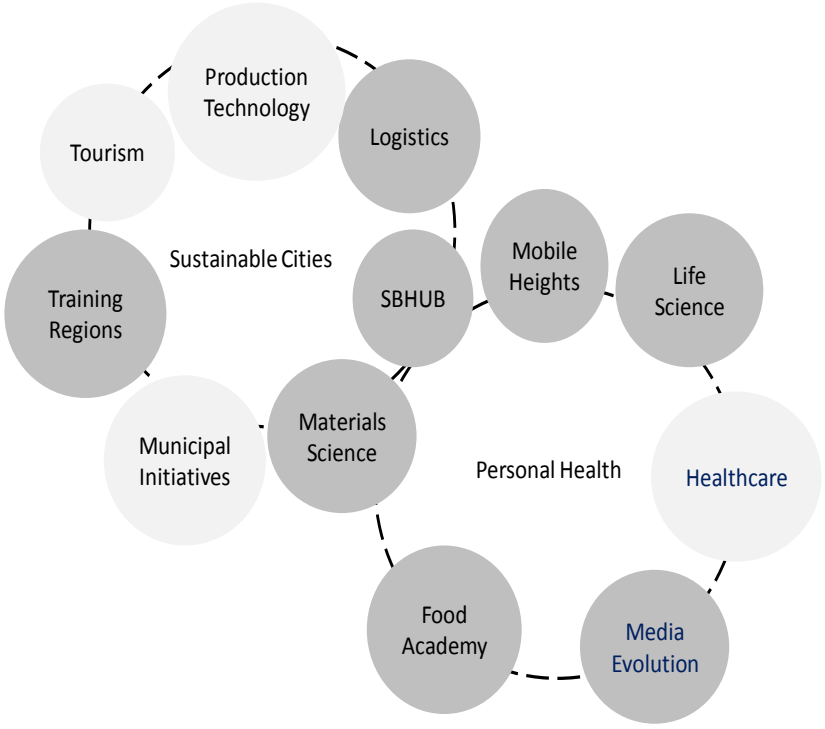
In the early parts of this chapter, we outlined an approach to regional economic change analysis that paid attention to the following key elements: multi-level relationships in governance and corporate structures and relations; resilience as an expression of a region's capabilities in absorbing 'shocks to the system' and returning to the position calmed down. The other, more common form of displaying resilience with the support of regional innovation agencies was to identify 'preadaptive' innovations that could be transferred from one industry or cluster to a different one. In some European regions like Bavaria and Lower Austria this is normal whereas in Värmland, in Sweden there is more of a search across a relatively narrow span of related regional industries for user and design-driven innovation in the 'adjacent possible'. In the key comparative case of Skåne region, this quest for the 'adjacent possible' is even more to the forefront across a broader span of industry clusters. In Table 3.2 the commonalities and divergences in this practice are summarised. It is clear that certain Grand Challenges have imposed shocks on the regional innovation system. These range from Climate Change imposing harsher winters on shared infrastructures in the Öresund region, deindustrialisation with

the major closure of Kockums shipyard in Malmö and its rapid transformation into a 'cognitive-cultural' quarter housing the media, ICT and many other clusters as well as the regional development agency in close proximity. Downsizing of established large ICT corporations faced with massive global competition emanating from Asia, and China in particular has been another shock, resiliently responded to by 'open innovation'. Finally the demographics of ageing have also imposed strains on the system, recognition that services are deteriorating and efforts to respond with innovations that optimise on infrastructure, ICT, food and healthcare expertise and capabilities in the region but serving Sweden and the wider world. Exploiting the region's proximity and relatedness advantages has been key to the response made thus far. Indeed, each cluster is connected into a set of interlocking circles that represent two strategic Grand Challenges the overall Region Skåne strategy is meant to address, as shown in Fig. 3.11.

Table 3.2 Matrix of Skåne Regional Innovation Platform Evolution Elements

Cluster Indicator	Media Evolution	Mobile Heights	SFIN	Tekno-pol	Pack-Bridge	Sustainable Busness Hub	Training Regions
Focus	New Media Convergence	Mobile ICT	Food	Start-up Advice & Funding	Packaging Innovation	Systems optimisation in renewable energy & recycling	Complex System integration
Shocks	Corporate Downsizing	Asian Competition	Sustainability, Losing Subsidy	Green Market, ICT & Life Sci. Downsizing	Climate Change; Personal Health	Climate Change; Energy Crisis	Environmental & Security Disasters
Responses	Open Innovation	Open Innovation	Green & Healthy Foods	Open Innovation	Green Packaging	Build energy & recycling platform	Systems Integration
Linkage	Gamifica-tion, Training Regions, 'Exploria' Science Theme Park	Health, Games, GIS	Media Evolution; MH; SBHUB; Pack-Bridge; Life Sciences	Mobile Heights, Life Sciences & SBHUB	Sustainable Hub; SFIN; Medicon Valley; Media Evolution; Training Regions	SFIN; Packbridge; Mobile Heights	Arena of 60 Disaster Managers in Öresund region; Serious games
Technology	Crowdsourcing, Crowdfunding etc.	Apps, Software	'T'-model Inno-Network & Lobbying	Apps; Internet of Things; Crowdsourcing & Positioning	Bioplastics; Biodegradability; GIS 'Food Finder'	Smart cities; Ecocity design & engineering	Gamification 'Simulation'; 'Theatre'

Figure 3.11 Region Skåne´s Two Strategic Grand Challenges Innovation Platform



In the remaining space, it is necessary to summarise the main 'transversalities' in each of the clusters in the Region Skåne innovation system discussed above, which is provided in Table 3.2. This shows recognition that regional industries have suffered significant shocks from Climate Change, Energy Scarcity, Corporate 'global shift' and downsizing, and Healthcare issues such as ageing of the population. In different ways, as with SFIN and Mobile Heights, the response to de-stabilisation is to engage in some form of 'platform-building' among clusters to produce innovate solutions with regional industry neighbours. Linkage is particularly pronounced towards the 'gaming' technologies of Media Evolution, and to SFIN. The technology projects they are working on include: sustainable technologies; new kinds of 'crowd' or user-driven innovation; and the use of gaming and simulation to stimulate learning and change management in meeting the shocks imposed by Grand Challenges such as Climate Change.

3.3 Shocks, Perturbations & Resilience Strategies in Swedish Clusters: Identifying Varieties of Transversality Management

At this interim point in reporting the latest strategic management moves of regions and clusters in Sweden's innovation system, it is important to portray one essential feature of regional and cluster trajectories. This is that even in a homogeneous country like Sweden, regional culture, geographical setting and industrial history are various and the policies adopted may also be varied although conditioned in common ways by the evolution of national and supranational governance priorities. Thus Sweden, like all European Union member-states seeks, in ways that suit its own national perspectives, to accommodate the EU's *Europe 2020* recovery plan following the global financial crisis of 2007-2010. This consists of the following broad targets:

1 Employment:

- 75% of the 20-64 year-olds to be employed

2 R&D / innovation:

- 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation

3 Climate change / energy:

- greenhouse gas emissions 20% (or even 30%, if a satisfactory international agreement can be achieved to follow Kyoto) lower than 1990
- 20% of energy from renewables
- 20% increase in energy efficiency

4 Education:

- Reducing school drop-out rates below 10%
- at least 40% of 30-34–year-olds completing third level education (or equivalent)

5 Poverty / social exclusion:

- at least 20 million fewer people in or at risk of poverty and social exclusion

The measure for innovation 'Innovation Union' and the specification of 'Grand Challenges' (identified by the European Research Area (ERA) Expert Group "Rationales for the European Research Area"), notably Ageing, Demography & Healthcare and Climate Change & Energy promoting flagship policies like 'Resource-efficient Europe' and 'Industrial Policy for the Globalisation Era' relate somewhat asymmetrically because the EU has no brief for healthcare. Nevertheless, member-states are advised that : With an ageing population and strong competitive pressures from globalisation, Europe' s future economic growth and jobs will increasingly have to come from innova-

tion in products, services and business models. With over thirty action points, the Innovation Union aims to improve conditions and access to finance for research and innovation in Europe, to ensure that innovative ideas can be turned into products and services that create growth and jobs. Innovation Union involves:

- refocusing R&D and innovation policy on major challenges for our society like climate change, energy and resource efficiency, health and demographic change
- strengthening every link in the innovation chain, from 'blue sky' research to commercialisation.

In Sweden, these Grand Challenges are, in relation to the instruments of 'Innovation Union' taken seriously as guideposts for Swedish national innovation strategy, in part addressed through the development of regional clusters into regional and national innovation platforms. This embodies a considered Swedish interpretation of the EU's notion of 'smart specialisation platforms' in ways that do not fall victim to the dangers of over-specialisation and over-centralised control of regional initiative. Smart specialisation has been perceived by many member-states as verging on a 'Soft Soviet' model when regions and even countries were allocated R&D specialisations in anything from potatoes (Romania) to adding machines (Bulgaria).

Currently, therefore Sweden's regional clusters are re-appraising their strategic focus in relation to Grand Challenges, on the one hand, and cross-cluster 'transversality', on the other, to increase innovation opportunities from exploration of 'white spaces' between clusters and cluster initiatives that might offer innovation potential and opportunities for Swedish firms. This approach is clearly in line with the measure on evolving and 'Industrial Policy for the Globalisation Era' by exploiting regional cluster knowledge organised increasingly in relation to Grand Challenges such as sustainability and elderly or personal healthcare. Operationalisation of these large scale abstractions is an important part of the transversality process. Transversality involves regional innovation intermediaries like regional R&D directors or cluster process managers helping overcome market failure and even innovation system failure to identify 'adjacent possibilities' for innovation, also 'preadaptation' opportunities, as shown in Fig. 3.2 above. This builds on the implicit 'relatedness' of industries or clusters that, because of a linear vision on the part of firms or clusters and their broader regional innovation systems, is not made explicit, remains hidden thus unexploited in value terms. While transversality success by no means relies on Grand Challenges, they can nevertheless be important catalysts or even sources of shocks or management perturbations invoking resilience from new thinking about possible 'white space' innovation interactions. As the 'Training Regions' example demonstrated, a stimulus like the 'Climate Change/Energy' Grand Challenge can provoke an initiative to establish a wholly new cluster related to system security by improved integration of large scale infrastructural system management.

3.4 Strategic Platform Management Models

In developing the narrative based upon the accounts provided of state-of–the-art practice in Sweden's regional clusters it is important to recognise that diversity in the economy is expressed in variety of strategic management approach. To help the narrative along, we identify four strategic transversality management approaches or styles that we have found to inform regional innovation system management in Sweden at this relatively early stage in this innovation system policy specification process. The first of these is already reasonably settled as both an hypothesis and a practice as represented in the Skåne approach indicated in Fig. 3.11. As may be seen, this is currently represented by the 'infinity sign ∞.

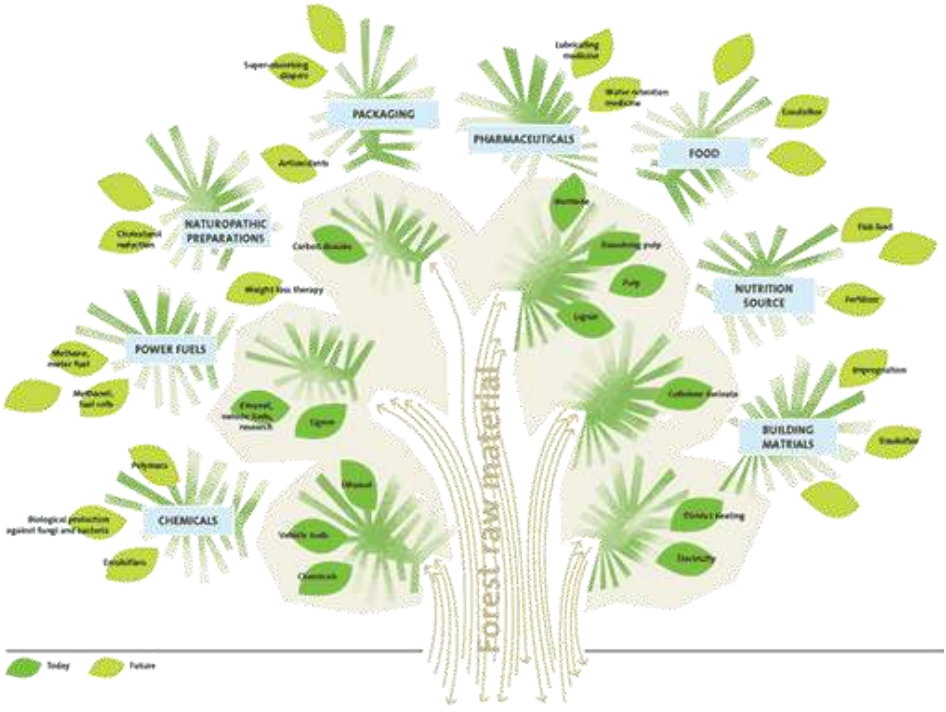
3.4.1 'Infinity' Innovation Platform Management Model

Grand Challenges have been focused on two arenas; Sustainability and Healthcare. However, these have been operationalised as 'Sustainable Cities', on the one hand, and 'Personal Healthcare' on the other. Respectively these integrate such regional clusters as 'Sustainable Hub', 'New Materials', 'Logistics' and 'Training Regions'. Personal health connects such clusters as 'Food Academy', Life Science', 'Mobile Heights' and 'Media Evolution' with overlapping clusters between the two main arenas as necessary. Accordingly, Grand Challenges have been 'translated' through 'Innovation Union' transversality to build integrated innovation platforms from the specialised elements contained in Skåne's regional clusters. Future evolution of this 'infinity' structure may move the innovation system forwards in terms of 'speciation' where a new Grand Challenge (e.g. water resource management or renewable energy) might emerge, or mutation, where existing elements from the two main foci merge to form a new one such as Healthcare Bioelectronics. It is accordingly a flexible but focused management methodology for searching out innovation 'white spaces' within and between the main hubs of the dynamic 'Infinity' perspective.

3.4.2 'Hub' Innovation Platform Management Model

An innovation platform management model that focuses upon a single high-variety capabilities hub is represented in the case of the *Processum* biorefinery hub at Örnsköldsvik in Region Norrland, Angermanland province. Its innovative applications are focused mainly on the Grand Challenges of Energy and Healthcare but include textiles, paints and food ingredients.

Figure 3.12 Processum Innovation Platform Management "Hub"



Centred upon a former pulp and paper mill this geographically proximate cluster occupies a single, large *Processum* business park. In close proximity are various process industry facilities as shown in Fig. 3.12, including biochemicals, biofuels such as biomass, bioethanol, biodiesel and biogas, packaging, pharmaceuticals, substitute cotton, sugar, food, nutritional ingredients and construction materials. These act as raw material feedstocks to other industries, the range of which is broad and includes paint, manufactured by cluster-member Akzo Nobel, substitute cotton, for which interactions are evolving through Västra Götaland's 'Smart Textiles' cluster at Boräs near Gothenburg with Hennes & Mauritz (H&M) clothing retail company. The reason for this innovative translation of specialist cellulose 'comfort fibre' into cotton textiles is that an era of 'peak cotton' is predicted in the textile industry because of the unsustainable production methods and steeply rising price of cotton on the world market. Sugar from forest products is currently mixed with imported sugar cane to produce bioethanol, something that should contribute to reductions in sugar cane imports but which can flexibly be redirected to other uses. Biomedical applications of forest products include tissues and cloths used in surgery, bio 'scaffolds' that support body parts temporarily before dissolving, and, again working with Smart Textiles, woven blood vessel replacements.

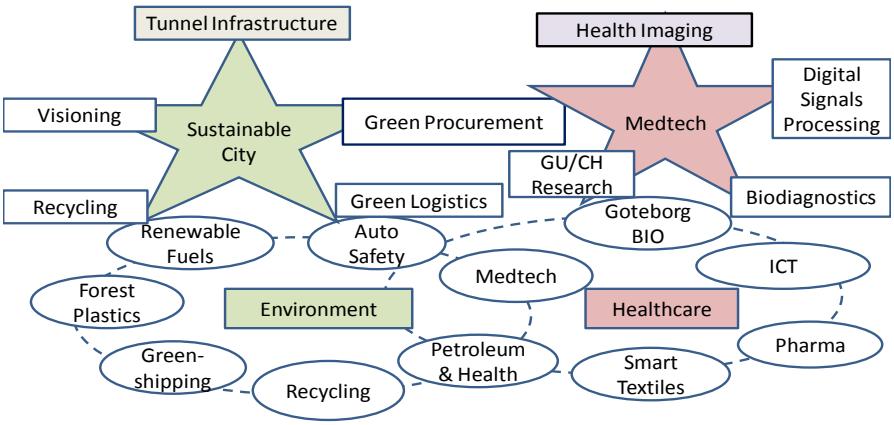
3.4.3 Market Shaping Innovation Platform Management

This approach, practised most clearly in Östergötaland, centred on Linköping and Norrköping, does not involve either organising clusters into hubs or Grand Challenge initiatives like 'sustainable cities'. This is because not many clusters were promoted through the Östsam regional development and innovation agency and strategy has been to conceive of national and regional markets as prime movers. Accordingly, policy attempts to shape existing markets wherever innovation opportunities are identified. One such market is Healthcare, which as in Swedish regions elsewhere is delivered regionally and is a major element in the regional economy. Here, VINNOVA support was achieved for a Distributed Healthcare initiative under the VinnVäxt programme. Public health is seen as in need of re-shaping but it is difficult to conceive it in terms of a regional innovation system. Accordingly, 'New Tools for Health' the cluster initiative works with user-driven innovation ideas that are transformed into innovations in neglected areas like drug delivery systems and specialised catheter technologies. The region has considerable capability in renewable energy technologies consisting of 90 firms supported by the Environmental Technology Centre (MTC) but there is little policy interaction since the market is perceived to be performing satisfactorily. An area where Östsam has been engaged in 'technology push' for decades concerns the Printed Electronics Arena' (PEA) in Norrköping, another VINNVÄXT supported initiative. This took an invention made in 1987 that showed a polymer could not only insulate but conduct electricity and in a determined, linear fashion aspired to transform the regionally important packaging logistics market. This would come from the greater range and sophistication of capabilities of printed electronic labelling utilising an innovative organic transceiving ink polymer. A committed effort to shape this market has met a number of serious obstacles, the most important of which has been failure to evolve an adequate supply chain, especially in the key systems design segment of the chain. This shock and management perturbation has caused a re-appraisal and a move away from a linear to a more transversal innovation platform management methodology. Accordingly new bio-markets have been identified, involving advanced cellular therapeutics based on remotely activated ion pumps. The organic character of PEA's product is clearly advantageous in this application. Another concerns advances in heart pacemakers where electricity can currently pump pace up but not down. If ions can be pumped biochemically into the heart a breakthrough application of printed electronics can be envisaged. In the energy field printed solar cells are another transversal opportunity. Accordingly, PEA is in discussions with the New Tools for Health cluster in Linköping and Karolinska Institute and KTH in Stockholm's biotechnology and bioengineering communities to broaden its applications focus with market shaping technological expertise.

3.4.4 'Iconic Projects' Innovation Platform Management

This is the characteristic approach taken in Västra Götaland region centred upon Gothenburg. The strategic decision was taken to concentrate initially on meeting the Grand Challenges of Climate Change and Healthcare, the first not least because the region had been one of the first in the world to publish in 2003 a Climate Change response strategy report '*Gothenburg 2005*' involving policies for 'Smart Energy' which has more recently evolved into the strategic Climate Change target of Region Västra Götaland being totally Fossil Fuel Free by 2030. This became known as the 'Gothenburg Model' of the Lisbon Strategy. However, having got the regional position on that Grand Challenge worked out well in advance gave scope for the new environmental strategy to be down-to-earth and practical. This means focusing on 'iconic projects' that are committed to as innovation, learning and collaborative platform management 'laboratories' (Fig. 3.13).

Figure 3.13 Västragötaland´s "Iconic Projects" Approach



Source: Centre for Advanced Studies

Thus the particularisation of the Climate Change Grand Challenge involves translating it into a 'Sustainable Cities' initiative triggered by an actual infrastructure commitment to a new tunnel. This brings together numerous regional clusters involved in renewable automotive fuels, forest plastics and petroleum and health. At a more detailed level this assembles pilot projects mixing expertise in cluster firm logistics, public transport, visioning (computer graphics and imaging) and green accounting. It links to a Triple Helix relationship with Chalmers University and firms like *Astra AB*. A comparable 'Iconic Project' approach is being taken in healthcare where the project in question involves a new Health Imaging Facility at the University Medical School. This connects transversally to digital signals processing (data compression) and medical diagnostics engineering expertise at Chalmers University and one of its spinout firms *Medfield Diagnostics*.

An interim conclusion regarding Swedish regional cluster innovation management is that the platform model of building upon different regional and non-regional cluster expertise is becoming established. This can be said to be the case increasingly where a less interventionist, market-led approach has traditionally been preferred as in Östergötland. Not least, market shaping has proved much more difficult than expected, either when pursuing a linear innovation model perspective as the PEA experience demonstrated, or seeking to shape a public quasi-market with localised innovations that perturb normal large scale procurement management practices. Condensing the contrasting regional approaches of Skåne and Västra Götaland, they are not as different as they at first seem except Skåne's approach builds its 'Infinity' bi-focus from the strategic level downwards while Västra Götaland, possibly having conducted strategic routemapping exercises earlier, can prepare and implement its action lines from a bottom-up, engineered perspective, calling in cluster expertise as and when required. This can include exploiting bridges with many extra-regional clusters on precise innovation agendas. Thus Smart Textiles contributes to the regional healthcare Grand Challenge through its links to biomaterials and bionics elaborated by interactions with the textiles arm of the Processum Hub. Equally Processum interacts with Göteborg BIO on new aspects of that cluster's transversality quest. This brings in biochemistry and biopharmaceutical inputs issues related to Västra Götaland's 'petroleum & health' initiative involving the regional oil refineries who are sympathetic to the region's Fossil Fuel Free 2030 initiative by becoming 'Greener' fuel processing businesses.

3.4.5 Cluster & Agency Perspectives on Meeting Grand Challenges

In what follows brief accounts are presented of a number of regional clusters and regional innovation support agency perspectives on their trajectories towards meeting the Europe 2020 goals mediated by the ERA Grand Challenges as orienting devices for regional and national innovation enhancement. The foregoing discussion reveals that all regions studied have accepted this method of proceeding, that they interpret how best to achieve this in their own way dependent on regional societal, political and economic-geography considerations. Central to this way of working is a recognition of the 'value variety' that comes from the successful search for 'relatedness' and 'transversality' to identify the 'white spaces' among Swedish and home-region clusters and industries as a prelude to improving market potential abroad as a response to the present globalisation imperative for industry everywhere.

However, each regional development agency is in the process of responding to various innovation perturbations consequent upon important changes in the inherited model of innovation support. The global financial crisis of 2008-2010 demonstrated to the world the folly of economies following the injunctions of linear innovation thinking as expressed first in sectoral, later in cluster models of industrial support policy. Econo-

mies that became too dependent upon the single sector of financial services and especially financial securitisation have had catastrophic experiences, the repercussions of which were still being felt years later in the revolutions occurring in North Africa. These and the earlier sovereign debt crises of Greece, Ireland and Iceland and severe downturns in economic activity in many OECD economies were testimony to the occlusion of the neoliberal experiment that lasted from the 1980s to the present day. Europe 2020 has been the EU's response and appeal to make European Union member-state economies more connected to real-world needs in terms of Sustainability, Energy, Healthcare and Demographic Ageing, the inputs for which demand domestic as well as reduced overseas sourcing that it is hoped will, nevertheless, enhance opportunities for EU businesses to penetrate new overseas markets in Cleantech, Renewable Energy, Sustainable Cities, Efficient Healthcare and various related Digital Applications. This means, to repeat, exploring 'white spaces' at home to innovate abroad.

Östsam Regional Development Agency, Östergötland

In the case of Östsam this means some reflection upon its central idea of market shaping and possibly taking bolder steps to assemble critical mass to engage in 'strategic niche management' of innovations in areas that hitherto have been largely left alone. Strategic innovation implies more collective, even collaborative knowledge-sharing and innovation exploration than was the case in the earlier less-regulated regime characterised by global free trade and neoliberal 'light-touch' regulation. A good example is the generally poor efforts made by governments to secure strong voluntary regulation of Climate Change influences in the shape of greenhouse gas emissions and associated global warming. In brief, more must be done at the lower, faster reaches of the multi-level complex adaptive system scale to speed up the workings of the larger, slower upper reaches of complex system adaptation. One way in which Östsam conceives of this is to face up to its previously sceptical view of their role as cluster-builders and recognise that, for example, it has a significant Cleantech cluster involved in manufacturing biofuels, biogas reactors and turbines (Siemens, Alstom turbines) and waste-for-power recycling. Linköping supports biogas buses, taxis and car pools with free parking. But because Östsam focused on technology push largely based on academic excellence the Grand Challenges concept of evolving demand-driven innovation platforms was overlooked. This, and disappointing experiences with PEA and HMV technology push has caused a partial re-think. Reliance largely on big firms to elaborate demand through their value-chains or value-stars for university-initiated innovation has been difficult. Indeed the Triple Helix model itself has been put in question because two-thirds of the partners can contribute so little on innovation.

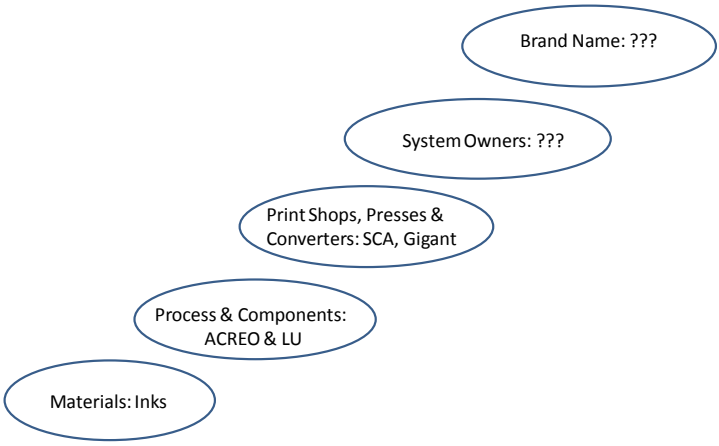
Accordingly, Östsam and its few clusters have to demonstrate resilience in the face of such difficulties. As noted, PEA now faces medical and biotechnology as a market more than packaging, while HMV after many management turbulences has had to devote attention to communicating a narrower vision focus in its mission to the market it

aims to shape. Many bridges have had to be built or re-built with transverse organisations in smart e-health, biosensors, self-monitoring devices, alarm systems, memory systems and even defence research and public institutions like ALMI, Innovationsbron alongside VinnVäxt clusters like Smart Textiles, Robotdalen and Halmstad Living Lab's main application field of health technology aimed at empowering elderly people. Outside the region and Sweden innovation contacts with Norway, Denmark and BSR 'stars' are new cluster-to-cluster initiatives.

Printed Electronics Arena (PEA)

Printed Electronics Arena (PEA) is a VinnVäxt cluster working with a typical projects-innovations-start-ups model prevalent in the 2000s. Taking the 2000 Chemistry Nobel-prize-winning research of Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa and adapting its findings on polymer conductivity to the packaging industry. Since 1988 PEA has run with Acreo, Linköping and Norrköping Universities applications projects like Project Paella also with packagers *Stora Enso*, *SCA* and *Tetrapak* on 'Thin Film Electronics' to try to introduce organic polymer inks to the logistics aspects of packaging, without success. The main success story in regard to this technology was the development by South Korean firm *Samsung* of Active Matrix Organic Light Emitting Diode (AMOLED) technology as the replacement for liquid crystal technology in the screen its Android and 4G LTE smartphones. Over the years PEA sought to evolve a vertical value chain in organic printed electronics by aggregating five key nodes as shown in Fig. 3.14. The first three steps in the chain were built but although PEA was successful in building four or five start-ups to fill the system owners node, each one failed to grasp the opportunity. Without that, no larger firm like Ericsson would come in to complete the chain by its proprietary assignment of brand name status to the innovation. This was the proximate cause of the shift after thirty years of trying the linear model to the relatedness and transversality approach to cross-fertilising innovation horizontally between the printed electronics and bioelectronics industries. As noted printed electronics communicating with living cells in administering treatments with pinpoint accuracy now seems more promising.

Figure 3.14 Attempt to Build a Printed Electronics Value Chain



Experiments have shown ion pumping can raise and lower hearing capability. Similarly heart pacemakers can have heart pace raised or lowered if ions can be pumped into the heart chemically. Other issues, notably Home Diagnostics in a distributed healthcare system brings PEA and HMV's New Tools for Health VinnVäxt together with GSM specialist S.T. Ericsson. In the other main Grand Challenge field elsewhere in Sweden related to the Sustainable City and Renewable Energy, printed photovoltaics are in prospect if the right collaboration partners can be attracted. This may link to the new Sustainable City neighbourhood plan for the Royal Stockholm Seaport. In general PEA is of the opinion it can contribute (e.g. to the 'Internet of Things') in such a setting where low performance electronic systems are required for which prevailing technologies cannot meet specifications.

New Tools for Health (HMV)

Here the aim is to drive the innovation climate in facilitating cluster cross-overs to shape the public healthcare procurement market. This initiative found such ambitions hard to fulfil because it was dealing with a monopsonistic buyer. It also spanned a one hundred and eighty degree market, which was too broad so it now offers Distributed Healthcare at Home, something more people and institutions understand whereas before the initiative had failed to persuade a major supplier to join, had not hooked Linköping University in, nor the region or its cities. So it became imperative to clarify and narrow the message of the initiative's intentions. The new position is to support specific innovations in a small number of projects. For example for the Cadi-catheter HMV worked with healthcare stakeholders and sold the innovation to US firm Titus Healthcare. On its Medi-carousel Dosette machine that sorts, allocates and sounds the alarm by cellphone if a dosage has been missed, the product is commercialised through *S.T.Ericsson E-*

health. Self-monitoring equipment for healthcare in the home (heart, weight, blood pressure etc.) is licensed to *GE Healthcare*. Other transversalities from HMV outwards include to the Smart Textiles cluster at Boräs, Västra Götaland for biosensors, Robotdalen for the *Giraf* health robotics innovation and Norrköping's Food initiative to socialise the isolated elderly and enable them to eat nutritionally balanced food for improved wellbeing.

Processum Biorefinery 'Hub'

This initiative addresses the Grand Challenges of Energy, Sustainable Production and Healthcare. The centrepiece of this complex was the obsolescent *Modo* sulphite mill which now earns SEK 3 million per day producing specialist cellulose raw cotton substitute. The present global 'Peak Cotton' situation means this material used to sell $800-$1,000 per ton but now fetches $1,000-$5,000 per ton with 85% exported to China. More value-added could be extracted if the basic pulp mill was transformed into a cotton mill but major investment in new spinning and weaving technology is necessary before allowing any automated weaving products to be produced competitively in Sweden. Yet as cotton is pure cellulose, which also grows in trees, in principle it would not be impossible to at least consider on-site yarn spinning even if weaving is better conducted elsewhere in Sweden (Smart Textiles) or abroad. A pilot plant for assessing yarn-spinning capabilities is under consideration in this connection. Other outputs from the old sulphite mill include the former *Domsjö* pulp and paper mill. After 4 years on the closure list, it was acquired by a private consortium in 2000. They set a new course and turned the ailing pulp mill into a highly profitable biorefinery. Europe's first pulp-mill-biorefinery is achieving a 40% return on investment, at a time when pulp and paper mills in general are struggling to break even. After the crisis of 2008, when the global pulp and paper industry plunged into a loss of $8 billion, the Top 10 in both Europe and Canada remain in the red, although there are signs of recovery in the USA. The biorefinery is the *Domsjö Fabriker* mill which is currently preparing to extend its biorefining capacity with the installation of the Chemrec gasifier, expected to start up in 2013. It will convert the spent brown liquor of the sulphite process into 40 million gallons a year of automotive fuel, namely BioDME and BioMethanol. Processum also makes construction materials like ligno-sulfonate, which is dried and used in concrete, making it stronger and with less water content, cellulose derivatives as thickeners for construction plaster, while green liquor sludge is tested for dirt-road binding where it acts as an innovative dust inhibitor material. Close links exist with the Smart Textiles cluster and Göteborg BIO not only for fashion textile materials for H&M but medical fabrics for firms like Mölnycke Medical Fabrics AB a world-leading producer of single-use surgical and wound products where weaving of tissue and surgical cloth has been implemented at Gothenburg. A project on blood vessel replacement textiles is under way with Smart Textiles at Boräs, near Gothenburg. With GöteborgBIO, verification of bio 'scaffolds' bionics products is the subject of project discussions. Elsewhere SEKAB plans a

new torrefaction unit to extract three green ethanol products from black liquor to be used in varieties of gasification. Overall Processum funds 50-60 projects, most of which are taken on to innovation assessment stage.

3.4.6 Region Västra Götaland

As noted, Grand Challenges are presumed to be future markets. RDI strategy has been stable in recent years with both cluster building and horizontal cross-cluster co-operations in focus. A hierarchy of strategic levels from Europe 2020, Innovation Union, Smart Specialisation, Swedish National Strategy and regional cluster-platforms informs strategic thinking. However smart specialisation is found unsatisfactory for its over-centralised control emphasis which is seen as likely to hamper competition and at worst reproduce a 'Soft Soviet' model that dictated Romania should specialise in potatoes and Bulgaria in adding machines. This is treated especially warily in former Soviet Bloc countries and Slovenia that find even DG Regio and DG Research in conflict over regional Cohesion versus Excellence issues in regard to regional specialisation. The compromises of 'Staircase to Excellence' and 'Sustainable Specialisation Platforms' are seen as a somewhat patronising 'fix' of some conceptual confusions on the part of the Commission. Using regional clusters as tools for 'innovation' in the manner that Göteborg BIO interacts with Smart Textiles over biotextiles or with Processum over cotton substitute inputs is emphasised as part of the region's post-cluster approach to innovation management. The collaboration around 'Sustainable Green Transport' is used to bring together expertise from the auto cluster, renewable fuels, 'green shipping' (a Tillväxtverket initiative) in a similar manner. Regional innovation to meet Grand Challenges has already been described as following the 'Iconic Projects' methodology framed by policy statements and strategies promoting 'Smart Energy', 'Fossil Fuel free 2030' and 'Sustainable Cities' in the 'green' area as examples.

Göteborg BIO

This VinnVäxt cluster has the difficult task of stimulating innovative projects leading to start-up business activity supported by seed corn and incubator resources in a period when risk investment in biotechnology worldwide has been n the doldrums. However two things have happened recently to moderate the rather grim scene. First, medical technology firms in the cluster have grown and spin-outs have occurred from them, especially related to dental implant technologies from *Nobel BioCare* which spawned *AstraTec* and another which was acquired by Australian firm *CoClear*. In biomaterials, *Sandvik* Sweden's materials specialist and supplier of specialist medical technologies has engaged with cluster research to develop its steel and ceramics expertise into replacement joints and surgical needles, for example. Another piece of good news is that AstraZeneca will consolidate its closures at Lund and Charnwood (UK) at the Gothenburg R&D site. The second elements of good news are the aforementioned horizontal

innovation platform development with Smart Textiles for medical textiles, Processum for raw materials and even for nutraceuticals inputs of the kind Sanofi-Aventis and other 'big pharma' are showing an appetite for. In other respects innovation around fluids important for in vitro fertilization and the transportation of transplant organs have spawned spin-outs alongside *Solartis* a stem cells testing operation.

Centre of Visualisation

Centre of Visualization Göteborg is an organization for stimulating growth in the field of digital visualization. The organization spreads visualization technology into new and existing industry segments and provides industries with sharper tools in for example production, processes, product development and design. The Centre of Visualization also stimulates cross-overs between visualization and other technologies in order to create new innovations and applications. Its vision is that Centre of Visualization will become an important factor in contributing to economic growth and development in the Göteborg region. As visualization becomes increasingly important for industries, business, Governments and consumers, Centre of Visualization will through its members provide knowledge and competence to support the transformation from traditional industries to knowledge-based industries. Since summer 2007 Centre of Visualization is one of three national Knowledge Arenas within the network VISARD, Visualisation in Sweden - Arenas for Research and Development supported by the Knowledge Foundation, Invest in Sweden Agency, Swedish Foundation for Strategic Research, The Vårdal Foundation and VINNOVA. Centre of Visualization Göteborg is a membership organisation managed by Business Region Göteborg and Chalmers University of Technology. Among its joint projects is 'Urban games: mutual learning for sustainable development.' This project focuses on the use of games and visualisation to understand the city as a complex system. The Centre of Visualization, City of Gothenburg and GRUL, which is GR's project on experience-based learning, are some of the participants in this project.

3.4.7 Further Conclusions

There are two dimensions to these further interim conclusions, which will be fully concluded with the inclusion of survey results from the other cluster initiatives promoted by Sweden's leading innovation support agencies. The first interim conclusion is drawn in response to the comparison of cluster-platform experiences in Table 3.3, which is constructed using the same variables as Table 3.2.

Table 3.3 Matrix of Regional Innovation Platform Evolution Elements

Cluster Indicator	Östsam	PEA	HMV	Process-sum	Region Västra Götaland	Göteborg BIO	Visualis-ation
Focus	Regional Innovation & Deve-lopment	Printed Electronics	Distribu-ted Healthca-re	Biorefinery & Bio-products	Regional Innovation & Deve-lopment	Regional Innovation & Deve-lopment	Computer Graphics
Shocks	Market Shaping Difficulties & Grand Challenges	Failure of Tech-push Approach	Public Procure-ment in Health-care Quasi-market	Globa Competi-tion in Pulp & Paper. Grand Challenges	No shocks but how to mobilise for Grand Challenges	Investment drought (VC) in Biotech	Grand Challeng-es
Respon-ses	Seek User & Demand-Driven Innovation Opportuni-ties	Explore Bio Healthcare Apps	Clearer & Narrower Market Focus	Discover New Markets. Textiles, Bio-products	Meet Grand Challenges With 'Iconic Projects'	Evolve wider Healthcare Apps. Bio-chemicals, Medtech, Biotextiles	Stimulate Technolo-gy Cross-overs
Linkage	Food, Agro-Tech, Renewable Energy, Cleantech	Bio-electronics, Printed Solar Cells, Home Diagnostics	Bio-Sensors, e-health, Health Robotics, Healthy food	'Smart Textiles'; Organic Fertilizer, Bio-construc-tion, Rene-wables	Sustainable Cities – Smart Energy, Visualisa-tion Logis-tics. Health – Imaging, ICT	Bio-Materials, Medtech, In Vitro, Smart textiles	Grand Chal-lenges Imaging; Sustaina-ble Cities
Techno-logy	Focus more on Food Technolo-gy, Clean-tech & Renewable Energy	Pumping Ions, Heart Pacemak-ers, 'Brains & Bricks' (materials)	Smart Systems, Self-monitor-ing, Bio-sensors	Gasifiction, Cellulose-spinning, automated weaving, Compo-sites	Smart Infra-structure, 'Fossil Free' 2030; Digital Signals Imaging	Bio-Materials, Prosthetics, Bio-fluids, Stem cells	Gamifica-tion 'Simu-lation'; Sustaina-ble City & Creative Apps

What differs between Table 3.2 and Table 3.3 is the apparently stronger influence of the Healthcare Grand Challenge and the lesser influence of Skåne's Mobile Telecommunications technological innovations in 'apps' utilising, for example 'crowdsourcing'. This is in part a question of the division of labour between Skåne and more central parts of Sweden, partly our relatively limited exploration of Skåne's life science cluster, although advanced biosensors in mobile telephony and more focus on functional foods in diabetes treatments were noted as activities involving start-up business incubation. Accordingly, there is some inter-regional relationship, particularly in mobile diagnostics and its requirements regarding 'positioning', 'visualisation' and associated serious gaming. Similar between Skåne and Västra Götaland in particular is the focus on Sustainable Cities and Healthcare as Grand Challenges although their preferred methodologies are quite different. Skåne has a quite strong 'systems' approach to Grand Challenges platform-building, which identifies 'white spaces' like 'Training Regions', 'Sustainable

Hub' and 'Packbridge' and aims to build these up. Västra Götaland, by contrast, takes a more 'engineered' approach because of its relatively stable evolution based on a wide variety of clusters ready for integration as platforms focused on specific Grand Challenge projects and early adoption of Grand Challenge thinking. This has taken the form of 'Green Regional Strategies' since the first in 2005 (RG Green Strategy), followed by 'Smart Energy' (2008) whose vision was to heavily reduce the region's dependence on fossil fuels and to secure a sustainable energy supply by 2030. This is now embodied in the policy 'Fossil Fuel Free Region by 2030'. Contributing to that aim is Gothenburg's integrated waste system that has collected, sorted and burnt 345,000 tonnes of rubbish annually. Compared to an oil-based energy strategy waste-to-energy production saved the city an estimated 205,060 tonnes of CO2 even in 2006.

Figure 3.15 Main Inter-cluster Innovation Platforms in Sweden

Accordingly, as a revealing illustration of the manner in which VINNOVA and Tilväxtverket's regional and national cluster programme alongside Region Skåne's exploration of its regional 'white spaces' initiatives have, mostly in the second half of the 2000s, begun to integrate innovative platforms that enhance Sweden's innovative economic development we consider Fig. 3.15 to be instructive. It shows three main structural features. Keeping in mind that not all regional clusters can be shown around

two of Sweden's main cities, Malmö and Göteborg, where they are concentrated, these two city-regions have considerable variety and city-region cluster interactions in their two main Grand Challenge platforms of Sustainable Cities and Healthcare.

Accordingly, they can be seen to be relatively self-sustaining as they progress their 'Innovation Union' growth strategies. Second, they have different relatedness and platform characteristics even though on the surface they may seem to have similar economies and Grand Challenge selections.

However, Skåne displays global-strength innovation capability in its mobile apps and new media model of open innovation for global customers (signified by recent inward acquisitions by RIM and Apple). Göteborg has some of this but I, importantly, one of the most advanced places in Europe in engineering apps for 'green technologies' and a leading city-regional governance and research system promoting this trajectory. Finally, though, there are two outlying clusters that seem to exert important exogenous demand for advanced cross-cutting products and services. These are Processum at Örnsköldsvik and Smart Textiles at Borås that display a more national, accordingly strategic, role in Sweden's national innovation system. This is because both operate as platforms processing scarce, but due to 'Peak Oil', on the one hand and 'Peak Cotton', on the other, increasingly valuable feedstock functions that pervade economic activity now and with exponential growth prospects in future.

4 Strange Attractors: Resilience, Relatedness & Complexity Geography

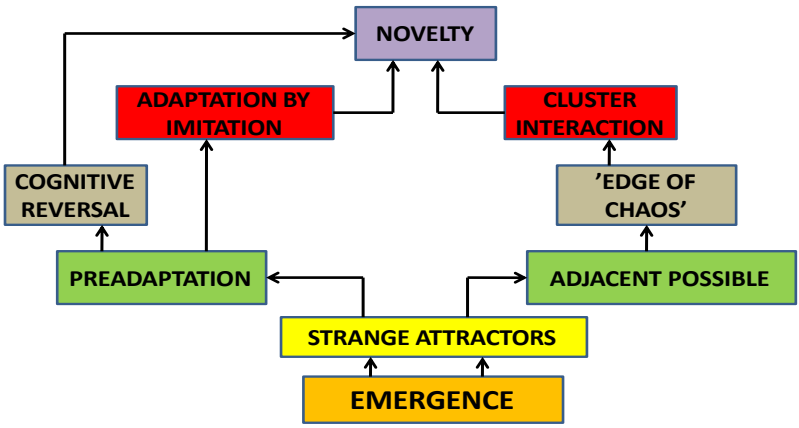
4.1 Introduction

In this chapter it is proposed to introduce Design Theory as a key approach to tackling key issues raised about new imperatives in regional policy practice. In doing this we build upon the analyses offered in section 3 and Figs. 3.2 and 3.3 by exploring 'relatedness' of the unexpected kind represented by 'strange attractors'. This is because it is now clear that 'wickedness' and 'complexity' combine to make this the predominant way in which knowledge combinations for regional innovation occur. It also indicates the imperative for policy-makers to practise 'transversality' to stimulate innovations among 'strange attractors' rather than either assuming the market alone will do it or that innovation occurs mainly among neighbouring industries or clusters with many capabilities in common. It will be recalled that we proposed to analyse relatedness and transversality from the perspective of the complexity sciences rather than from the more usual rationalist perspective of either 'individualist' explanations of change (e.g. Popper; Hayek) or systems or 'structures' perspectives (e.g. structuration) that privilege these macro-entities while still allowing for 'global controller' roles in innovation like 'innovators', 'designers' and the like. In the complexity sciences such 'controllers' are excluded in favour of complex adaptive system effects. One of these, of particular interest for students of regional development is the phenomenon of 'strange attractors'. For those recalling the big theme of this report it is that innovation occurs mainly horizontally as regional path dependence leads to path interaction and new path creation (Figs. 3.2; 3.3). The possible cause is either an external de-stabilisation (resilience effect) or an endogenous system topology that, due to new energy, allows for path inter-dependence of the kind discussed by Martin & Sunley (2010). What occurs from such co-evolutionary fusion is termed 'revealed related variety' in that it could never have been predicted yet results in innovation or novelty of some kind.

In Fig. 3.3 emergence of novelty is the end point, whereas in Fig. 4.1 *emergence* is presented as a general process of which 'novelty' or 'innovation' are possible outcomes. It is crucial to underline this non-physics-like process that is non-reductionist and non-predictable because human systems are, as described in Chapter 2 concerned with life and evolutionary biology teaches that life, its mutations and speciations cannot be predicted *ex ante*, only understood *ex post*. Indeed, this is gradually becoming understood

in evolutionary economic geography as a key characteristic of 'emergence' (see Martin & Sunley, 2011). Such processes are in Kauffman's (2008) terms, essentially 'lawless'. In Fig. 4.1 a scheme is elaborated of the complex 'emergence' of innovation through 'preadaptation' and/or the 'adjacent possible' in relation to 'attractors' and especially 'strange attractors' after Kauffman (2008).

Figure 4.1 The Nature of Emergence of Innovation: A Complexity Perspective



Source: Centre for Advanced Studies

What occurs in Fig. 4.1 (compare Fig. 3.3) is that Martin & Sunley's path interdependence evolves on the plane of a complex adaptive system. In analogue form, this is a regional economy that is invested with a topology (Fig. 2.2). The topological routeways (path dependencies) favour certain deviations and disfavour others. At a given point they meet as the convergence of socio-technical systems (STS). This concept comes from the co-evolutionary multi-level perspective (MLP), which demonstrates how innovation occurs through the interaction of STS that were hitherto path dependent (Geels, 2007). This occurs not only when such trajectories are related or natural attractors but particularly when they are 'strange attractors'. Strange attractors display 'revealed relatedness' rather than obvious relatedness. While both can facilitate innovation, that caused by 'strange attractors' has the possibility to be of the most radical kind. This is because an adjacent possible that is utterly unknown is being explored. This means the possibilities for secondary innovations are great, as can be demonstrated in relation to 'informatisation' which has released cascades of innovation – ranging from graphic interface and 'mouse' to e-mail, Internet and *Facebook*. Contrariwise in Fig.4.1 (unlike Fig. 3.3) the 'preadaptation' route is either moderately surprising because it involves a 'cognitive reversal' of an existing innovation – as in Kauffman's favourite metaphor of the tractor chassis that always broke due to the weight of the engine, being replaced by the engine itself being bolted to the back axle and drive-train. Alternatively 'preadapta-

tion' is incremental innovation and quite close to 'imitation' because it takes an innovation from one field and applies it to another. Innovation agencies sometimes facilitate this by mounting innovation 'fashion shows' where a 'smart textile' in automotive seats can be a solution to the quest for stay-clean medical uniforms in hospitals (Chapter 3). The harder, more rewarding innovation route comes where strange attractors merge at what complexity theorists call 'the edge of chaos' which is both stable and unstable with much interaction, communication and 'buzz' going on between, for example, clusters or, more precisely, innovation-spotting members of two or more clusters. A breakthrough here among say mobile telephony, internet media and life sciences may lead to many big leaps forward in mobile diagnostics and even therapeutic treatment delivered by 'smartphone'.

In what follows, we shall proceed to an explication and exemplification of regional change by directing discussion towards the concept of 'strange attractors' which, for the purposes of this report show, with startling illumination, how related variety and relatedness of the unpredictable kind, occur as emergent features of complex systems like regional economies. On occasion, reference is made to the substance of Chapter 2 in relation to such concepts as 'dialogical' reasoning and 'narrative discourses' involving storytelling and theatre as means of sense-making (Weick, 1995) about complex organisational processes. This is because communication and connectivity are key to understanding how innovation is made. Elsewhere, deeper analysis of the operation of variety upon regional innovation, principally by firms as system agents, is provided. Although the whole tenor of this report concerns the functioning of variety in relation to innovation in externalised and complex system adaptation and organisation, elements of the explanation offered are assisted by the complexity science critique of theories of internalised systems by which learning organisations are presumed, wrongly, it is shown by Stacey (2001) to function. Thus the chapter proceeds with initial explanations of 'emergence' as the process by which transition (transformation or innovation) occurs from interaction between diverse entities (i.e. the interaction of entities displaying variety). In Martin & Sunley (2011) these are organised in an MLP way. Here they are more geographical (i.e. spatially interactive). It then moves into a discussion of the role of 'attractors' of path interaction that are better-known to regional scientists as (regional) 'path dependences'. That is, an industry in a region evolves with an historical trajectory which, possibly after a regional or industrial 'shock', deviates to an intersection with a different industrial path dependence in the same region (proximity effect). One variant of these kinds of interaction is 'strange attractors' where there is no a priori reason for even imagining their trajectories might converge and coalesce to produce innovation. In passing, mention is made of 'normal attractors'. These are less surprising, as, for example, when the pre-existence of a certain engineering knowledge allows for innovation in a neighbouring engineering field. In complexity science, such 'neighbourhood effects', facilitate 'learning curve' thinking, like 'scale-effects' the relative predictability of

which acts as a kind of 'rule of thumb'. After this, a second take on 'emergence' is identified as the system zone where stability and instability intersect. This is known as the 'edge of chaos' (see below).

Accordingly, this comes together by reference to Kauffman's (1995) early complexity science work on stability and instability at the 'edge of chaos' where a crucial role is played by *clusters* (centres of energy) and their isolation versus interaction. Isolation of clusters, or the existence of one or very few in a system, promotes system stability. However, interaction (e.g. knowledge cross-pollination) facilitates path interdependencies from which innovation springs in a 'self-organised' manner. Thereafter, some degree of 'sense-making' is redeployed to discuss the role of identity, ideology and power in the reception by 'power clusters' (centres of political energy) entailed by the processes of complex system adaptation. Resilience theory, with its concepts of multi-level 'revolt' and 'remembering' also comes into play here. An example of this complex process can be observed in the emergence of renewable energies, where it is a 'shock' for society to understand that carbon energy is dangerously polluting the atmosphere (of which this planet only possesses one). This shock sets in train attention to and efforts to innovate non-polluting energies. This brings together surprising 'strange attractors' like agricultural engineering, marine engineering cross-pollinating with, for example, windmill technology (wind power) or less strange ones like mirror technologies that can concentrate sunlight to heat water (early solar power). Such energy 'hot-spot' regions are clusters (in the complexity science sense of being 'centres of energy'). Accordingly, they are geographical points at which path interdependencies create an 'edge of chaos' meaning, in this case, the possible overturning of the carbon energy paradigm which has dominated the modern industrial world for two hundred years, and its replacement – aided by 'power clusters' at multiple levels of governance - by renewable energy which comes to be the prevailing global source.

4.2 First-level Emergence of Regional Innovation

From a 'social constructivist' perspective, which occasionally displays small overlaps with complexity science, Shotter (1993, 57) speaks of the 'strange dialogic space' in which a transitional epistemology reveals three key things about contemporary existence. The first is that the future is under perpetual construction – in other words instead of a conventional belief that 'New York will be a wonderful place when it's finished' we know that 'New York will never be finished'. Continuing this theme, second, the fact that the future is unknowable does not mean it is not recognisable. Thus when 'smartphones' appear, we know their origins in mobile telephony, on the one hand, and internet computing, on the other. But even though this 'convergence' was long-mooted, we maybe did not expect the 'apps' explosion, or even 'social networking' (Shirkey, 2010) or 'crowdsourcing' (Howe, 2009). Finally, such convergence expresses continuity and transition simultaneously, motivated by collective identity, and leading to the pro-

duction of novelty, to variations never seen before. Such micro-interactions both sustain collective identity and transform it. This produces the first (spatial) perspective on 'emergence' where agents interact with each other according to local organising themes (e.g. clusters) that perform the reproduction of the cluster and its transition towards something else.

Social processes of interaction between entities exploring variety give rise to transition so *emergence* is a sign of such transition. This is unlike structuration theory (Giddens, 1985) which has no interaction of diverse entities to energise the process. Complexity theory says much the same as social constructivism in giving capacity for (system) continuity and transition at the same time. Using computer simulations, it seeks to model evolution as an internal dynamic expressing identity and variety simultaneously. The system has a life of its own, is less susceptible to outside control by 'controllers' or 'designers' and is thus perpetually constructing its own future as a process of continuous transition.

4.3 The Question of Attractors: Higher Order Emergence

Given that coherent patterns of order emerge from the self-organisation of interacting agents according to local rules (e.g. a cluster) without a global controller or designer, path dependence itself constitutes an *attractor* of path dependent interaction. This means that strong path dependence on a particular industry attracts agents to it and repels or ignores agents that have no cause for interaction with it. Such attractors take a number of 'dynamical' (or dynamic) forms dependent upon such parameters as their energy-flow, their connection density or 'connectivity' in the resilience sense of governance links, and the diversity or variety of agents (innovative potential, in resilience terms; Folke, 2006). Some attractors are orderly, being set at a stable or equilibrium point. This means they are in a high degree of isolation from one another, as might be the case in a regional economy with low related variety clusters (including industry forms, such as oligopolies, that are not clusters in the economic geographical sense) thus no impulse to interact. When parameters 'go critical,' as with a surge or collapse of energy, a tension arises between stability and instability. These are attractors that are stable and unstable at the same time or, in complexity terms, 'on the edge of chaos,' meaning capable of change in some significant way. Chaos theory also talks of 'strange' or fractal attractors in this context. This is the point where agents interact and adapt in ways that may result in mutation or speciation in the presence of diversity or variety from which novel attractors can emerge. This cannot be predicted in a physics-like way. Thus attractors are forms of path dependencies and strange attractors are path-interdependencies from far from equilibrium agents or clusters that cannot be predicted. New attractors thus arise from this self-organising process as emergence where stability

and instability intersect. Thus 'smartphones' emerge from convergence of mobile telephony and internet computing with characteristics like 'apps' and 'crowdsourcing' that cannot be predicted. Disruptions generate variety and the spontaneous emergence of novelty depends on variety (Allen, 1998).

In Kauffman (1995) simulations provide an analogy for regional development and innovation. First he reiterates that the number of connections between agents in a complex system determines the dynamics of the system. When these numbers are small, the system displays stability and high path dependence. This is because with a small number of connections constraints or divergences between paths are few. However, when connectivity is high, system dynamics are highly unstable because the conflicting constraints imposed on each other by agents are numerous. Moreover, at a state with neither too few nor too many connections the dynamic of at the 'edge of chaos' arises. This is neither stable enough to obstruct potential for innovation and change nor so unstable as to destroy path dependence. The dynamic of 'living systems' is to be 'changeable' according to Kauffman.

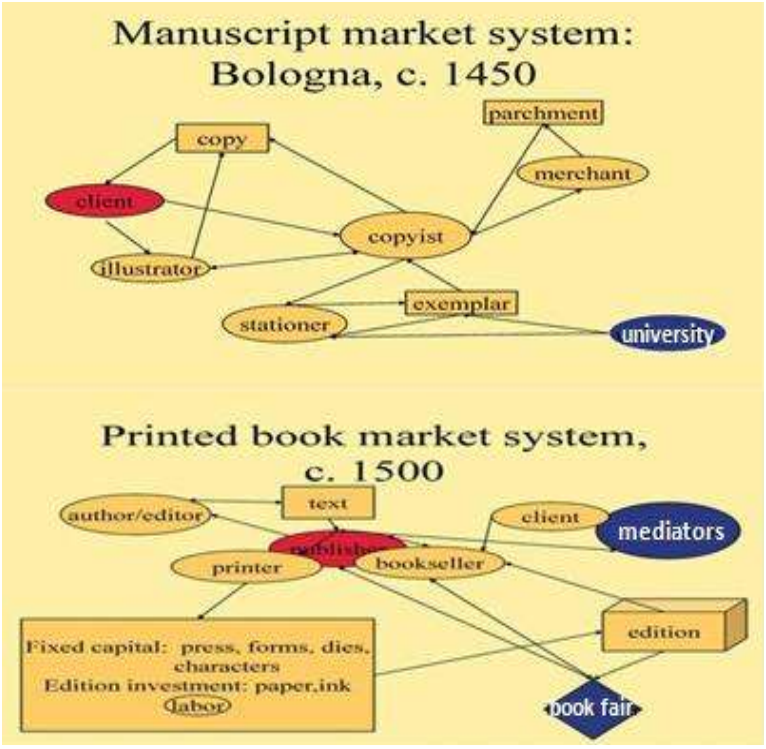
System evolution is influenced by 'clusters' with high internal but low external links to other clusters. Weak ties clustering across the system stabilise it. However, clustering towards the 'edge of chaos' with strengthening cluster interactions produces innovation, change and novelty. System self-organisation thus gives emergence first to new clusters and second their inter-connection in 'platforms'. This occurs first, possibly in 'shadow themes' between clusters or informal interactions (e.g. 'gossip') that, if successful, may become formal inter-connections. This produces systemic regional organisation in terms of webs and networks that are superior to system hierarchies for finding innovation (see also Arthur, 2009). Closely linked clusters establish power differences within and between clusters, constraining others, but in a less destabilising way than if there were very close interactions between all clusters. Only interaction between diverse entities gives rise to potential transitions associated with path inter-dependence. Weick (1995) also argues that cross-disciplinary and cross-functional connections stimulate new insights as interaction may amplify small differences not major discontinuities in understanding. He continues that ambiguity and equivocality may even occur due to misunderstandings from cross-functional interaction. Identities may be threatened. Anxiety may be raised from transition. Current power relations can be threatened as can official ideology. And it may provoke resilient 'remembering' in the face of 'revolt' from below by higher orders in the multi-level resilience perspective (Folke, 2006).

4.4 Complexity and Path Dependence

The 'adjacent possible' refers in effect to the fulcrum of evolution, connecting the restless character of economic or ecological life to progress beyond the current *status quo ante*. It is a cumulative capacity in which the more variety the system displays, 'the easier is the creation of still further novelty' (Kauffman, 2008, p. 151). However, be-

cause distance out from the present human capability decays dramatically, such novel moves are generally fairly short-range but adjacent. Adjacency means 'close at hand' but it implies no particular directionality. Thus it can be straightforward, or an angle forwards, sideways or, interestingly, backwards. This captures the Schumpeterian notion of innovation being intimately bound up with new combinations of knowledge, including re-combinations of old knowledge as well as of combinations of new and old and even, conceivably, new and new knowledge. Consider Fig. 4.2 which is a before and after depiction of book production following the radical Gutenberg book printing system paradigm shift. First, consider what is 'old' knowledge represented in the shift from illuminated copying typical of the book market before (e.g. as in Bologna *circa* 1450) to the Gutenberg process by *circa* 1500. This is especially interesting because only the 'client' is common to both Lane's (2009) representations of the rise in complexity from the one to the other. In the lower diagram, while elements of fixed capital such as the press and dies appear to be new, one (the press) was a preadaptation of the wine press, still a relatively recent introduction to the Mainz region with its rapidly growing wine industry, while the other (dies and characters) were invented earlier in China. Where can new and old knowledge be seen combining? The institutions of the bookseller and book fair were innovations new to the book trade but not to economies in general. Perhaps the newest productive elements were those associated with the author, editor and printer and, associated with them new mediators such as agents, copyrighters and lawyers. The new, new knowledges were a mixture of those just discussed but much more, the increasingly complex publishing system as a whole. This included the new skills associated with printing, the new ways ink was applied to paper, the interactions between various new actors and the institutional innovations associated with these such as serial rather than one-off production of editions, their marketing, mediating and competitive publishing.

Figure 4.2 Radical Complexity in the Gutenberg Printing Innovation



Source: Lane (2009)

A significant amount of path dependence was carried over from manuscript copying to book printing. Peter Schöffer, Gutenberg's apprentice, tried to simplify the illustration process, notably by only offering text-illumination in three colours for black, red and blue letters. But the medieval idea that initial capitals should be illuminated, albeit from a simpler palette, persisted. To allow illuminated letters, Johann Fust, goldsmith, lawyer and investor in Gutenberg's venture developed a system of inserting into the press metal characters to shape the areas to be illuminated. This process constituted one of the more novel technological innovations of press-based printing but it was complicated and expensive. Accordingly, simplified illumination by hand remained common practice until the eighteenth century, an indication of innovation involving reverse adjacency. On the other hand, the Mainz Psalter was the first printed book to give the date and place of printing and the printers' names. Nevertheless, as comparison of the two models in Fig. 4.2 reveals, much also changed in a relatively short time. The key role of copyist-illustrator was demoted to that of anachronistic adjunct to the new process. The power of the church, in the main, to be the key driver and repository (through universities) of manuscripts declined in favour of, on the one hand, affluent private clients and,

on the other, monarchies or councils that granted privileges (comparable to modern day patents) or monopolies to publishers for lengthy periods thus exerting censorship over what could be read. These powers could also be wielded benignly such that privileges might be granted in larger numbers where regimes sought to stimulate literary creativity. In Holland (1995) the presence of non-linearity and variety in complex adaptive systems generates path dependence as local rules of interaction change as the larger system evolves and develops.

4.5 Where Lies the Individual in Complex Adaptive Systems?

As can easily be seen from the above reasoning, complex adaptive systems theory is resolutely 'structural,' at times making arch-structuralist Louis Althusser (Althusser & Balibar, 1970), with his notion of the individual being hailed or experiencing 'interpellation' from a structural element like ideology, seem almost humanistic at times. According to Stacey (2001) individualistic explanations of social processes are vitiated for three reasons. The first is that individualism supposes that individuals can encompass all the knowledge required to make perfect decisions regarding social phenomena such as firms or other organisations. Simon (1973) comprehensively rubbished that idea, hitting the first nail into the coffin of rational-comprehensive planning in the process. A second, related criticism of individualism is that it presumes the individual can not only understand but predict. While this may be true in physics, life is not like physics, biology is unpredictable and in Kauffman's (2008) judgement thereby 'lawless'. Nevertheless, we know that individuals matter, at least in regard to innovation, the subject of this contribution, even if we know they do not act alone. So in this regard complexity science, brilliant as it is in contributing to a hugely improved way of understanding social processes like regional development, innovation and growth, is either mistaken, neglectful or somehow 'over-socialised' in the way that Althusser was accused of being over-determined in his structuralist explanation of (nearly) everything.

The task is, therefore, to right this wrong not by throwing the complex adaptive systems baby out with the 'structuralist' bathwater but by introducing a parent to towel the baby down. Innovation analysis is a peculiarly suitable sub-discipline in which to perform such system-individual articulation because it and its near neighbour invention studies are known by everyone to be fundamentally studies of collective enterprise which are always reduced to a named inventor or innovator, sometimes allowing two or three but seldom more. Measures of invention like patents are the same because of the legal individualism of contracts, responsibilities and accountability. Accordingly, the effort of the sections of this Chapter that follow are devoted first to an analysis then to a synthesis which gives space to the concept of individual and collective action which is nevertheless consistent with the notion of institutional and organisational evolution

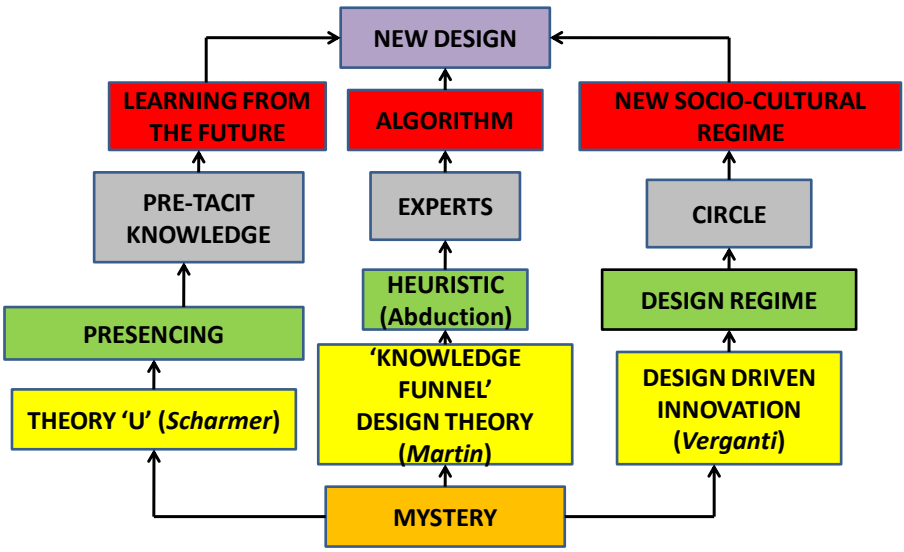
refracted through the lens of complex adaptive systems. In Stacey's (2003) work, which is dismissive of most individualist theories of organisation, he nevertheless gives support to 'symbolic interactionism' after George Mead. This is primarily because of its inter-personal communicative content, which relates to the more modern narrative, discourse and even dramaturgical turn that is characteristic of the 'dialogical' strand of contemporary organisation theory. Meanwhile, hybrid theories like structuration, considered by others to be a successful attempt to unify structural and individual agency interactions, are critiqued for their apparent imputation of omniscience to individual action, as we have seen (Giddens, 1985; Garud & Karnøe, 2001). The narrative strand is consistent both with the element of 'critical organisation theatre' represented by the likes of Boje (2008) and the 'cognitive-cultural' approach of Weick (1995). In particular, Boje's (2008) 'critical dramaturgy' of *Enron* used narrative fragments of the individual performances and corrupt logic of this 'beyond the edge of chaos' corporate scandal, which is a useful corrective to the more managerial platitudes of the mainstream change management literature (Schreyögg & Höpfl, 2004).

A bridge from Boje's (2008) 'critical dramaturgy' with its exploration of the psychologically dark impulses and identities driving individual motivation to commit fraudulent actions to the sunnier uplands of design creativity is found in Lester & Piore (2004). They discuss firm innovation strategies based on interviews with managers and make three relevant points in their book. First, managers are expected to be analytical but are in fact frequently interpretive: analytical management is based on predictability, interpretive management has to work with ambiguity and uncertainty. We know why this is from the foregoing lengthy discussion of the complexity perspective, which demonstrates the unknowability of the future in the face of the nevertheless 'adjacent possible'. The adjacent possible, which is a complex adaptive system space composed of 'structural holes' or 'white spaces' (Burt, 1992; Johnson, 2010) contains topological information that makes some moves more likely to be fruitful than others. Certain system element or 'cluster' characteristics displaying 'relatedness' and feasible 'path interdependence' can act as guides away from the known into an adjacent possible knowledge recombination or 'combinative evolution' (Arthur, 2009) and consequently an interpretive innovation 'design space'.

Hence, we conclude from this first point that the interpretive manager is a *designer*, as indeed is made clear as follows; *'...Designers develop an instinct for what customers want...'* (Lester & Piore, 2004, 98). This sounds pretty vague, so what does it mean? One thing it contrasts with is the analytical manager where; *'Designers listen to the voice of customers....'* (*ibid*). So this is a contrast between so-called design driven innovation, after Verganti (2006) and user driven innovation after Von Hippel (2005). As we shall see, the former is critical of user driven design for its clipboards, consumer surveys, and market research modelling on the grounds that the consumer seldom knows what he or she genuinely wants in any non-trivial way. Very much in line with Arthur's

(2009, 17-18) notion of technology being always an evolved combination of already existing knowledge as produced by varieties of previous designers from whom emerges a 'dominant design', the final consumer gets scarcely a look-in where the design of at least complex technologies like locomotives or jet engines is concerned.

Figure 4.3 Three Rationalist Design Theorists



Source: Centre for Advanced Studies

The second salient point is that, for Lester & Piore (2004) the firm is both analytical and interpretive depending on the perspective taken of it and, particularly, in relation to time. Thus in times of high uncertainty, the emphasis on interpretation grows and the purely analytical can look absurd. In Cooke et al. (2010, 286) we quoted Goldman Sachs finance chief David Viniar bewailing the 2009 US stock market's performance being 25 standard deviation moves out from his model predictions for several days in a row. The probability of this happening was equivalent to once in the estimated life of the universe, meaning such a meltdown was statistically impossible, but nevertheless occurring. At other times, if or when retreat from beyond the 'edge of chaos' has happened, the firm will look more analytical. In other words there is always quantum wave/particle structuration between the analytical and the interpretive depending on the perspective of the observer and the context of the observation. The third salient point is that, organisationally, firms at the 'edge of chaos' regarding innovation behave similarly. They engage in internally open, across-barriers communication and conversations. But open structures are costly because they stimulate too much 'buzz' and associated development of special features based on internal experimentation and excessive user driven information from sales and marketing. Withdrawal from this stage can be painful

and additionally costly because of pushing the pendulum back to hierarchical control. Thus in early cellular telephony, *AT&T* spun off *Lucent* but managed it hierarchically. *Ericsson* did the same but structured it so that traditional telephone culture dominated the 'lawless' cellular radio engineers, dividing labour into specialised project units. These spawned further specialised units to re-integrate the imposed division of labour in a Byzantine creativity-destroying 'hierocracy'.

The group of theorists most closely addressing these analytical-interpretive organisational issues as well as the main focus of interest in this contribution, which is the study of regional innovation from a complexity geography perspective, are what might collectively be called the 'design theorists'. These are represented in Fig. 4.3; each of them is highly focused on the rational, individual, creative action process involved in innovation. Importantly, each is interested in design as a communicative process involving interaction with external actors not just those inside a particular organisation. Moreover, each departs somewhat from purely analytical or deductive individual reasoning in favour of a more interpretive analysis of collective innovation processes. These are interesting to the extent they inform and take further in explanatory terms results like 'preadaptation' or even more interestingly exploitation of the 'adjacent possible' as identified in complexity science by the likes of Kauffman (2008).

Learning from the Future

We start from the left side of Fig. 4.3 with Scharmer and his Theory 'U' perspective. There is an unknown space where, say, an innovation lies – specified in Fig. 3 as the 'mystery'. For Scharmer, getting there is a matter of accessing pre-tacit knowledge, for him in the form of metaphors or analogies at the hermeneutic level. Stacey (2001) also seeks to transcend tacit knowledge as irremediably compromised because of the contradiction that it involves 'expressing the inexpressible'. Contrariwise, he points out that Polanyi made no binary distinction between tacit and codified knowledge of the kind overdone by the likes of Nonaka & Takeuchi (1995). Accordingly, for Stacey knowledge is continuous, communicative and collective in organisations *and elsewhere*. This would include clusters, where the hypothesis that tacit learning determines the proximity imperative clearly requires a total re-think. Innovation involves imagining and indeed 'learning from the future' not simply learning from the past. Such acts of imagination, individually and *collectively*, involve a process of 'presencing', meaning being aware of the present but sensing the future. This involves giving serious *attention* to collective reflections, *observing*, to check them, opening the mind for *sensing* and '*presencing*' an emergent future, *crystalising* the new idea, *prototyping* it and, finally, *performing* or implementing it. This can seem like management mumbo-jumbo, it has to be said. Moreover, as presented, the movement through the seven precepts down the left side of Scharmer's 'U' and up the right side looks to be a remarkably linear, rationalist process. Nevertheless, as we shall see, Scharmer goes a little deeper into more iteratively presented processes aimed at solving the 'mystery' than the other two authors, contributing

to the notion of a design process that not only can be but has been deployed successfully in evolving actual regional development platforms (Harmaakorpi, 2006).

In the elaboration of the regional development platform model, in which Harmaakorpi participated in Finland, collective thinking about what moves firms and support agencies could make into the 'adjacent possible' occurred in diverse entrepreneur panels. These engaged in a resilience discourse process to develop path interdependence, identifying new technological trajectories they could collectively pursue. One of the selected platforms in the Lahti region was clean technology and renewable energy. Entrepreneurs and the regional Lahti Innovation Centre (a branch of Lappeenranta University) then implemented this adjacent possible, creating a new path from furniture production into eco-innovation. Some 10% of Finnish cleantech business is nowadays based in the Lahti region, with the focus on optimising material efficiency and energy efficiency. Global leaders in the waste-to-energy concept include *Lahti Energia* in gasification power plants. Supply chain linkage of main equipment involves *Metso Power*, while *Lahti Aqua* produces district heat from biogas in its two waste water treatment plants. Finally, the *Energon Clean Energy Centre* began operations in 2010, developing equipment for processing biogases, bio-oils, solar energy, solid renewable fuels and hybrid solutions, hiring out its facilities and equipment for research institutes and companies. Thus, starting from 1998, a new approach to regional innovation was heralded, informed by collective assessment of demand profiles and market opportunities. This came from addressing future global 'Grand Challenges' such as climate change, the energy crisis, demographics and healthcare megatrends.

The Knowledge Funnel

An explicit design theory for innovation at the firm level is advanced by Rotman School, Toronto's, Roger Martin. Informed by American pragmatist philosophy (Peirce, Dewey, James), Martin first emphasises the inappropriateness of scientific reasoning, based on either inductive or deductive reasoning, for organisational creativity and innovation, advancing Peirce's concept of 'abductive reasoning' in preference. Unlike inductive logic, that reasons from the specific to the general as with comparative case analysis (but beware the 'black swan' problem), for example, or deductive logic that reasons from the general to the specific (all crows are black, so the brown one is not a crow), abductive reasoning requires an evolving interaction with the environment and others until a leap of faith, informed by metaphor or analogy can be executed to produce a solution to 'the mystery'. 'Abductive logic sits squarely between the past-driven world of analytical thinking and the knowing-without-reasoning world of intuitive thinking' (Martin, 2009, 26). This translates into decision cultures in organisations which are divided into a past-driven 'reliability' logic of accounting, measuring and predictability that is fatal for innovation and 'exploration,' and a 'validity' logic that can be vulnerable but favours 'exploration' over 'exploitation' of knowledge (March, 1991). This inclination makes it clear this position is not very far from Scharmer's pre-tacit 'pre-

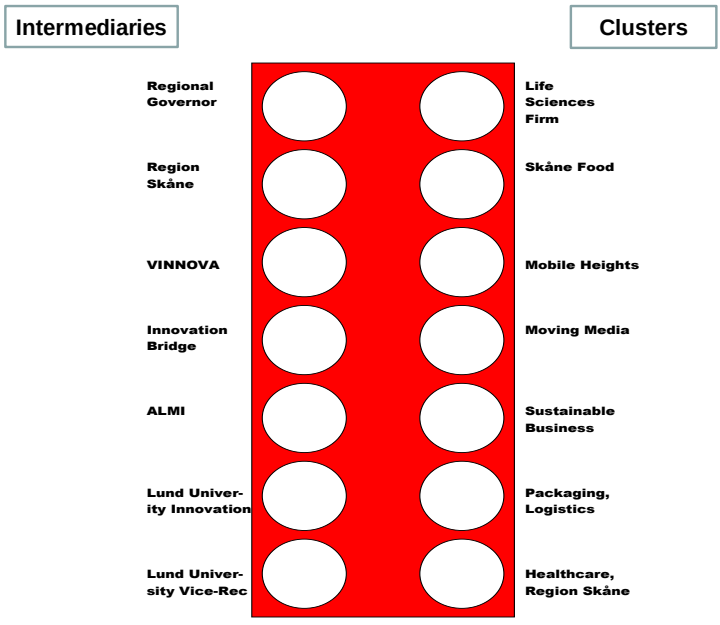
sencing' in order to 'learn from the future.' Diverse individuals engaging in collective discourse are, however, involved in a slightly different way.

Here, Martin introduces the 'knowledge funnel', a linear three-step process that takes 'personal knowledge' from, first, addressing the 'mystery' to, second, developing a 'heuristic' in order to identify any underlying pattern to inform actions and, thirdly, refining the heuristic to an 'algorithm' that facilitates implementation of the innovation. Dialogue is present from the outset, although in *ex post* accounts such interactions normally get obscured by mainstream quests to identify the legal intellectual property owning individual. Thereafter, organisations proceeding with this approach – examples include *Research in Motion* (BlackBerry); *Procter* & *Gamble* (open innovation; Chesbrough, 2003); and Herman Miller (the *Aeron* office chair) – hire a 'sounding board' of design theory experts (including Martin) to advise on the heuristic-to-algorithm parts of the design process and projects. Three vulnerabilities lie in Martin's approach in light of the perspective adopted here. First, despite the 'sounding board' it is individualistic in its stress on 'personal knowledge' as the key driver of the design process. Second it is unclear how design teams interact with sounding board members, whether individually or collectively, virtually or proximately. Third, as he admits, there will inevitably be a 'revolt of the analyticals' intending to wrest control back from the 'wilful negligence' of the 'flaky' creatives to protect shareholder interests. To which threat, Martin offers no theoretical protection. Accordingly, it could be concluded that the knowledge funnel is just a species of idealism unless large numbers of firms had already decided to adopt such an approach at the highest level, something Martin's own estimates suggest is overwhelmingly far from the case.

Nevertheless, the knowledge funnel is implicitly practised in the Region Skåne exemplar in Sweden (Fig. 4.4). In their regional innovation process this region practices some of the key elements of design theory, notably the concept of 'white spaces' as their terminology for the 'mystery' of wherein regional innovation lies (Johnson, 2010). This is cognate to Burt's (1992) idea of 'structural holes' between strong ties clusters with evolved social capital 'bridging' that asset across to a 'related variety' strong-ties cluster to explore adjacent possibilities for innovation in-between Kauffman, 1995). This is also referred to as seeking the 'blue ocean' of novelty where competition is low or non-existent rather than the red water of bloody competition in regard to corporate (or regional) strategy (Kim & Mauborgne, 2005).

The second way in which Region Skåne's regional innovation strategy echoes the knowledge funnel is its deployment of a 'sounding board' heuristic of regional experts to facilitate interactions between clusters and the variety of regional support agencies or intermediaries responsible for risk capital, skills formation, innovation bridging, research and regional innovation governance. Thus in Fig. 4.4 ALMI is the regional branch of Sweden's national training agency while, similarly decentralised 'Innovation Bridge' funds innovation links between firms and research institutes.

Figure 4.4 Region Skåne´s "White Spaces Sounding Board"



Source: Centre for Advanced Studies

Finally, Region Skåne's algorithm focuses all its clusters around two 'Grand Challenges'. The first addresses climate change mitigation by integrating regional innovation competences in renewable fuels, recycling, logistic systems integration and its Food Academy in a 'sustainable cities' innovation platform. The second relates to Personalised Healthcare. Key to these initiatives is knowledge transfer across cluster interfaces to explore innovative 'white spaces', share social value and exploit global market opportunities.

Design Driven Innovation

The third rationalist perspective on design theory in innovation concerns the notion of design driven innovation as practised in Italian furniture, kitchenware and lighting firms, on the one hand and, more broadly, the Lombardy innovation system in general. Both are subjects engaged with by Verganti (2006; 2009). Verganti sees design not as a process of individual abduction but a collective process involving knowing what knowledgeable others think about society as well as being creative regarding series rather than one-off innovations. Accordingly, a manufacturer's ability to understand, anticipate and influence the emergence of new product meanings is built by engaging external interpreters (designers, firms in other industries, suppliers, schools, artists, the media etc.) who share the same problem; to understand the evolution of new socio-cultural models, and propose new visions and meanings. In this way, second, exploration of the

'mystery' involves exploring socio-cultural meaning much as regime change accompanies technological innovation. This involves wholly separate definition of design compared with user driven innovation whereby: user driven design implies that product development should start from a deep analysis of user needs (i.e. *analytical–reliable* in Martin's 2009, or 'analyticals' in Lester & Piore's, 2004 terminology). Such analysts observe customers as they use existing products and track their behaviour in consumption processes

However, design driven firms like Lombardy domestic goods and appliances firms such as *Alessi*, *Artemide* and *Kartell* (also non-Italian design-intensive firms like *Apple* & *B&O*) practise something else. They *propose* innovations that radically re-define what a product means to the consumer. An example is the *Alessi* kitchenware product line which was transformed from simple tools to 'transition objects' that embodied transgressive forms like toys thought likely to appeal to child-like affections dormant in adults. This is not 'technology push' but 'design push' and conceivably 'regime push'. The research meta-model is the result of a *networked research process* where *knowledge* of design languages and meanings is shared among firms and external interpreters. Accordingly, in this model new designs explore new routes, satisfy latent needs and aspirations, move the frontiers of design languages, set new standards of interpretation, and eventually strengthen the brand value. Moreover, knowledge is *distributed* among users, firms, designers, products, media, cultural centres, schools and artists as a network of actors, which creates a continuous *design discourse* among a *circle* on socio-cultural regime change and its implications for consumption.

At regional innovation system level Lombardy is, unlike certain stereotypes, considered no higher in its social consciousness and valuation of design than regions elsewhere. Lombardy is a key centre of furniture manufacturing, possessing some 25% of all Italian furniture companies while Italy is Europe's largest furniture exporter, with 45% of its output exported. Regional furniture growth rates exceeded both the Italian and European Union levels from 1994-2003. However, Lombardy's schools, studios, manufacturers and research centres were little better than in other design clusters. Nevertheless, the region was distinctive for the number and strength of links between diverse actors in the regional innovation system. This is underlined by a comparison with an underperforming design territory like New York's Finger Lakes region where it is shown how platform potential fails to evolve, largely for socio-anthropological reasons, industrial tribalism and lack of communication. Its main city Rochester is home to *Xerox* and the *Gannett* media firm. *Bausch & Lomb*, a leading lens maker, is present as is *Eastman Kodak*. *Corning* fibre glass is nearby, alongside numerous specialist optical networks companies. The state of New York established the Centre for Electronic Imaging Systems as a collaboration between *Xerox*, *Kodak* and Rochester University's optical engineering school. Rochester Institute of Technology is a leading print media college while Alfred University excels in ceramics and glass sculpture. Eastman House is a

pre-eminent museum of photography. However, despite these institutional riches, there is little interaction among the regional assets, 'cross-town rivalries' predominate over creative collaboration, even among artists and designers, let alone manufacturers. Large firms like *Corning* scarcely interact with specialist glass acquisitions like *Steuben* and if the former changes specifications there is outcry. Accordingly, with almost zero social networking going on among the potential digital optical platform it is not surprising that the sub-region displays low job growth and prison recruitment policies that mean a majority of new residents are incarcerated.

Conversely, a success story like Helsinki has numerous small design studios, several designers' associations, research centres focused on design, a design museum, and the Aalto Design University. Aalto University was established on January 1, 2010, when the Helsinki University of Technology, Helsinki University of Economics and the University of Art & Design Helsinki were merged. Aalto University thus created a new design, science and arts community promoting transversality in education and research. This is like Lombardy which is also pronounced in these transverse industries and the skills interface of entrepreneurs and their equally mixed territorial identities. Thus the founders of *Alessi* and *Cassina* are lawyers, *Artemide*'s is an aerospace engineer; others are from such disciplinary backgrounds as economics. Leading designers include Israeli Ron Arad, American Michael Graves, Philippe Starck from France, Richard Sapper (German) and Ettore Sottsass (Austrian). Accordingly, combinative rather than primarily cumulative knowledge is the source-code for the Lombardy design platform. Verganti (2006) is strongly convinced that cross-pollination from outside the country and profession in which design driven innovation operates is crucial, and cites UK designer Jonathan Ive, designer of iMac and most subsequent Apple innovations as a case in point. He previously designed bathrooms.

Synthesis

As noted, this is a more collective design method than the knowledge funnel which makes it preferable for regional innovation. However it is relatively linear in its 'design-push' posture, which compares with a somewhat dated 'technology-push' dimension more typical of the early technological regimes and paradigms approach to long-wave influenced innovation studies. Finally, its elitism and exclusivity may make it somehow acceptable in luxury market niches but hardly so in more affordable markets. It is probably salvaged from the waste-bin marked corporate 'authoritarianism' by the interesting transversality of expertise engaged in the advisory 'circle' that reflects on and helps imagine the new socio-cultural regime at the heart of the design 'mystery'. So, in conclusion, we may say that some progress has been made in integrating the 'systemic' and the 'collaborative' dimensions of design-based innovation thinking. The best parts of all three of the design theories considered and represented in Fig. 4.3 are where they synchronise with, first, the insights of complexity science regarding, in particular, how the 'adjacent possible' actually gets explored, and second where they can be shown to be

expressed in varieties of actual regional innovation system evolution. In that respect the summary of regionalised variants of the three approaches is presented in Table 4.1.

Table 4.1 Comparisons of Regional Innovation by Design

Region Dimension	Lahti	Skåne	Lombardy
Focus	Furniture	Shipbuilding	Design goods
Shocks	Hollowing-out	Deindustrialisation	Socio-cultural regime
Responses	Platform method	'White Spaces'	Regime change
Linkage	Expert panels	'Sounding Board'	Design Circle
Technologies	Cleantech	Sustainable City	Design innovation

Source: Centre for Advanced Studies

Key elements of commonality across all three of these deductive cases include the need to respond to large shocks or more modest market turbulence, which causes the concentration of minds in the first place and encourages focus in the second. Second, there is commonality in that each case displays a cross-cluster, cross-expertise mode of knowledge assembly and narrative interfacing in the process of moving towards a 'heuristic' to face the 'mystery'. And finally there is comparability in at least some reliance upon collective rather than mainly individualistic modes of innovation dialogue and discourse to achieve the 'algorithm' parameters for implementing the agreed design. In the 'knowledge funnel' theory it remains unclear how 'sociable' such interaction is between design teams and expert board but in its regional innovation system implementation it was clearer that it was more collective than 'authoritarian'.

4.6 Strange Attractor Innovation Biographies

In this brief final section of this contribution, the aim is to achieve three things in relation to the propositions contained in the complex systems and design driven innovation synthesis as developed in the preceding exposition. These are: to test the main propositions regarding system 'relatedness' in regional economic development; to test related propositions regarding policy 'transversality' in that process; to assess the 'strange attractors' thesis regarding actual 'innovation biographies'. Recall that the main effort expended in evolving this combined approach was to account for regional economic development in interesting and informative ways that engaged complexity geography with design-based innovative creativity at the individual and group level. It was, furthermore, to consider the extent these were consciously understood processes by firm-focused agents who are its 'carriers' and intermediary agencies who can be its supports. The exemplification in the preceding section showed that some, selected policy organisations evolve interventions that resonate with the theoretical propositions of design theory. Furthermore, they do this with some understanding that regional innovation involves exploring the 'mystery' of 'white spaces' or 'structural holes' in the innovation

landscape. Although this does not mean geographical proximity alone is the 'design space' under exploration, it nevertheless recognises that geographical proximity is crucial for assembling the recombined knowledges, from inside and outside the region, that constitute the innovative solution to the 'mystery'. In this manner, geographical proximity is restored to a prior position in the hierarchy of 'relational spaces' that have been advanced for understanding the role of geography in a globalised world. We use three innovation biographies to test out these propositions, beginning with the origin of a 'functional food' known as a 'probiotic drink' that used biotechnology to develop a 'health claim' for the product.

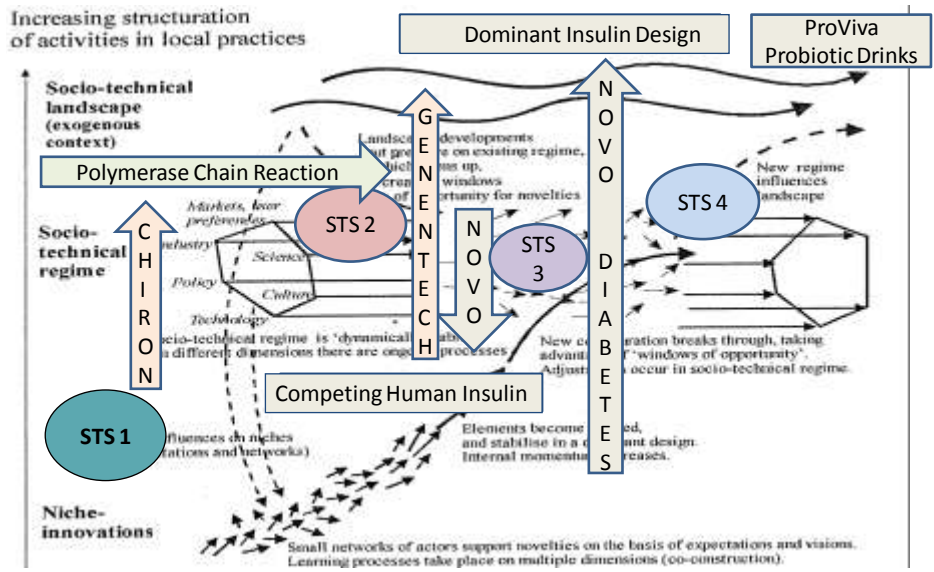
Probiotic Drinks

The probiotic drink in question, brand-name ProViva has been produced by Skåne, Sweden dairy producer Skånemeijerer. In purely commercial terms it had a chequered history described in Cooke (2007, 202-208) the main elements of which include the following. The product began life in the laboratory in the mid-1980s as a by-product of globally significant biopharmaceuticals innovation in the field of human insulin (Fig. 6). ProViva was a non-milk based progenitor of the kind of digestive support ingredient also represented by related 'healthy bacteria' dairy products like Yakult, Benencol, and Activia. In 1994 the product, consisting of a cocktail of bacteria and aimed at a supermarket audience was produced and marketed. Because of its alleged health gain properties – for example, relieving then-fashionable irritable bowel syndrome - it was sold at a premium price. As such, it sold relatively poorly in its earliest Nordic-centred markets. A new marketing launch in the UK also failed to attract customers. However, by 2010, there had been a market turnaround and the product line was purchased by *Actimel*'s owners *Danone* for €50 million. Hence, what seemed an innovation failure turned into a marketing success. However, of greater interest here is the history of the drink. It begins with the quest for an alternative to animal pancreases as the only source of human insulin until the 1980s. Two companies, the pioneer biotechnology firms in California *Cetus* and *Genentech* made two breakthroughs, the former in its genetic engineering process innovation *polymerase chain reaction*, the latter in actually producing synthetic insulin by using the genetic engineering tool in question. This defeated competition from Danish pharmaceuticals company *Novo Nordisk*, partnered by Massachusetts biotechnology firm *Biogen*. *Novo* decided to redouble its efforts into becoming a specialist diabetes firm, expert in all stages of treatment of the disease. Diet is important to recovering diabetes patients and research *Novo* was engaged in identified the forerunner of *ProViva* as a valuable digestive supplement for recovering patients. Swedish pharma firm *Astra* now *AstraZeneca* was a main partner and transferred this knowledge through Lund Technical University to *Skånemeijerer*, where it was eventually successfully developed as a commercial product. In analytical terms this innovation represents multi-regime and paradigm interaction (Fig. 6). This involved STS 1 centred upon genetic engineering, STS 2 specialising in therapeutic biopharmacy, both in the US, STS 3 the Danish bio-

pharmaceuticals competitor and STS 4, the Swedish functional food company that successfully commercialised ProViva. Hence, distant, relational networking brought innovative knowledge recombination opportunity to a specific agro-food firm operating in geographical proximity to the biopharmaceutical knowledge source.

Figure 4.5 Innovation Biography Pro Viva

Co-evolutionary Transition Model: Niche>Regime>Landscape for Human Insulin & Functional Food (Source: After Geels, 2006)



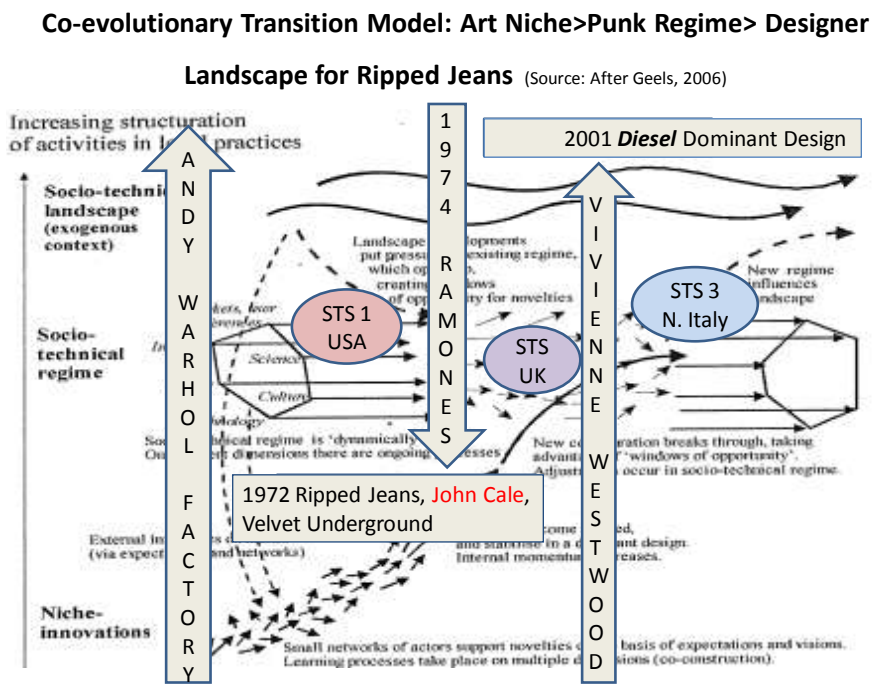
Source: Centre for Advanced Studies

Diesel Distressed Jeans

Punk fashion in the UK can be traced to the ripped jeans, torn t-shirts, spiky haircuts, and worn and torn leather jackets sported by members of the Sex Pistols. When they released *Anarchy in the UK* in 1976, The Sex Pistols were dressed by Malcolm McLaren, their manager, whose wife Vivienne Westwood owned a clothes store called 'Let It Rock' in the Kings Road, Chelsea area of London. These styles can be traced back further to New York artists at the Andy Warhol Factory or bands such as the Velvet Underground, Patti Smith Group, Ramones or New York Dolls. Until the turn of the denim wheel towards skinny and/or elaborately embroidered jeans in 2010, the dominant jeans fashion 2000-2009 was for a seriously 'distressed' aesthetic. To observe the process by which the distressed look was achieved was an exercise in observing 'creative destruction' in action (Cooke et al, 2007, Chapter 4). This involved sourcing indigo denim jeans (and jackets), then exposing them to a multi-stage division of labour to 'distress' them. This might begin with special enzyme-tolerant coatings being applied to the fa-

bric, or in other cases immediate application of high-pressure powdered glass spraying, to 'wear' and 'age' the appearance of the cloth. After this, hand sanding further distressed the fabric at strategic points. Then grafitti were pressure- bonded into the fabric, after which rips were strategically made to prominent parts of the product. The final production stage involved the rips and tears of the distressed garments being elaborately sewn up. The fashion element in this value-adding innovative product and process was intentional and design-intensive. The pioneer of this kind of distressing was innovator Renzo Rosso's anti-*haute couture* firm *Diesel.*

Figure 4.6 Innovation Biography for Distressed Jeans



Source: Centre for Advanced Studies

The *Diesel* brand emerged in 1978 in northern Italy, and is today an innovative international design company, manufacturing jeans and casual clothing as well as accessories. It is present in over 80 countries with 10,000 points of sale and some fifty company-owned stores. When Rosso founded the company in 1978, he intended for it to be a style leader, a risk-taking firm with a clear and unambiguous identity. He hired designers internationally – for example chief designer Wilbert Das from the Netherlands and his 2010 replacement Bruno Collin from France – who were innovators and outsiders who rejected the predominant trend-following typical of the fashion industry. This meant evolving a more dynamic and imaginative line of clothing than was available

anywhere. Designers were given broad stylistic freedom, to identify independent creative clothing niches. Accordingly, Diesel's design team also rejected the market research and consumer forecasting of the fashion establishment. Thus Diesel became an innovator in developing styles, fabrics, manufacturing methods and quality control, guaranteeing an outstanding quality product.

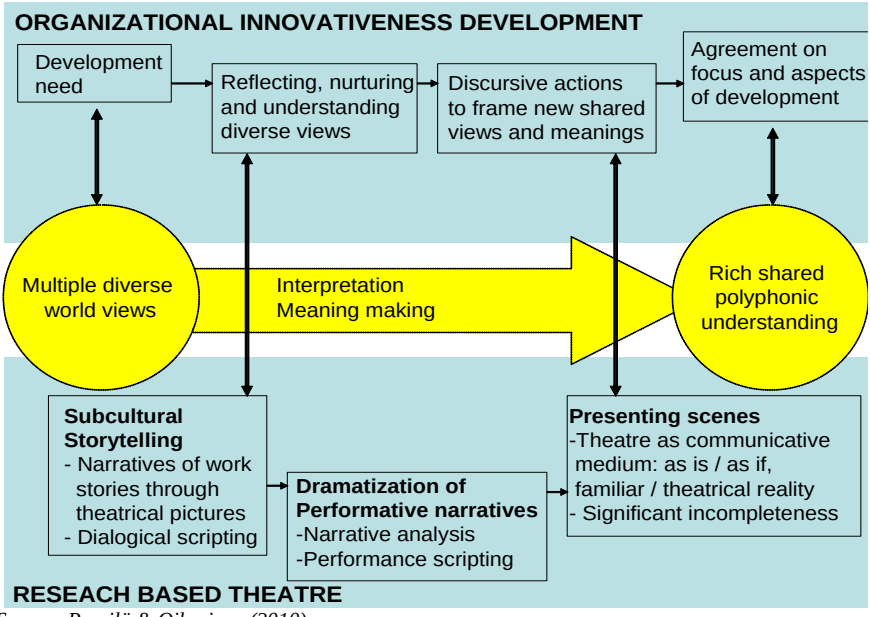
Lahti: Research-Based Theatre

The last brief example of 'strange attractor' system innovations concerns a process innovation practised in the public sector as pioneered in Lahti, Finland. The use of theatre in corporate management has grown during the 2000s (Schreyögg & Höpfl, 2004). In Lahti, confronted with the 'adjacent possible' for future regional development, interest lies in creating novel intermediary techniques to aid communicativeness and connectivity to advance innovativeness. Instead of the mainstream 'change management' alternative worldviews distributed throughout the organization and facilitate creation and communication of rich shared, multi-voiced understanding. (See Fig. 8) Accordingly, a key challenge is how to create theatrical and narrative techniques which enrich collaboration and joint understanding?

The chosen method is called research-based theatre. It is an interdisciplinary approach combining organizational development and innovation management studies with art and cultural studies, applied theatre and social sciences. In RBT the understanding of an individual is developed in a co-operative social context, and meanings are made of the experiences of the participants. The behaviour of individuals in groups and between different groups can be understood by getting to know the system of scripts and schemas behind actions. The main effort is to interpret the system of meanings together with the members of the organization and thus this approach of theatre is both communicative and a dialogue.

The key factor is a collective growth of joint, shared understanding constructed using theatre as a narrative approach. In this paper we propose a novel narrative technique of storytelling. The main idea is narration through images. The images are theatrical pictures made by applied theatre and drama students. In a storytelling situation theatrical pictures are interpreted as a text of social reality status, habits and practices. Storytelling is an attempt to reveal something we assume to be natural even it is a socially constructed habit or attitude. Storytelling is creating meaning through images and it attempts to trace significant meanings in lived and experienced social life. The approach underlines that an organization is a social, cultural and collective construction Dialogical scripting is used as a means to produce a fictionalized narrative (i.e. script) through a collective interactive process.

Figure 4.7 Research Based Theatre



Source: Passilä & Oikarinen (2010)

This is still relatively uncharted territory in most regional intermediary agencies and firms interested in the pursuit of innovation as a means to achieving regional economic development. Its use in mainstream corporate contexts has been widely critiqued for its managerialist focus. Boje (2008) has evolved a 'critical dramaturgy' method of deconstructing organisational biases and asymmetries that acts as some inspiration for the research-based theatre approach. It would be interesting to see it applied to other contexts, notably the externalised world of the regional innovation system, and other cultures where, as yet, complex adaptive systems and varieties of design thinking remain, as much as anything, a continuing 'mystery'.

5 Conclusions and policy implications

5.1 Summing up

Reframing the regional development problem

There is in our view substantial value in deploying complex adaptive systems theory to 'reframe' the regional development problem. It is clear that, for example, 'emergence' is hindered where 'relatedness' is undeveloped or 'clusters' are few and far between. An additional dimension of this reframing is that there is much to be explored by taking a horizontal perspective on knowledge flow dynamics rather than the clearly questionable 'smart specialisation' promulgated by the likes of the EU, still under the sway of 1960s 'sector policy' concerns and their modern variant of the pursuit of 'cluster-building' policy. It has been shown that leading firms and intermediaries are already benefiting from exploring 'platform' convergence opportunities among hitherto 'strange attractors'.

Complexity science is not enough

A second conclusion is that complexity science is not enough as a guide to regional development theory and practice, though it is an extremely powerful tool facilitating regional analysis. Because it lacks a theory of action, even though it explains in a satisfactory manner how life constantly presents individuals and institutions with the challenge of the 'adjacent possible', it is incomplete for practical purposes. The analysis presented found the implications of a design theoretical approach moved some way towards filling that intellectual gap. Moreover, it was interesting and important to turn up evidence that accomplished intermediaries had anticipated design theoretic insights.

Complexity geography

Thirdly, and returning to the core of complexity geography, it was shown that evidence can readily be adduced to show that much innovation is a product of 'revealed relatedness' among 'strange attractors' at the individual level. This hints at the growing power of complex evolutionary economic geography compared to the inheritance from mainstream 'social physics' which is now revealed to be a truly inappropriate metaphor for the analysis of social processes. This stance is also underpinned by the wholes to parts interaction referred to in chapter 2.

Complexity thinking challenges linear policy making

Policy is designed and implemented in the form of push programs to use the language of John Hagel III and John Seely Brown (2010). This is among other things a consequence of New Public Management. A push program has to define its goals, its targets and its operational mode to reach the defined target population. The action logic is more or less based on the ability to foresee and control results. The reality is that these assumptions are less and less valid due to wickedness and complexity. The result is less efficiency in reaching policy targets which in the prevailing mode of operation calls for more stringent controls and more focused action which just aggravates the lack of performance and relevance in terms of addressing wickedness. Resilience theory discovered this in the problem of linear eco-management failures (Chapter 3.1 above).These are general observations to show that platform policy represents a challenge for policy design. Policy seems to be looking for simple solutions to complex problems partly because of the inherent logic of politics. In recent years this trend towards simplification has been reinforced by the mediatization of society and policy making. The latter is a phenomenon of special importance for forward looking policies like innovation policy which more or less by definition fails to respond to the dramaturgy of media for immediacy and conflict.(Hajer,2009)

5.2 Policy rationales and policy options when facing complexity

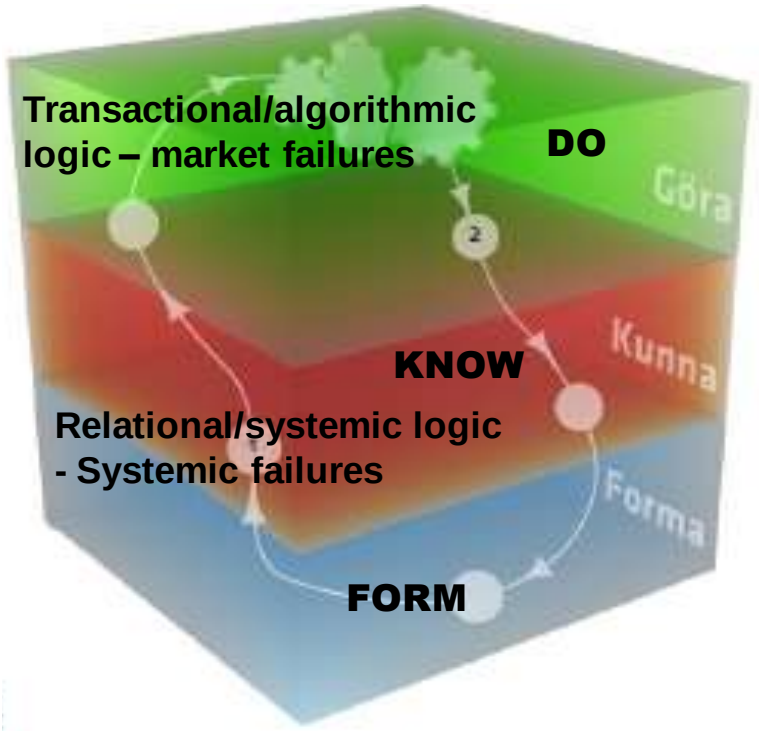
The view in the literature on evolutionary theory, systems thinking and complex adaptive systems is a bit troublesome from a policy perspective by questioning the possibility to control societal change. This is valid both for policy making as well as for evaluation of policy that is often even more grounded on the illusion of policy being in control. This does not mean that all events are effects of bottom-up and self-organised actions of agents beyond political control. Eve Mitleton Kelly (2011) who is a complexity researcher states that, based on the logic of complexity theory, tools and methods are necessary but not sufficient in bringing about organizational and societal change. They can, however, be used to develop an in-depth understanding of the multi-dimensional problem-space. No complex issue, challenge or problem can be addressed effectively by focusing on a single issue or dimension, as they do not exist in isolation; the different inter-related dimensions interact and influence each other. Once the complex problem-space has been identified that understanding can be used to co-create with the relevant stakeholders an enabling environment, which addresses all the relevant inter-related issues at the same time. Complex problems often do not have a single definitive solution, but an enabling environment which is responsive and coevolving with its changing broader social ecosystem, is much more likely to address the issues effectively. This is her key message both for policy makers in the public sector and decision makers in the

private sector. The approach applies according to her equally to organizations and to societal and national issues.

Platform content is a result of different sorts of measures with different policy rationales. One distinction can be made between market failures that affect exchange and transactions. In innovation policy such market failures are associated with venture capital, information asymmetries, thin markets and property rights and the public goods character of knowledge to mention the types of failures most often referred to. The analysis in the first section where knowledge flows, relationships and social capital were mentioned indicates however that a set of systemic failures also becomes of interest. Researchers mention interaction failures, connectivity failures and communication failures and they are all related to the interdependencies and heterogeneity between actors and/or resources. Market failures have a direct influence on the ability to take decisions concerning individual transactions and resonates with Martin's (2009) idea of the algorithm as key for decision making and thus for capacity to DO, (see Figure 5.1). Systemic failures affect individual transactions indirectly by limiting/blocking access to knowledge and by limiting/blocking the search for novel solutions due to low quality of relational assets etc. These are factors of great importance for innovation which means that a policy mix to support innovation in a collaborative manner to take systemic aspects into account. The consequence is that measures might be designed to influence primarily FORM (FORMA) i.e. the cognitive dimension, the knowledge dimension, KNOW and not only the real world, DO in the framework. Another difference is that measures to affect FORM and KNOW have to take account of the interpretative element of sensemaking and knowledge creation. This leads to recognition of a process perspective and "how-to" issues as we saw in chapter 4.

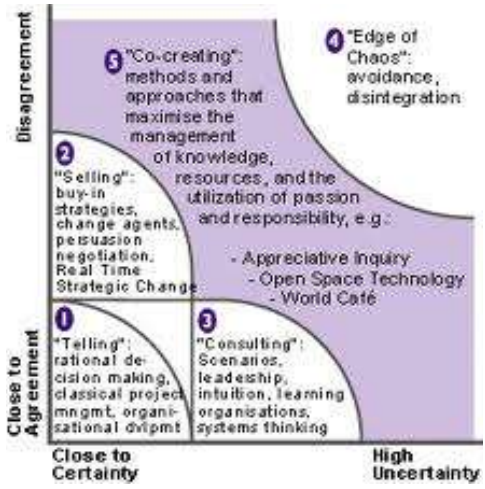
To DO – make a decision, use a technology, co-produce a service- is an act where knowledge as a cognitive and intangible construct is impacting on the tangible or real world; where it becomes an asset in value creation, where it is a building block in capability building and where it is again contextualised. For policy purposes and also because of the contextual aspects of knowledge it is important to note that the abstract notion of a selection environment or interaction fields as we refer to them later on, in practice refers to "context markers" acting as attractors like clusters, business ecosystems, technological regimes or innovation systems. Taking that type of analytical perspective is often associated with a multi-level perspective and often with a focus on some notion of a meso level. One example which we have referred to is between technological landscapes, technological regimes and technological niches in what is called strategic niche management. The relationship between clusters and (regional) innovation systems can be seen in the same way.

Figure 5.1 The Cube



Innovation is an emerging entity. There must be capabilities that support strategic action. To KNOW and to DO is thus to possess structured knowledge but also to command the skills required to make use of knowledge and transform it to knowledge in action; i.e. capabilities and routines. Another way to put it is that these are the requirements for knowledge to be absorbed and to have an impact on value creation. Over time operational routines become obsolete. This may be due to external and/or internal perturbations. A new learning cycle starts with unlearning and forgetting and the activation of search and problem solving routines. The social learning cycle can be divided in two major parts namely an exploration phase and an exploitation phase. The focus in this report has been on the explorative issues. Exploration requires variation. Exploitation destroys variation. It must be stressed that the social learning cycle is an aggregate of many individual and organisational learning cycles. This also means that there will always be an overlay of learning cycles in different phases. So, the social learning cycle can therefore also be a means to a richer understanding of the issues involved in balancing exploration and exploitation. Both exploration and exploitation are needed and the one important issue for businesses is how to achieve that in their organizations (March, 1991).

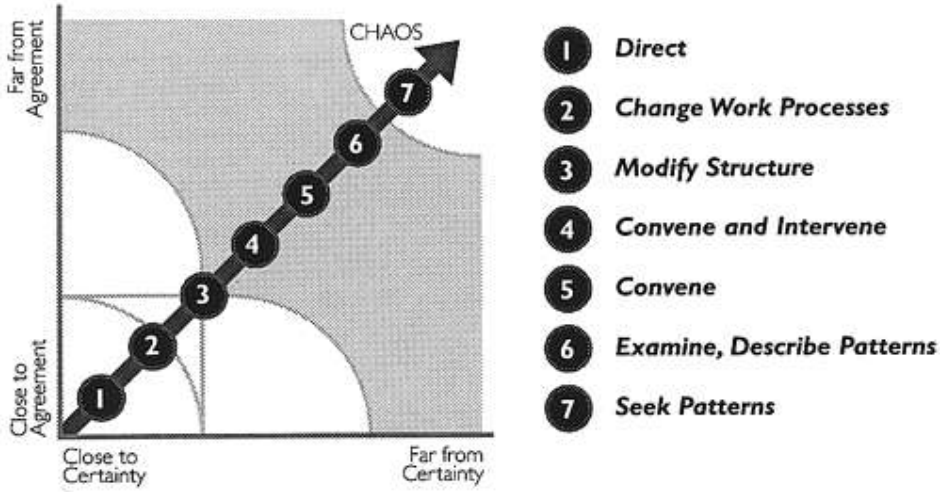
Figure 5.2 Stacey Matrix



Source: Stacey (2002)

The issue for policy makers is then how to best influence FORM, KNOW and DO in order to support innovation-led economic growth. The preferred way for policy making is – as is shown by approaches like New Public Managment and Evidence based policy making - to rely on complexity reduction which works in the zone closest to origo (bottom left) in figures 5.2 and 5.3. The figure is called the Stacey matrix (Stacey 2002). Close to certainty and close to agreement policy is then the assumption for policy design and its implementation. As we have argued these assumptions are not fulfilled when it comes to grand challenges and innovation. These are wicked issues. Zones 2 and 3 require some changes in work process not least in terms of understanding the environment but it does not fundamentally change the policy "landscape". This is however the case in zones 5 and 6. In the chaotic zone the major achievement may be to understand and translate the environment into actionable patterns which is a kind of "order" that moves issues form chaos to the complexity zone where still action has to be characterized by co-creation applying design thinking and similar approaches.

Figure 5.3 Policy design using the Stacey Matrix



In summary then the mix of policy rationales – market and systemic failure – leads to a mix of policy that covers a broad spectrum from issues of meaning and sensemaking to knowledge creation to directly influencing market transactions.

5.3 Addressing grand challenges

What is special with grand challenges?

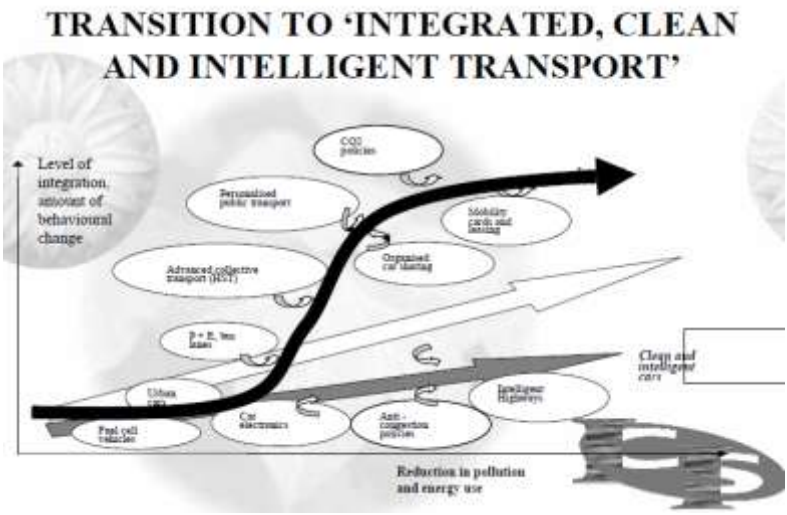
There are two different approaches to grand challenges. The first is to try to deal with them within the prevailing paradigm of "science push". That means a strong focus on research and technology. The other is to see grand challenges as a type of social problems that require not only new technologies but also social innovation and a systemic approach in addressing them.

The difference between the science & technology push approach and the society pull approach is illustrated in figure 5.4 with the case of transition to "integrated, clean and intelligent transport". The example is taken from a presentation by Jan Rotmans, (Rotmans 2002). The point to be made is that even though the society pull approach is declared the way to go it is very easy to still be a victim of the science and technology push thinking that has been used for a long time. The arrows in figure 5.4 represent change within regimes – staying in the same valley in terms of orthogenetic landscape and the term Rotmans use for this is system optimization constrained by the regime´s attractor.

Change of regimes requires a bundle of activities that influence the environment or the policy landscape. The difference between approaches is shown in figure 5.4 to be the level of integration of steps taken and the amount of behavioural change associated

with system change. Roberto Verganti talks about innovation of meaning (Verganti, 2009). Including new types of instruments that affect the policy mix like demand side programs may influence the conditional probabilities establishing new pathways between regimes – path interdependence – which by stimulating demand can influence what turns out to be the adjacent possible .

Figure 5.4 System innovation and system optimization



Source: Rotmans J, from presentation to the OECD on Transitions & Transition Management for sustainable development, 2002

In making the level of integration a distinguishing aspect of the innovation response Rotmans also points to the importance of governance or orchestration in addressing grand challenges. What kind of governance and who has the authority to perform it are issues here. In governance terms the previous arguments point to governance of business transactions as well as governance of relational issues associated with interaction and connectivity exemplified with framing of issues and mobilizing a diverse set of stakeholders for visioning activities. Grand challenges include specific governance issues concerning thin markets and market shaping. It is obvious that companies play a crucial role in this together with policy as regulator, risk taker and market shaper through innovative procurement and being first user in some areas (e.g. societal demand driven innovation).

The major implications of what has been said from an innovation perspective is first that one might assume that wicked issues present potential business cases but that the approach to define them and develop them requires an experimental approach and involvement of many stakeholders. These are requirements for collaborative governance. From a governance point of view this analysis leads to the conclusion that forms of

governance are dependent on the rationale for intervention/action. If the focus is on transactions and exploitation then companies are well positioned to be orchestrators. Those forms of governance that strive to shape and "co-ordinate" frames and lead to innovation of meaning require more of public/civic governance and/or self-organisation responsive to external constraints.

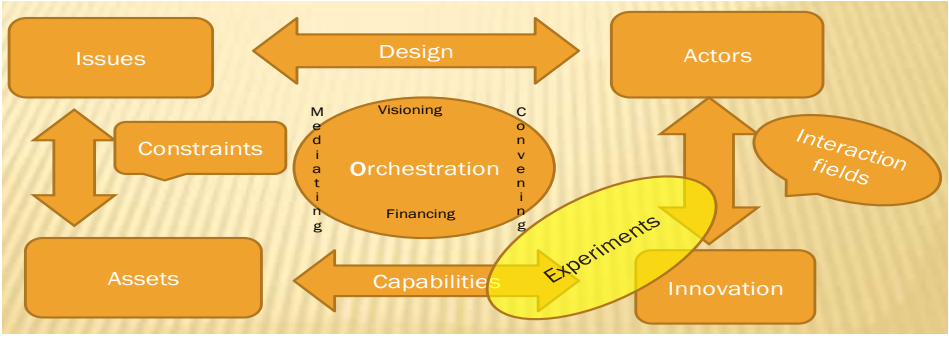
A process model for making Grand Challenges actionable

Collaborative governance in this particular context is about aligning issues, actors, (including users), processes and assets to develop and deliver products. Figure 5-5 illustrates the "content" of orchestration. The basic premise is that a grand challenge has to be interpreted and framed in a collaborative process to be made actionable. The event logic illustrated there is that the Grand Challenges are defined at a societal level. The way they are framed in that perspective is most often not a framing that is actionable. There is a need for issues to be interpreted and translated by constellations of stakeholders. Because they are so complex or wicked the process of making them actionable in a meaningful way must meet certain requirements in terms of how the process of interpretation is orchestrated and who should be involved in the process. This is captured by the design arrow between issues and actors. We saw in chapter 4 that design thinking is emerging as a fruitful approach to cope with complexity in such a way that differing interpretations and intentions can be represented and lead to a shared interpretation that is meaningful and actionable. The typical feature of applying design thinking is to work with visualisation of ideas and concepts and use prototypes that are provisional but "testable". This means that many views, perspectives and constraints are shaped into a "totality" and iteratively given more precise and detailed features. Using a concept from communications theory these prototypes can function as boundary objects that allow conversation and sense-making between actors with very diverse backgrounds. As we showed in chapter 4 theatre may also be used to open for interaction and sense-making.

However, this initial shared interpretation defines a community of stakeholders with different concrete meaning for different subgroups, individual companies, business networks, clusters or business ecosystems. So design thinking is given more precise content in various contexts because different types of users may be involved as one example or that business models differ (e.g. sustainable cities versus personalised healthcare). The term interaction fields is being used to label these different contexts and is shown by the vertical arrow linking actors to products in Fig 5-5. The word is selected to stress that in situations where there are shared problems and where there exist interdependencies between actors, interaction is a key for coordinated action (co-action) to deliver solutions that may be innovations. From an orchestration or governance perspective interaction can be based on self-organisation, network management or contractual relationships as in a strategic alliance. It may also be so that this type of dealing with complexity could be useful for designing a relevant policy mix instead of hoping for ministries/governments to sort this out in administrative fashion. Having this

kind of iterative process is especially important if innovation is expected to occur by (re)combination of concepts and assets from different sources or contexts, via path interdependencies as referred to in chapter 4.

Figure 5.5 Elements of orchestration



This leads to the link between issues and capacities. Seen from the issue-actors perspective the design process is about expression of (collective) intent which implies different types of requirements in terms of capacities like knowledge, production or distribution to be "conditioned by" available capacities and capabilities. In the design phase these impose constraints that have to be taken into account. Collaboration can be one way to overcome constraints or in other words to improve and strengthen capabilities. Constraints are also very important from a governance or orchestration perspective in that rules and regulations can be both drivers and barriers for innovation. Multi- level governance can also be seen as being about defining, enforcing and overcoming or dismantling constraints. So, constraints operate as a link between issues and capacities while capabilities act as a link between capacities and serving markets with products. Constraints can exist as available technological expertise, access to markets etc. In short therefore orchestration deals with design, interaction fields, constraints and capabilities to promote innovation that is not only technical but also social and organisational. This is necessary in a program that addresses Grand Challenges according to figure 5.5.

In a study with a business strategy perspective on wicked problems John Camillus presents four techniques to deal with them

- Involve stakeholders, document opinions, and communicate
- Define the corporate identity
- Focus on action (muddling through, learn from experiments)
- Adopt a "feed-forward" orientation, (envisioning, design thinking)

Given what has been said about the non-reductionist approach the first step is to apply design thinking to make grand challenges actionable while maintaining a sense of the big picture guiding the process of translation and negotiation that is at the core of

this. Applying design thinking starts with the explorative question "What might be the solution?" (to the mystery; Fig. 4.3) This is iteratively given shape and contour via experimenting and prototyping by, for example, using Living Labs. In a collaborative setting this process is a co-creative effort with learning, interpretation and negotiation from individual to group and back to individual, leading to provisional shared interpretation of what might be actionable.

How to compose a relevant policy mix?

The process described above is inclusive in the design phase so that in principle public agencies should be involved and giver their contributions in the translation/ specification process. In principle this kind of interagency collaboration is asked for and allowed in the Swedish governance system. In practice it does not work so well. There exist both formal and informal blockages to interaction that might increase the connectivity between ministries and agencies. One is that policy design of "ill defined" issues have been left to special investigators (särskilda utredare) or to parliamentary commissions in part because the organising idea for ministries and agencies is to reflect independence rather than interdependence. That means that collaborative governance that as a rule must be founded on the perception of interdependence and "shared fate" is not the first response to complexity. For agencies to participate in collaborative design processes with other groups of stakeholders might also in some instances be considered to be at odds with impartiality. For these reasons it might be advisable to develop collaborative thinking and training for public actors in Sweden on "issue driven policy design and collaborative governance". The work with a national innovation strategy might be a good example to start with. The fact that several regions are doing the same strategizing for their regions adds further strength to the idea.

The next step is managing e the interfaces between ministries and agencies in the implementation of a designed policy mix. Remember then the message about actors having a repertoire of actions of which some were activated by whole-parts "causation". The collaboration in the US between the Eeconomic Development Agency (EDA) and other national agencies concerning Regional Innovation Clusters seems for an outsider to follow that logic. The entry point is a call about proof of concept launched by EDA where successful applicants can leverage funds received by getting additional funds from about 8-10 other agencies if certain provisions are met. Collaboration here is issue based.

That is also the case with the collaboration between VINNOVA and Tillväxtverket concerning cluster policy where in addition *shared* practice developed over a longer time period facilitates the successful collaboration between these agencies. This experience lends some evidence to the hypothesis that joint implementation will not be successful unless it is based on joint design.

References

Althusser, L. & Balibar, E. (1970) *Reading Capital*, London, Verso

Arthur, B, Durlauf, S. & Lane, D. (1997) *The Economy as an Evolving Complex System II*, Reading, MA, Addison-Wesley

Arthur, B. (2009) *The Nature of Technology*, London, Penguin

Ashby, W.R. (1968). Variety, constraint, and the law of requisite variety, reprinted in E:CO Issue Vol. 13 Nos. 1-2 2011 pp. 190-207

Australian Public Service Commission (2007) *Tackling Wicked Problems – A Public Service Perspective*, Commonwealth of Australia

Blair, T. (2010) *A Journey*, London, Hutchinson

Boje, D. (2008) *Storytelling Organizations*, London, Sage

Boisot, M.H & MacMillan I.C & Han S.K (2007) *Explorations in Information Space*, Oxford, Oxford University Press

Boisot, M. and Child, J. (1999), ``*Organizations as adaptive systems in complex environments: the case of China*", Organization Science, Vol. 10 No. 3, pp. 237-52

Burt, R. (1992) *Structural Holes: The Social Structure of Competition*, Cambridge MA, Harvard University Press

Camillus, J.C. (2008) *Strategy as a Wicked Problem*, Harvard Business Review, May 2008, Harvard Business School Press

Carlile, P (2002) *A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development*, Organization Science, Vol. 13, No. 4, pp. 442–455

Chesbrough, H. (2003) *Open Innovation*, Boston, Harvard Business School Press

Churchman,C W. (1967) *Wicked Problems*, Guest Editorial, Management Science, 14: B141-142, 1967

Cilliers, P. (2001). *Boundaries, hierarchies and networks in complex systems*. International Journal of Innovation Management, 5 (2): pp. 135–147.

Cooke, P. (2010b) Regional innovation systems: development opportunities from the 'green turn', *Technology Analysis and Strategic Management*, 22, 831-844

Cooke, P. (2007) *Growth Cultures: the Global Bioeconomy and its Bioregions*, London, Routledge

Cooke, P, De Laurentis, C, Tödtling, F. & Trippl, M. (2007) *Regional Knowledge Economies*, Cheltenham, Edward Elgar

Cooke, P, De Laurentis, C, MacNeill, S. & Collinge, C. (eds.) (2010) *platforms of Innovation*, Cheltenham, Edward Elgar

European Commission (2008) *Challenging Europe's Research: Rationales for the European Research Area (ERA)*, Report of the ERA Expert Group, Brussels, EC Directorate General for Research

European Commission (2010) *Europe 2020*, Brussels, European Commission

Folke, C. (2006) Resilience: the emergence of a perspective for social-ecological systems analysis, *Global Environmental Change*, 16, 253-267

Foray (2009) Understanding smart specialisation, in Pontikakis, D. Kyriakou, D. & van Bavel, R. (eds.) *The Question of R&D Specialisation: Perspectives and Policy Implications*, Luxembourg, EC

Frenken, K., van Oort F. & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth, Regional Studies 41, 685-697

Garud, R. and Karnøe, P. (2001) Path Creation as a Process of Mindful Deviation, in Garud, R. and Karnøe, P. (eds.) *Path Dependence and Creation*, London: Lawrence Erlbaum, 1-38

Geels, F. (2004) From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory, *Research Policy*, 33, 897-920

Geels, F. (2006) Co-evolutionary and multi-level dynamics in transitions: the transformation of aviation systems and the shift from propeller to turbojet (1930-1970), *Technovation*, 26, 999-1016

Geels, F. (2007) Analysing the breakthrough of rock 'n' roll (1930-1970): multi-regime interaction and reconfiguration in the multi-level perspective, *Technological Forecasting & Social Change*, 74, 1141-1431

Gell-Mann, M. (1995) *Let´s Call It Plectics*, Complexity, Vol 1, No 5, 1995/96

Giddens, A. (1985) *The Constitution of Society*, Cambridge, Polity

Gould, S. & Vrba, E. (2002) Exaptation – a missing term in the science of form, *Paleobiology*, 8, 4-15

Gunderson, L. & Holling, C. (eds.) (2002) *Panarchy: Understanding Transformations in Human and Natural Systems*, Washington DC, Island Press

Hajer, M.A (2009) *Authoritative Governance,* Oxford University Press

Harmaakorpi, V. (2006) Regional development platform method as a tool for regional innovation policy, *European Planning Studies*, 14, 1093-1112

Holland, J. (1995) *Hidden Order: How Adaptation Builds* Complexity, Reading, MA, Addison-Wesley

Howe, J. (2009) *Crowdsourcing*, New York, Three Rivers Press

Johnson, M. (2010) *Seizing the White Space*, Boston, Harvard Business Press

Juarrero, A (2002) *Dynamics in Action*, Cambridge MA, 'The MIT Press

Kauffman, S. (1995) *At Home in the* Universe, Oxford, Oxford University Press

Kauffman, S. (2008) *Reinventing the Sacred*, New York, Basic Books

Kemp, R. (2002) Environmental protection through technological regime shifts, in A. Jamison & H. Rohracher (eds.)*: Technology Studies and Sustainable Development,* Munich, Profil Verlag

Kim, C. & Mauborgne, R. (2005) *Blue Ocean Strategy*, Boston, Harvard Business School Press

Lane, D. (2009) Complexity and Innovation Dynamics, Reggio Emilia, University of Modena (mimeo)

Lester, R. & Piore, M. (2004) *Innovation: the Missing Dimension*, Cambridge, Harvard University Press

March, J. (1991) Exploration and exploitation in organisational learning, *Organisation Science*, 2, 71-87

Martin, Ron L. and Sunley, P. (2010) The place of path dependence in an evolutionary perspective on the economic landscape, in Boschma, R. and Martin, R.L. (Eds.) *Handbook of Evolutionary Economic Geography*, Cheltenham: Edward Elgar, pp. 62-92

Martin, Ron L. and Sunley, P. Forms of emergence and the evolution of economic landscapes (2011) *Journal of Economics of Business and Organisation* (forthcoming)

Martin, Roger L. (2009) *The Design of Business*, Boston, Harvard Business Press

Maturana, H., & Varela. F. (1980). Autopoiesis and cognition: The realization of the living. Boston: Reidel.

Midgley, G (2000) *Systemic Intervention: Philosophy, Methodology, and Practice*, Kluwer Academic/Plenum Publishers

Mitleton-Kelly, E (2011) *Identifying The Multi-Dimensional Problem-Space And Co-Creating An Enabling Environment*, E:CO Vol. 13, Issue 1-2, p 1-25

Mitleton-Kelly E. (2003). *Ten principles of complexity and enabling infrastructures, in E. Mitleton-Kelly (ed.), Complex Systems and Evolutionary Perspectives on Organizations: The Application of Complexity Theory to Organizations*, ISBN 9780080439570.

Nonaka, I. & Takeuchi, H. (1995) *The Knowledge-Creating Company*, Oxford, Oxford University Press

Page, S. (2007) *The Difference*, Princeton, Princeton University Press

Pässilä, A. & Oikarinen, T. (2010) Research-based theatre as a facilitator for organizational learning, in Meusberger, P. & Berthoin-Antal, A. (eds.) *Knowledge in Organizations – Learning Organizations*, Berlin, Springer

Scharmer, O. (2007) *Theory U: Leading from the Future as it Emerges*, San Francisco, Barrett-Koehler

Schreyögg, G. & Höpfl, H. (2004) Theatre and organisation: editorial introduction, *Organisation Studies*, 25, 691-704

Seely Brown, John; John Hagel III, Lang Davison (April 2010). *The Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion*. Basic Books.

Shannon, C. (1948). *A Mathematical Theory of Communication.* Bell System Technical Journal 27 (July and October): pp. 379–423, 623–656.

Shirkey, C. (2010) *Here Comes Everybody*, London, penguin

Shotter, J. (1993) *Conversational Realities: Constructing Life through Language*, London, Sage

Simon, H. (1973) The organization of a complex system, in Pattee, H. (ed.) *Hierarchy Theory*, New York, George Braziller

Stacey, R. (2002) *Strategic management and organisational dynamics: the challenge of complexity.* 3rd ed. Harlow: Prentice Hall

Stacey, R. (2001) *Complex Responsive Processes in Organisations: Learning and Knowledge Creation*, London, Routledge

Star SL & Griesemer JR (1989). *Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology*, 1907-39". Social Studies of Science 19 (4): 387–420.

Storper, M (1997) *The regional world: territorial development in a global economy.* New York, The Guilford Press

Thelen, E., & Smith, L. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT Press.

Verganti, R. (2006) Innovating through design, *Harvard Business Review*, December, Reprint R0612G, 1-9

Verganti, R. (2009) *Design Driven Innovation*, Boston, Harvard Business Press

Von Hippel, E. (2005) *Democratizing Innovation*, Cambridge, MIT Press

Weaver, W & Shannon, C. (1963). *The Mathematical Theory of Communication*. Univ. of Illinois Press. ISBN 0252725484.

Weick, K. (1995) *Sensemaking in Organisations*, London, Sage

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