University of Sussex
SPRU – Science & Technology Policy Research

Sussex Energy Group

STEPS centre

The Dynamics of Sustainability

durability, stability, resilience and robustness

Andy Stirling

presentation to ESRC / Environment Agency workshop on
'*Complexity Economics for Sustainability*', Oxford, 28th November 2008

University of Sussex
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Dynamic Sub-properties of Sustainability

durability, stability, resilience and robustness

- from **sustainability** to ‘resilience’
- the objects of resilience – specific **qualities**
- the dynamics of resilience – key **properties**
- from properties to **strategies**
- a focus on **diversity**
- sustainability as complex dynamics

Andy Stirling

presentation to conference of the TERESA Project on
‘*Rural Potentials for Rural Development*’, Vienna, 27th November 2008

Resilience and Sustainability

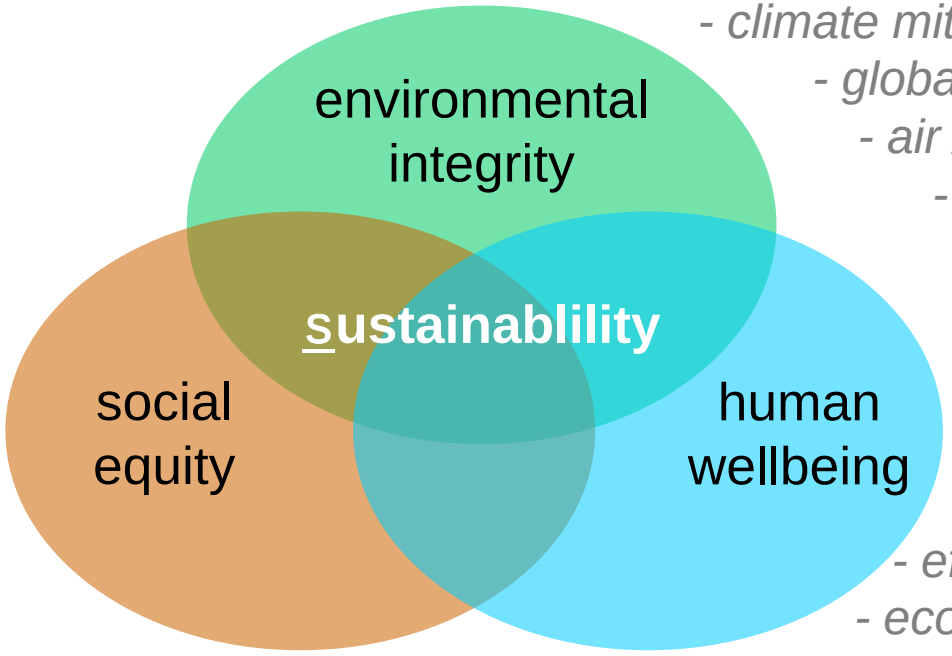
‘Sustainability’ = “maintenance of something indefinitely over time”

‘Resilience’ = the … act of rebounding or springing back”

Both are adjectives; what noun? What is ‘maintained’? What ‘rebounds’?

After Brundtland (1987); Rio (1992), Millenium Development Goals (2001)

Specific objects of “Sustainability” policy are the **‘Brundtland qualities’**:



- climate mitigation / adaptation
- global / local biodiversity
- air / water / soil quality
- culture / aesthetics

- political equality
- community involvement
- social cohesion

- quality of life
- poverty reduction
- efficiency/productivity
- economic development
- employment / livelihoods

The Objects of Resilience?

Non-specific ‘resilience’, like ‘sustainability’, is open to expediency

eg: UK DEFRA sustainability indicators include pesticide use

all agricultural activities referred to as ‘sustainable farming’

thus: support for pesticide programmes is ‘sustainable’

pesticide support at DEFRA agencies is ‘sustainable science’

Conventional approaches conflate structure and function

resilience *“(1) the amount of change a system can undergo and still retain the same controls on* ***function and structure****, or still be in the same state, within the same domain of attraction”*

Resilience Alliance, 2003

Purely ecological structures – may be synonymous with function
But with social dimension – structure and function are different
eg: DEFRA interests, multinational firms, EU institutions, technological systems

Structural resilience is a means to an end, not an end in itself

The Objects of Resilience?

Structural resilience can militate against sustainability

eg: ‘resilient’ centralised electric infrastructure challenge **s**ustainable energy

‘resilient’ intensive farming systems challenge **s**ustainable agriculture

‘resilient’ chlorine supply chain challenges **s**ustainable materials

For functions valued positively, resilience to change is also positive

Where a structure is questionable, then its **resilience can be negative!**

Sustainability policy needs to be clear: exactly **what** is sustained / resilient?

In contexts of policy-making on sustainability …

… objects of resilience should be same specific ‘Brundtland qualities’

The Dynamics of Resilience?

Like sustainability, resilience is not just about static qualities

(like Brundtland environmental integrity, social equity, human wellbeing)

Resilience in complex socio-ecological systems *(eg: Resilience Alliance)*

Holling introduced resilience to ecology (1973) *"to understand nonlinear dynamics, such as the processes by which ecosystems maintain themselves in the face of* ***perturbation and change****"*

Berkes et al (2003) apply resilience to social-ecological systems: "*…the processes by which ecosystems maintain themselves in the face of* ***perturbation and change***"

Adger (2000) applies to institutions: "*The greater their resilience, the greater their ability to absorb shocks and* ***perturbations and*** *adapt to* ***change****.*"

But perturbation and change can hold radically contrasting implications and so can demand **very different practical policy strategies**

eg: *drought as transient* ***shock****:* *utilise water stocks, reinforce infrastructure*

drought as enduring ***stress****:* *adapt crops and agronomic practices*

Key Dimensions of Dynamics

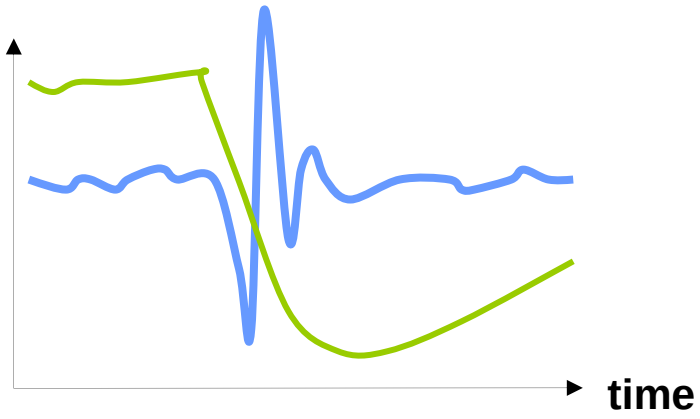
Need to distinguish two fundamentally different dimensions:

1: temporality of change – are changes manifest as:

quality level *(economic / social / environmental)*

stimulus

shocks



eg: ***price spikes***

disease outbreaks

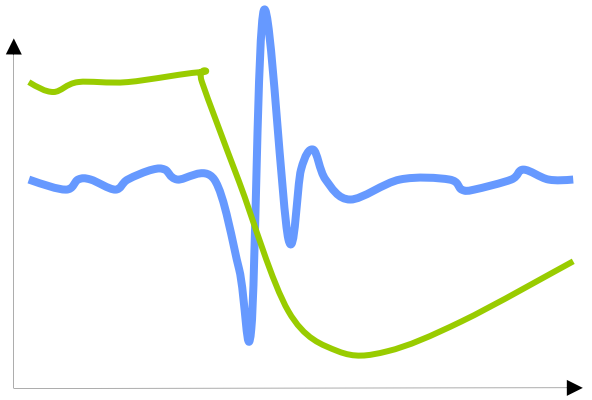
severe floods

Key Dimensions of Dynamics

Need to distinguish two fundamentally different dimensions:

2: potency of action – do interventions aim at:

shocks

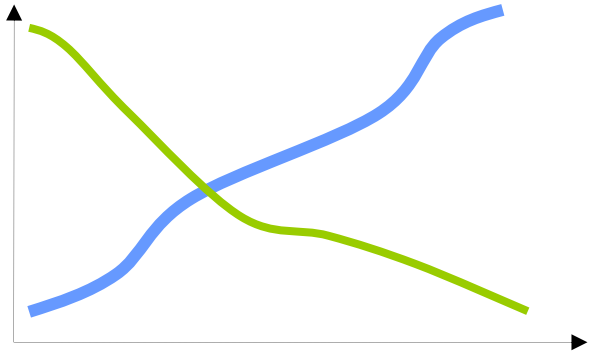


eg: price spikes

disease outbreaks

severe floods

stresses



eg: market trends

demographic shifts

climate change

Key Dimensions of Dynamics

Need to distinguish two fundamentally different dimensions:

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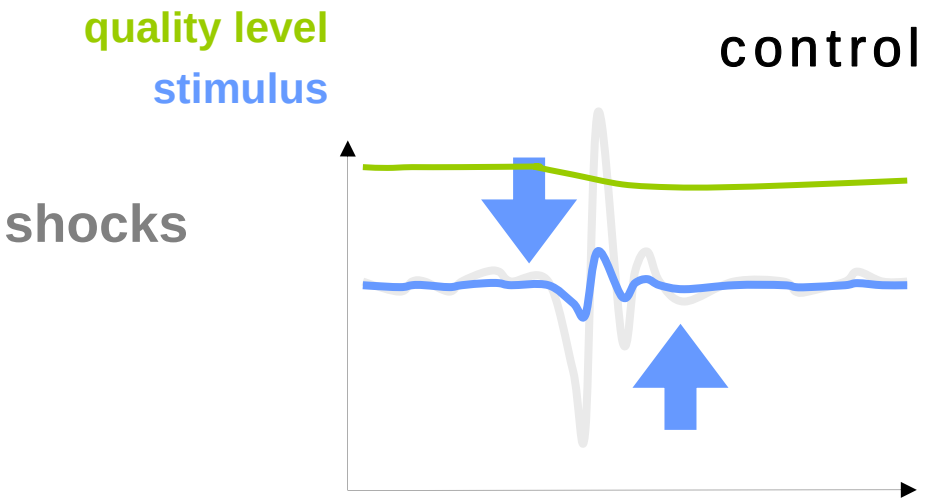

eg: regulate prices

vaccinate disease

flood defence

Key Dimensions of Dynamics

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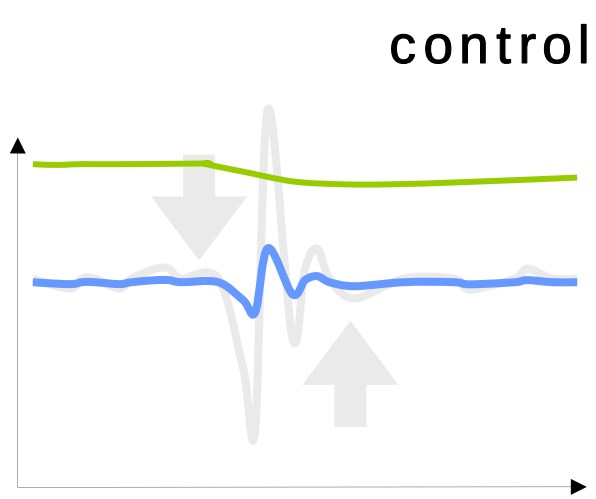

shocks

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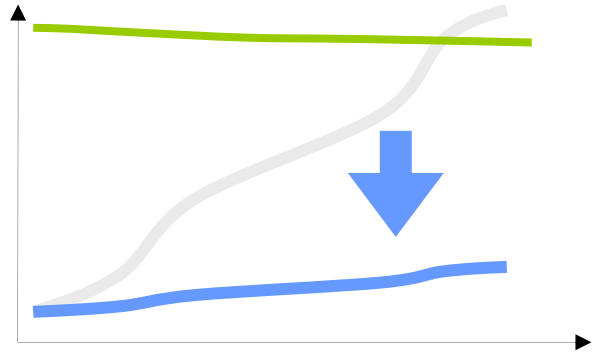

stresses

eg: market intervention

population measures

emissions abatement

Key Dimensions of Dynamics

Need to distinguish two fundamentally different dimensions:

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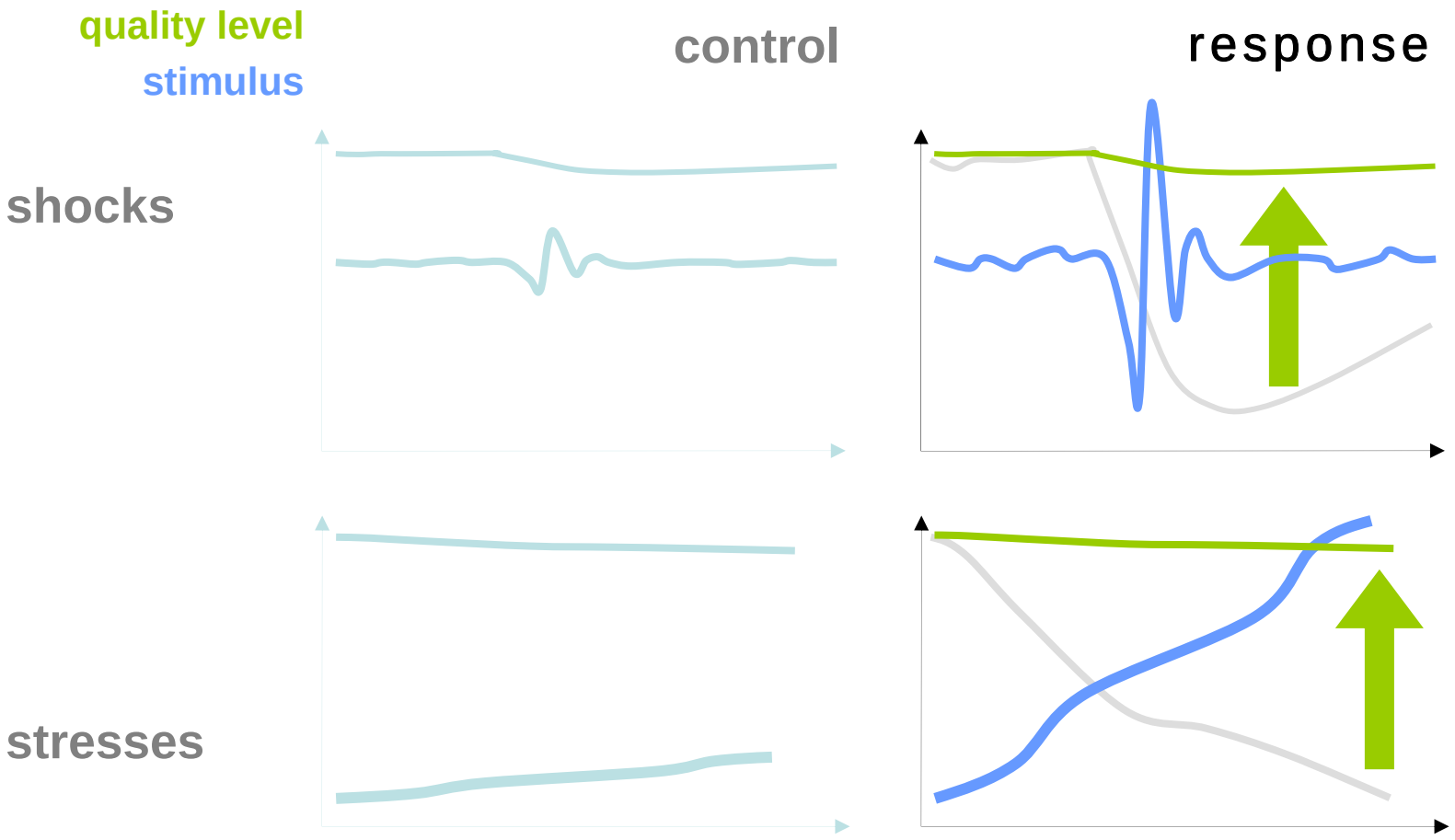
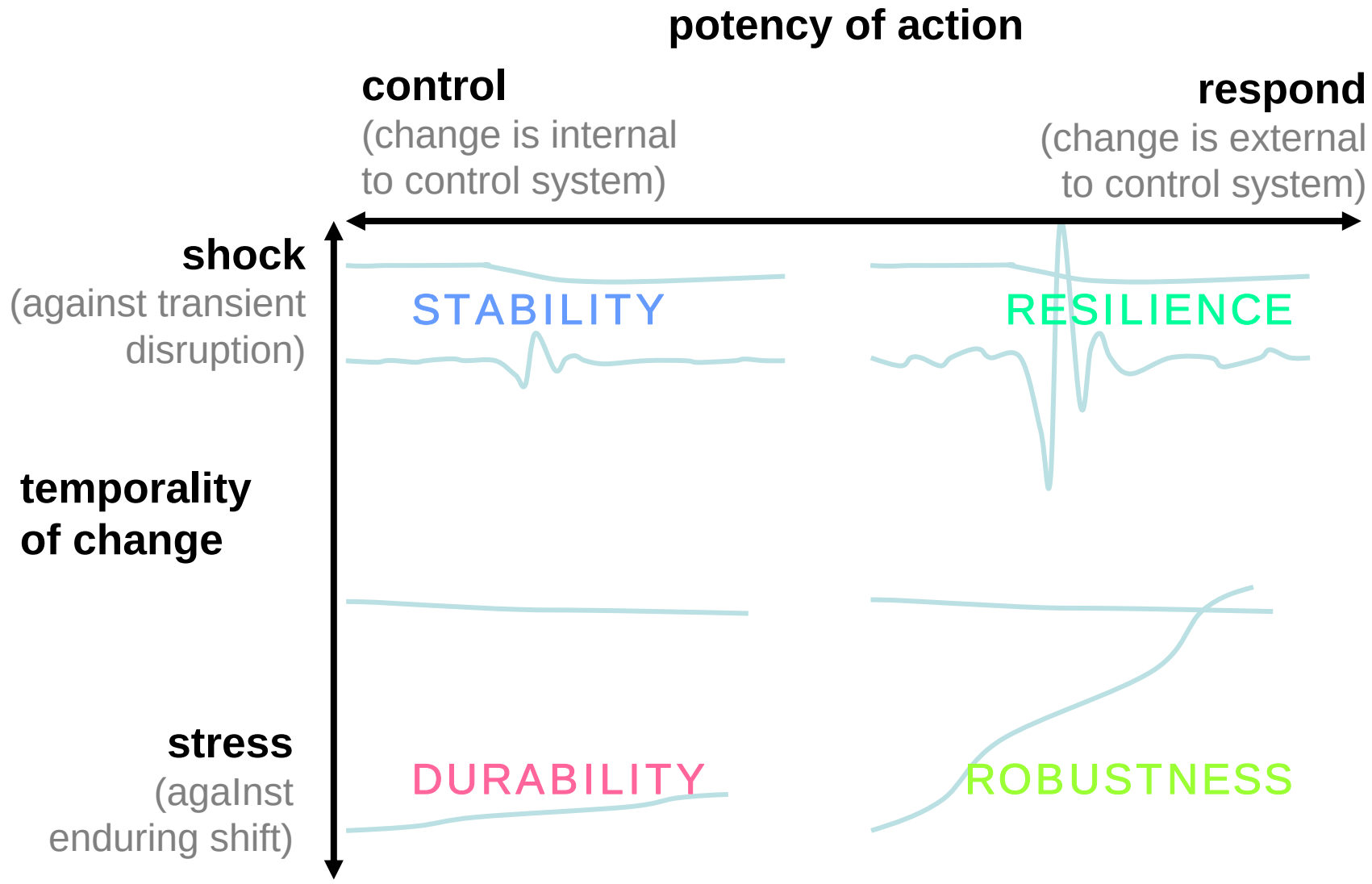


Distinguishing Dynamics

A heuristic framework



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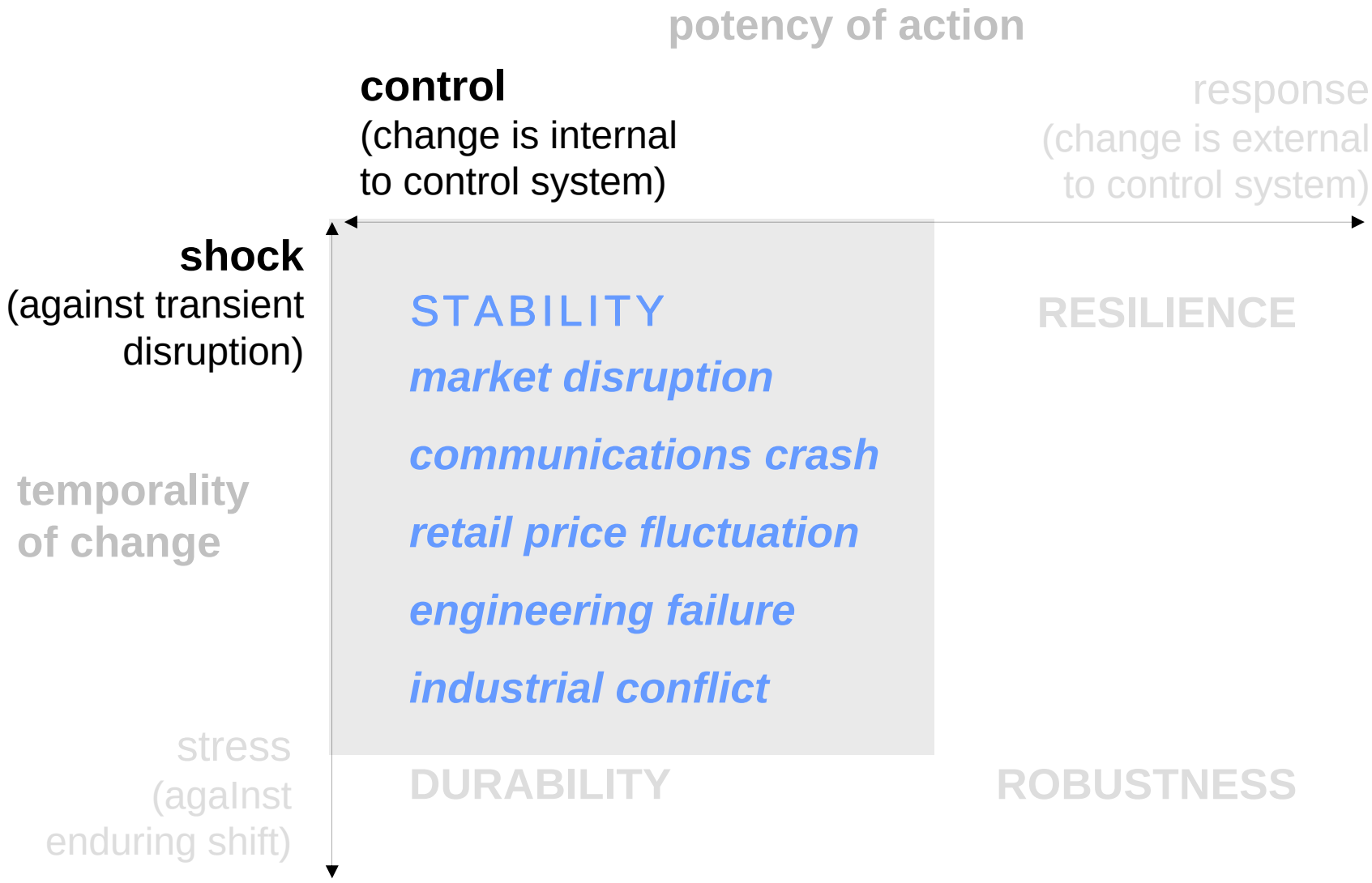

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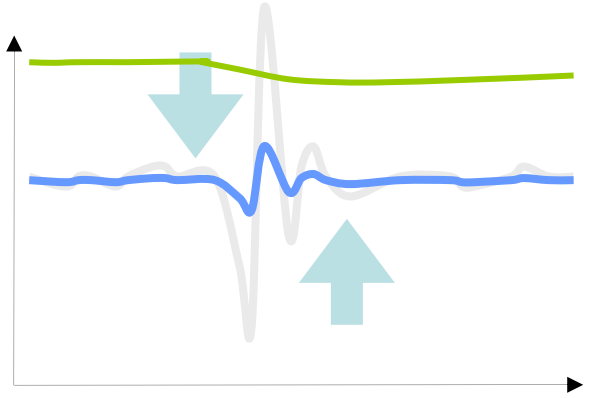
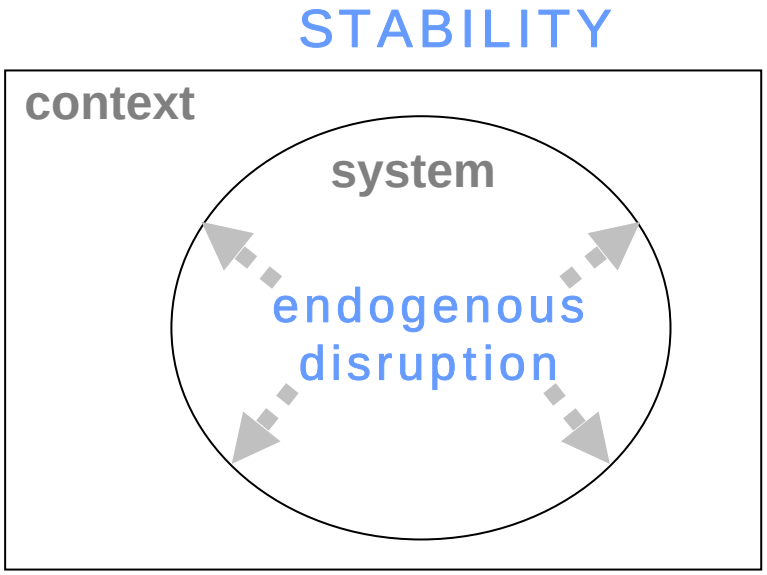




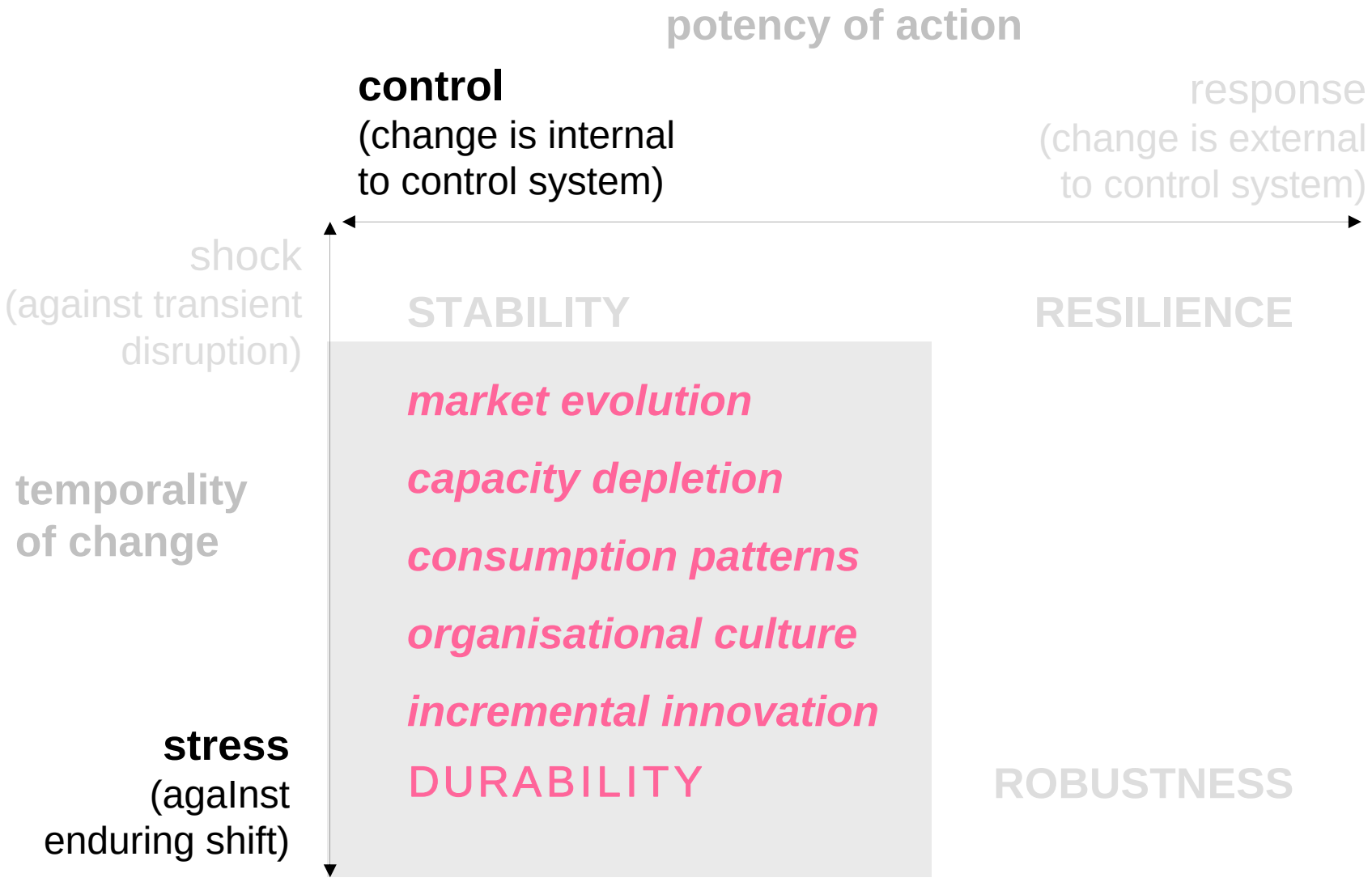
control internal shock

causes held to be broadly subject to control system

(eg: regulatory intervention
industrial relations
infrastructure repair
disease control)

Distinguishing Dynamics

A heuristic framework



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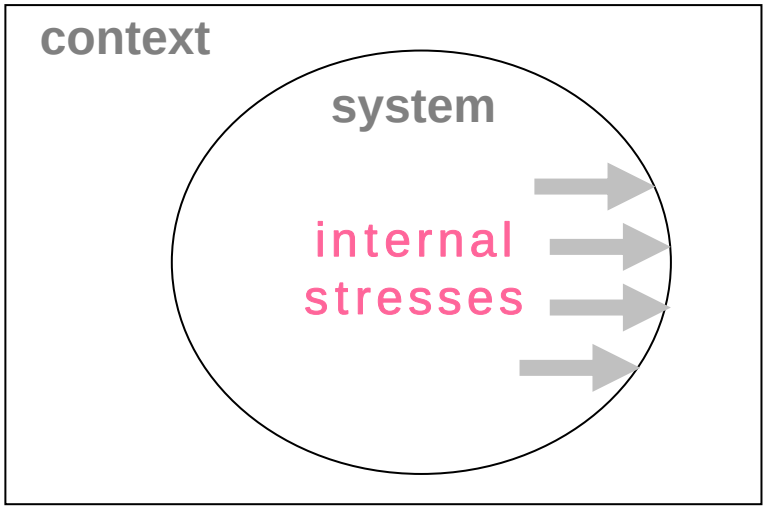
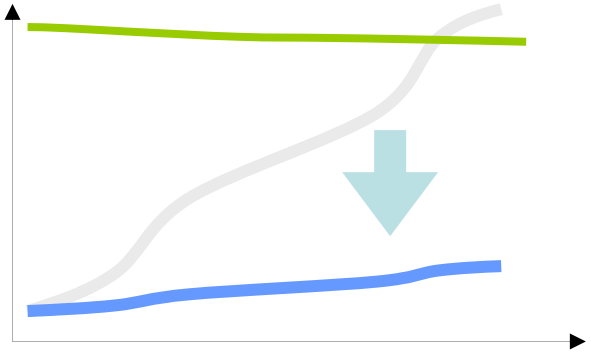
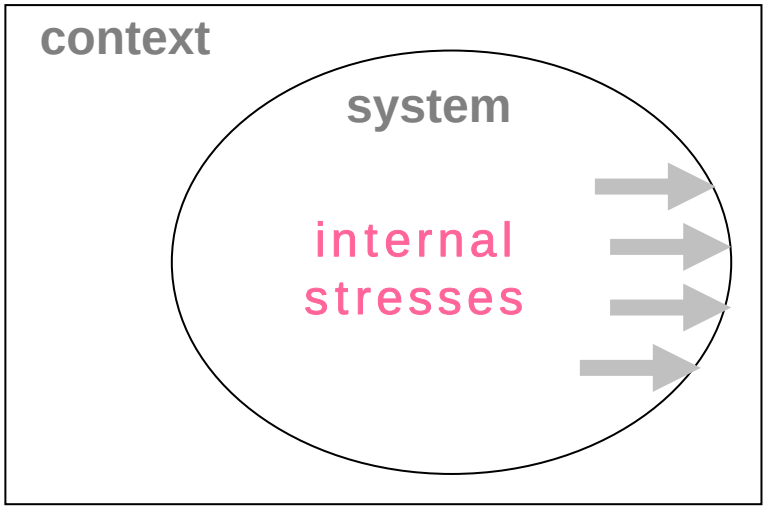


DURABILITY

Distinguishing Dynamics

A heuristic framework





DURABILITY

control internal stress

causes are held to be broadly subject to control system

(eg: resource substitution

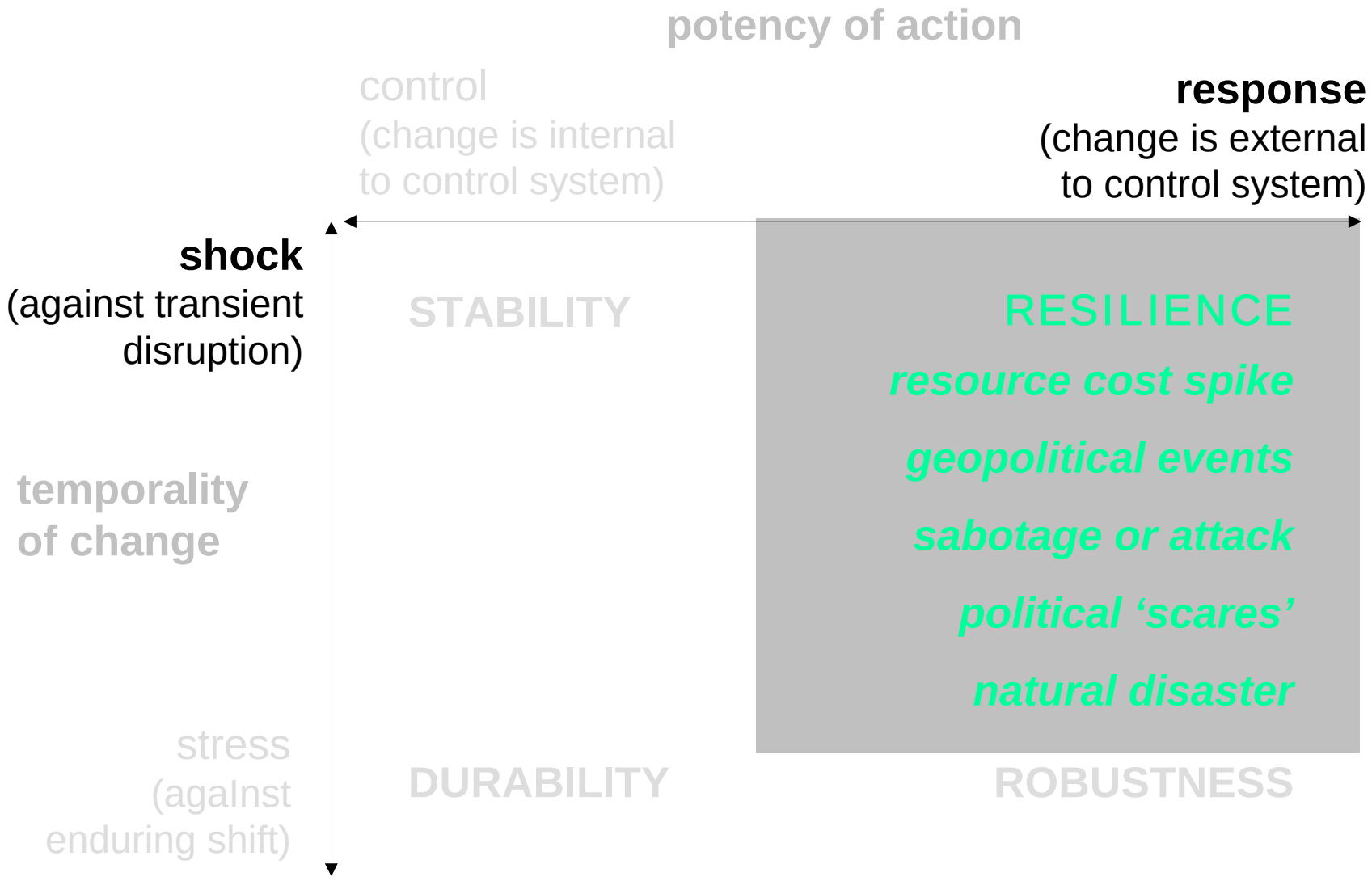
market regulation

contractual terms

innovation incentives)

Distinguishing Dynamics

A heuristic framework



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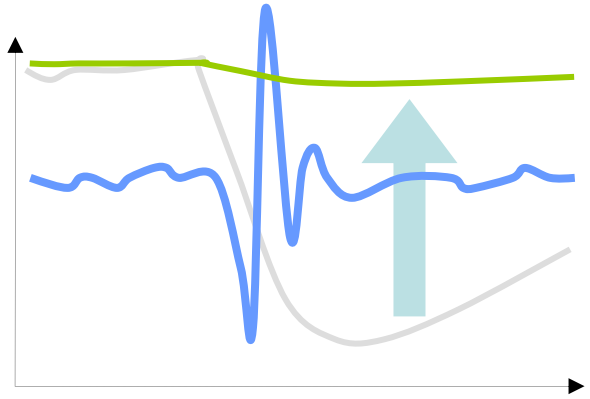


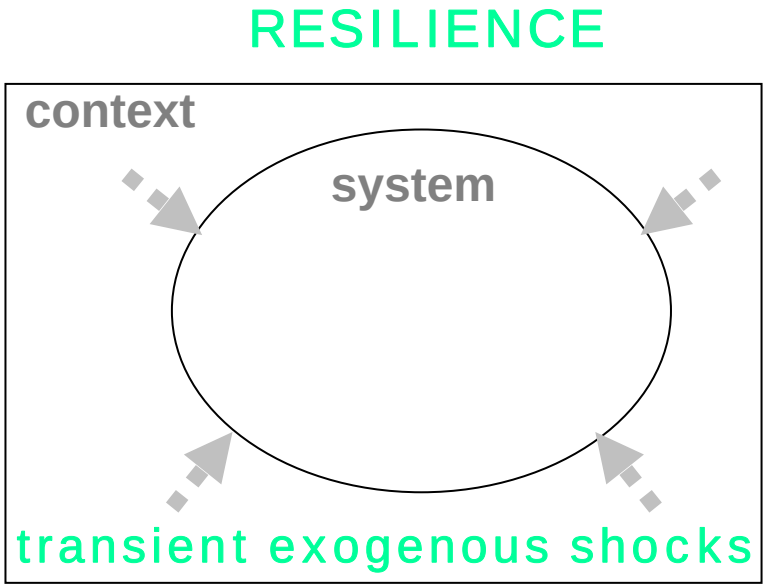
respond to external shock

causes are held to be beyond control system, so subject only to response

(eg: flexible infrastructures

redundant capacity

supply chain flexibility)



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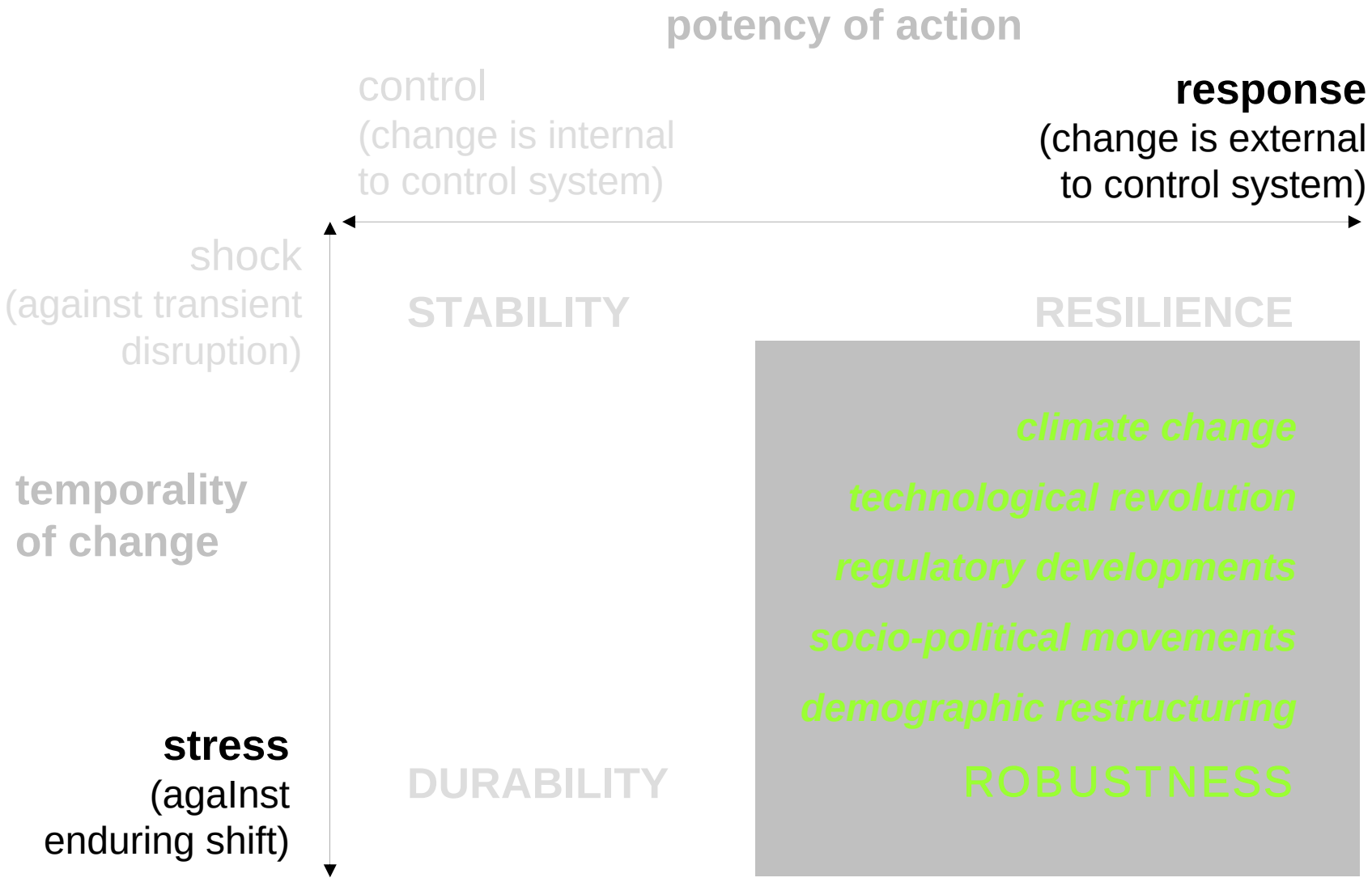

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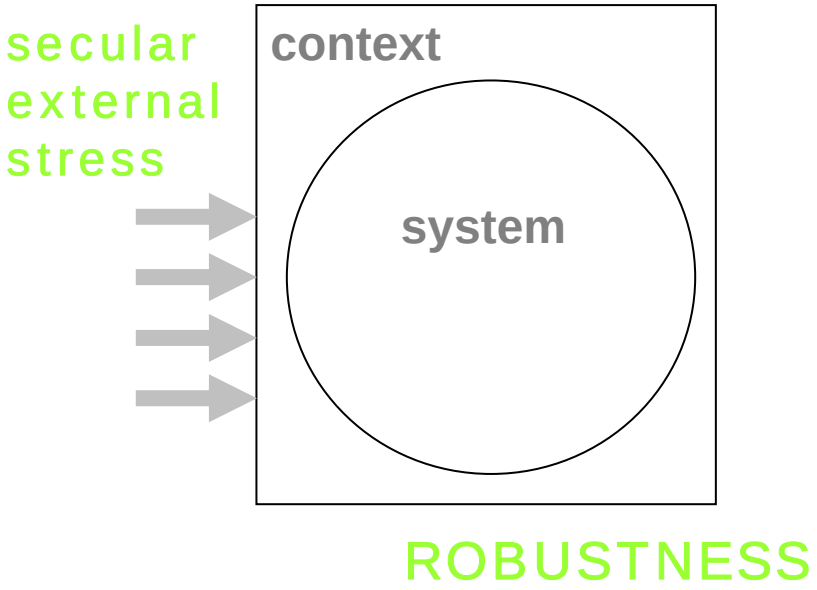

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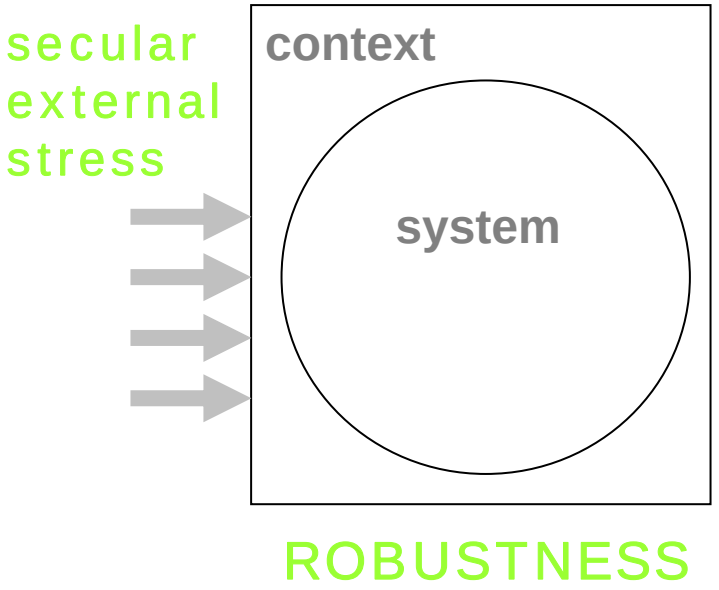

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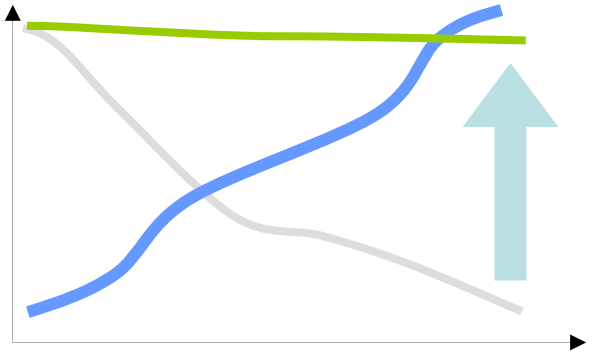
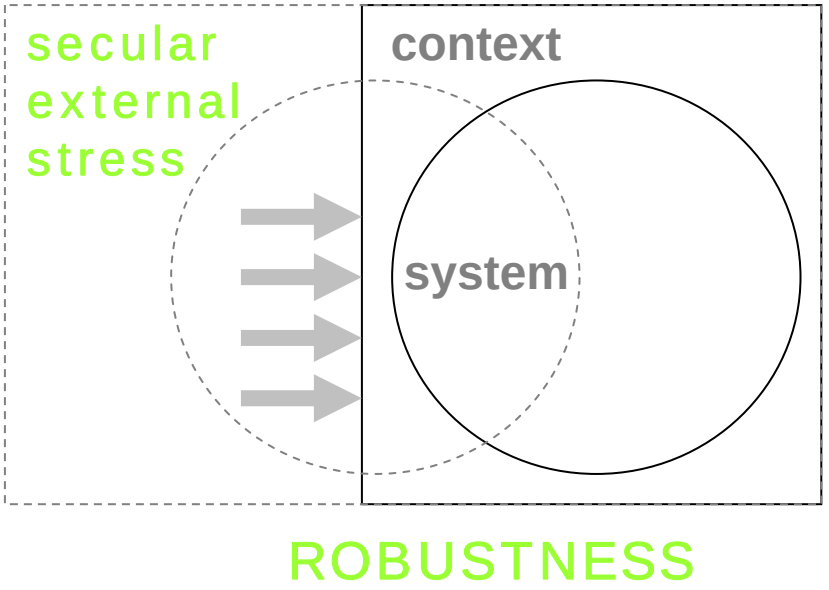


respond to external stress

causes are held to be beyond control system, so subject only to response

(eg: climate adaptation adaptive infrastructures transiton management sectoral diversification)



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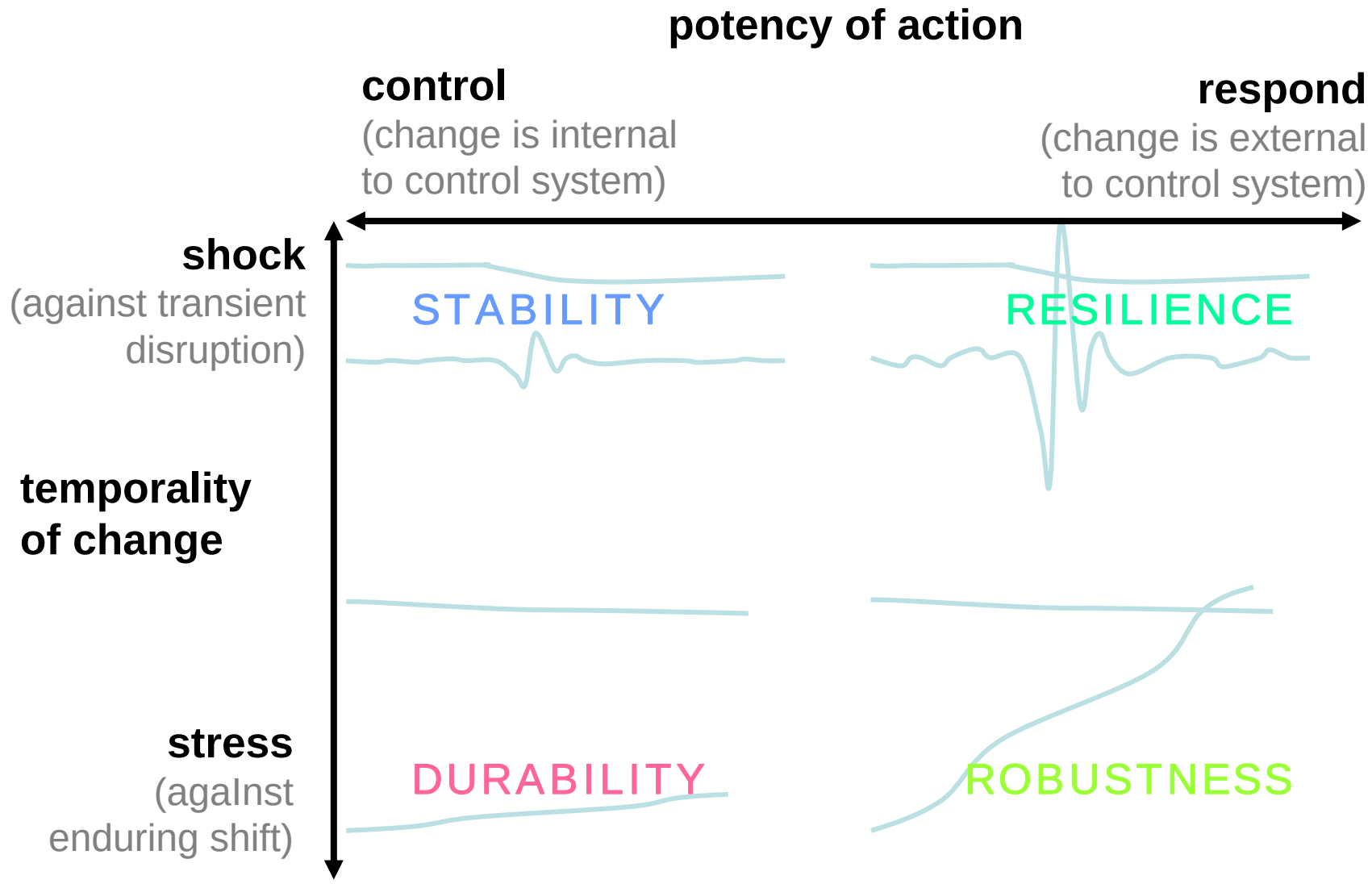
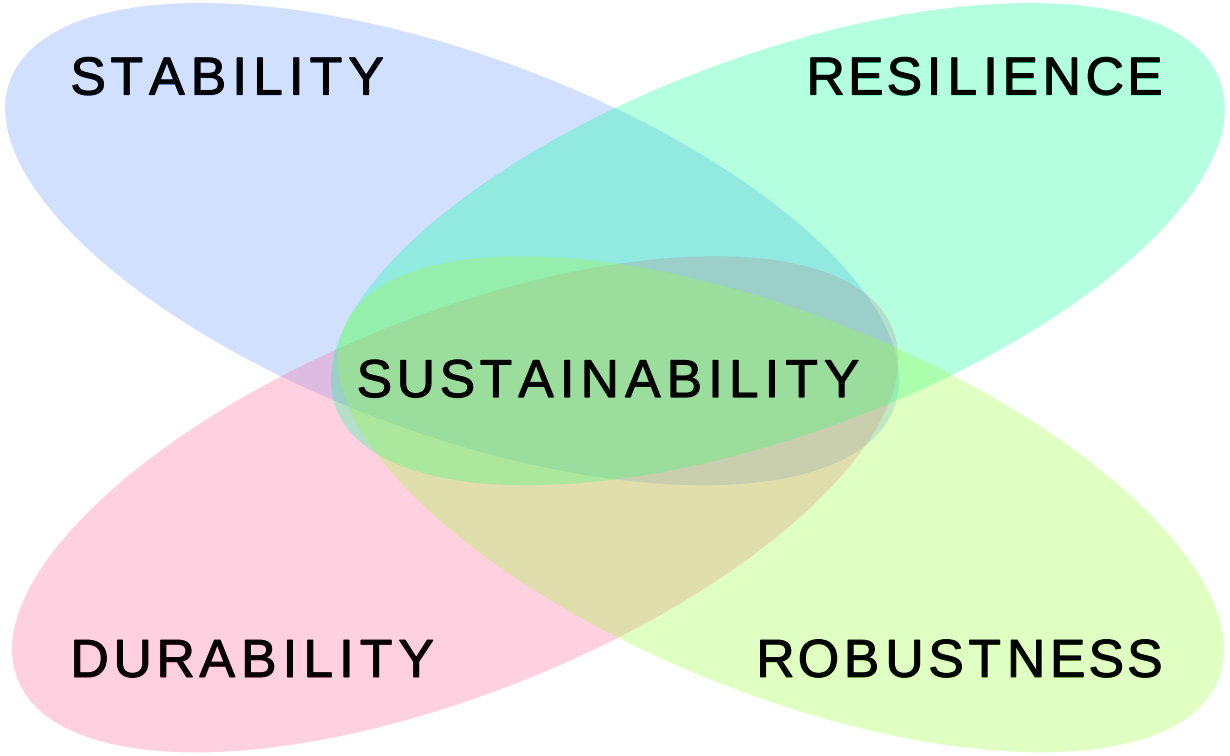


Dynamic Sub-properties of Sustainability

‘sustainability’ = “maintenance of some object indefinitely over time”

(in ‘sustainability’: object is ‘Brundtland qualities’ (environment, society, wellbeing)

To ‘maintain’ implies addressing multiple conditions of time and action:



constitute four necessary & sufficient sub-properties of sustainability

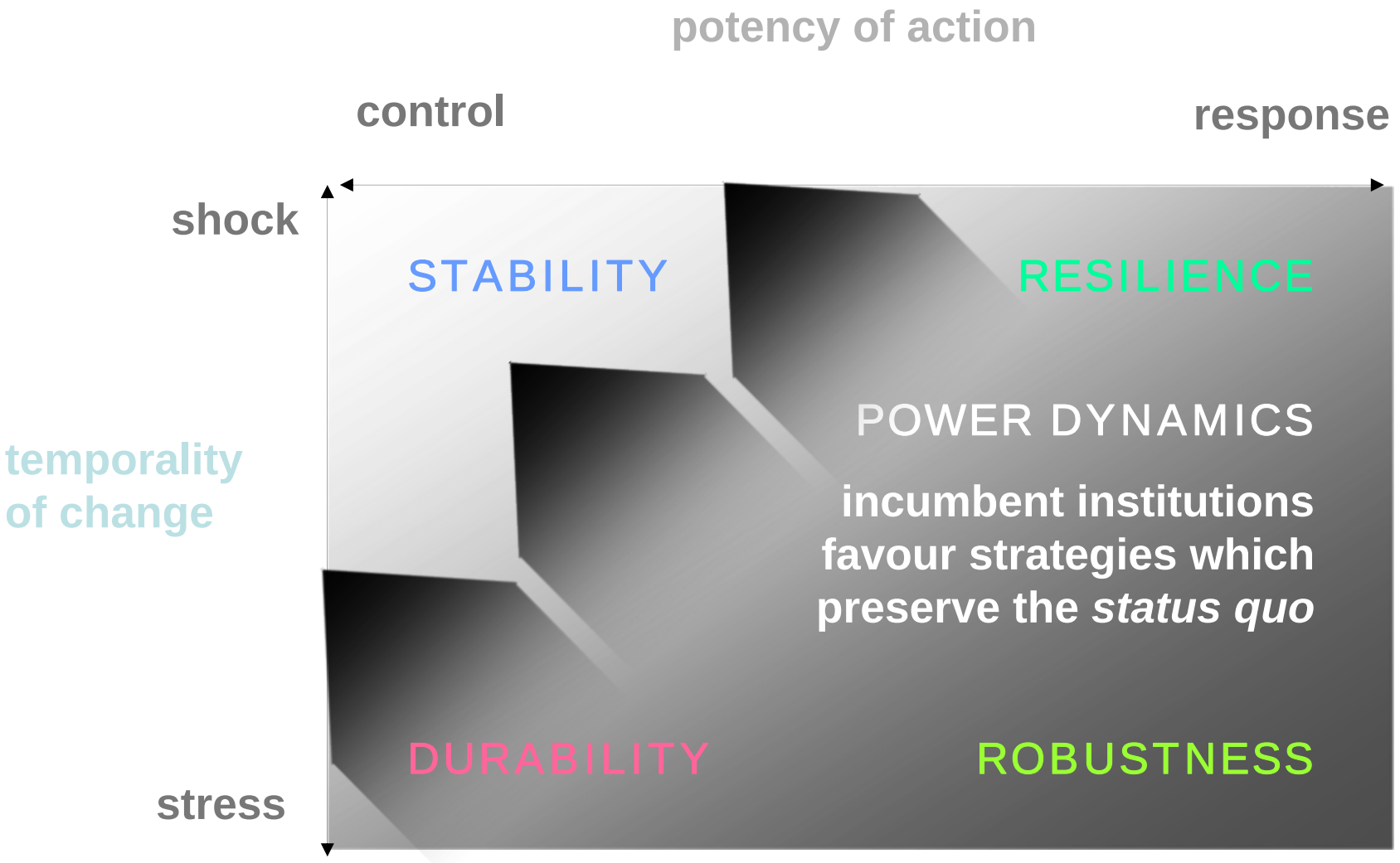
From Properties to Strategies

Examples of strategies for 'resilience' *(addressing variety of properties)**:***

Focus on **vulnerability** :	directly addresses key qualities (poverty, equity)
Attention to **legitimacy** :	provides coherent alignment of interests
Reflexive governance:	humility, irony, engagement, deliberation
Autonomous agency:	distributed, context-specific decision-making
Agile institutions**:**	can realign models, networks and practices
Adaptable infrastructures:	transformative capacity accommodates change
Responsive co-ordination:	good information and attention capabilities
Redundant resources:	modular or multiple back-up possiblities
Flexible strategies:	capacity to reverse 'lock-in' in commitments
Diverse portfolios:	balanced mix of a variety of disparate options

The Lens of Power

Power conditions ways that dynamic properties are represented



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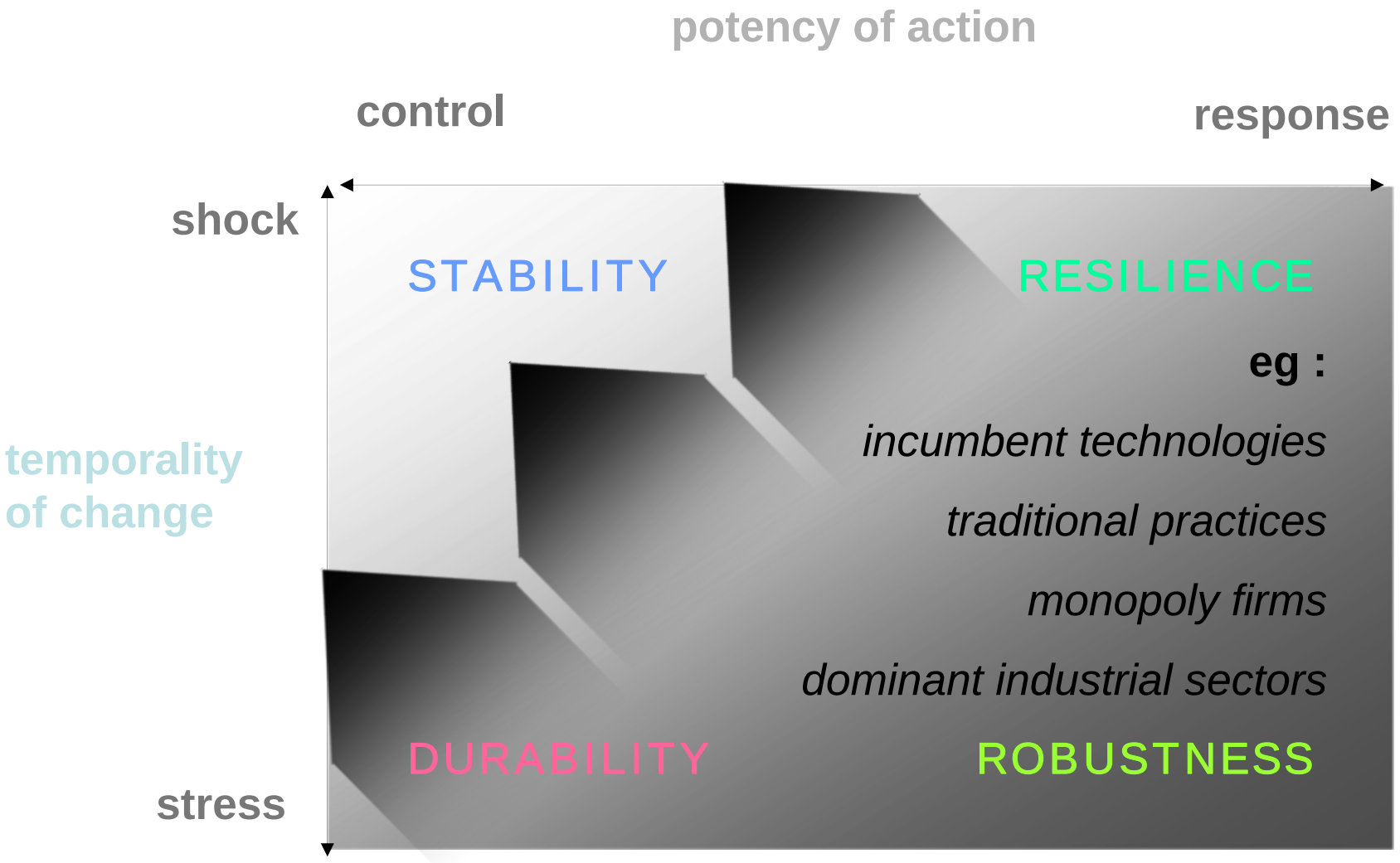
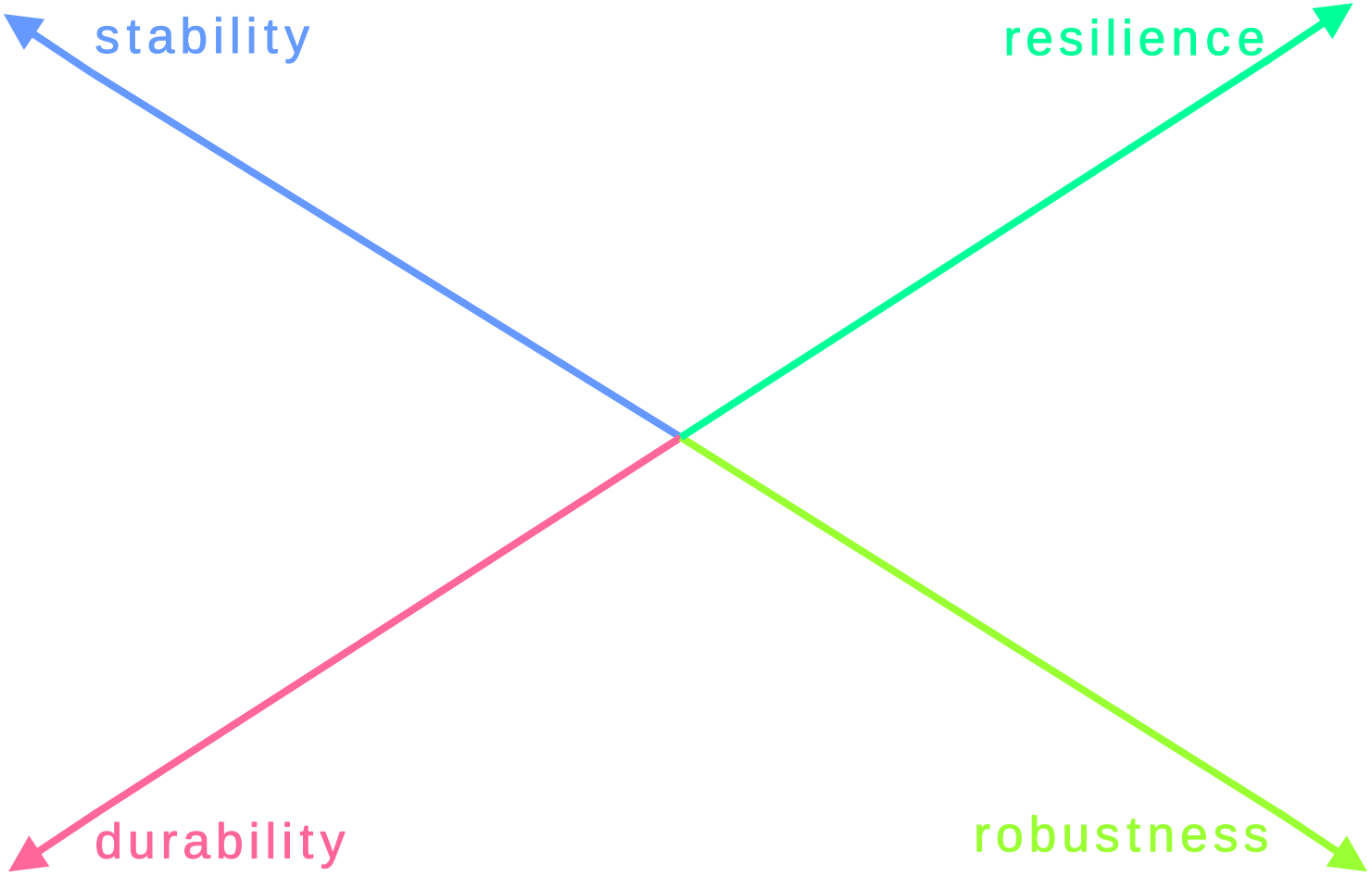


The Lens of Power

Power conditions ways that dynamic properties are represented

Strategic Implications

Hypothesis: different strategies promote different properties



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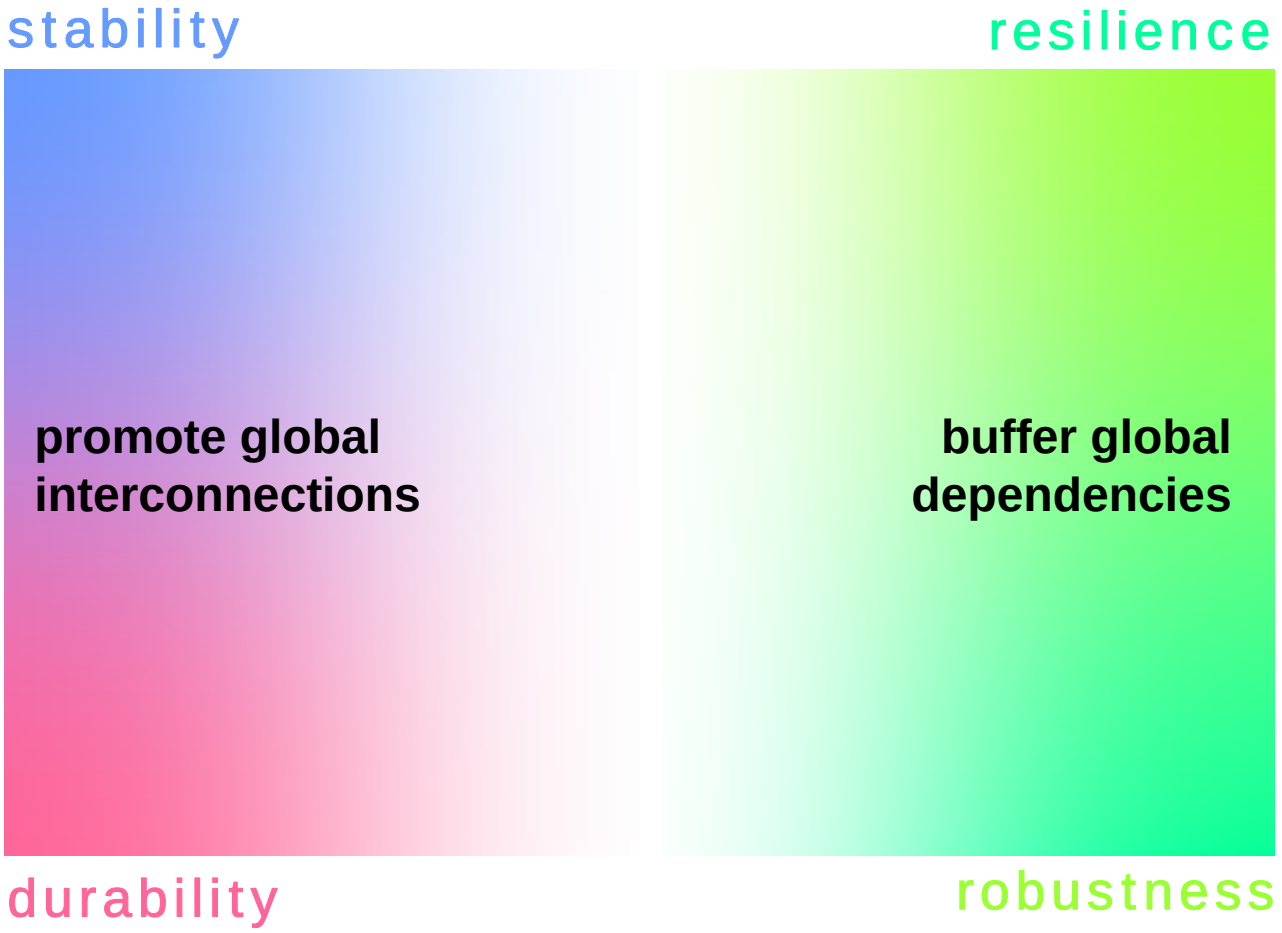

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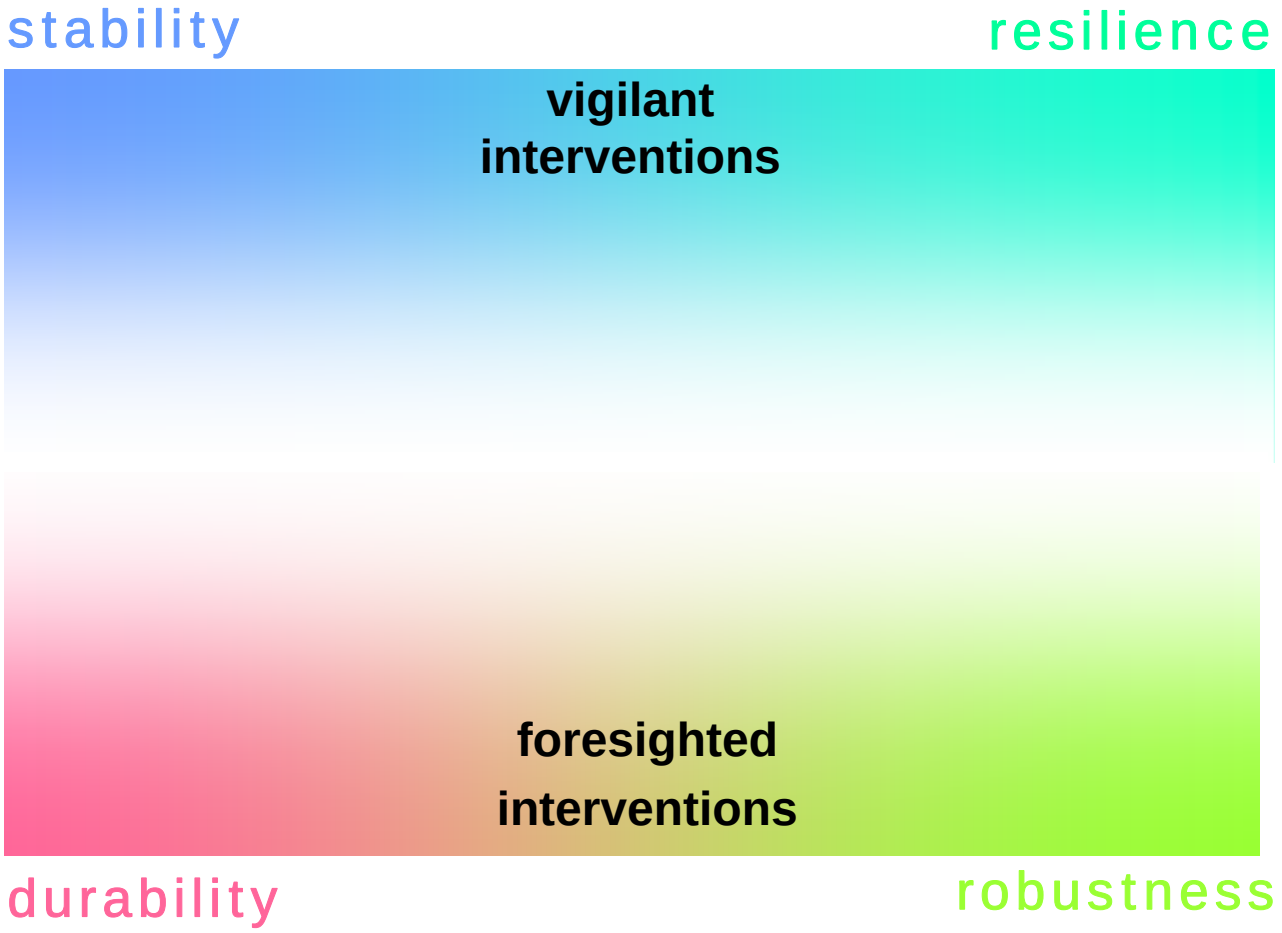

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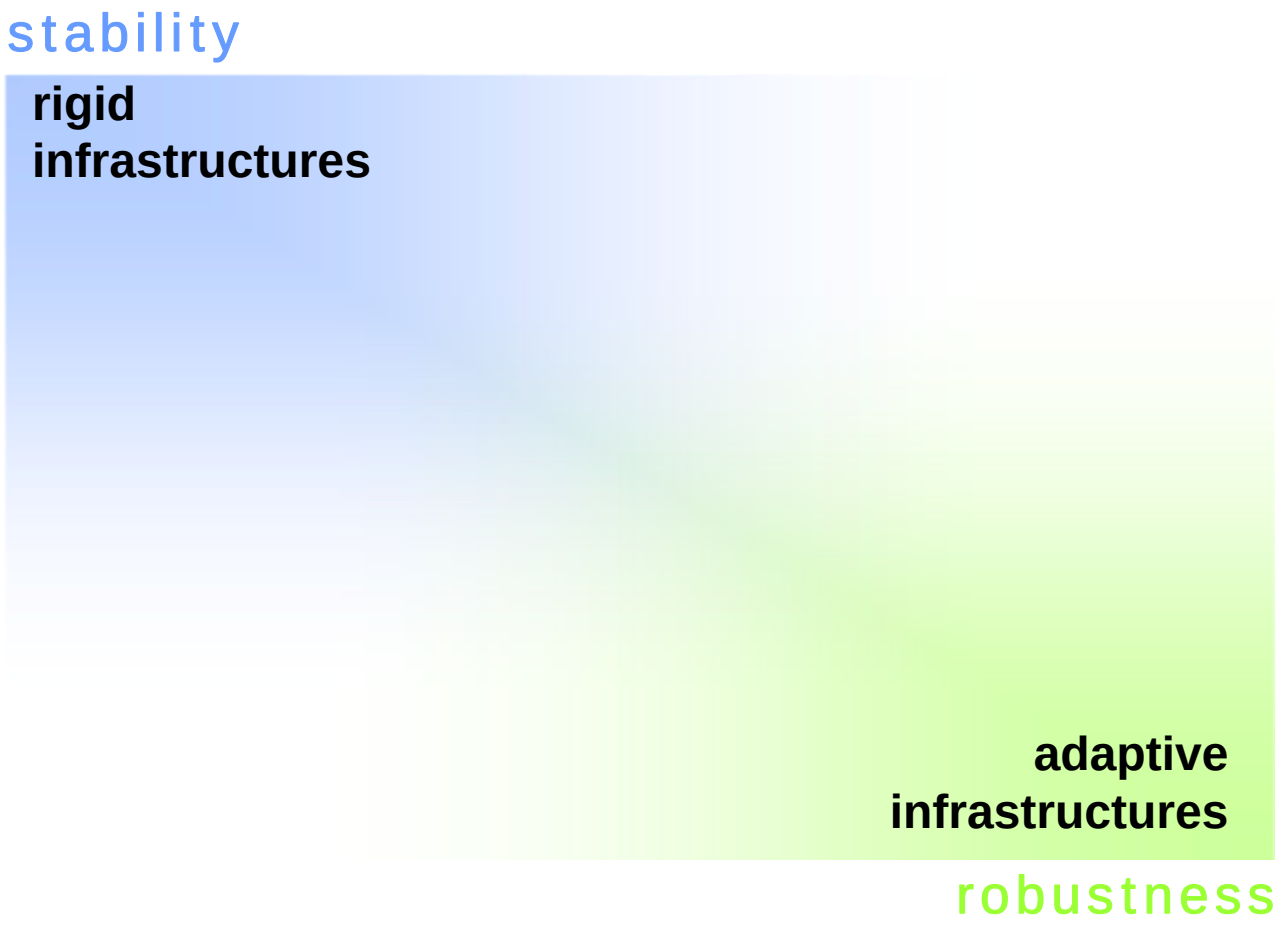

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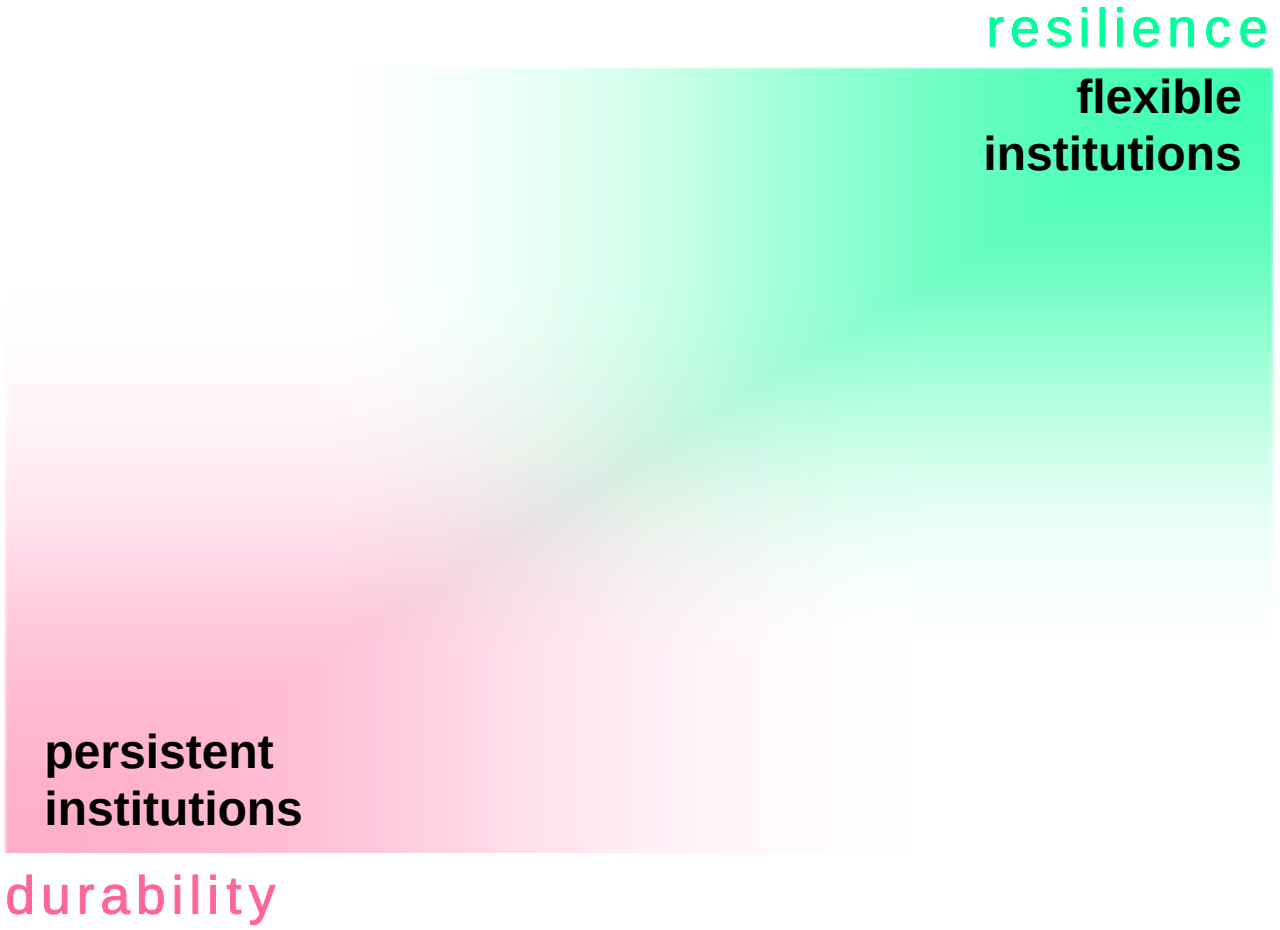

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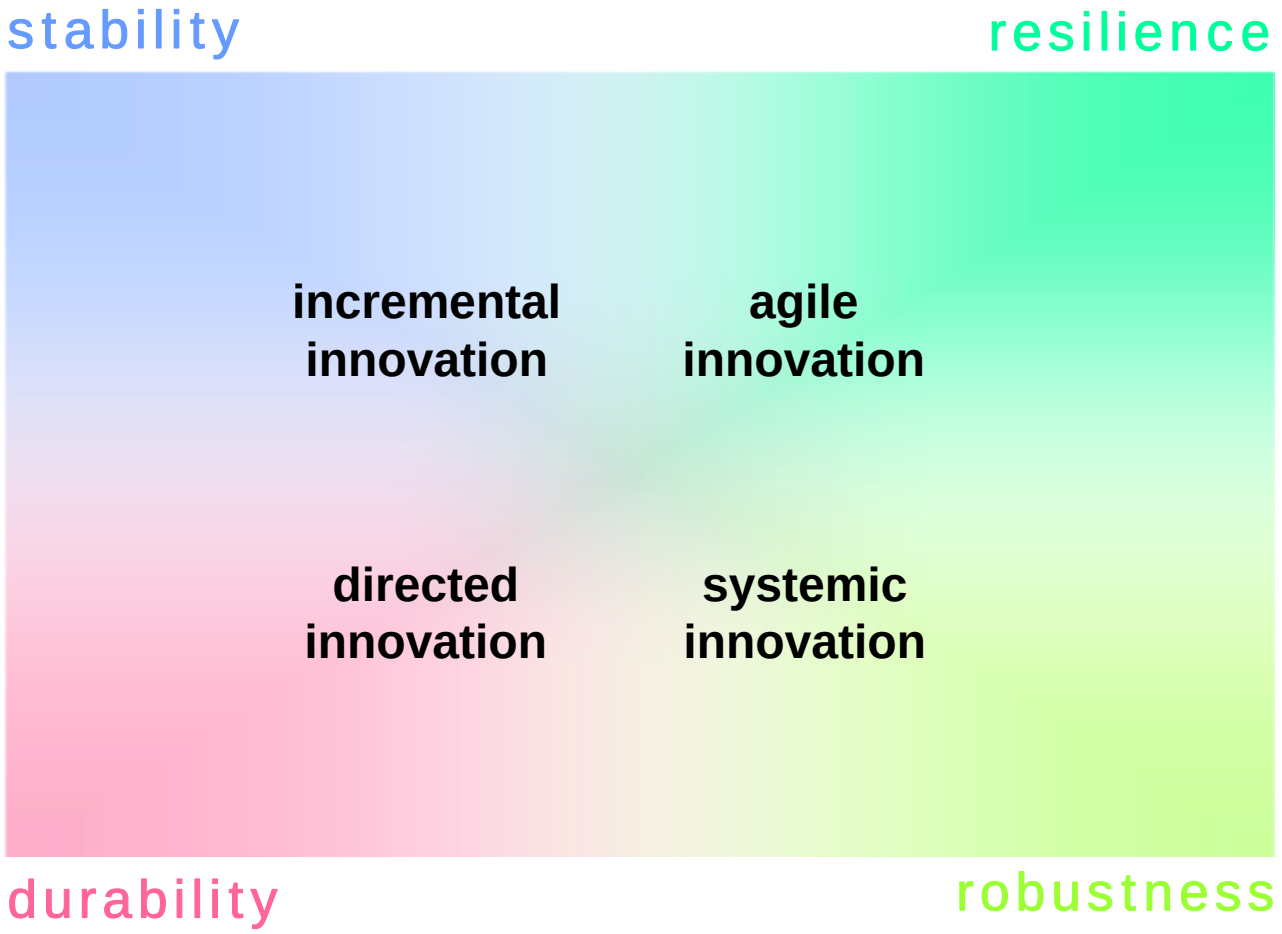
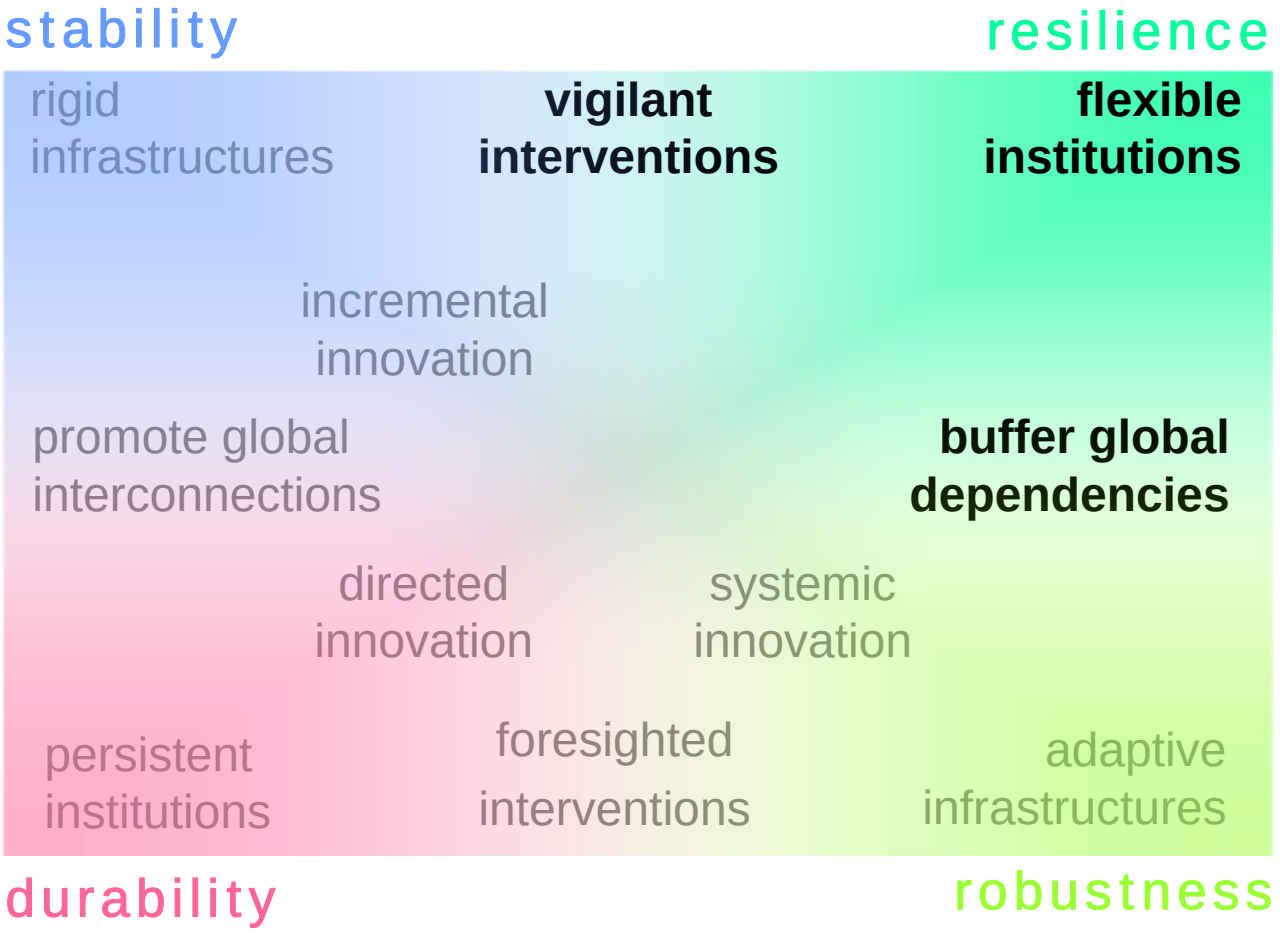


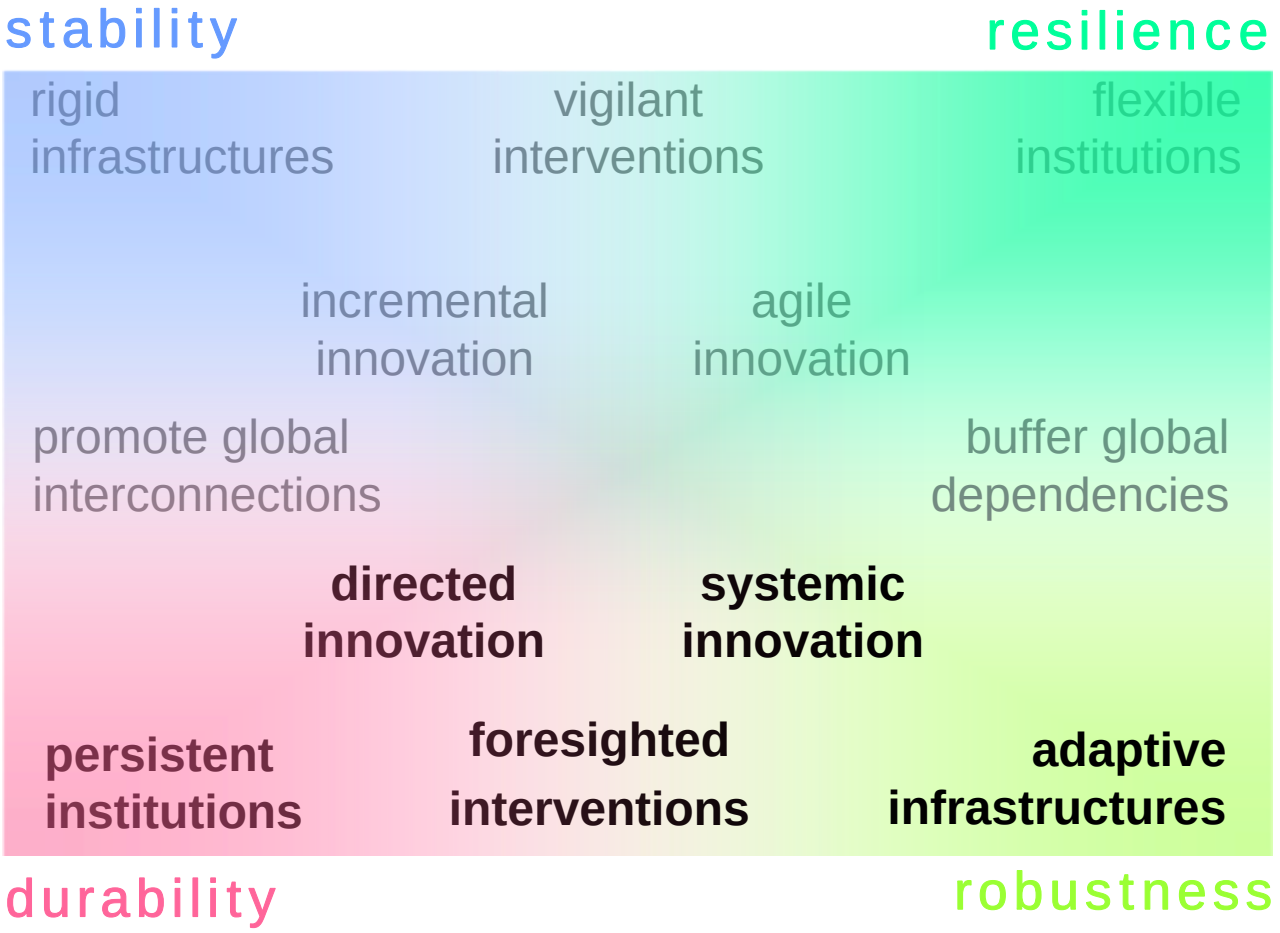
Strategic Implications

Hypothesis: only some of these promote resilience in the strict sense



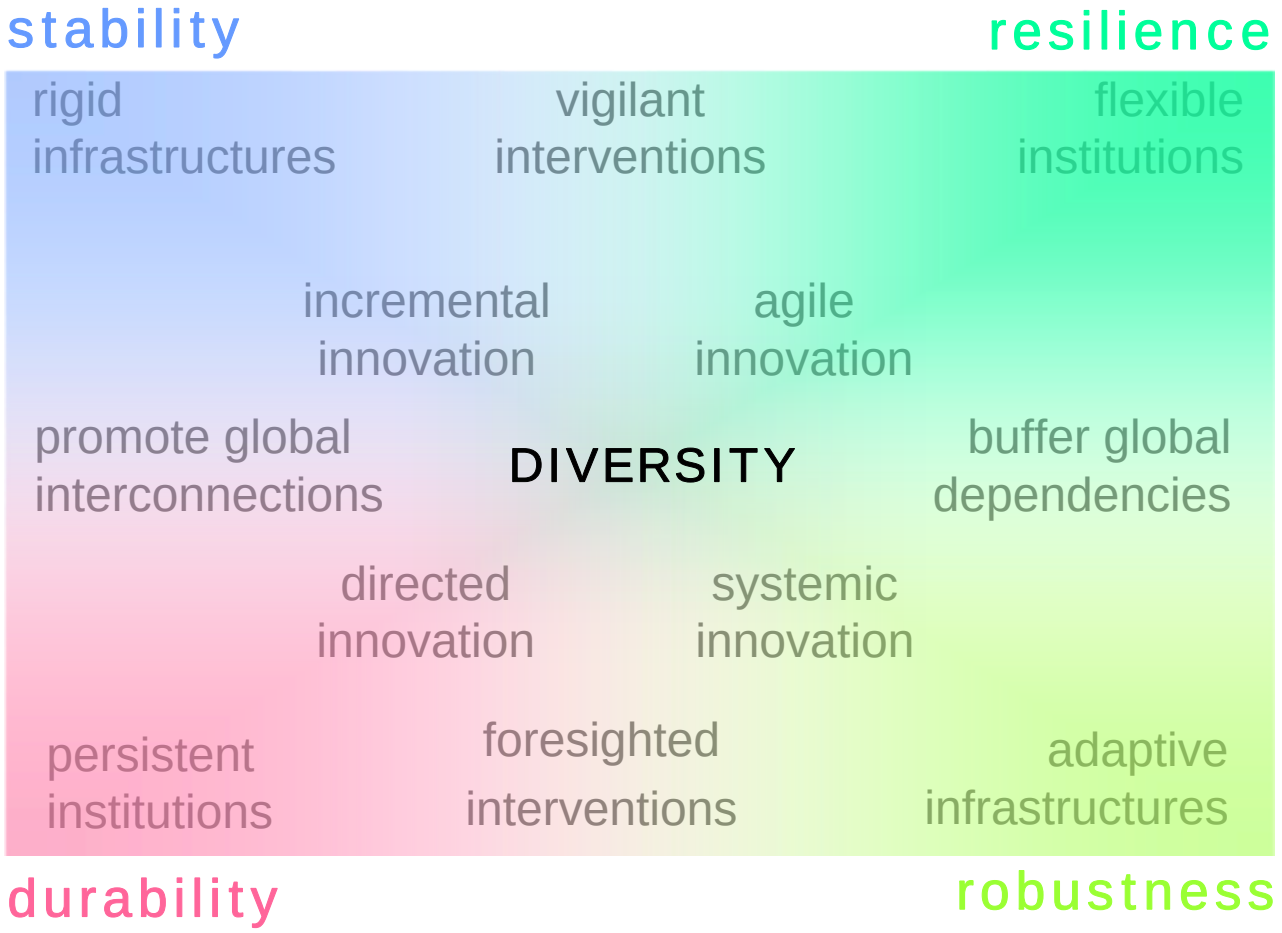
Strategic Implications

Hypothesis: others promote robustness or durability



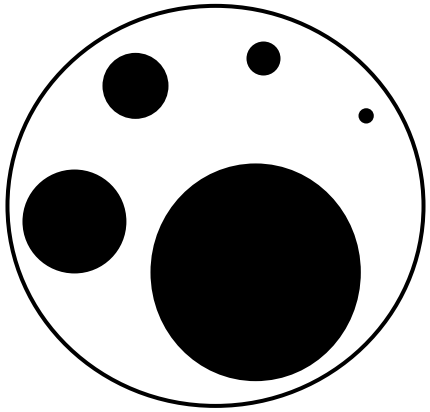
Strategic Implications

Hypothesis: some are generally effective in promoting all properties



Different Aspects of Diversity

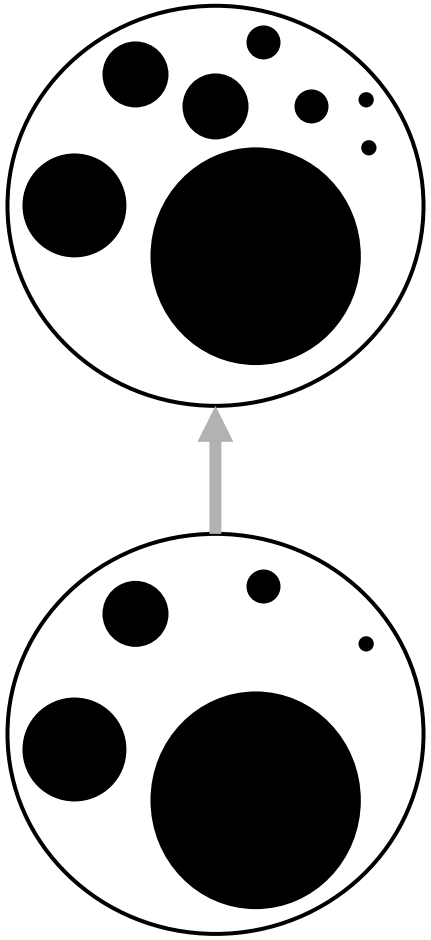
diversity can be increased
in three different ways



capital investments / research programmes / technology strategies
primary resources / generating capacities / electricity outputs
comprising mix of ‘options’
eg: coal, oil, gas, nuclear, wind

Different Aspects of Diversity

increasing diversity



variety

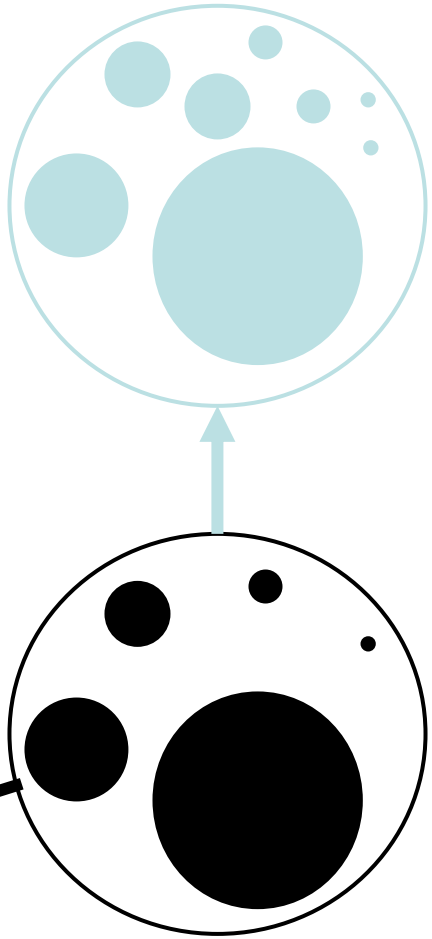
number of elements in mix

eg: Norway vs USA

Different Aspects of Diversity

increasing diversity

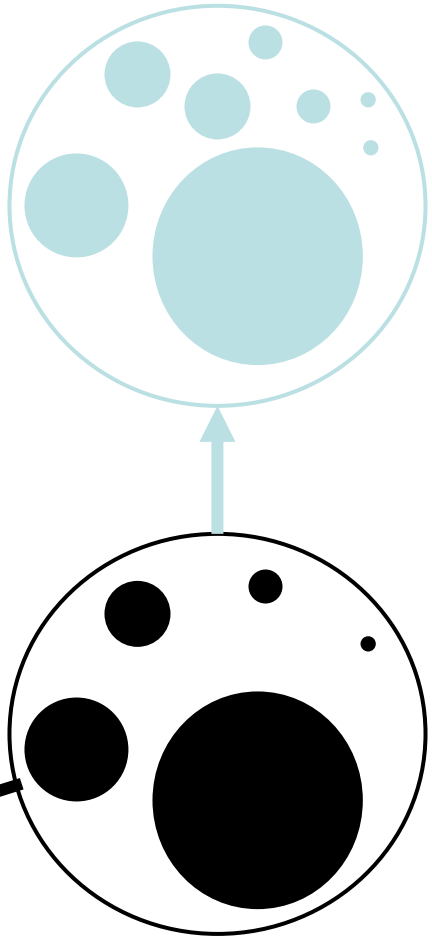
variety
number of elements in mix



balance
evenness in contributions
eg: nuclear – Japan vs France

Different Aspects of Diversity

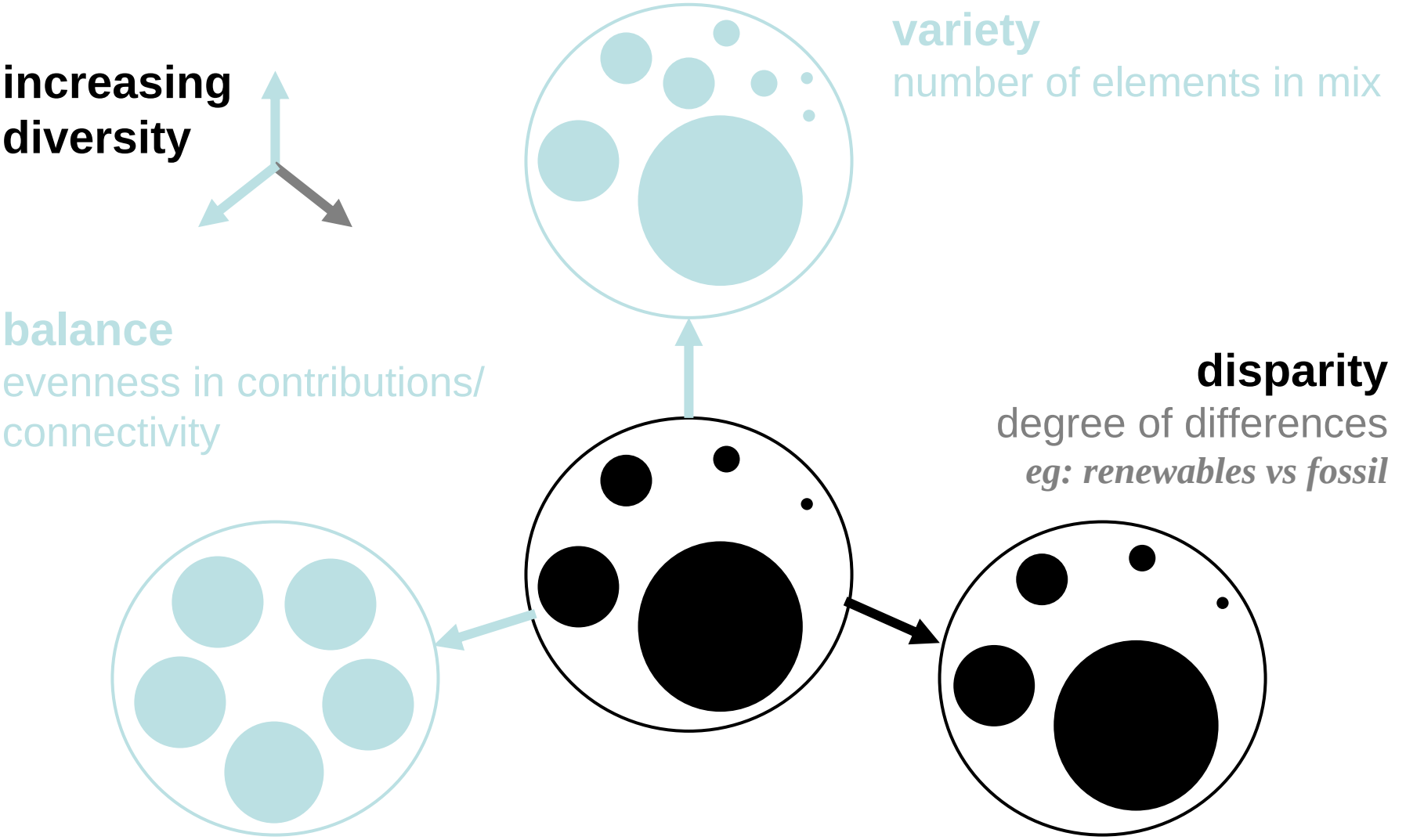
increasing diversity



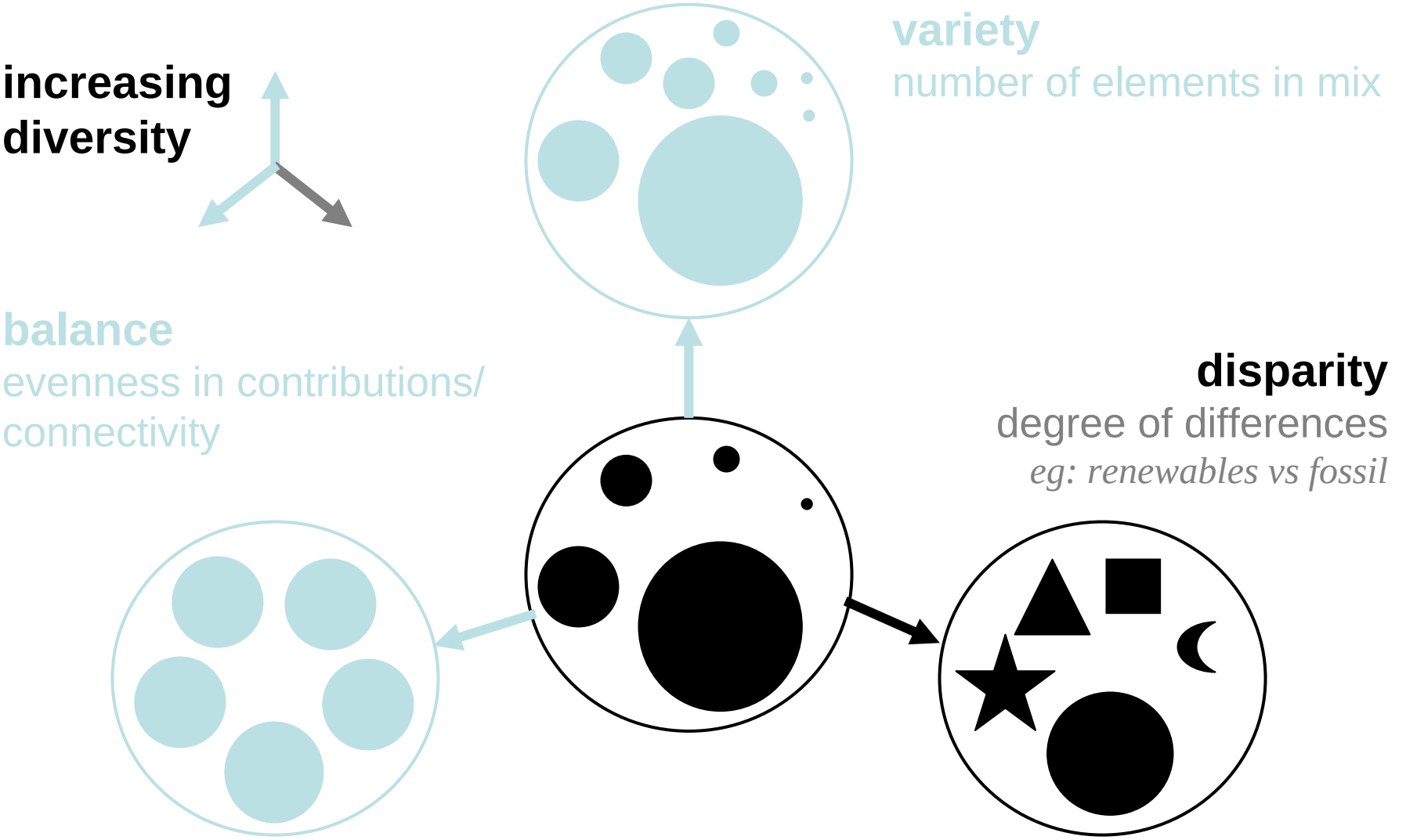
variety
number of elements in mix

balance
evenness in contributions / connectivity
eg: nuclear – Japan vs France

Different Aspects of Diversity



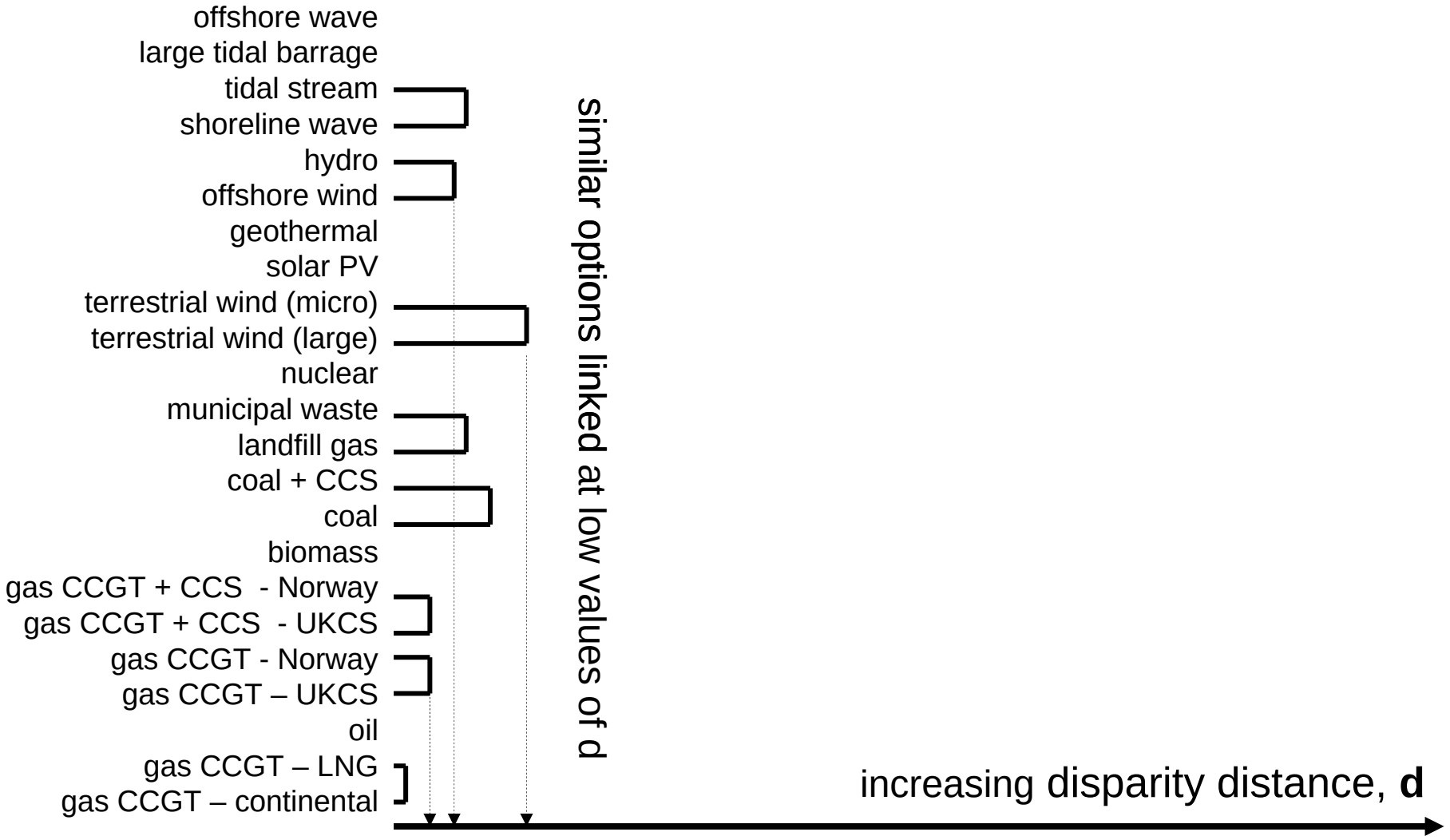
Different Aspects of Diversity



Disparity of technologies is fundamental to energy diversity

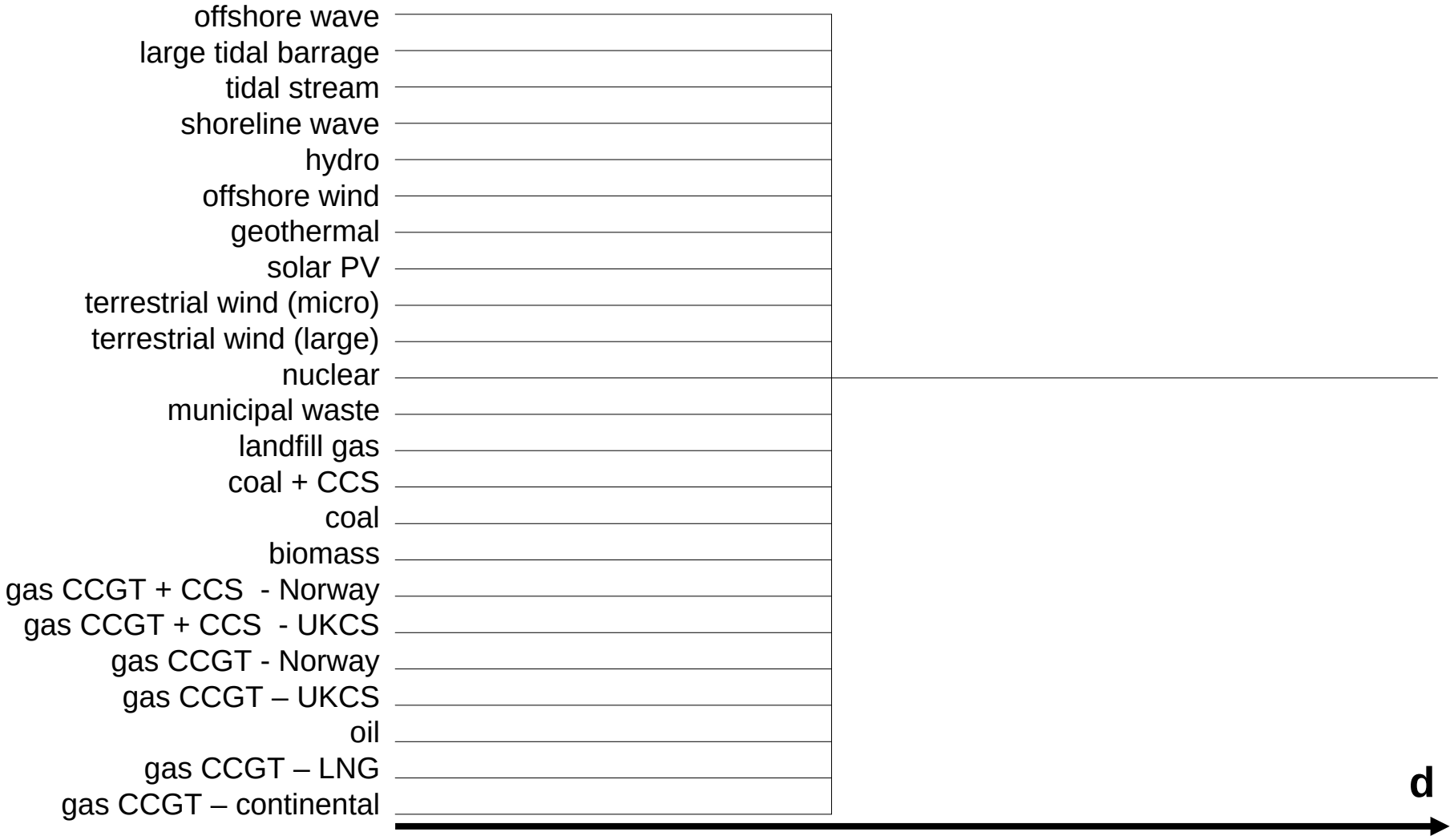
Diversity in Energy Sustainability

Sustainability: multivariate performance yields endogenous disparity metrics



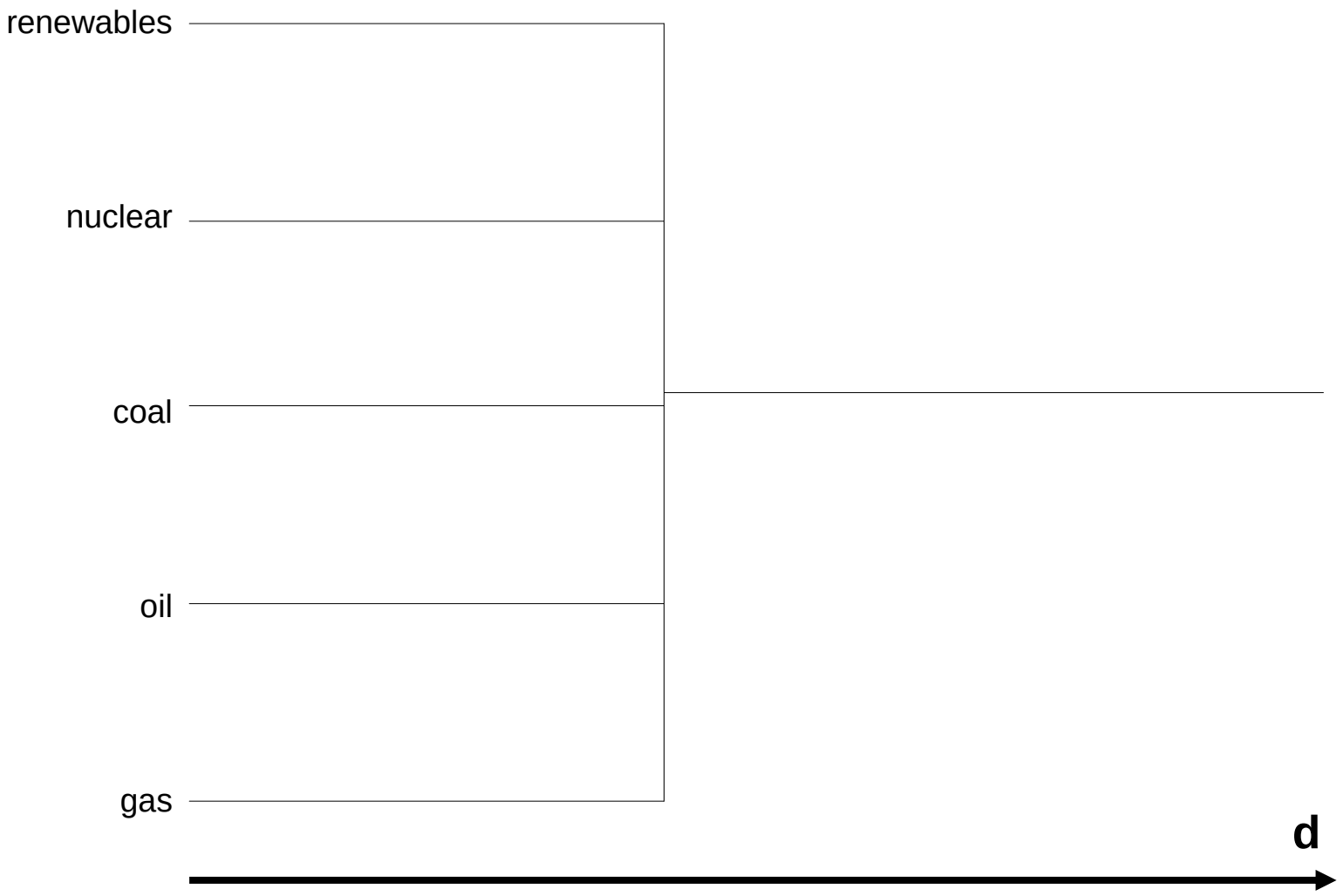
Conventional Ideas of Energy Diversity

Casual treatment of diversity sees all named options as equally diverse



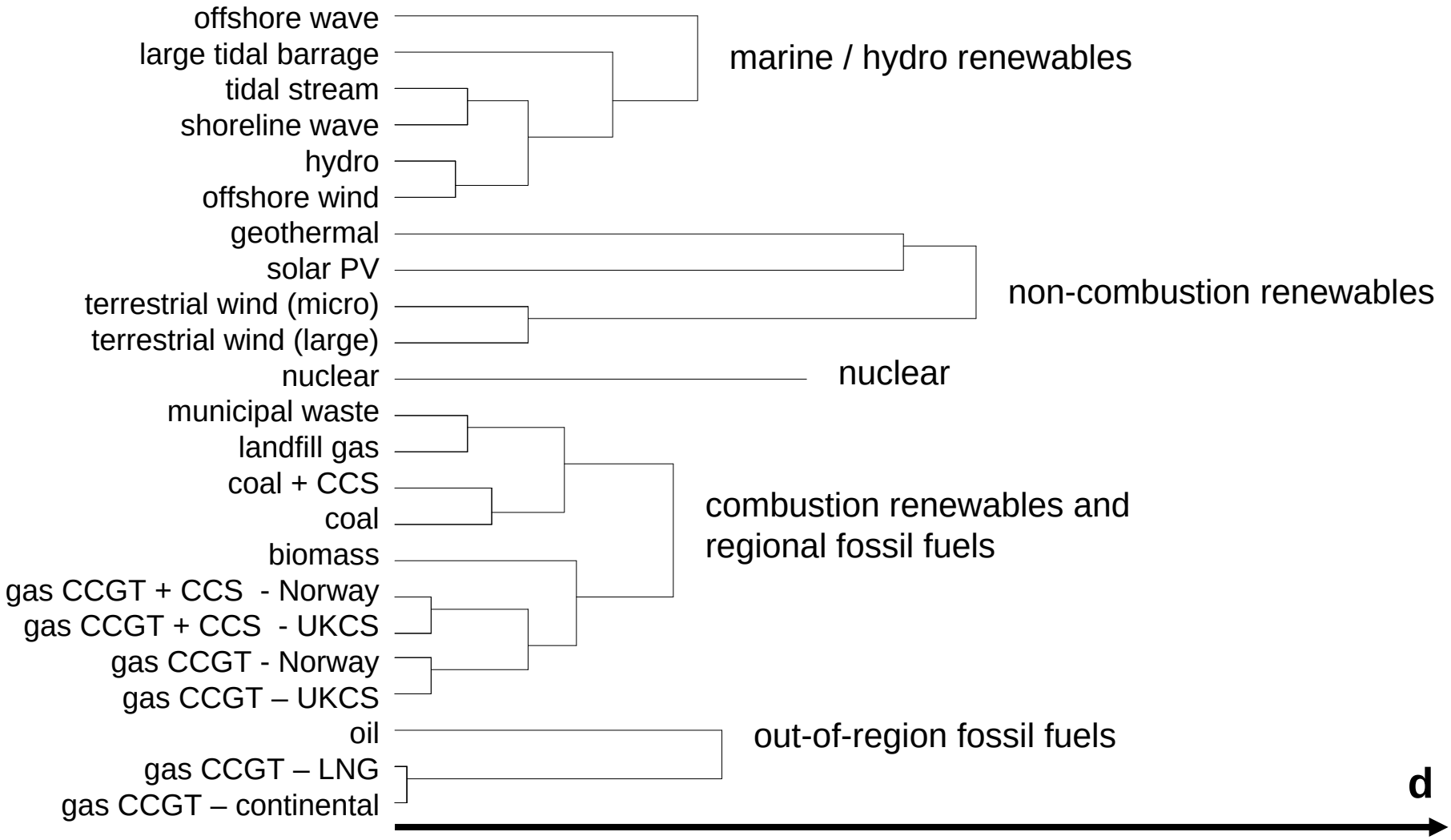
Conventional Ideas of Energy Diversity

Often, renewables are all grouped together as if one option



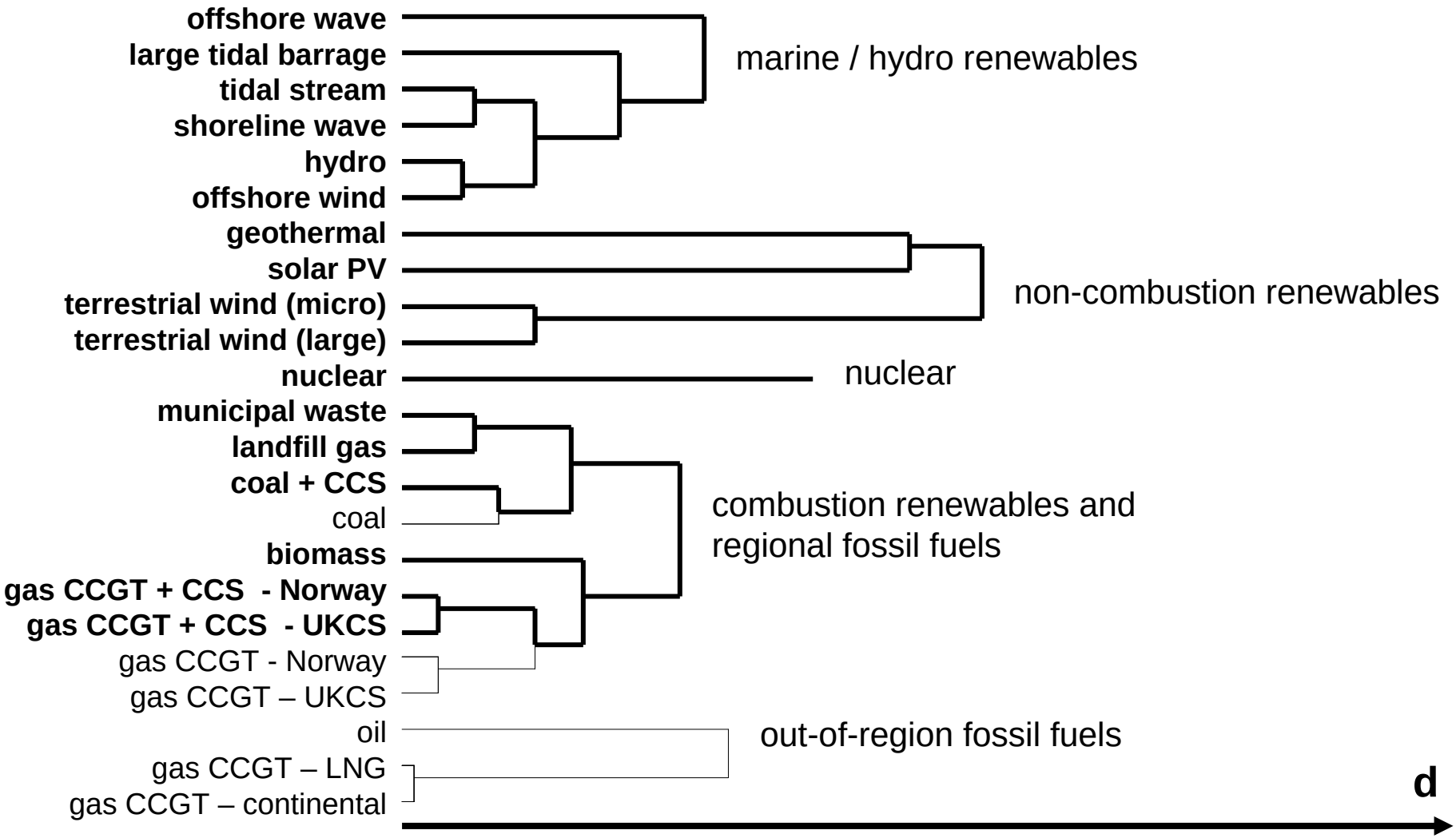
Diversity in Energy Innovation

Detailed multicriteria diversity analysis reveals structure of disparities



Diversity in Energy Innovation

Candidate **s**ustainable options for energy diversity



Dynamic Strategies for Sustainability

start with sustainability

objects of resilience are functional qualities, not structures
environmental integrity, social equity, human wellbeing
functions rather than structures (institutions, technologies)

multiplicity of properties

resilience just one dynamic sub-property of sustainability
different actions (control / response) and timings (shock / stress)
distinguish: **stability, durability, resilience, robustness**

extend scope of strategies

certain strategies promote some properties and not others
eg: connect / insulate; rigid / supple; react / foresight
powerful incumbents emphasise stability-strategies

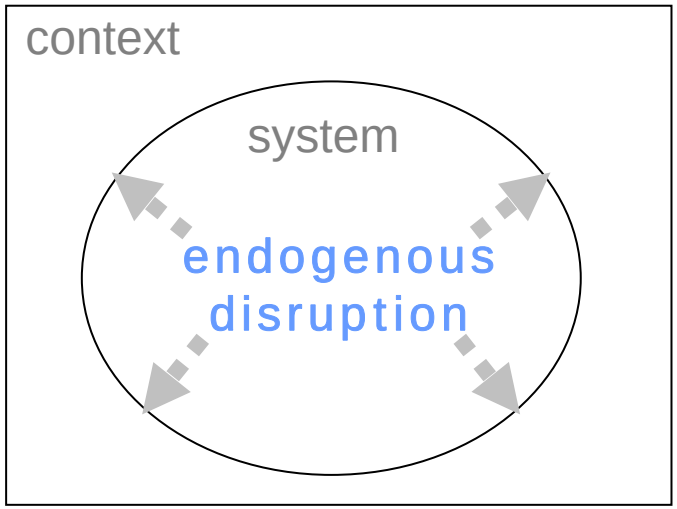
identify more general strategies

eg: diversity equally addresses all sub-properties?
define qualifications, trade-offs, conditions, assumptions and
engage stakeholders to define key levels / dimensions

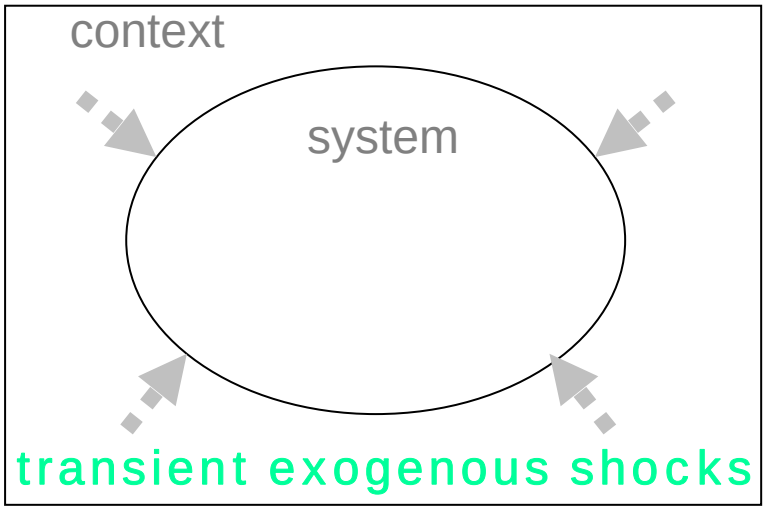
Towards rigour and accountability in policy analysis of sustainability dynamics

Dynamic Sub-properties of Sustainability

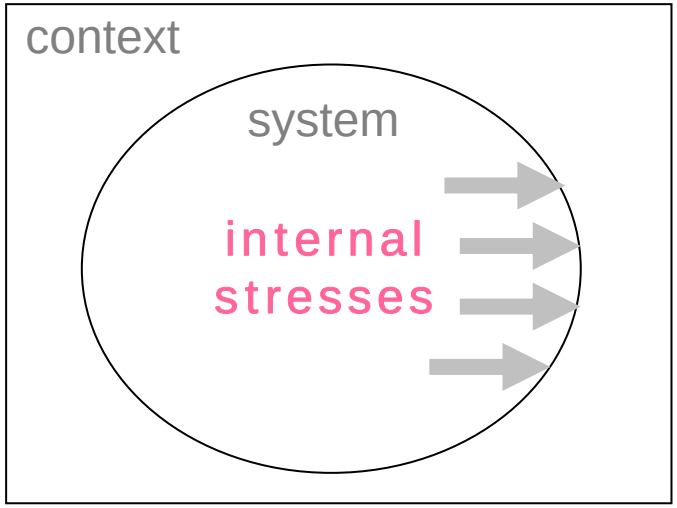
STABILITY



RESILIENCE



DURABILITY



ROBUSTNESS