

# MOT113A | Technology Dynamics

Lecture 01 | Setting the stage  
Course introduction

Dr. Sander Smit | 22 April 2025



# MOT113A – Lecture 1 | Contents

Topic
<b>Setting the stage</b>
Course introduction

## Setting the stage | Technology dynamics

*Technology dynamics is the study of how **technological change** **unfolds over time** through **interactions** between **technical** developments, **institutional** structures, **user** practices, and **socio-economic** forces. It explores both the internal evolution of technologies and the **systemic** conditions that shape their development, diffusion, and impact*

## Setting the stage | Technology dynamics

**Kick-off discussion:** what is a technology you have seen evolve in your lifetime?

- **How** do you think the changes happened?
- **Which** factors played a role?

## Setting the stage | Anderson & Tushman (1990)

The paper represents technological change as a **cycle**:



- Technological **discontinuity**
  - Breakthrough innovation disrupts the existing trajectory
  - Can be **competence-enhancing** (builds on know-how embodied in the technology that is replaced) or **competence destroying** (renders obsolete the expertise required to master the technology that it replaces)
- Era of **ferment**
  - High uncertainty and experimentation
  - Competing designs and architectures emerge
  - Market and technical standards are unclear
- **Dominant** design + **incremental** change
  - One design gains widespread acceptance
  - Followed by gradual, efficiency-oriented improvements
  - Eventually sets the stage for the **next disruption**

## Setting the stage | Application of Anderson & Tushman (AT)

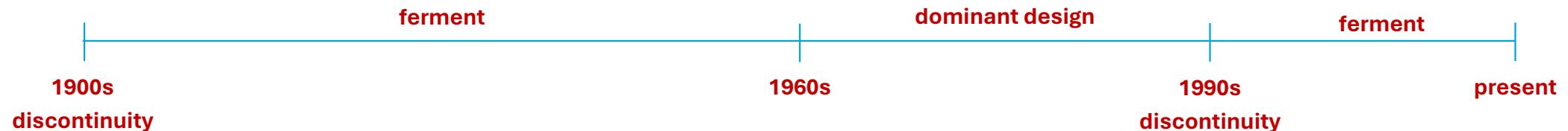
How did you travel to today's lecture?

- Think about the **last mode of transportation** in your travel: bike, bus, walking, ...
- Probably, there is not much interesting to say about **city buses**... or is there?



## Setting the stage | City bus evolution through AT's lens

### Timeline



# Setting the stage | City bus evolution through AT's lens: before the city bus

## A brief timeline

- **Stagecoaches** (1700s – 1800s)
  - Known as diligences, they were the **dominant** form of **long**-distance passenger transport
  - Often coordinated with **postal** services (dual function: mail + people)
  - Growth supported by **road infrastructure** investments in the early 1800s
- **Horse-drawn** omnibuses (mid-1800s)
  - Emerged as urban **mass** transport for **shorter** distances
  - Offered higher passenger **capacity** than stagecoaches
  - Some systems used metal guide rails (early **precursor** to trams/streetcars)
  - Increased regularity and affordability in city mobility
- **Motorized** omnibuses (early 1900s)
  - Internal **combustion** engines gradually replaced horses
  - Offered greater **flexibility** than trams (no rails)
  - **Early models often unreliable** and competed with established horse/tram systems

**mobility aligning  
with urbanization  
and demand  
aggregation**

**motorization  
represents a  
technological  
discontinuity**



## Setting the stage | City bus evolution through AT's lens: ferment

The era of ferment: variation and experimentation (1900s – 1960s)



## Setting the stage | City bus evolution through AT's lens: ferment

The era of ferment: **variation** and **experimentation** (1900s – 1950s)

Category	Factor	Example
Institutional context	WWII-related constraints	Forced use of wood-gas buses, experiments with trolley buses
Technological convergence	Search for the most optimal configuration	Rear-engine became dominant because of comfort- and safety considerations
Production fragmentation	Mostly hand-build bodies by local coach builders	Lack of standardization, difficulties to scale or maintain fleets
Governance fragmentation	Cities managed their own bus fleets & trials	Lots of municipal pilots with different suppliers
Emerging demand patterns	Urban population growth, modal shifts	Pressure to scale-up capacity (e.g., through trailer buses)

## Setting the stage | City bus evolution through AT's lens: dominant design

### Standardization as of the 1960s



Leyland-Triumph-Werkspoor, 1965



CSAI, 1966



CSAI, 1976



CSAI, 1982



CSAII, 1983



ST2000, 1987



Duyedec, 1993

## Setting the stage | City bus evolution through AT's lens: dominant design

### Factors that **stalled** standardization efforts

Category	Factor	Example
Governmental shift	Decentralization of government tasks	Fragmented procurement, local authorities gained control over bus specifications
Systemic pressure	Institutional pressure for change	Push for cleaner technologies made standard models obsolete
	Infrastructural demands	Local choices depended on fueling, charging and spatial constraints
Market evolution	Blurring of city vs. regional bus markets	Producers entered new niches, standardization no longer matched operational diversity
	Procurement globalization	Dutch operators increasingly sourced from international bus manufacturers
Technology feedback & anticipation	Lack of enthusiasm for ST2000 (CSAIII)	Design failures and poor fit for new requirements reduced support for standardization
	Anticipation of new breakthroughs	Shift toward experimentation and pilots, re-entry into ferment phase

## Setting the stage | City bus evolution through AT's lens: new era of ferment

**Experimentation** with alternative fuels, transmission and models as of the 1990s



natural gas, 1988



hybrid, 1997



Phileas, 2004



superbus, 2011



hydrogen, 2017



hybrid, 2000



electric, 2011

## Setting the stage | City bus evolution through AT's lens: new era of ferment

Public **perception** of alternatives: even when performance is promising, safety perceptions can delay or even hamper adoption



## Setting the stage | LLMs through AT's lens: Think, pair, share

Now it's your turn! Let's apply Anderson & Tushman (1990) to Large Language Models

- Step 1: **Think**
  - Where would you position the current development of generative AI in A&T's model?
    - Are we in a stage of ferment, dominance or approaching a new discontinuity? Why?
  - What competing designs or approaches can you identify in the current generative AI landscape?
    - Think about open-source vs. closed models, use cases (text, image, code), hardware differences,  
...
  - Who are the key actors shaping the trajectory of generative AI?
    - Firms, governments, users, others?
  - What could be a dominant design in generative AI and what would that look like?
  - Can you think of a factor -technical, institutional, societal- that might delay or accelerate convergence?

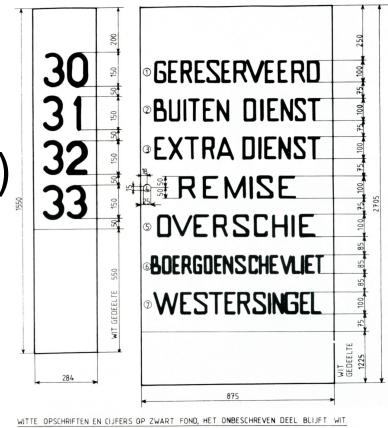
## Setting the stage | LLMs through AT's lens: Think, pair, share

Now it's your turn! Let's apply Anderson & Tushman (1990) to Large Language Models

- Step 2: **Pair**
  - Compare your answers generated in step 1 in pairs or trios
- Step 3: **Share**
  - Share your insights with the room

Setting the stage | Some questions when applying the AT model

- Which technological **level of analysis** is relevant to consider?
    - A&T focus on industries and product classes, but what about, e.g., subsystems?
  - How to **operationalize** a technological discontinuity?
    - AT **define** this as “*innovations that dramatically advance an industry's price vs. performance frontier*“ (pp. 604)
    - One-off event or part of the process?
  - Which **boundaries** to draw?
    - Of the technology (e.g., city buses, buses in general, public transport, ..)
    - Of the system (e.g., based on geography, technology, ..)?
  - Which **actionable** insights derive from this cycle?
    - For firms? For policy makers?



# MOT113A – Lecture 1 | Contents

Topic
Setting the stage
<b>Course introduction</b>

## Course introduction | Learning goals

After having followed this course, you can:

- **Describe** the **nature** of **technology dynamics** based on **established** theoretical approaches
- **Contrast** different theoretical approaches, within and across levels of analysis
- Explain the **antecedents** of technological change from a systems-level perspective
- Develop **actionable recommendations** for firms based on these approaches for managing technological innovation and change

## Course introduction | Learning goals

Why does **understanding** technology dynamics **matter**?

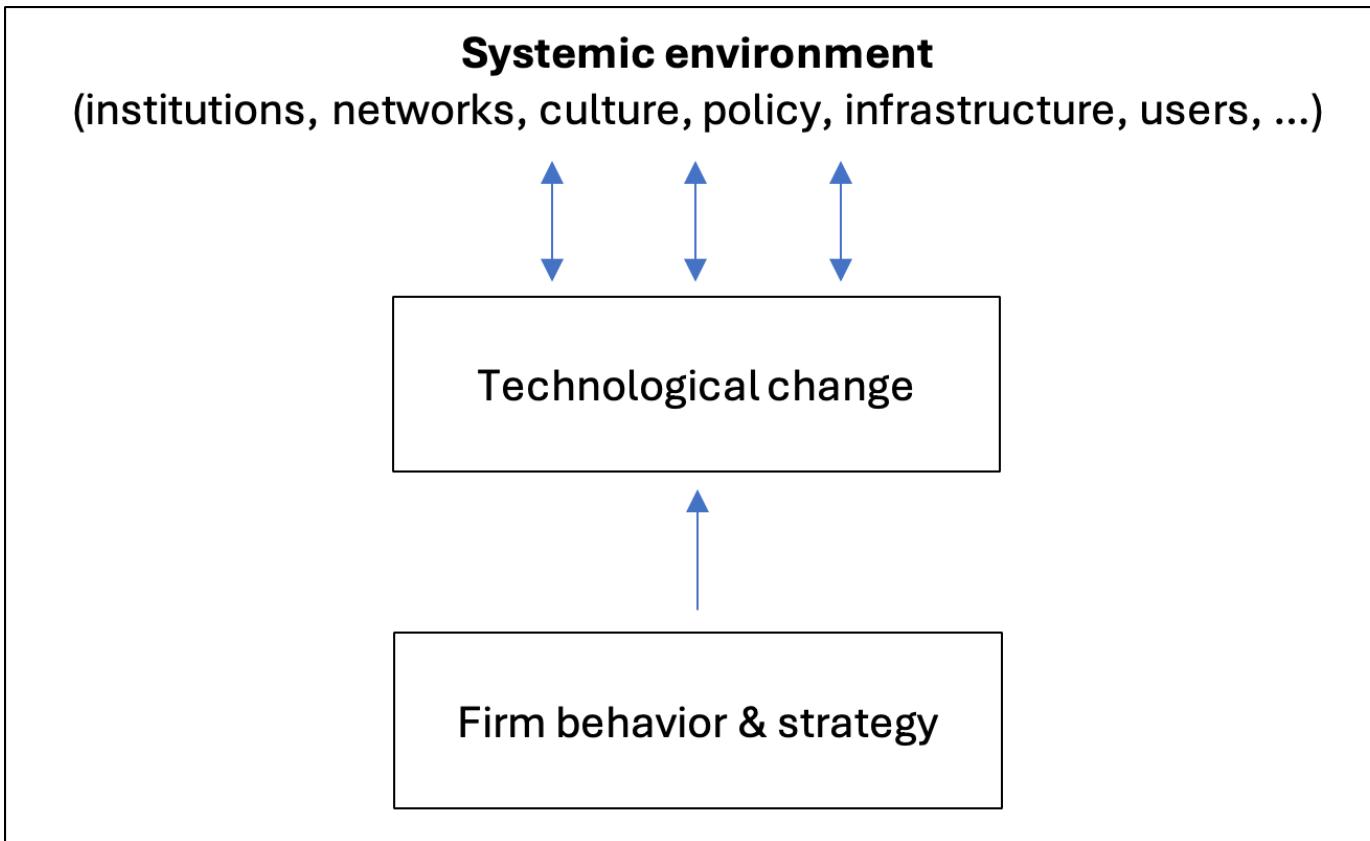
- **Key** observations drawn from the city bus case
  - Technological **change** is **layered** and **uneven**: changes occur at different levels (components, systems, infrastructures), often at different speeds
  - **Institutions** and **governance shape** the **direction** of change: public procurement, decentralization and standardization all played a major role
  - User needs, **public perceptions**, and public discourse **matter**: safety concerns, accessibility and public image affected what technologies were adopted or rejected
  - Innovation often emerges from **collaboration**: municipalities, manufacturers and operators co-shaped what buses were developed and deployed

## Course introduction | Learning goals

Why does **understanding** technology dynamics **matter**?

- The dynamics mentioned on the previous slide are **not** unique to city buses. Instead, they occur in many technological fields. Understanding them helps you to:
  - **Anticipate change** and **uncertainty**: recognize where technologies are in their lifecycle and where disruption might occur
  - Make better innovation decisions: **align** R&D, investment and product development strategies **with broader system trends**
  - **Navigate** institutional and systemic **constraints**: Understand how policy, regulation and infrastructure enable or block innovation
  - **Shape** technological **trajectories**: as a firm, government actor, or intermediary, influence which designs, standards or practices become dominant
  - **Collaborate more effectively** across actors: know who matters in innovation ecosystems and how to align interests and timing
- Let's now explore the framework and perspectives we'll use to analyze technology dynamics systematically

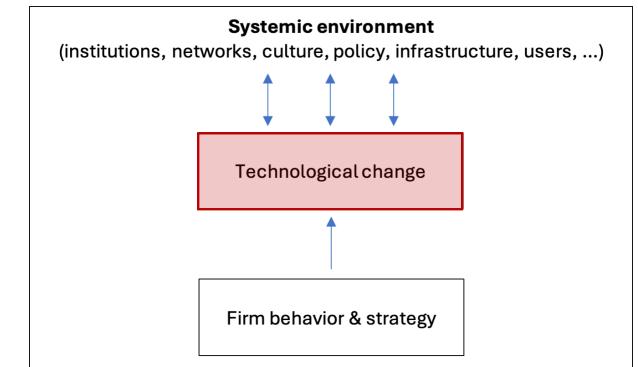
## Course introduction | Guiding conceptual model



# Course introduction | Explanation of main perspectives

## Describing technological change

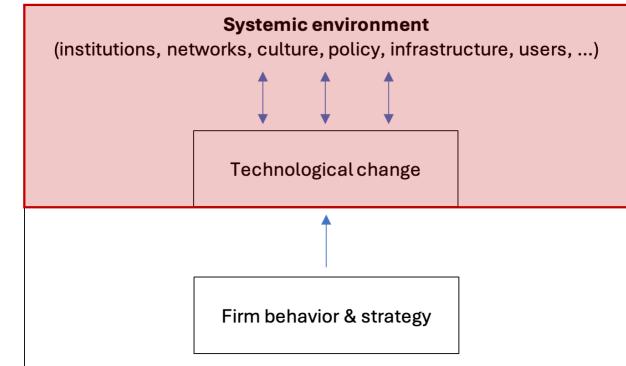
- Lecture 2
- Prof. Dr. Roland Ortt
- **Three** classes of descriptive models
  - Diffusion
  - Evolutionary (see e.g., Anderson & Tushman (1990))
  - Chaos-based / complexity oriented
- Rather than focusing on *why* change happens, we'll examine **how** different perspectives have described the patterns of technological change, what their **core assumptions** and **focal points** are, and how they **relate** to one another



# Course introduction | Explanation of main perspectives

## The **innovation systems** perspective

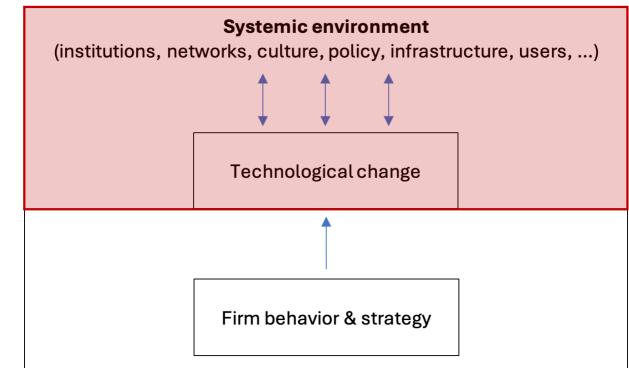
- Lectures 3 and 5
- Dr. Claudia Werker
- **Two** interconnected perspectives
  - Innovation systems (lecture 3)
  - Responsible research and innovation systems (lecture 5)
- We will examine how innovation emerges from **broader systems of actors**, such as firms, governments, and universities, operating within **institutional, infrastructural, and policy contexts** (innovation systems), and how this raises questions about **direction, inclusiveness, and societal impact** (responsible innovation)



# Course introduction | Explanation of main perspectives

## The **socio-technical perspective**

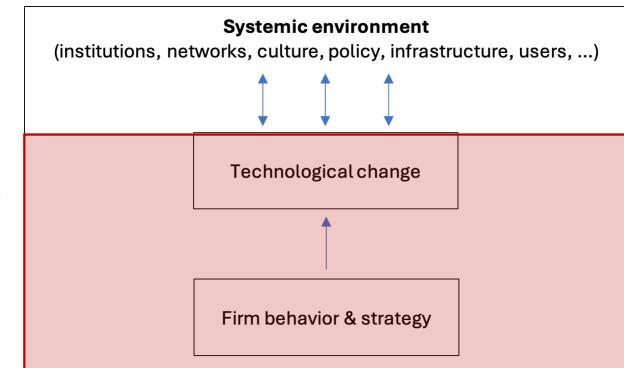
- Lecture 4
- Dr. Nthabi Mohlakoana
- **Two** core features
  - Focus on **transitions**
  - **Multi-level perspective**
- We will examine how **transitions**, such as shifts to sustainable energy or mobility, **unfold over time**, and how they are **shaped by interactions** between technology, society, and governance structures. This perspective also highlights the multi-level dynamics involved in transitions, from **niche innovations** to **regime shifts** and emphasizes the **structural transformation of entire systems**, rather than enabling innovation within them



# Course introduction | Explanation of main perspectives

## The **interorganizational network** perspective

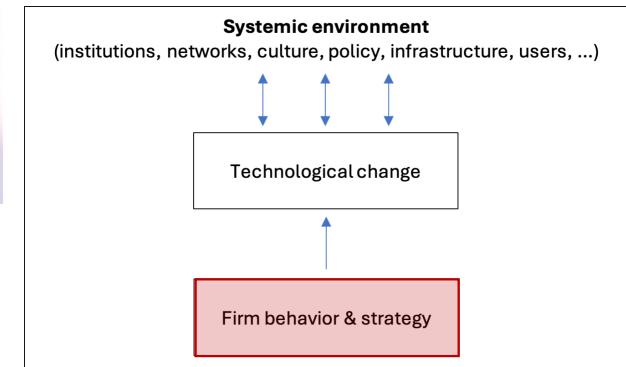
- Lecture 6
- Dr. Sander Smit
- **Two** main ideas:
  - Bottom-up network management
  - Top-down network management
- We will examine **how technological innovation emerges through relationships between organizations**, such as firms, research institutes, governments, and intermediaries. While the innovation systems perspective highlights the broader institutional environment, this perspective focuses on **how network structures**, governance arrangements, and relational dynamics **influence** the coordination, direction, and effectiveness of **innovation** efforts.



# Course introduction | Explanation of main perspectives

## The **practitioner's** perspective

- Guest lecture 7 – **optional**, week 4.8
- Tom Drozdowski (ARS T&TT)
- Two components
  - Sharing business perspective
  - Application Q&A
- Using the introduced perspectives, we will examine questions such as
  - *How can small tech firms influence large, complex innovation systems?*
  - *What systemic barriers constrain innovation in sectors like transport and mobility, and how can they be overcome?*
  - *How do firms align their innovation efforts with public missions and societal values?*
  - *How can strategic networks be built and managed to scale innovation in conservative or heavily regulated environments?*



## Course introduction | Explanation of main perspectives

The **practitioner's** perspective – teaser video

# Course introduction | Overview

Week	Day	Date	Time	Format	Lecturer	Theme / Topic	Literature <sup>1</sup>	
4.1	Tu	22-04	10:45 – 12:30	Lecture 1	AS	Setting the stage	<ul style="list-style-type: none"> <li>Anderson &amp; Tushman, 1990</li> </ul>	
4.2	Tu	29-04	10:45 – 12:30	Lecture 2	RO	Describing technology dynamics	<ul style="list-style-type: none"> <li>Dosi, 1982</li> <li>Tripsas &amp; Gavetti, 2000</li> </ul>	
4.3	We	07-05	10:45 – 12:30	Lecture 3	CW	Innovation systems	<ul style="list-style-type: none"> <li>Bergek et al., 2015</li> <li>Balconi et al., 2010</li> <li>Nevzorova, 2022</li> <li>Marxt &amp; Brunner, 2013</li> </ul>	
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	Th	15-05	08:45 – 10:30 10:45 – 12:30 13:45 – 15:30 15:45 – 17:30	Mini-conference 1 <sup>2</sup>	AS	Foundational papers in Technology Dynamics	<ul style="list-style-type: none"> <li>Arthur, 1989</li> <li>Geels, 2002</li> <li>Hekkert et al., 2007</li> <li>Murmann &amp; Frenken, 2006</li> <li>Wanzenböck et al., 2020</li> </ul>	
4.5	We	21-05	10:45 – 12:30	Lecture 5	CW	Responsible Research and Innovation (Systems)	<ul style="list-style-type: none"> <li>Edquist, 2011</li> <li>Taebi et al., 2014</li> <li>Werker, 2020</li> </ul>	
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4.9	We	18-06	13:30 – 16:30	Digital open-book exam				

## Course introduction | The mini-conferences

- **What** are they?
  - Structured, small-group sessions **engaging** with foundational technology dynamics literature
    - Mini-conference 1: Week 4.4 – Foundational technology dynamics papers
    - Mini-conference 2: Week 4.7 – Networks & Innovation perspective
  - Each session covers **five** papers, set up as an **academic conference** session
  - For each paper:
    - A team of 5–6 students **presents**, as if they are the **original author team**
    - Another team acts as **discussants**, critically responding to the paper
- What is their **purpose**?
  - **Deepen** your understanding of the course literature
  - **Practice** academic interpretation and structured discussion
  - **Prepare** for the case-based, written exam, where you will apply this literature

## Course introduction | The mini-conferences

### Enrollment and time slots

- Each mini-conference day offers **four available time slots**. In each slot, a maximum of **five teams (5–6 students per team)** can enroll:
  - Time slot 1 – 08:45 – 10:30 | Team 1 – 5 (25-30 students)
  - Time slot 2 – 10:45 – 12:30 | Team 6 – 10 (25-30 students)
  - Time slot 3 – 13:45 – 15:30 | Team 11 – 15 (25-30 students)
  - Time slot 4 – 15:45 – 17:30 | Team 16 – 20 (25-30 students)
- Enrollment **opens** today @ 13:00. **Deadline:** 25 April, 09:00
- **Paper assignment** per team for the first mini-conference will be **published** on 25 April before 17:00

# Course introduction | The mini-conferences

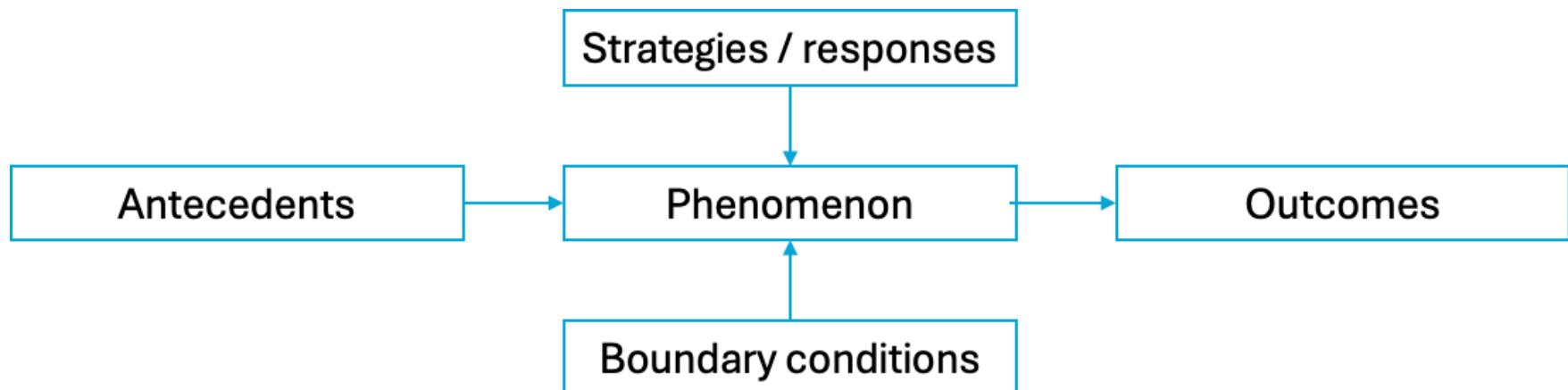
## Participation & attendance

- Full team attendance is **mandatory** for both mini-conferences
  - These sessions are designed as collaborative, peer-driven learning experiences. Your presence is essential, not only for your own learning, but also as a sign of respect toward your teammates and fellow students
- **Absence** will be registered and must be **repaired** later
  - Further instructions on how to do so will be communicated **after** the second mini-conference
- **Grading:** PASS / FAIL per mini-conference
  - Assessed at the team level. **Time keeping** is a crucial skill!
  - Based on both content and presentation style (see the **course manual** for criteria)
- Only exceptional personal circumstances (e.g., serious illness or family emergency) are considered **valid** reasons for absence. Work obligations, internships, or travel plans do **not** qualify

## Course introduction | The mini-conferences

### Reading the papers

- Keep in mind that **virtually every** well-structured **article** engages with **one or more** of the **following elements** (Strauss & Corbin, 1990)



- Tip: use the above model to **position the paper** that is assigned to your team!

## Course introduction | The mini-conferences

**Reading** the papers:

- **Phenomenon:** What is the **main** concept, mechanism, or dynamic being examined?
- **Antecedents:** What conditions or drivers **lead up** to the phenomenon being studied?
- **Outcomes:** What effects, **consequences** or implications are identified?
- **Boundary conditions:** Under **what conditions** does the phenomenon occur (or not)? Which assumptions, constraints or environments shape how it unfolds?
- **Strategies or responses** (optional): How do actors respond to the phenomenon?
- Do **not** forget about the **arrows**: These indicate **causal relationships** and embody the underlying mechanism(s)

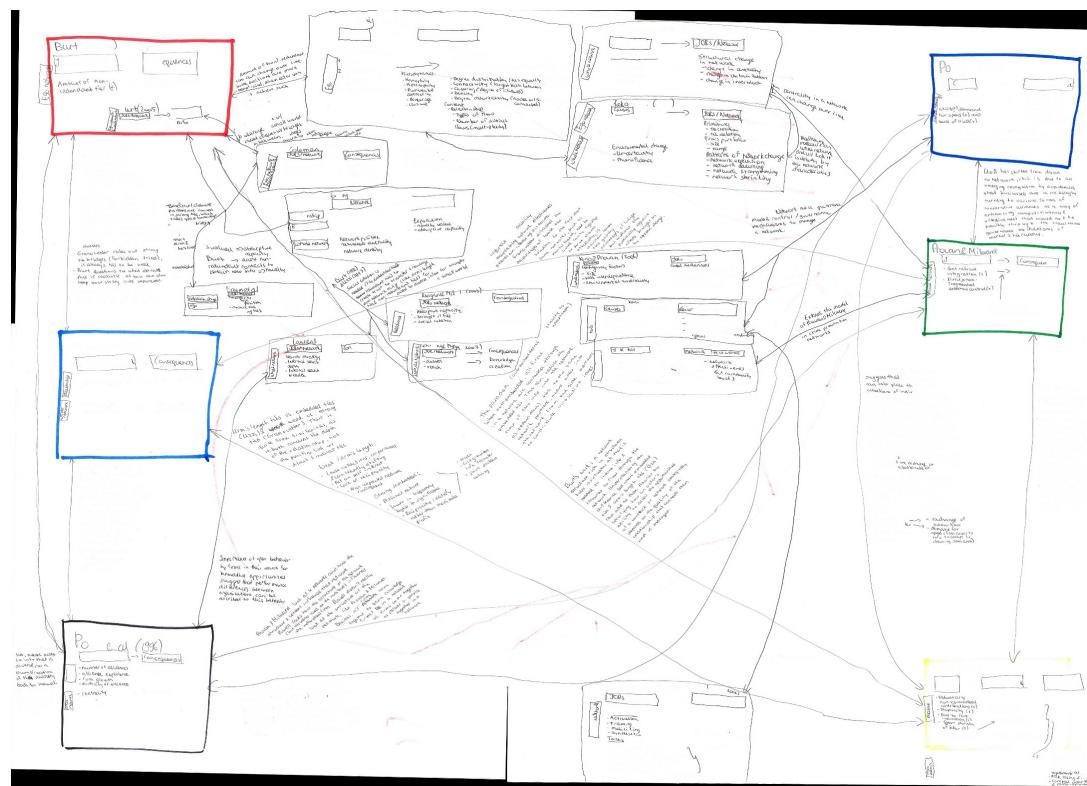
## Course introduction | The digital exam

Applying what you have learned to case studies: the digital exam

- Digital, on campus & **open** book
- **Assesses** your ability to:
  - **Interpret** key concepts and arguments
  - **Apply** theoretical insights to real-world innovation challenges
  - **Connect** the readings to each other and practical examples
  - **Translate** academic findings into actionable advice for firms or governments
- Open book **≠** easy
  - An open book exam may seem like good news, but it requires:
    - **Deep familiarity with** what **each paper** contributes
    - A clear sense of **how the papers relate** to one another
    - The ability to **quickly find and apply** relevant material to new contexts

# Course introduction | The digital exam

## Applying what you have learned to case studies: the digital exam



## Course introduction | Grading

To pass the course, you must have:

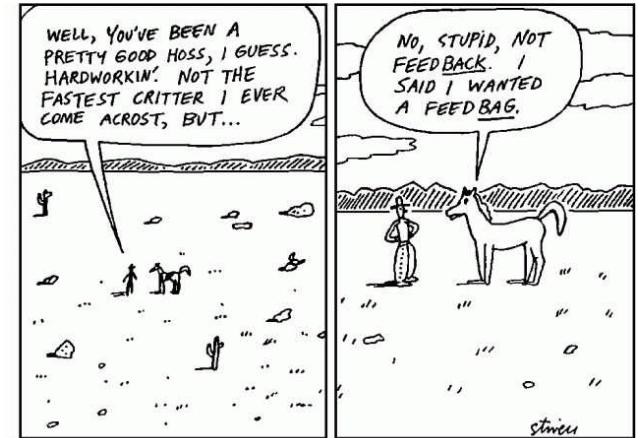
- A PASS for **both** mini-conferences
- An **exam grade** of at least 5.8

## Course introduction | Rules of engagement

- Come **prepared**: do the readings
- Be **curious** and **analytical**: ask questions, spot assumptions and seek underlying mechanisms
- **Engage** in discussion
- **Reflect** critically on practice. Don't take theory for granted
- **Read** the course manual from A to Z and from Z to A.
  - Ask questions to sharpen the course manual. If your question is answered in there and you ask it anyway, you owe the module manager a **beer**
- **Embrace** ambiguity and vagueness. Not everything is right or wrong. The exciting stuff usually starts where clarity ends
  - When does it get exciting in your field? Probably when it is no longer clear-cut

## Course introduction | Feedback

- This course has undergone a **major revision** (a **discontinuity!**)
  - This academic year: **1<sup>st</sup> run** of revised course (**ferment!**)
- Your feedback is **much appreciated!** Help us work toward a **dominant design** by **sharing your input:**
  - With me, the **module manager** ([A.C.Smit@tudelft.nl](mailto:A.C.Smit@tudelft.nl)) who will be present during all lectures
  - With your fellow students via the lecture response group (**CRG**)
  - Through the official **course evaluation** at the end of the course
- **Early birds are more likely to catch a worm**, though we cannot always promise we will catch it ourselves (e.g., Board of Examiners-level decisions). Still, timely feedback **gives us the best shot** to improve your experience while the course is running!



## Course introduction | What have you learned today?

- What will you **take away** from today's lecture? For example:
  - Challenges / limitations of the A&T model
  - Key insights you expect the remainder of the course to provide
  - A surprising insight you did not have before
  - ...

## Course introduction | Next steps

- Form teams of 5-6 students and enroll via Brightspace (opens 13:00)
  - First come, first serve!
  - Before Friday 25 April, 09:00
- The allocation of teams to the papers (to be presented and to be discussed) for the 1<sup>st</sup> mini-conference will be published on Friday 25 April, before 17:00

## Next week

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Questions?