

# Mapping and Quantifying the Impacts of Digital Applications on Energy Use

**Charlie Wilson**, Vlad Coroama, Hazel Pettifor, Maureen Agnew  
ECEEE  
June 2024

iDⓂDDLE

[idoddle.org](http://idoddle.org)



European  
Research  
Council

Consolidator Grant #101003083



Network for Digital Economy  
and Environment



Environmental Change Institute  
SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT

# How does digitalisation impact energy use ... and by how much?



**causal mechanisms**



**$\Delta$  energy**



*problem 1:*  
generic set of  
mechanisms not  
clearly resolved

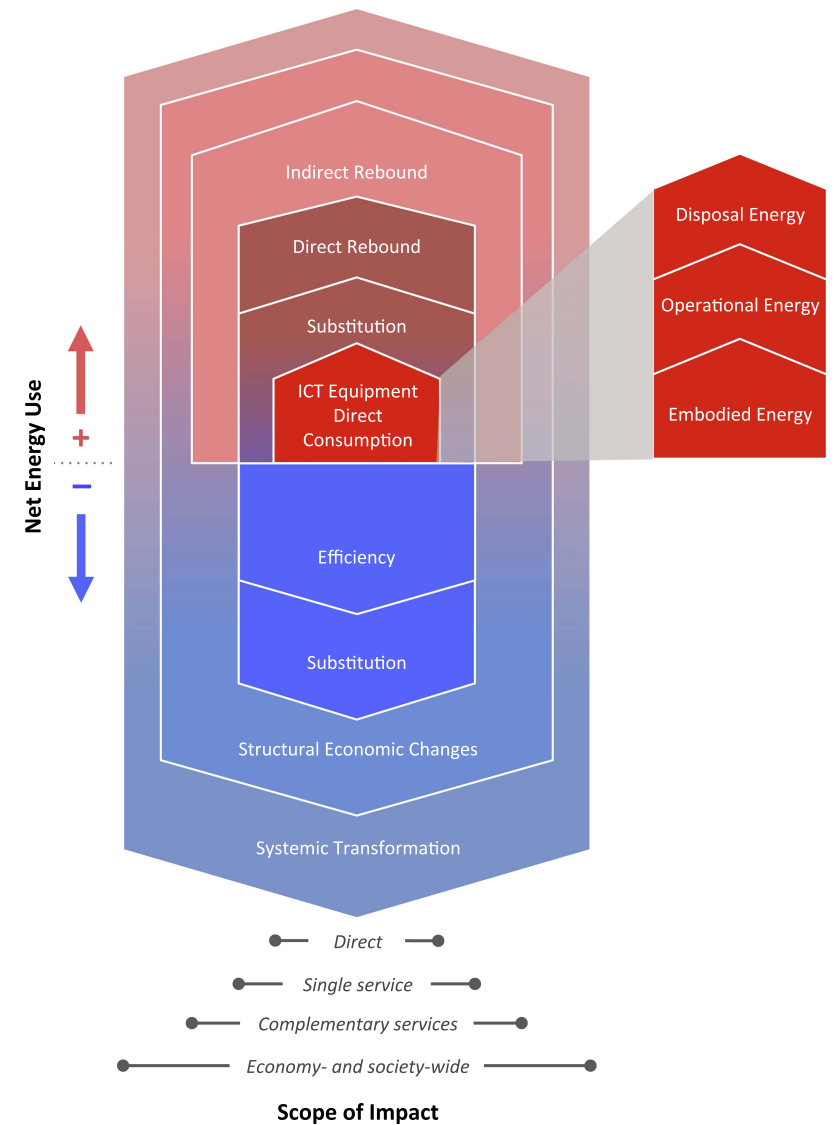
*problem 2:*  
no standardised  
method of impact  
assessment

*result:*  
no generalisable insights  
on digitalisation impacts

# Common taxonomies of digitalisation impacts do not explain underlying causal mechanisms

**\*\* focus in this talk on indirect impacts \*\***

**(not direct footprint)**



Horner et al. (2016). "Known unknowns: indirect energy effects of information and communication technology." *Environmental Research Letters* 11 (10):103001.

# RQ1. How do digital applications impact energy use (in buildings)?



**mechanisms**

**outcomes**

**$\Delta$  energy**



Fig 5.12 in Creutzig et al. (2022).  
Chapter 5 of Working Group III: *IPCC Sixth Assessment Report*.

# RQ1. How do digital applications impact energy use (in buildings)?



**mechanisms**



**outcomes**

**$\Delta$  energy**

**substitute** with a less energy-intensive form of service provision

**access** a service instead of owning a good

**exchange** or **coordinate** surplus supply with demand

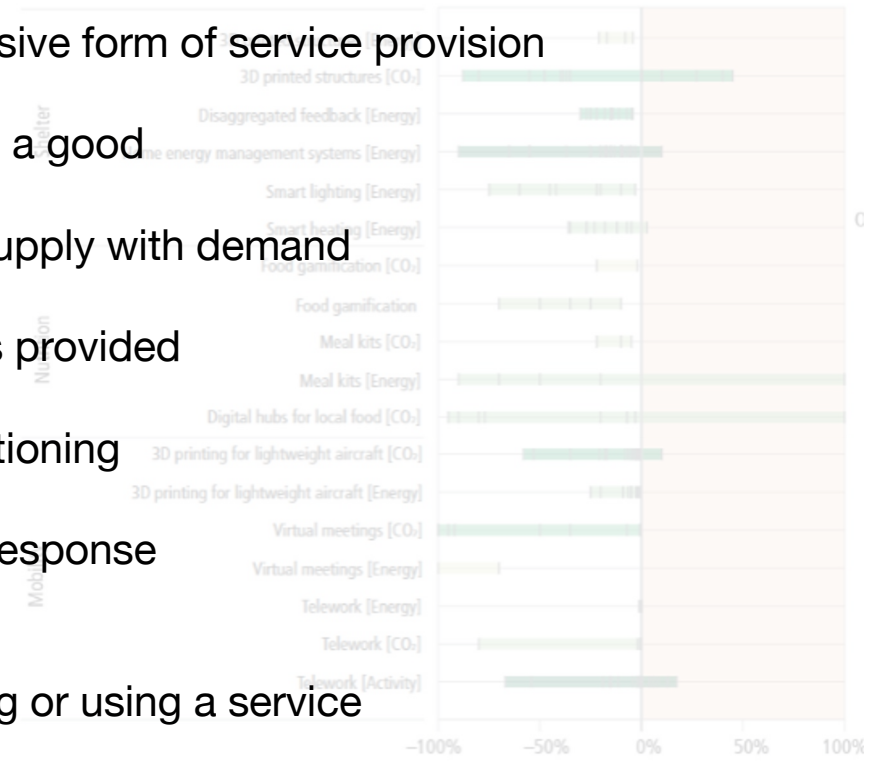
**control** or manage how a service is provided

**integrate** or **optimise** system functioning

**communicate** to enable adaptive response

**reduce effort** or friction in providing or using a service

**reduce cost** of providing or using a service



# RQ1. How do digital applications impact energy use (in buildings)?



**mechanisms**

**outcomes**

**$\Delta$  energy**

*substitute*

*(access)*

*higher service efficiency*

*exchange*

*higher utilisation rate*

*control*

*less waste*

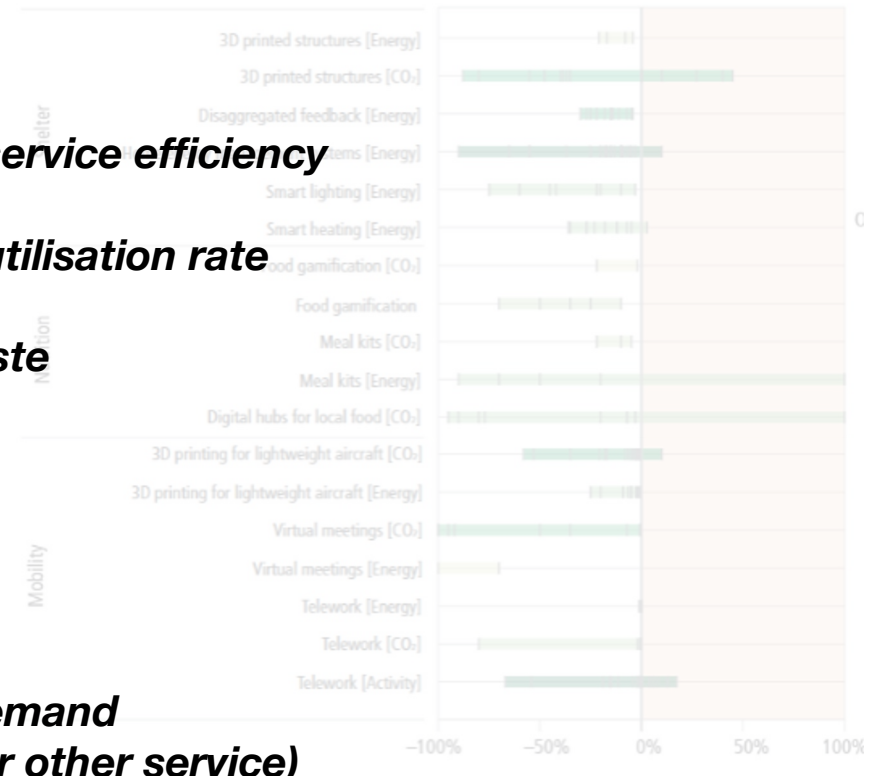
*integrate*

*communicate*


*reduce effort*

*more demand  
(same or other service)*

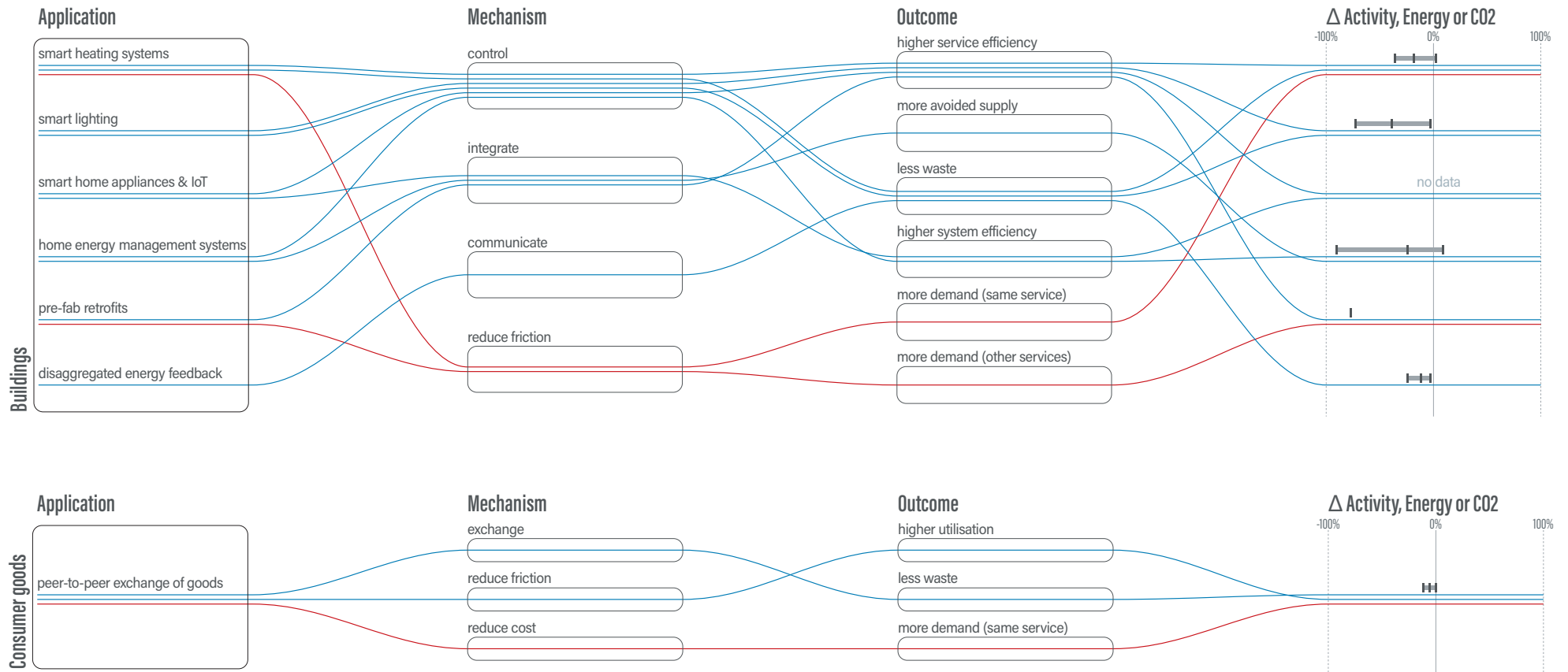
*reduce cost*



# RQ1. How do digital applications impact energy use (in buildings)?

<b>application</b>	<b>mechanisms</b>	<b>outcomes</b>	<b><math>\Delta</math> energy</b>
	<i>control</i>	<i>higher service efficiency</i>	$\Delta-$
	<i>control</i>	<i>less waste</i>	$\Delta-$
	<i>reduce effort</i>	<i>more demand (same service)</i>	$\Delta+$
	<i>exchange</i>	<i>less waste</i>	$\Delta-$
	<i>reduce cost</i>	<i>more demand (other services)</i>	$\Delta+$

# RQ1. How do digital applications impact energy use (in buildings)?



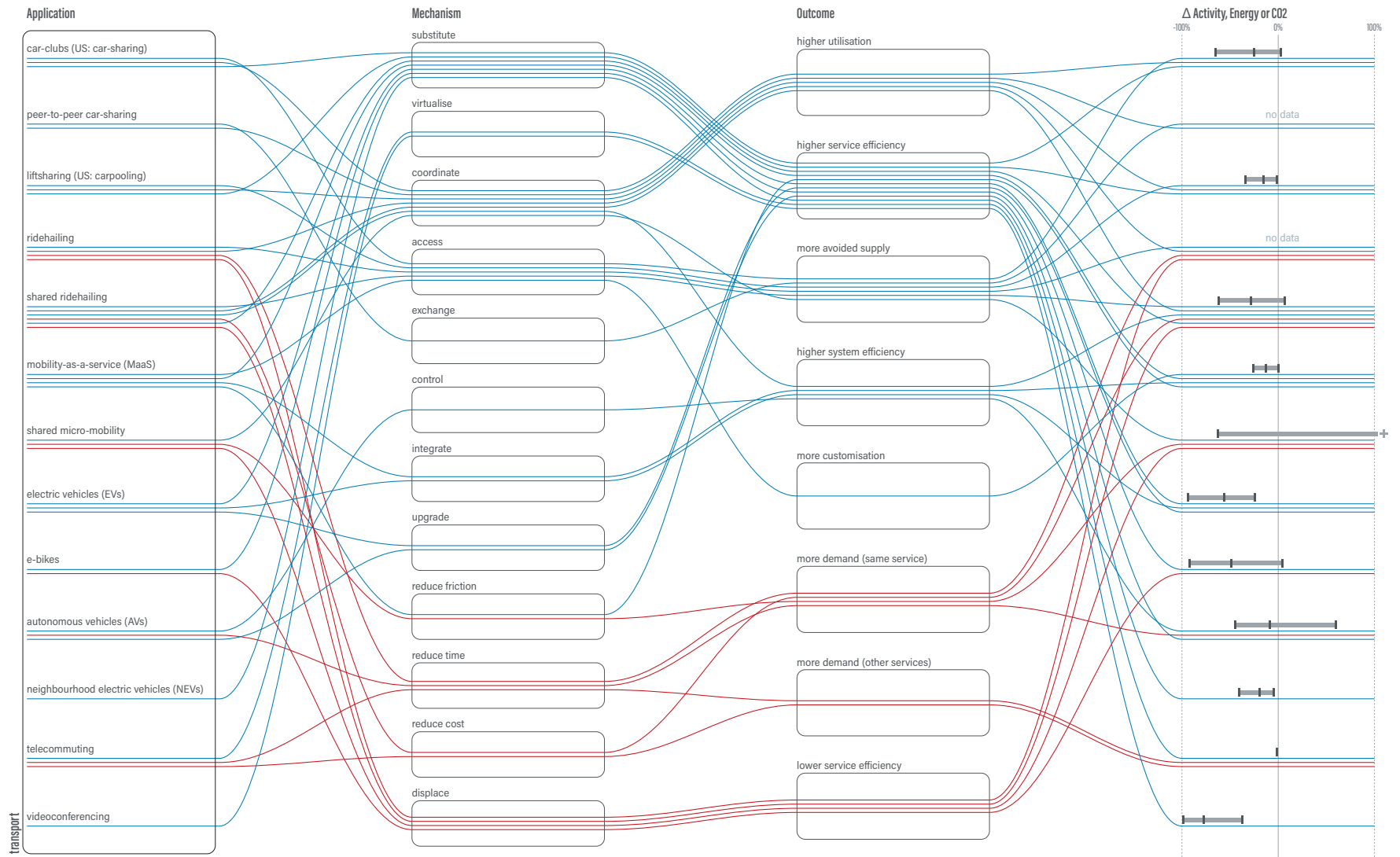
RQ1. How do digital applications impact energy use (in buildings)?

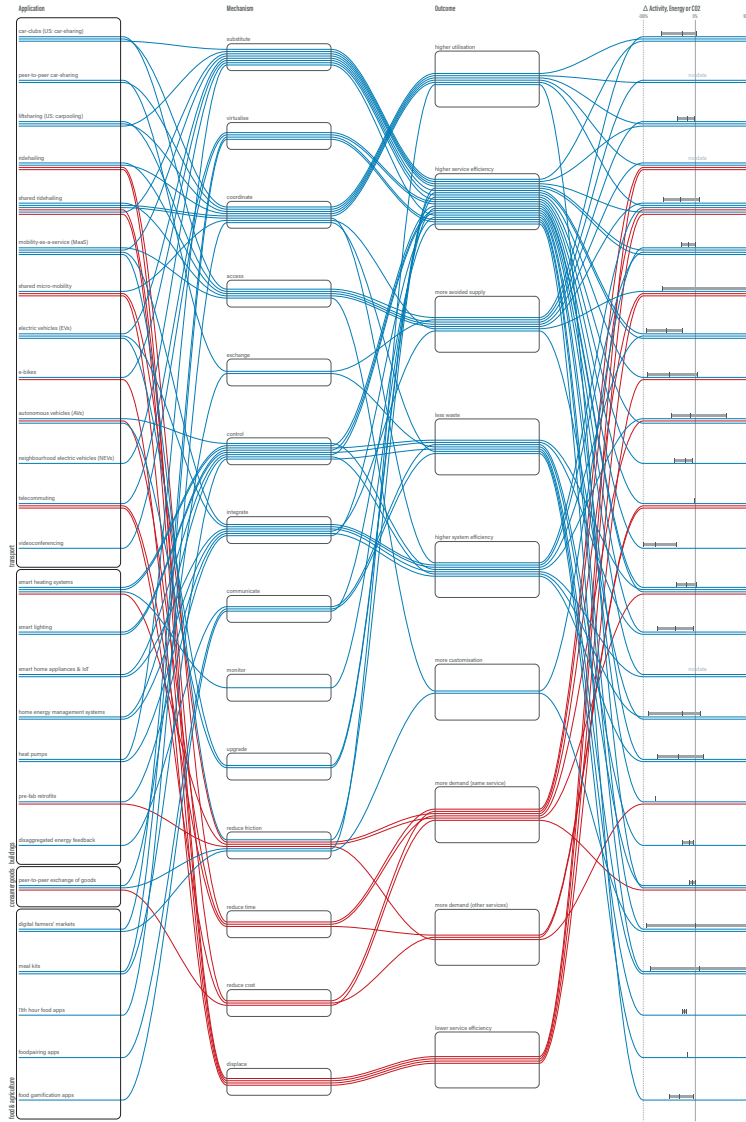
### **Impact pathways**

- link applications to energy impacts via generalisable causal mechanisms

### **Visualisations**

- communicate complexity
- identify prevalence of certain mechanisms (e.g., *control*)
- make explicit both energy-saving and energy-increasing mechanisms per application





# RQ2. Which impact mechanisms have the largest energy-saving benefits?



mechanisms

outcomes

$\Delta$  energy

meta-analysis

sample of 23 digital applications

141 estimates of  $\% \Delta$   
(from 99 different studies)

subset of 5 digitalisation mechanisms tested

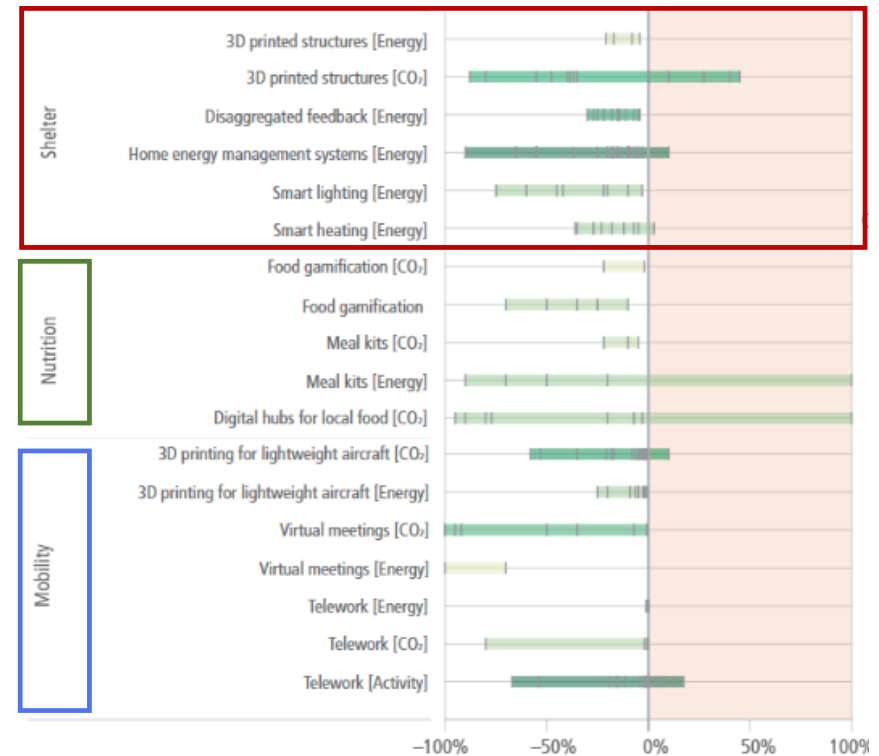
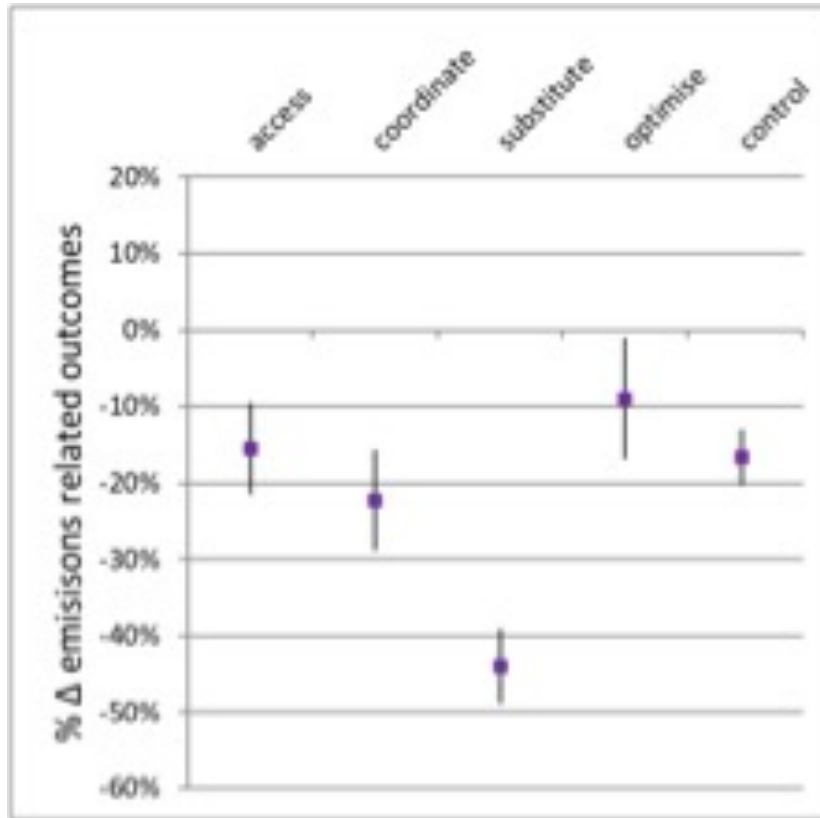


Fig 5.12 in Creutzig et al. (2022).  
Chapter 5 of Working Group III: IPCC Sixth Assessment Report.

RQ2. Which impact mechanisms have the largest energy-saving benefits?

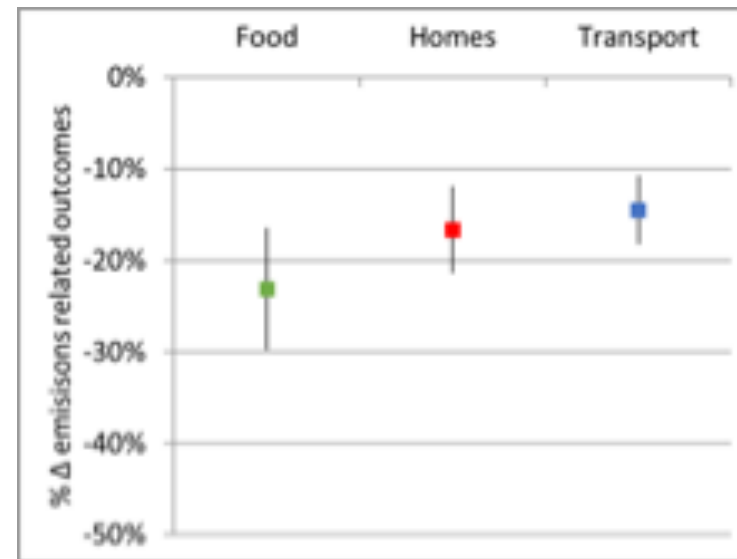


controlling for variation in deployment context  
but not study design

**controls for variation in deployment context**

*domain of application*

- homes, transport, food



# How does digitalisation impact energy use ... and by how much?



**causal mechanisms**



**$\Delta$  energy**



*problem 1:*  
generic set of  
mechanisms not  
clearly resolved

*problem 2:*  
no standardised  
method of impact  
evaluation

*result:*  
no generalisable insights  
on digitalisation impacts  
(why & how much)

## RQ2. Which impact mechanisms have the largest energy-saving benefits?

### controls for variation in study design

*internal validity (robustness)*

- e.g., control group?

*external validity (generalisability)*

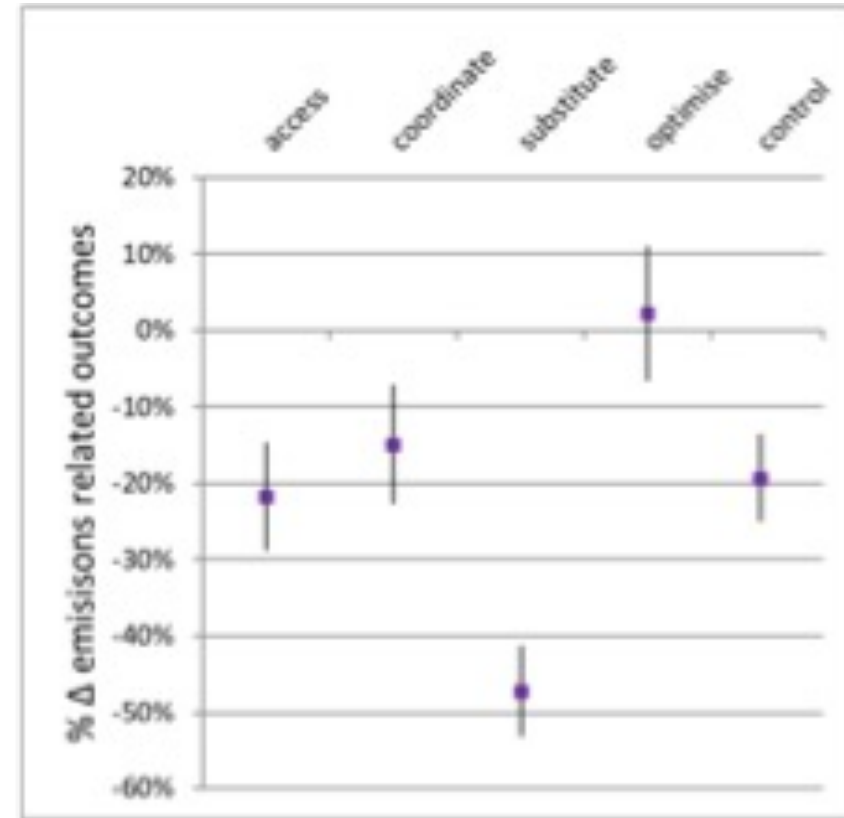
- e.g., sample size, real-world context

*method*

- e.g., empirical, simulation

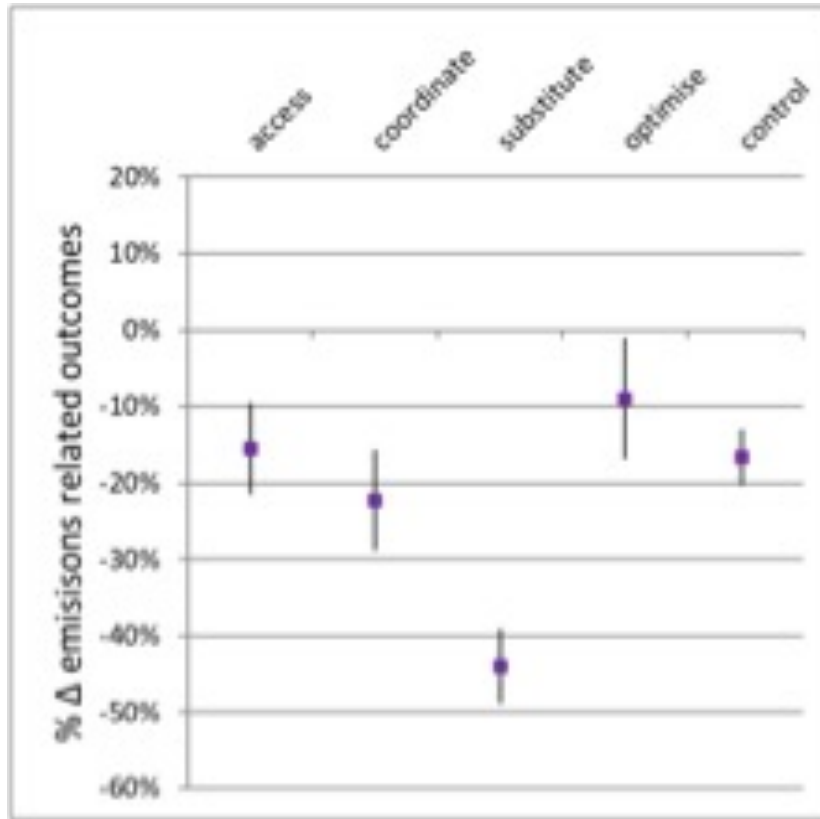
*metric*

- e.g., activity, energy, carbon

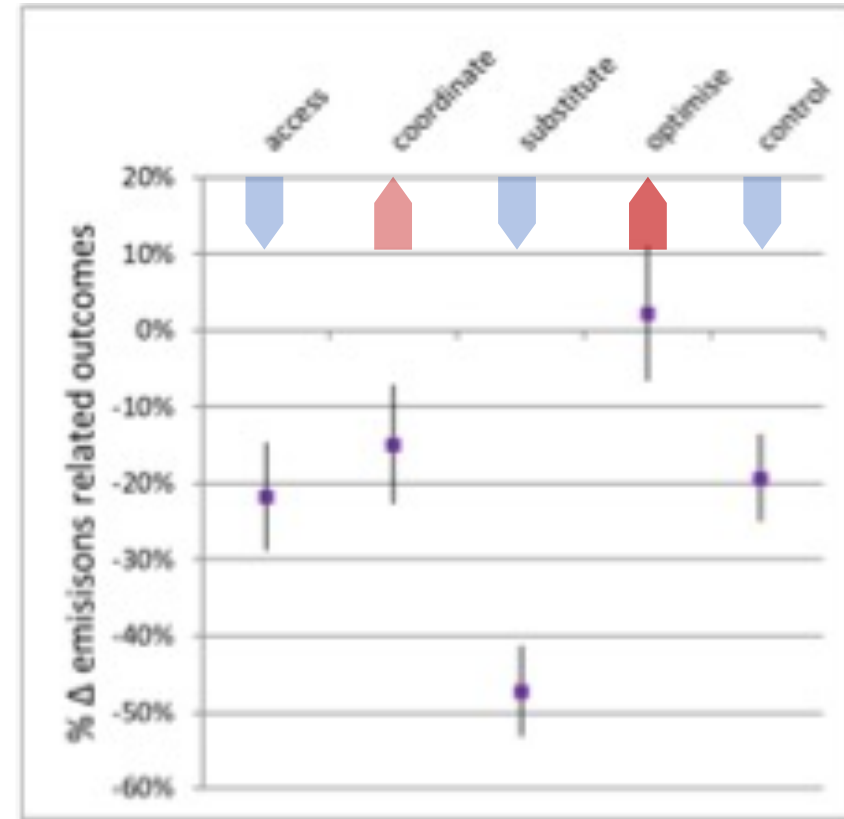


controlling for variation in deployment context and study design

RQ2. Which impact mechanisms have the largest energy-saving benefits?



controlling for variation in deployment context but not study design



controlling for variation in deployment context and study design

# How does digitalisation impact energy use ... and by how much?

1. Mechanisms explaining digitalisation impacts have distinct ‘fingerprints’:
  - *Substitute*: largest energy-saving benefit (mean = -43.9%) across all applications.
  - *Coordinate, Access, Control*: consistent net energy-savings.
2. Relationships between mechanisms (how) and impacts (how much) generalisable across domains. Helps inform prospective assessments.
3. Study design characteristics moderate the relationship between digital application and impact estimates:
  - Studies with lower internal or external validity report larger energy impacts.
4. Not all digital functionality linked to energy savings.
  - Rebound effects for certain types of digital application: *Optimise*.

# Mapping and Quantifying the Impacts of Digital Applications on Energy Use

**Charlie Wilson**, Vlad Coroama, Hazel Pettifor, Maureen Agnew  
ECEEE  
June 2024

iDⓂDDLE

[idoddle.org](http://idoddle.org)



European  
Research  
Council

Consolidator Grant #101003083



Network for Digital Economy  
and Environment



Environmental Change Institute  
SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT