How do new things spread?
The diffusion of digital low-carbon innovations

Oxford Energy Colloquium
November 2020
Charlie Wilson
silci.org
Life is digitalising.

9.1 Daily internet users during the three months preceding the survey, 2019

Daily internet users during the three months preceding the survey, 2019 (% of people aged 16-74 years, by NUTS 2 regions)

EU-27 = 77

- < 60
- 60 - < 70
- 70 - < 80
- 80 - < 90
- ≥ 90
- Data not available


Overview of talk.

1. Potential climate benefits of digital consumer innovations
2. How new things spread
3. New evidence on the diffusion of digital low-carbon innovations
4. Implications
Climate impacts of digitalisation tend to focus on (1) supply & infrastructure, (2) employment. ... and are highly uncertain
Digital **consumer** innovations can potentially help reduce emissions in (at least) five ways.

(1) Shift from owning to **accessing**.
Digital *consumer* innovations can potentially help reduce emissions in (at least) five ways.

(1) Shift from owning to **accessing**.

(2) Increase **utilisation** & reduce waste.
Digital **consumer** innovations can potentially help reduce emissions in (at least) five ways.

(1) Shift from owning to **accessing**.

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(3) Substitute for physical **movement**.
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(4) Improve **control** & management. (+ electrification of end-use)

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- smart heating
- smart lighting
- electric vehicles
- e-bikes
Digital **consumer** innovations can potentially help reduce emissions in (at least) five ways.

(1) Shift from owning to **accessing**.

(2) Increase **utilisation** & reduce waste.

(3) Substitute for physical **movement**.

(4) Improve **control** & management. (+ electrification of end-use)

(5) Improve **system performance**.
Digital innovations can also challenge mainstream consumption norms.

Overview of talk.

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How do new things spread?
The diffusion of digital low-carbon innovations

Diffusion = Communication over time about an innovation among members of a social system

greenbanana.wordpress.com
How do new things spread?
The **diffusion of innovations** ... and viruses

Four key mechanisms of **virus transmission**

1. **People are different (heterogeneity)**
   - varying susceptibility to infection or potential for spreading
   *e.g., age, profession, risk preferences & behaviours*
Four key mechanisms of **virus transmission**

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2. **Interpersonal transmission**
   - infection through social contact
   *e.g., talking, sneezing, touching*
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3. **Social networks of interaction**
   - number, frequency and diversity of social interactions
   *e.g., travel & mixing*
Four key mechanisms of *virus transmission*

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3. **Social networks of interaction**
   - number, frequency and diversity of social interactions
   *e.g.*, *travel & mixing*

4. **Attributes**
   - characteristics of virus (which make it infectious)
   *e.g.*, *persistence, capacity to evade immune system*
Four key mechanisms of **innovation diffusion**

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<th></th>
<th><strong>1. People are different (heterogeneity)</strong></th>
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<td>- varying tolerance for uncertainty, personal situation</td>
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1. Potential climate benefits of digital consumer innovations

2. How new things spread

3. New evidence on the diffusion of digital low-carbon innovations

4. Implications
Over the past 3 years we’ve been collecting and analysing data on a diverse set of innovations.

Research team: me, Hazel, Barnaby  Emilie, Emma, Laurie, Mark

Innovation-focus: broad (comparative analysis)  deep (case study analysis)

Data collection: lit. review, structured elicitations  early adopter surveys, interviews, focus groups ...

‘BigSurvey’ n=3,000 (UK + Canada)  Wave 1: Oct-Nov 2019
Wave 2: now!
Sampling design:

quotas of
~100 adopters and
~100 non-adopters
per innovation

(UK sample, Oct 2019)
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Four key mechanisms of innovation diffusion

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   - *e.g.*, travel & mixing

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   - characteristics of innovation (which make it appealing)
   - *e.g.*, ease of use, compatibility
Adoption propensity varies as a function of personal characteristics & risk preferences.

en.wikipedia.org/wiki/Diffusion_of_innovations
**Models predicting adopters (vs. non-adopters) test for differences consistent across innovations.**

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<tr>
<th>Independent Variables</th>
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Models predicting adopters (vs. non-adopters) test for differences consistent across innovations.
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Logistic models:
Coefficients (odds ratios) > 1 = more likely in adopters
Coefficients (odds ratios) < 1 = less likely in adopters

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Adopters differ from non-adopters in their sociodemographic characteristics.

Adopters of **car clubs** are ...
   *younger, more educated, and more likely to be in employment*

... compared to non-adopters
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don’t look down!
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Adopters of digital low-carbon innovations are ... 

_younger, more likely to be in employment, higher income, living in multi-person households_

... compared to non-adopters
Adopters differ from non-adopters in their values, *digital skills*, and ‘lifestyle’ activities.

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<td>Technological Lifestyle Activities (5 items)</td>
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<td>Personality: Neuroticism (3 items)</td>
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<td>Personality: Openness (3 items)</td>
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<td>Personality: Extroversion (3 items)</td>
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<td>Personality: Agreeableness (3 items)</td>
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<td>Personality: Conscientiousness (3 items)</td>
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</tbody>
</table>
Adopters differ from non-adopters in their values, digital skills, and ‘lifestyle’ activities.

Adopters of car clubs are...

*open to change (values), digitally skillful, technologically active, unconscientious (personality)*

... compared to non-adopters.
Adopters differ from non-adopters in their values, digital skills, and ‘lifestyle’ activities.

Adopters of digital low-carbon innovations are ...

*digitally skillful, environmentally active, technologically active*

... compared to non-adopters
Adopters can also be differentiated in their values, digital skills, and ‘lifestyle’ activities.
Adopters can also be differentiated in their values, digital skills, and ‘lifestyle’ activities.
Adopters can also be differentiated in their values, digital skills, and ‘lifestyle’ activities.

Innovators:  
- score highly on everything!

Technological early adopters:  
- egoistic values, tech. lifestyles

Environmental early adopters:  
- biospheric values, env. lifestyles
Four key mechanisms of innovation diffusion

1. **People are different (heterogeneity)**
   - varying tolerance for uncertainty, personal situation
   *e.g.*, age, income, technophilia

2. **Interpersonal transmission**
   - information exchange through social contact
   *e.g.*, word of mouth (WoM), peer effects

3. **Social networks of interaction**
   - number, frequency and diversity of social interactions
   *e.g.*, travel & mixing

4. **Attributes**
   - characteristics of innovation (which make it appealing)
   *e.g.*, ease of use, compatibility
Interpersonal exchange of information on low-carbon innovations = social influence.

meta-analysis of 21 studies of social influence on EV adoption: all 4 mechanisms had similar effect sizes

Adopters differ from non-adopters in their exposure and receptiveness to social influence.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>CAR CLUBS</th>
<th>P2P CAR-SHARING</th>
<th>RIDE-SHARING</th>
<th>SHARED RIDE-HAILING</th>
<th>EVS</th>
<th>E-BIKES</th>
<th>DIGITAL FOOD HUBS</th>
<th>MEAL KITS</th>
<th>11TH HOUR APPS</th>
<th>SMART HOMES</th>
<th>SMART LIGHTING</th>
<th>SMART HOME APPLIANCES</th>
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</thead>
<tbody>
<tr>
<td>INFORMATION FLOWS</td>
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<td>Domain Innovativeness (3 items)</td>
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<td>Social Influence (8 items)</td>
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<td>info Sources Inter-Personal (4 types)</td>
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<td>info Sources General Media (2 types)</td>
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</tbody>
</table>
Adopters differ from non-adopters in their exposure and receptiveness to social influence.

Adopters of car clubs...

*are more innovative (in a transport context),
receive more information through inter-personal exchange (about car clubs)

... compared to non-adopters,

*but don’t differ in how they seek information to shape their opinion*
Adopters differ from non-adopters in their exposure and receptiveness to social influence.

Adopters of digital low-carbon innovations...

*are more innovative (in a transport / food / homes context),
receive more information through inter-personal exchange (about the innovation)*

... compared to non-adopters

*but don’t differ in how they seek information to shape their opinion*
All 4 social influence mechanisms consistently explains adoption, and propensity to adopt.

- **adopters**
- **high propensity non-adopters**
- **low propensity non-adopters**

- word of mouth (WoM)
- e-WoM
- neighbourhood effects
- social norms
All 4 social influence mechanisms consistently explains adoption, and propensity to adopt.

Adopters > ***
High propensity non-adopters > ***
Low propensity non-adopters > ***

- Word of mouth (WoM)
- e-WoM
- Neighbourhood effects
- Social norms

Same for all 3 clusters: innovators, tech, env
All 4 social influence mechanisms consistently explains adoption, and propensity to adopt.

Word of mouth (WoM)
e-WoM
neighbourhood effects
social norms

adopters
high propensity non-adopters
low propensity non-adopters

same for all 3 clusters: innovators, tech, env

largest effect?
All 4 social influence mechanisms consistently explains adoption, and propensity to adopt.

word of mouth (WoM)
e-WoM
neighbourhood effects
social norms

adopters
high propensity non-adopters
low propensity non-adopters

> ***
> ***
> ***
> ***

same for all 3 clusters: innovators, tech, env

eWoM: largest effect
Four key mechanisms of **innovation diffusion**

1. **People are different (heterogeneity)**
   - varying tolerance for uncertainty, personal situation
   *e.g.*, age, income, technophilia

2. **Interpersonal transmission**
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3. **Social networks of interaction**
   - number, frequency and diversity of social interactions
   *e.g.*, travel & mixing

4. **Attributes**
   - characteristics of innovation (which make it appealing)
   *e.g.*, ease of use, compatibility
Social network size & structure mediate flows of information between people.

“The slow pace of diffusion is often a result of network structures” (Valente 2010)

“Social network characteristics fundamentally impact the dynamic (communication) processes within” (Borgatti et al. 2014)
Adopters differ from non-adopters in their use of social media... but not in their social networks.
Adopters differ from non-adopters in their use of social media... but not in their social networks.

Adopters of car clubs...

have more diverse online networks (in general),

... compared to non-adopters

but have social networks of similar sizes, transitivity, and homophily (in general)
Adopters differ from non-adopters in their use of social media... but not in their social networks.

Adopters of digital low-carbon innovations... have more diverse online networks (in general), ... compared to non-adopters but have social networks of similar sizes, transitivity, and homophily (in general)
Mapping innovation-specific information flows makes the role of social networks clearer.

Looking back over the last six months, please tell us the first name or initials of up to 5 close friends.

<table>
<thead>
<tr>
<th>Friend 1</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Friend 2</td>
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<td></td>
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<tr>
<td>Friend 3</td>
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<tr>
<td>Friend 4</td>
<td></td>
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<tr>
<td>Friend 5</td>
<td></td>
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</tr>
</tbody>
</table>

... generated 2850 alters from samples of 353 adopters and 360 non-adopters of smart home technologies

Mapping innovation-specific information flows makes the role of social networks clearer.

- Actively seek info from diverse sources: ***
- Seek opinion leaders: ***
- Communicate more about innovations: ***

Mapping innovation-specific information flows makes the role of social networks clearer.

- Adopters actively seek info from diverse sources and opinion leaders, communicate more about innovations. 

  - Opinion leaders: > *** 
  - Communication: > ***

  *but*

- High transitivity (= cliquey) and high income homophily.

Mapping innovation-specific information flows makes the role of social networks clearer.

- Adopters actively seek info from diverse sources and opinion leaders. They communicate more about innovations than non-adopters.
  - High transitivity (cliquey)
  - High income homophily

- Non-adopters' opinions are shaped by strong ties, but 3 times less likely to know anyone with smart home technology.

Four key mechanisms of innovation diffusion

1. **People are different (heterogeneity)**
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2. **Interpersonal transmission**
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4. **Attributes**
   - characteristics of innovation (which make it appealing)
   *e.g.*, ease of use, compatibility
Five attributes make innovations more or less appealing to potential adopters.

relative advantage
ease of use
compatibility
trialability
observability
Adopters differ from non-adopters in their perceptions of innovation attributes.

- relative advantage
- ease of use
- compatibility
- trialability
- observability
- climate benefits

adopters > ***
non-adopters > ***
Do innovations with ‘weak’ attributes need more specific types of social influence?

- relative advantage
- ease of use
- compatibility
- trialability
- observability

WoM (word of mouth)

eWoM

peer effects

social norms
Do innovations with ‘weak’ attributes need more specific types of social influence?
Do innovations with ‘weak’ attributes need more specific types of social influence? No.

- Relative advantage
- Ease of use
- Compatibility
- Trialability
- Observability

WoM (word of mouth)
eWoM
Peer effects
Social norms

No evident links between specific attributes and specific social influences
Summary of new evidence on the diffusion of digital low-carbon innovations

1. People are different (heterogeneity)
   - adopters are younger, in employment, with higher digital skills
   - adopters differentiate into innovators, egoistic techies, biospheric enviros
Summary of new evidence on the diffusion of digital low-carbon innovations

1 People are different (heterogeneity)
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2 Transmission mechanisms
   - adopters receive more social influence of all types (particularly eWoM)
   - adopters have higher domain innovativeness (= opinion formers)
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   - adopters have similar social network size & diversity (except online)
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   - adopters have similar social network size & diversity (except online)
   - info flows from adopters can get trapped in homophilous cliques

4. Attributes
   - adopters perceive higher relative advantage, ease of use, compatibility
   - non-core attributes differentiate appeal of innovations from mainstream
Overview of talk.

1. Potential climate benefits of digital consumer innovations
2. How new things spread
3. New evidence on the diffusion of digital low-carbon innovations
4. Implications
Mechanisms of transmission or diffusion determine outcomes (e.g., growth rates).
Mechanisms of transmission or diffusion determine outcomes (e.g., growth rates).

Germany: New daily confirmed Covid19 cases. [Johns Hopkins: coronavirus.jhu.edu/data/new-cases]

en.wikipedia.org/wiki/Diffusion_of_innovations
Mechanisms of **transmission** or diffusion also point to control measures.

<table>
<thead>
<tr>
<th>HOW NEW THINGS SPREAD</th>
<th>SLOWING THE SPREAD (of coronavirus)</th>
<th>SPEEDING UP THE SPREAD (of digital low-carbon innovations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People are different</td>
<td>isolate spreaders, protect vulnerable</td>
<td>recruit opinion leaders, incentivise early adopters</td>
</tr>
<tr>
<td>Inter-personal</td>
<td>physical distancing, quarantine</td>
<td>neighbourhood schemes, (digital) open houses</td>
</tr>
<tr>
<td>transmission</td>
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<tr>
<td>Social networks of</td>
<td>travel bans, rule of six</td>
<td>cross-national exchange, eWoM on social media</td>
</tr>
<tr>
<td>interaction</td>
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<td></td>
</tr>
<tr>
<td>Attributes</td>
<td>[indirectly – drugs, vaccines]</td>
<td>product development, market differentiation</td>
</tr>
</tbody>
</table>

* if and when it’s safe *
**Social influence** can accelerate *potential* climate benefits from widespread adoption ...

... so like other accelerants, should be a target for public policy.
Social influence can accelerate potential climate benefits from widespread adoption ...

<table>
<thead>
<tr>
<th>Global 2°C scenarios</th>
<th>Technological learning only</th>
<th>Social learning only</th>
<th>Both types of learning</th>
</tr>
</thead>
</table>

‘social learning’ about an innovation (reducing perceived risk)

‘technological learning’ (reducing costs and improving performance)

Social influence can accelerate potential climate benefits from widespread adoption ...

‘social learning’ about an innovation (reducing perceived risk)
+ ‘technological learning’ (reducing costs and improving performance)
= accelerated diffusion

How do new things spread?
The diffusion of digital low-carbon innovations

Oxford Energy Colloquium
November 2020
Charlie Wilson
silci.org