Positive effects vs rebound effects in specific domains: **Telework**

Digitalization and the Rebound Effect – Seminar HS2019

Outline

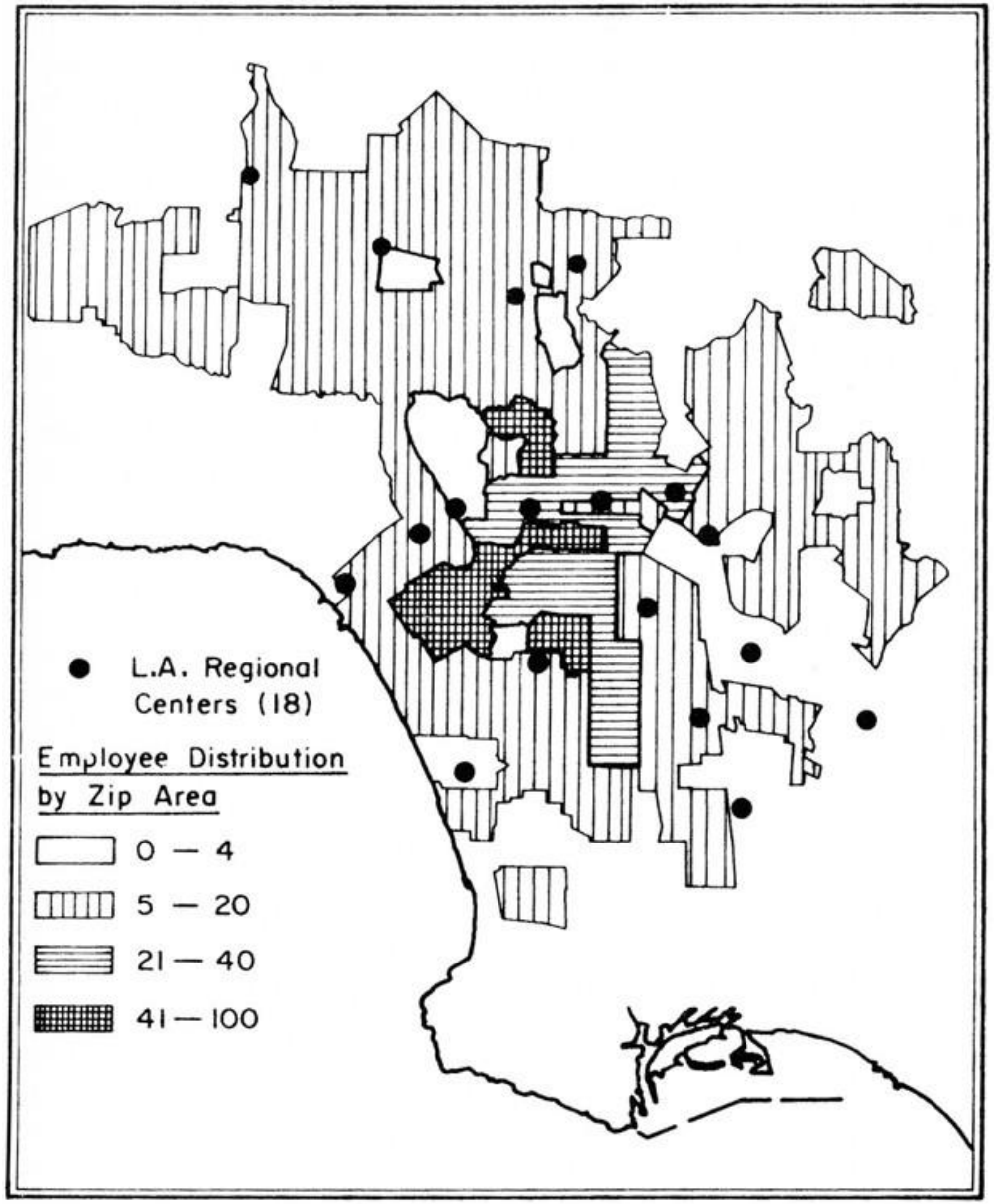
- **Telework: motivation and definitions**
- Adoption and evolution over time
- Proposed benefits
- Possible rebound effects
- Measurement strategies and results
- Outlook and discussion

Telework

- Also known as “telecommuting”, or simply “working from home”
- A proposed way of reducing the time spent commuting to a place of work, with potential personal and environmental benefits
- Early research was carried out during the 80s
  - Only transportation, no rebound
  - Typically California-centered

Telework: origin

- The term "Telecommuting" was first coined by Jack Nilles (University of Southern California) in 1973
- No Internet at the time
- Instead of "working from home", concept of "satellite offices" close to home



Teleworking and environment

- We want to study telework from an environmental perspective
  - Energy use, greenhouse gases, pollution

- If the potential for savings is significant enough, we can implement policies to foster teleworking on a wider scale

- We need to estimate:
  - Benefits (based on current teleworking population), minus rebound effects
  - Population that can potentially telework

Telework: definitions

- Unfortunately, no unique definition
  - Occasional vs part-time vs full-time
  - Companies implement specific policies
  - Difficult to compare research works or surveys between different countries

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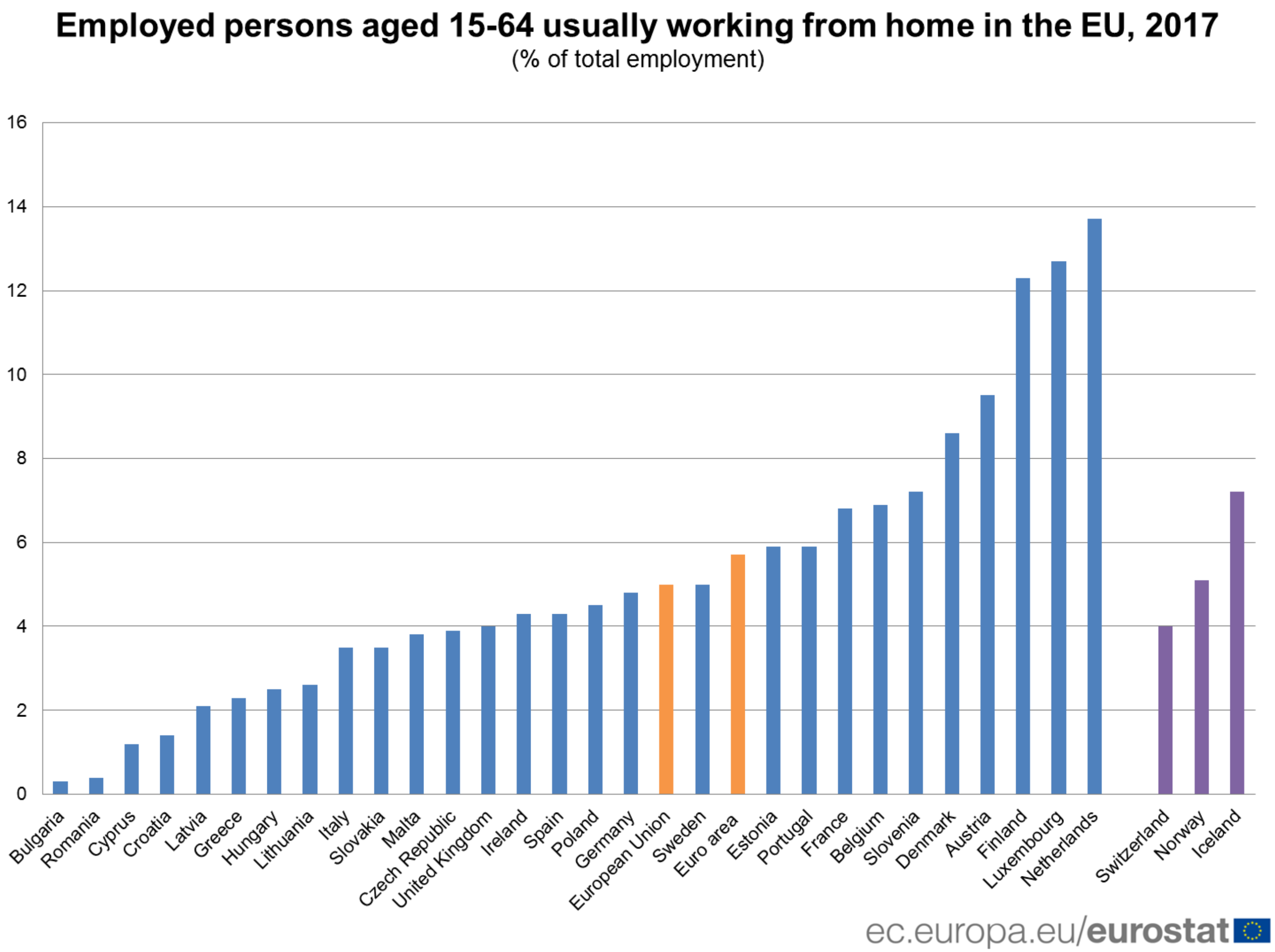
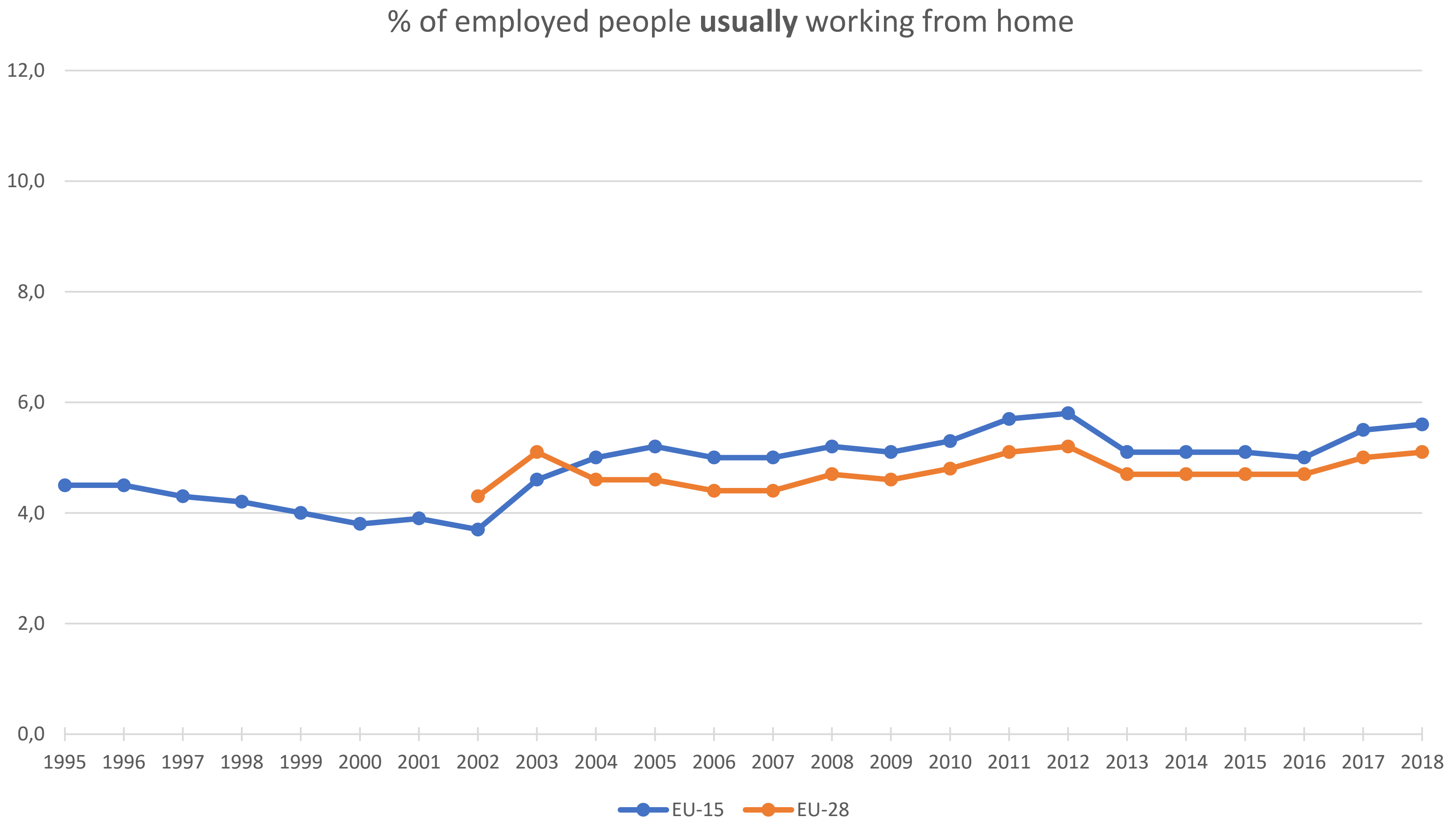
Adoption statistics

- No global surveys
- Most statistics are country- or region-specific
  - **United States**
  - European Union
  - **Japan**
- Most research focuses on an individual region
- Numbers vary a lot according to chosen definition

Adoption (Europe, 2017)

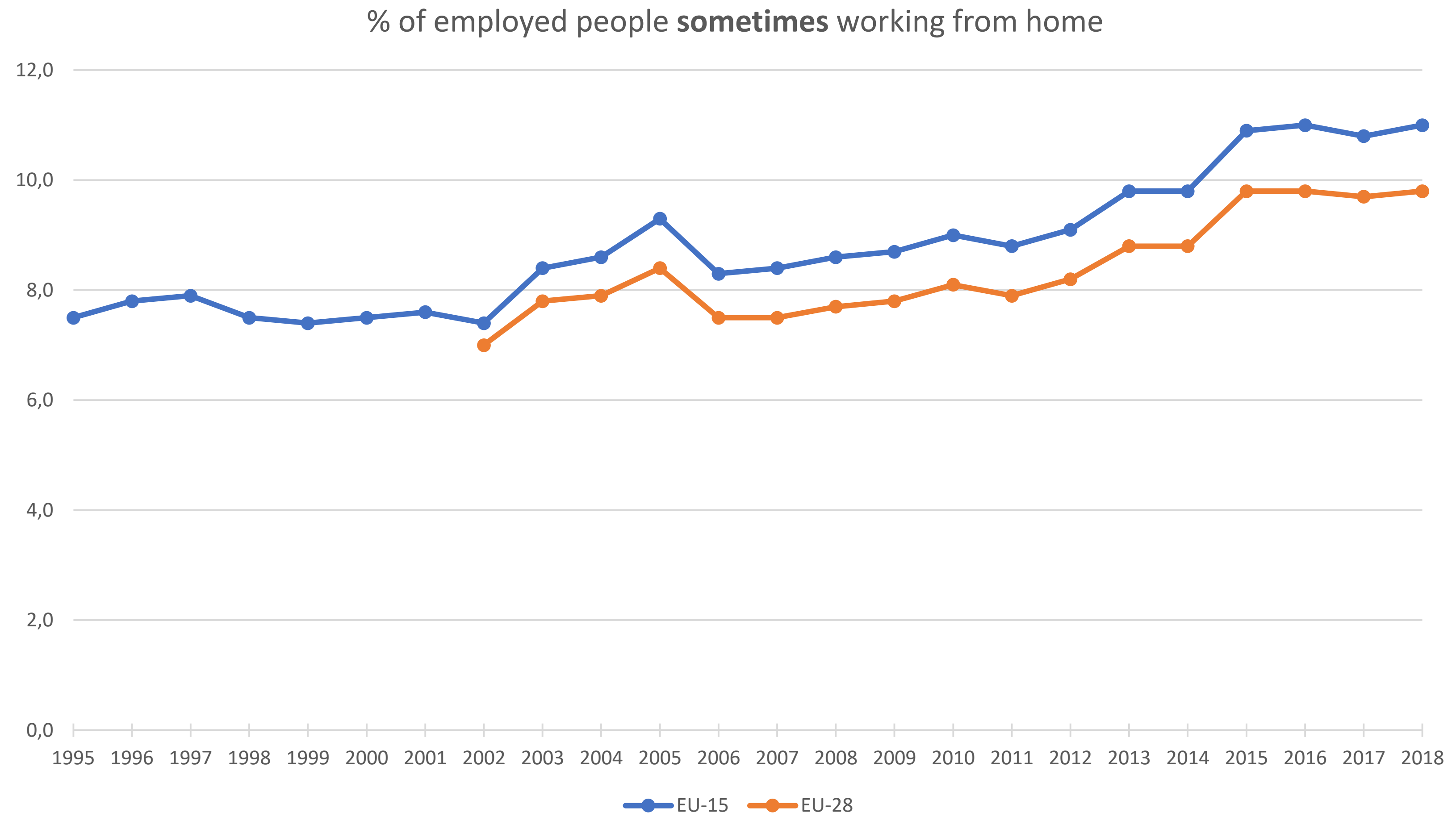


Evolution (Europe)



Data source: Eurostat **lfsa_ehomp**

Evolution (Europe)



Data source: Eurostat **lfsa_ehomp**

Adoption (United States)

- US Census Survey of Income and Program Participation (SIPP)
  - Clear distinction between home-based and “mixed workers” *(Kuenzi and Reschovsky 2001)*
  - Mixed workers work from home at least 1 day/week
    - 2.9 million in 1997
  - Entirely home-based
    - 6.4 million in 1997

- Total in 1997: 9.3M out of 133M (7%)
- In 2010: 13.4M out of 142M (9%)

Adoption (Japan)

- Japan Telework Association (JTA)
  - “Broad definition teleworkers”: less than 8h/week on average
    - 6.34 million in 2002
  - “Teleworkers”: at least 8h/week
    - 4.08 million in 2002
  - Comprises both salaried employees and self-employed
- Total in 2002: 10.42M out of 67M (15%)

Who can telework?

- To estimate the **potential** (as opposed to **actual**) environmental benefits, we need an upper estimate of the teleworking population

- Information workers *(Matthews and Williams 2005)*
  - Those who work in information and do not have to be physically present at the workplace

- 40% of the total workforce in the US – 44% in Japan
- 50% of these can potentially telework *(Mokhtarian 1998)*

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Proposed benefits

- Work- and life-related
  - More free time (controversial)
  - Lower transportation/gas expenses
  - For some, better productivity (controversial)

- Environmental aspects
  - Our focus in this presentation

Proposed environmental benefits

- Private transportation
  - Less gas/energy used
  - Less greenhouse gases
  - Lower pollution
- Less of a factor in areas where public transportation is common
  - California vs Switzerland

Proposed environmental benefits

- Traffic congestion
  - Energy saving is a non-linear function of the number of cars taken off the road *(Matthews and Williams 2005)*
  - Reducing traffic may “boost” savings in non-teleworking population
  - Advanced models should take this into account
  - Models evolve over time (e.g. Start & Stop, Hybrid cars)

Proposed environmental benefits

- Reduction or elimination of office space
  - Less energy spent to build new infrastructure
  - Office space reduction translates into lower HVAC costs

- Hard to assess

- Only pays off for organized teleworking

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Rebound effects

- Household energy consumption
  - On teleworking days, more energy used for heating, AC, lighting
  - *(Matthews and Williams 2005)* make a distinction between U.S. – centralized heating – and Japan – manual heating

- Worse for occasional teleworking
  - Not offset by office building energy reduction

Rebound effects

- Increase of non-work-related transportation
  - Driving to the grocery store instead of stopping by on the way home
  - Taking children to school
- Social effects *(Mokhtarian 2009)*
  - People may become more compelled to drive on weekends

Rebound effects

- Time rebound and income effects
  - Time saved by not commuting is used for something else, either more work or energy-consuming tasks
  - Saved gas translates into more money that can be spent on something else

Rebound effects

- Relocation *(Ory and Mokhtarian 2006)*
  - People who telecommute may move further away from the workplace *(Hilty and Aebischer 2015)*
  - Longer commute on non-teleworking days
  - The causality direction is still not clear

- Telecommuters travel 35.4 km on average
- Non-telecommuters travel 19.3 km
  - *(Roth, Rhodes, Ponoum 2008)*

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Measurement

- *(Roth, Rhodes, Ponoum 2008)*
  - Ground transportation, residential buildings, commercial buildings
  - Energy and greenhouse emissions
  - US focus
  - Income effects not considered

Measurement: ground transportation

$$E_T = (VKT_{TC} - VKT_{base})\frac{E_{fuel}}{KPL}F_{auto}$$

E_T = net energy impact (MJ or kWh)
VKT_{TC} = vehicle km traveled on telecommuting days (incl. non-work trips)
VKT_{base} = vehicle km traveled on non-telecommuting days
E_{fuel} = energy content of fuel (34.9 MJ/L or 9.69 kWh/L for gasoline)
KPL = fuel economy in km/L (8.9 km/L in 2008, U.S.)
F_{auto} = embodied energy multiplier (1.29), takes into account gas transportation

Measurement: ground transportation

- *(Matthews and Williams 2005)* provide a similar analysis
  - Distinction between US and Japan
  - For Japan, public transport is taken into account

- *(Koenig, Henderson, Mokhtarian 1996)*
  - Thorough emissions profiling (CO2, CO, NOx, particulate matter)
  - Advanced models (e.g. engine cold starts)
  - The situation might be different today

Measurement: residential buildings

- *(Roth, Rhodes, Ponoum 2008)*
  - ICT Energy (e.g. PCs), lighting, **heating/cooling**
  - Energy/lighting: increment over 9h on telecommuting days
  - Heating: proportional to spent fuel

TABLE II: RESIDENTIAL HEATING AND COOLING IMPACT CALCULATION VALUES

Space Heating

Fuel	E_{SHR} [EJ]	η_{fuel}	$L_{Heat,R}$
Natural Gas	3.7	80%	3.0
Heating Oil	0.90	80%	0.72
Propane	0.30	80%	0.24
Electricity	0.44	200%	0.89
Total	5.4	N/A	4.8

Fuel	C_{energy}	$E_{Heat,R}$ [EJ]	Reference
Natural Gas	1.08	4.0	[17]
Heating Oil	1.15	1.0	[14][a]
LPG	1.15	0.34	[14][b]
Electricity	3.83	1.7	[17], [19]
Total	N/A	7.1	

[a] Based on Diesel fuel
[b] Assumed same as heating oil

Measurement: residential buildings

- *(Matthews and Williams 2005)*
  - Again, US case and Japan case
  - In the US, central heating is common → less potential for savings
  - In Japan, room-by-room control is common
  - Rough estimate: heating of one extra room on telecommuting days

Measurement: office buildings

- *(Roth, Rhodes, Ponoum 2008)*: similar analysis as residential buildings
  - ICT Energy: estimated 1.4 kWh/person per telecommuting day
  - Floorspace: 9.3 m^2/employee, 708 kWh*/m^2/year
    - For comparison, an average house in the US consumes 1000 kWh/month
    - Frequent telecommuting promotes shared spaces
  - Heating: correlated with electricity saving. 1 kWh → 0.28 kWh* saved in HVAC

* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Measurement: office buildings

- *(Matthews and Williams 2005)*
  - They first propose a linear model
  - Total site consumption in offices: $0.3 \cdot 10^{12}$ kWh* in 1999 (US)
  - 29M employees work in office buildings
  - Hence: 10555 kWh*/year per office worker, from which we discount TC days
  - This would assume 100% office savings, which is unrealistic
  - They propose multiple scenarios (0%, 16%, 60%, 70% savings)

* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Results: transportation

- *(Roth, Rhodes, Ponoum 2008)* (US only)
  - 47 km saved on a TC day
  - Each TC day saves on average E_T = 66 kWh*
  - 0.4 kg/km of CO_2 saved
  - Does not consider rebound effects on weekends (no data)

* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Results: transportation

- *(Matthews and Williams 2005)*
  - Assumes that transportation rebound effects are negligible
  - No ridesharing on 80% of cars
  - 11666 kWh* over 250 work days (46.6 kWh/day) in the US
  - 4000 kWh* in Japan (public transport, shorter commute)

* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Results: residential buildings

- *(Roth, Rhodes, Ponoum 2008)* (US only)
  - 5.5 kWh* used on TC days
  - Only 45% of homes reduce temperature when not at home
  - Lighting: 150W per 9 hours on TC days (1.35 kWh/day)

- *(Matthews and Williams 2005)*
  - US: 2694 kWh* per year (5 TC days/week), ~10.5 kWh*/day for 250 days
  - Japan: 888 kWh* saved per year (Japan has a lower baseline)

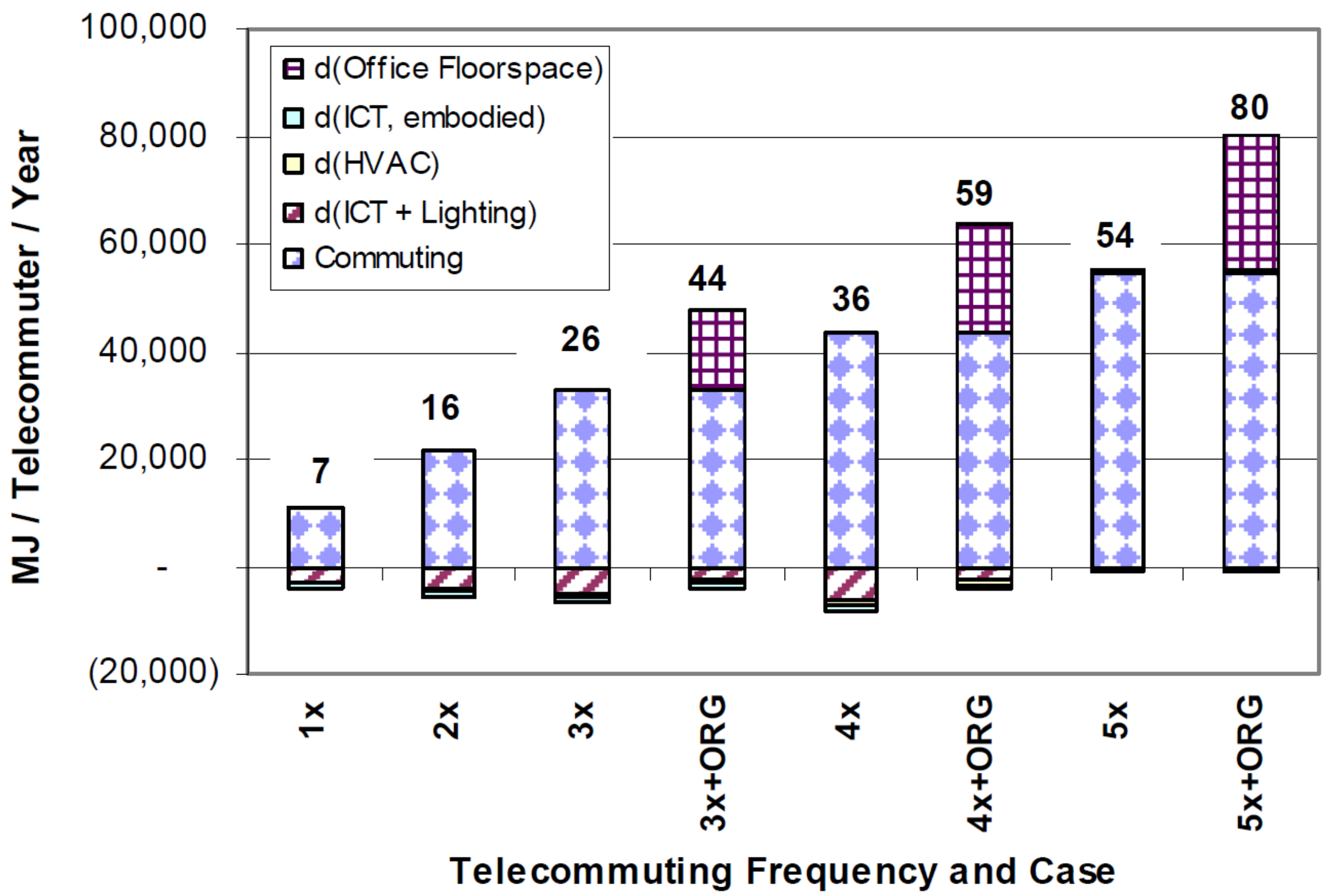
* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Results: office buildings

- *(Roth, Rhodes, Ponoum 2008)* (US only)
  - ICT energy savings: 1.3 kWh per TC day
  - Floorspace: 9.3 m^2/worker for organized telecommuting
  - N·7222 kWh*/year saved for N days of telecommuting/week

* Reported as MJ in the paper. 1 kWh = 3.6 MJ

Energy savings in perspective



Roth, Rhodes, Ponoum 2008

Limitations

- The discussed research focuses on US/Japan
- It would be interesting to see more data related to Europe
- Research from the 90s may not necessarily apply today
  - Greater fuel efficiency, electric cars, public transport
- Telework is rapidly transforming
  - Some tech companies are fully dematerialized

Limitations: rebound

- Although most research works identify potential rebound effects, some of them are not considered in calculations
  - Income effects, transportation rebound
- They are hard to model
- Often no data is available
- Future work should give more weight to rebound effects, especially if telework is adopted on a very large scale

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Outlook

- So far, the full potential of telecommuting has not been reached
  - Only a small percentage of potential teleworkers actually telecommute
- *(Matthews and Williams 2005)* estimate current energy savings as 0.01-0.4% in the US and 0.03-0.36% in Japan
- In a future scenario with 50% information workers telecommuting 4 days/week, national energy saving would be 1%

Outlook

- *(Roth, Rhodes, Ponoum 2008)* reach similar conclusions
- 0.13-0.18% energy savings in the US
- 0.16-0.23% CO_2 savings
- 0.8% less gasoline consumption in light-duty vehicles

Outlook

- By contrast, an improvement in fuel efficiency of 20% would reduce energy use in the US by 5.4%
- The numbers seem to point to the fact that teleworking is environment-friendly and rebound effects are not substantial
- Is 1% savings significant? Is it worth the effort by governments?
  - Considering life-related benefits (or drawbacks) as well

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Thank you for your attention

Questions?