

Peer effects in green technology adoption: Evidence from electric vehicles

Elisabeth Isaksen¹ Bjørn Johansen² Oddbjørn Raaum¹

¹The Ragnar Frisch Centre for Economic Research

²Institute of Transport Economics

International conference on innovation and climate change governance,
INRAE, Paris. May 20, 2022

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Introduction

- ▶ **Many of our decisions are influenced by what our peers are doing**
 - ▶ Information, learning, social norms, status seeking
- ▶ **Peer effects are documented in a lot of different domains**
 - ▶ Work and school performance, paternity leave, welfare cultures, consumption levels, energy conservation, solar panel adoption, etc.
 - ▶ Typically one network at a time (e.g., neighbors, colleagues, fellow students, family dynasty)
- ▶ **This paper: Peer effects in battery electric vehicle (BEV) adoption**
 - ▶ Does the BEV ownership of our peers affect own BEV adoption?
 - ▶ Networks: colleagues and family members
 - ▶ Detailed Norwegian registry data + quasi-experimental research design

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect of policy** = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Why study peer effects in the electric vehicle market?

- ▶ **Better understand what influences electric vehicle adoption**
 - ▶ 1.5° goal requires dramatic reductions in CO₂ emissions
 - ▶ BEV key technology to decarbonize transportation
- ▶ **BEVs are particularly relevant for studying peer effects/social multipliers**
 - ▶ **Visible good**: can be observed by peers
 - ▶ **New technology**: information and learning may be important
 - ▶ **Environmental externalities**: social norms may be particularly important
 - ▶ **Indirect network effects** via charging infrastructure:
Peers' buy BEV → more charging stations → my utility of a BEV ↑
- ▶ **Peer effects have important implications for policymakers**
 - ▶ **Total effect** of policy = **direct effect** + **indirect effects** (social interactions, indirect network effects)

Identification challenge

- ▶ Methodologically difficult to estimate peer effects that can be interpreted causally
- ▶ When members of a group behave similarly it may be due to:
 - ▶ **Similar characteristics and preferences** (e.g., income, age, climate awareness)
 - ▶ **Similar surroundings** (e.g. charging infrastructure, free parking)
- ▶ Additionally: the **reflection problem** (Manski, 1993)
 - ▶ A group's behavior is a mechanical reflection of its members' behavior
 - ▶ Solution: (data) structure with one-way influence
- ▶ Ideal experiment: randomize BEV ownership of individuals' peer groups. → Try to mimic a setup like this using an IV strategy

Identification challenge

- ▶ Methodologically difficult to estimate peer effects that can be interpreted causally
- ▶ When members of a group behave similarly it may be due to:
 - ▶ **Similar characteristics and preferences** (e.g., income, age, climate awareness)
 - ▶ **Similar surroundings** (e.g. charging infrastructure, free parking)
- ▶ Additionally: the **reflection problem** (Manski, 1993)
 - ▶ A group's behavior is a mechanical reflection of its members' behavior
 - ▶ Solution: (data) structure with one-way influence
- ▶ Ideal experiment: randomize BEV ownership of individuals' peer groups. → Try to mimic a setup like this using an IV strategy

Identification challenge

- ▶ Methodologically difficult to estimate peer effects that can be interpreted causally
- ▶ When members of a group behave similarly it may be due to:
 - ▶ **Similar characteristics and preferences** (e.g., income, age, climate awareness)
 - ▶ **Similar surroundings** (e.g. charging infrastructure, free parking)
- ▶ Additionally: the **reflection problem** (Manski, 1993)
 - ▶ A group's behavior is a mechanical reflection of its members' behavior
 - ▶ Solution: (data) structure with one-way influence
- ▶ Ideal experiment: randomize BEV ownership of individuals' peer groups. → Try to mimic a setup like this using an IV strategy

Identification challenge

- ▶ Methodologically difficult to estimate peer effects that can be interpreted causally
- ▶ When members of a group behave similarly it may be due to:
 - ▶ **Similar characteristics and preferences** (e.g., income, age, climate awareness)
 - ▶ **Similar surroundings** (e.g. charging infrastructure, free parking)
- ▶ Additionally: the **reflection problem** (Manski, 1993)
 - ▶ A group's behavior is a mechanical reflection of its members' behavior
 - ▶ Solution: (data) structure with one-way influence
- ▶ Ideal experiment: randomize BEV ownership of individuals' peer groups. → Try to mimic a setup like this using an IV strategy

Identification challenge

- ▶ Methodologically difficult to estimate peer effects that can be interpreted causally
- ▶ When members of a group behave similarly it may be due to:
 - ▶ **Similar characteristics and preferences** (e.g., income, age, climate awareness)
 - ▶ **Similar surroundings** (e.g. charging infrastructure, free parking)
- ▶ Additionally: the **reflection problem** (Manski, 1993)
 - ▶ A group's behavior is a mechanical reflection of its members' behavior
 - ▶ Solution: (data) structure with one-way influence
- ▶ Ideal experiment: randomize BEV ownership of individuals' peer groups. → Try to mimic a setup like this using an IV strategy

Identification of peer effects: key idea

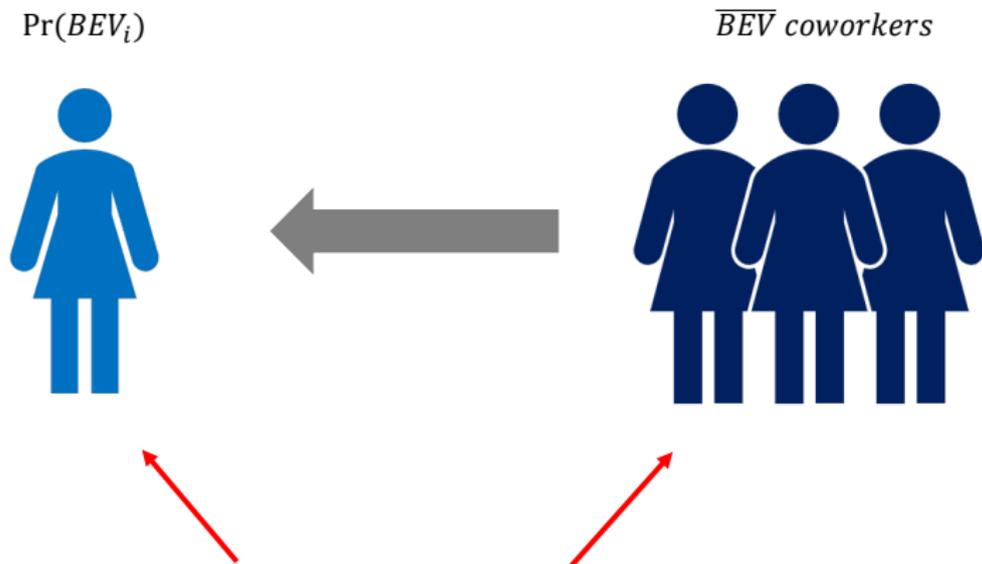
$\Pr(BEV_i)$



\overline{BEV} coworkers



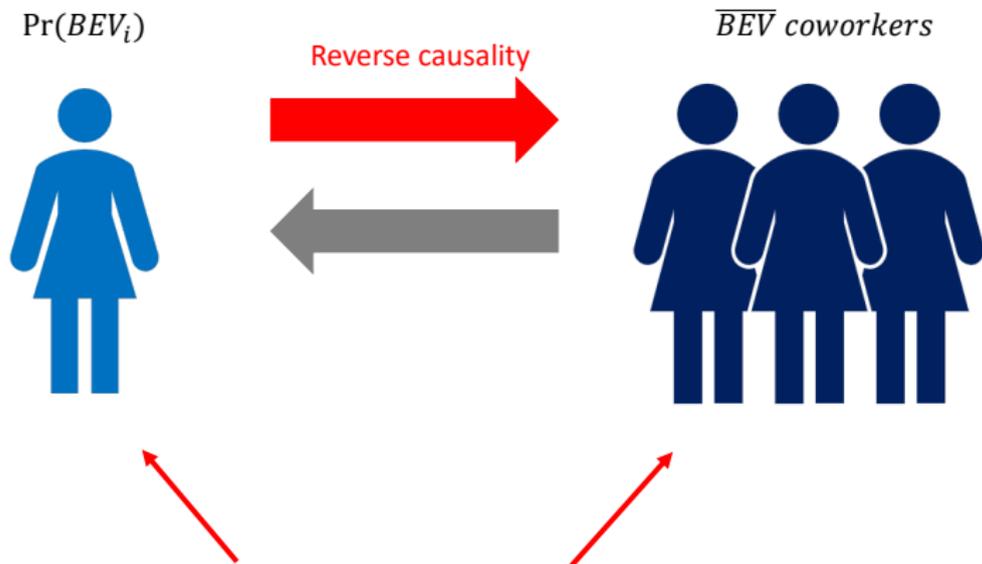
Identification of peer effects: key idea



Similar characteristics and context:

- Income, education, age, family type
- Environmental awareness
- Neighborhood amenities: charging facilities, free BEV parking

Identification of peer effects: key idea



Similar characteristics and context:

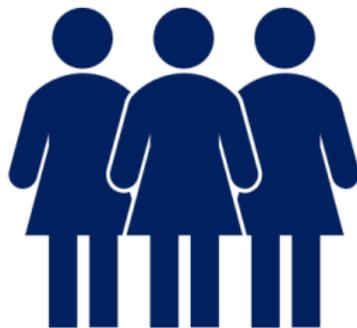
- Income, education, age, family type
- Environmental awareness
- Neighborhood amenities: charging facilities, free BEV parking

Identification of peer effects: key idea

$\Pr(BEV_i)$



\overline{BEV} coworkers



Identification of peer effects: key idea

$\Pr(BEV_i)$



\overline{BEV} coworkers



Identification of peer effects: key idea

$\Pr(BEV_i)$



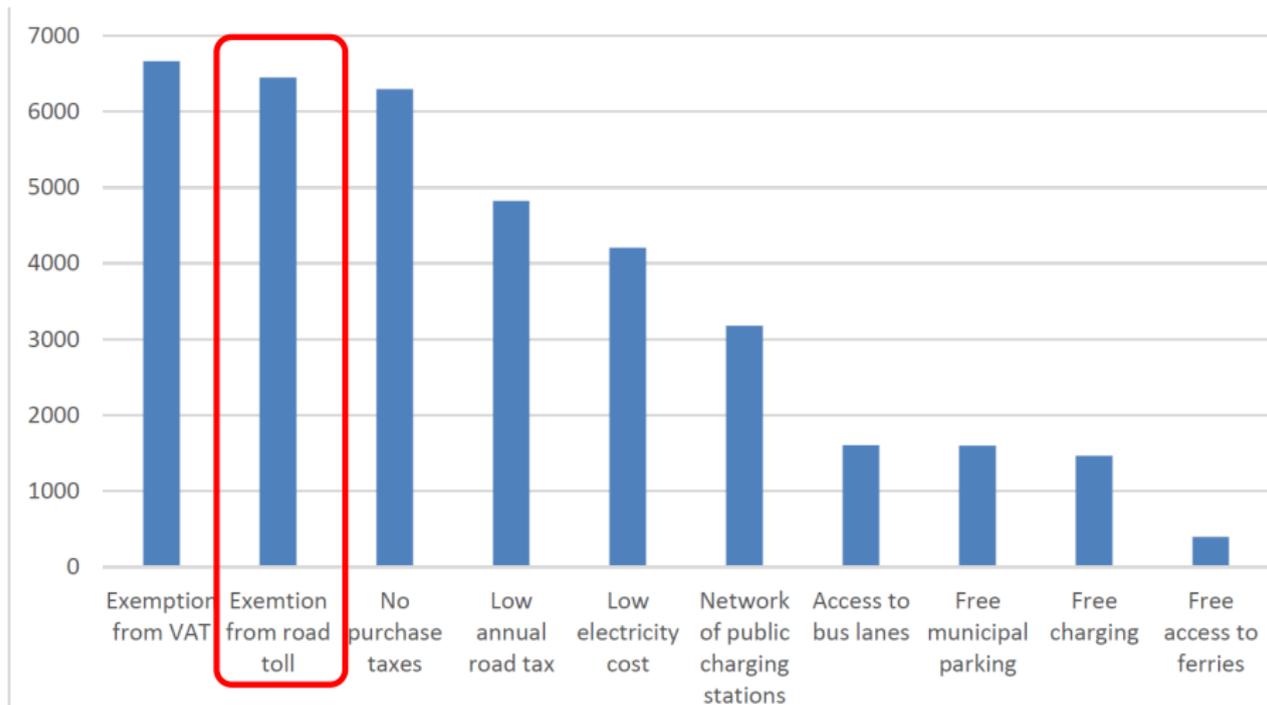
\overline{BEV} coworkers



Exploit quasi-random variation in exposure to road toll on the work commute



Exemption from road toll stated as an important incentive



Notes: Question: Select the 3 most important EV incentives. Number of respondents: 12,500. Source: [Norwegian EV owners survey 2017](#)

Potential mechanisms driving peer effects

$\Pr(BEV_i)$



Social interactions:

- Learning
- Information
- Social norm
- Status seeking



\overline{BEV} coworkers



Potential mechanisms driving peer effects

$\Pr(BEV_i)$



Social interactions:

- Learning
- Information
- Social norm
- Status seeking



\overline{BEV} coworkers



Indirect channel (network effects)

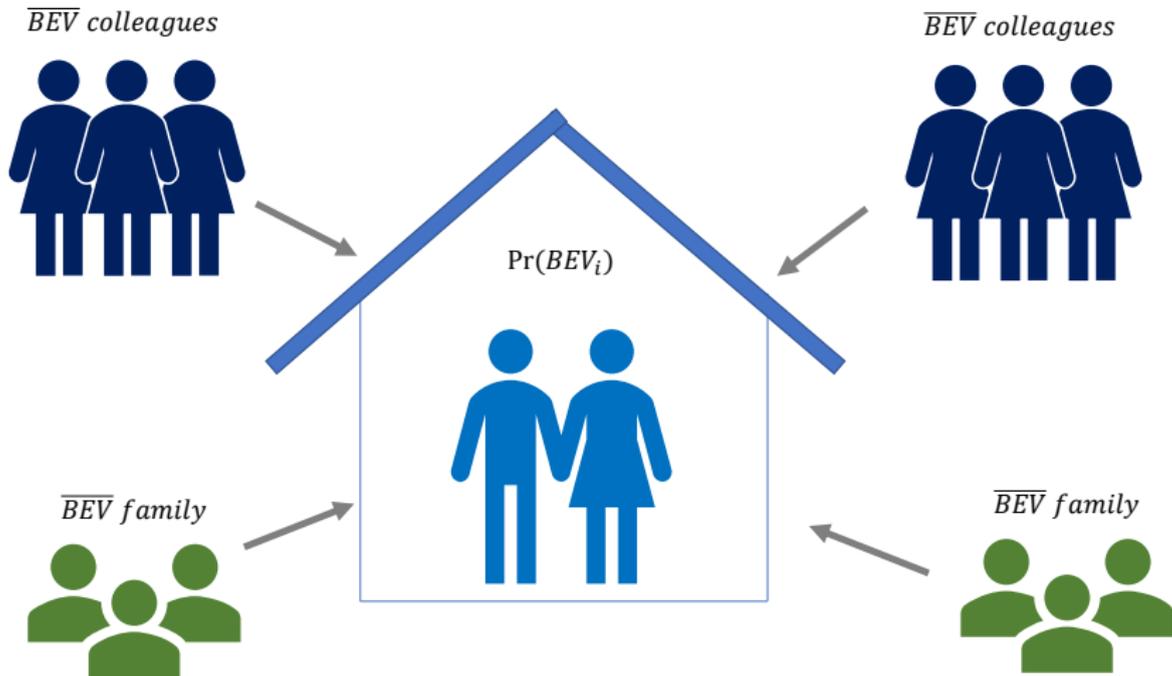
Higher BEV ownership among colleagues

→ More charging facilities at work

→ More charging facilities close to work



2×2 peer groups



Literature

▶ Peer effects in various markets/domains

- ▶ **Labor markets** (Cornelissen et al., 2017), **product adoption** (Bailey et al., 2019), **consumption** (De Giorgi et al., 2020), **program participation** (Dahl et al., 2014), **retirement saving** (Beshears et al., 2015), **car purchase** (Grinblatt et al., 2008), etc.

▶ Peer effects in climate-friendly technologies or goods

- ▶ **Energy use** and social comparison (Allcott and Kessler, 2019; Bailey et al., 2019; Brandon et al., 2019), **Rooftop solar panels** (Bollinger and Gillingham, 2012; Bollinger et al., 2019), **Conspicuous conservation and hybrid cars** (Sexton and Sexton, 2014), **Water conservation** (Bollinger et al., 2020), etc.

▶ Policies to promote electric vehicle adoption

- ▶ **Road tolls and bus lanes** (Halse et al., 2022), **HOV lanes** (Bento et al., 2014), **Charging infrastructure** (Li et al., 2017), **subsidies and tax rebates** (Gallagher and Muehlegger, 2011; Muehlegger and Rapson, 2018; Clinton and Steinberg, 2019), etc.

Contribution to literature

1. One of few papers on peer effects in green technology adoption
2. First empirical paper on peer effects in BEV adoption
3. Exceptionally detailed data → better positioned to identify causal effects (compared to other observational studies)
4. Examine two distinct peer groups simultaneously (colleagues, family)
5. Quantify the social multiplier of electric vehicle policies

Contribution to literature

1. One of few papers on peer effects in green technology adoption
2. First empirical paper on peer effects in BEV adoption
3. Exceptionally detailed data → better positioned to identify causal effects (compared to other observational studies)
4. Examine two distinct peer groups simultaneously (colleagues, family)
5. Quantify the social multiplier of electric vehicle policies

Contribution to literature

1. One of few papers on peer effects in green technology adoption
2. First empirical paper on peer effects in BEV adoption
3. Exceptionally detailed data → better positioned to identify causal effects (compared to other observational studies)
4. Examine two distinct peer groups simultaneously (colleagues, family)
5. Quantify the social multiplier of electric vehicle policies

Contribution to literature

1. One of few papers on peer effects in green technology adoption
2. First empirical paper on peer effects in BEV adoption
3. Exceptionally detailed data → better positioned to identify causal effects (compared to other observational studies)
4. Examine two distinct peer groups simultaneously (colleagues, family)
5. Quantify the social multiplier of electric vehicle policies

Contribution to literature

1. One of few papers on peer effects in green technology adoption
2. First empirical paper on peer effects in BEV adoption
3. Exceptionally detailed data → better positioned to identify causal effects (compared to other observational studies)
4. Examine two distinct peer groups simultaneously (colleagues, family)
5. Quantify the social multiplier of electric vehicle policies

Preview of preliminary results

- ▶ **BEV ownership among colleagues and family have a large and positive effect on a household's BEV ownership**
 - ▶ Colleagues have a larger effect than family
 - ▶ Male colleagues have a stronger influence than female colleagues
 - ▶ Social interactions more likely mechanism than charging stations
- ▶ **Social spillovers increase the effect of a BEV policy by ~60%**
 - ▶ Policy: road toll with exemption for BEVs

Preview of preliminary results

- ▶ **BEV ownership among colleagues and family have a large and positive effect on a household's BEV ownership**
 - ▶ Colleagues have a larger effect than family
 - ▶ Male colleagues have a stronger influence than female colleagues
 - ▶ Social interactions more likely mechanism than charging stations
- ▶ **Social spillovers increase the effect of a BEV policy by ~60%**
 - ▶ Policy: road toll with exemption for BEVs

Preview of preliminary results

- ▶ **BEV ownership among colleagues and family have a large and positive effect on a household's BEV ownership**
 - ▶ Colleagues have a larger effect than family
 - ▶ Male colleagues have a stronger influence than female colleagues
 - ▶ Social interactions more likely mechanism than charging stations
- ▶ **Social spillovers increase the effect of a BEV policy by ~60%**
 - ▶ Policy: road toll with exemption for BEVs

Data

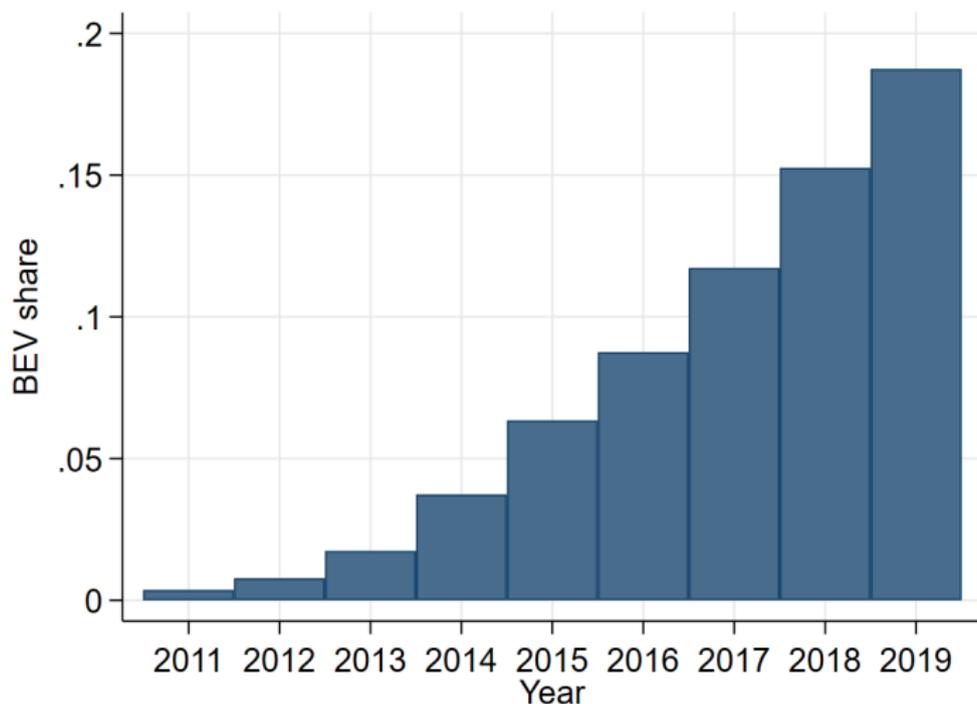
Data

1. **The National Motor Vehicle register**

- ▶ Full population of vehicles registered in Norway, 2011-2019
- ▶ Owner ID, car characteristics (e.g., model, fuel type)

Household-level BEV ownership share, 2011-2019

Figure 1: Share of couple households that own at least one BEV, 2011-2019



Notes: Sample is restricted to couple households where both are working.

Data

1. **The National Motor Vehicle register**

- ▶ Full population of vehicles registered in Norway, 2011-2019
- ▶ Owner, car characteristics (model, fuel type, etc.)

2. **Socioeconomic information and family network**

- ▶ Income, wealth, education, number of children, etc.
- ▶ Partner/spouse, **family members** (mother, father, siblings)

3. **Linked employer-employee data**

- ▶ Allows us to identify individuals' **colleagues**

4. **Geography**

- ▶ Residence and workplace location at the neighborhood level
- ▶ 14 000 neighborhoods, ~ 200 households per neighborhood

5. **Variables related to work commute** (calculated)

- ▶ **Road toll** on work commute (time-minimizing route between centroids)
- ▶ Driving distance, driving time, km of bus lane

Data

1. The National Motor Vehicle register

- ▶ Full population of vehicles registered in Norway, 2011-2019
- ▶ Owner, car characteristics (model, fuel type, etc.)

2. Socioeconomic information and family network

- ▶ Income, wealth, education, number of children, etc.
- ▶ Partner/spouse, **family members** (mother, father, siblings)

3. Linked employer-employee data

- ▶ Allows us to identify individuals' **colleagues**

4. Geography

- ▶ Residence and workplace location at the neighborhood level
- ▶ 14 000 neighborhoods, ~ 200 households per neighborhood

5. Variables related to work commute (calculated)

- ▶ **Road toll** on work commute (time-minimizing route between centroids)
- ▶ Driving distance, driving time, km of bus lane

Data

1. The National Motor Vehicle register

- ▶ Full population of vehicles registered in Norway, 2011-2019
- ▶ Owner, car characteristics (model, fuel type, etc.)

2. Socioeconomic information and family network

- ▶ Income, wealth, education, number of children, etc.
- ▶ Partner/spouse, **family members** (mother, father, siblings)

3. Linked employer-employee data

- ▶ Allows us to identify individuals' **colleagues**

4. Geography

- ▶ Residence and workplace location at the neighborhood level
- ▶ 14 000 neighborhoods, ~ 200 households per neighborhood

5. Variables related to work commute (calculated)

- ▶ **Road toll** on work commute (time-minimizing route between centroids)
- ▶ Driving distance, driving time, km of bus lane

Data

1. The National Motor Vehicle register

- ▶ Full population of vehicles registered in Norway, 2011-2019
- ▶ Owner, car characteristics (model, fuel type, etc.)

2. Socioeconomic information and family network

- ▶ Income, wealth, education, number of children, etc.
- ▶ Partner/spouse, **family members** (mother, father, siblings)

3. Linked employer-employee data

- ▶ Allows us to identify individuals' **colleagues**

4. Geography

- ▶ Residence and workplace location at the neighborhood level
- ▶ 14 000 neighborhoods, ~ 200 households per neighborhood

5. Variables related to work commute (calculated)

- ▶ **Road toll** on work commute (time-minimizing route between centroids)
- ▶ Driving distance, driving time, km of bus lane

Illustration of neighborhoods

City of Oslo

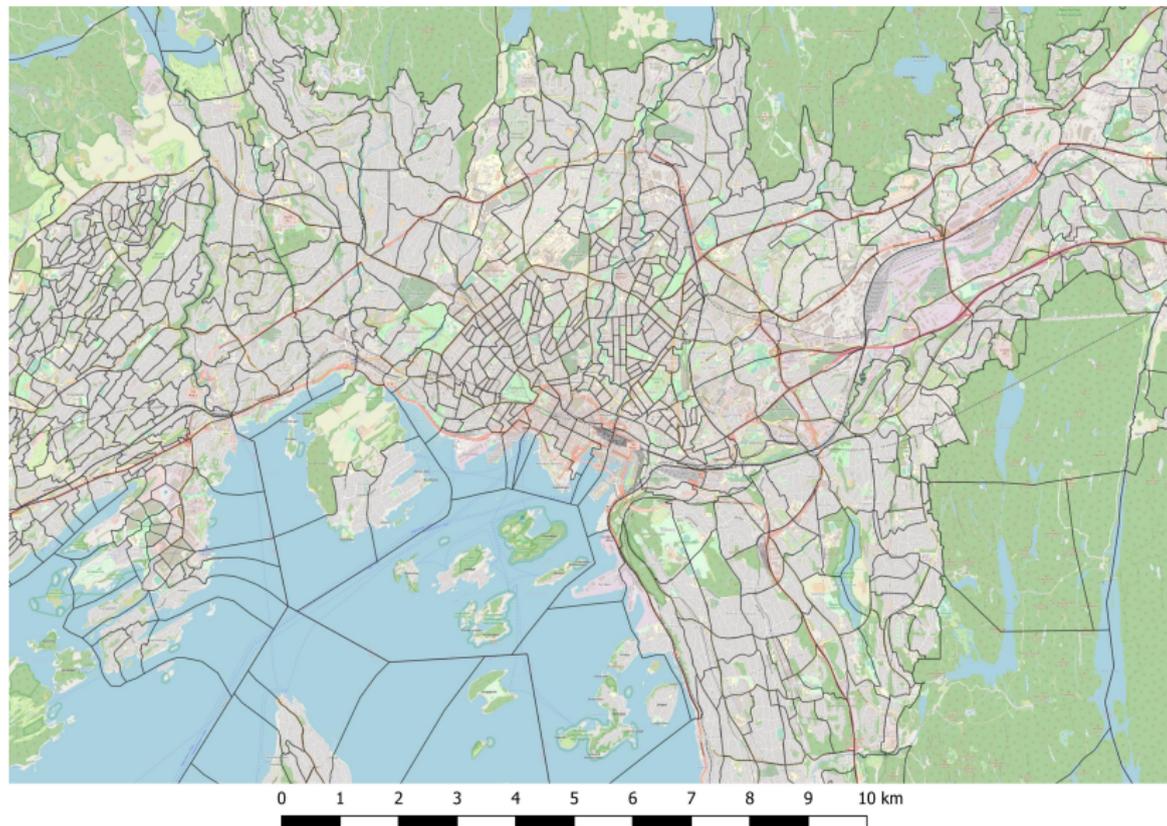


Illustration road toll locations (2016)

City of Oslo ▶ Norway

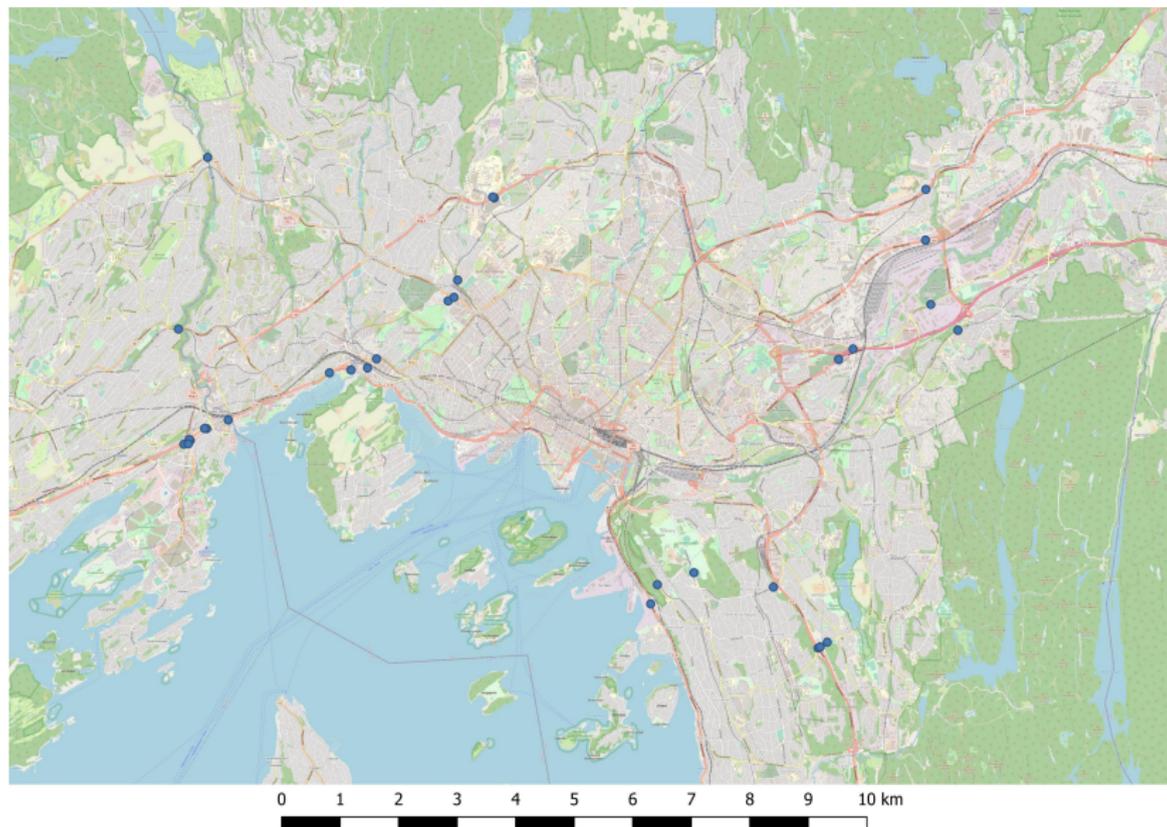
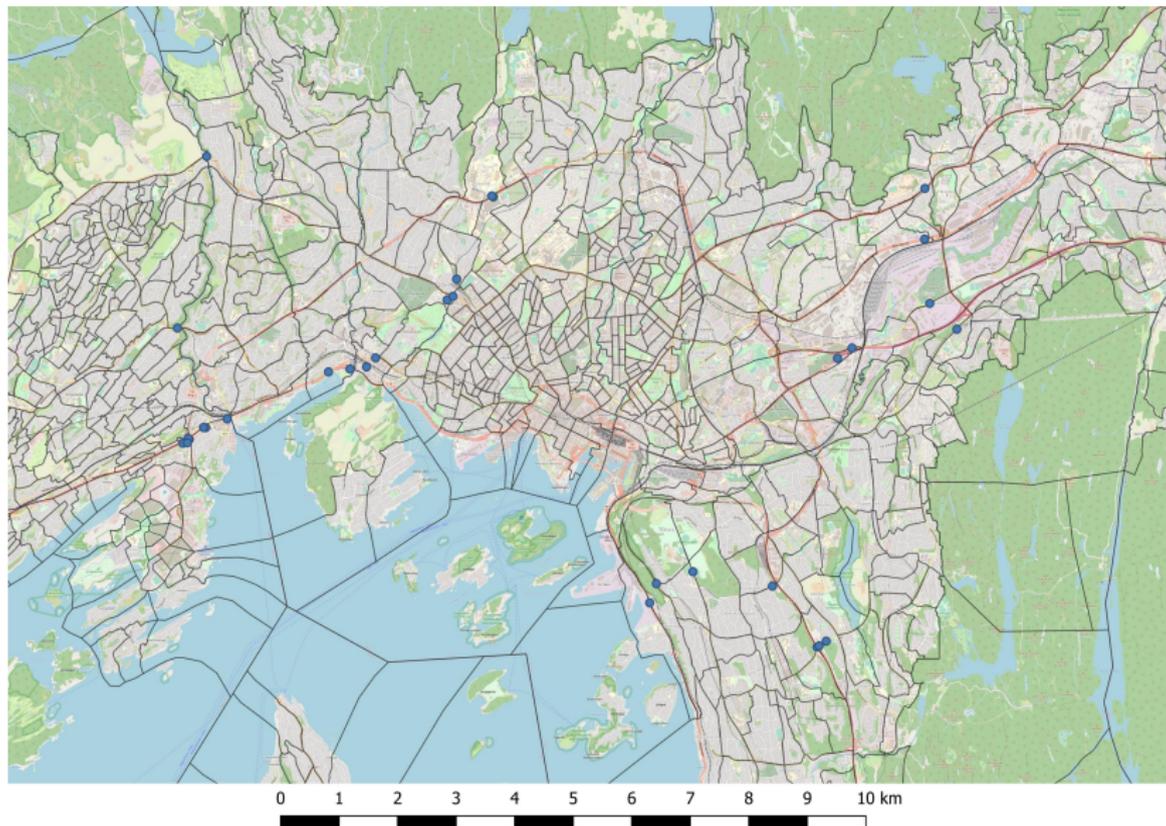


Illustration of neighborhoods and road toll locations (2016)

City of Oslo



Sample restrictions

- ▶ **Sample restrictions:**

- ▶ Couple households where both are working

- ▶ **Period:**

- ▶ Focus on 2017 (outcome) and 2016 (RHS variables) in main analysis
- ▶ Also show results for 2016-2019

Table 1: Summary statistics for couple households, **2017 and 2016** (10 NOK \approx 1 EUR)

	mean	sd	min	max	N
Household variables					
BEV _{t+1} (yes = 1)	0.12	0.32	0	1	377,590
Road toll (NOK)	5.6	8.5	0	1,412	365,806
Road toll (yes = 1)	0.45	0.50	0	1	365,806
Driving time to work (min)	15	12	0	119	365,806
Peer group variables: Colleagues					
BEV share	0.06	0.07	0	0.83	377,590
Road toll (NOK)	5.2	4.4	0	98	365,804
Road toll share	0.38	0.29	0	1	365,804
Driving time to work (min)	14	5	0	82	365,804
Number of colleagues	69	68	2	491	377,590
Peer group variables: Family					
BEV share	0.06	0.16	0	1	301,041
Road toll (NOK)	4.9	6.2	0	139	299,436
Road toll share	0.37	0.35	0	1	299,434
Driving time to work (min)	13	9	0	119	299,436

Notes: All variables are 2016 values with the exception of the first variable in Panel A, BEV_{t+1} (yes = 1), which reflect the 2017 value. Population is restricted to couple households where both are employed. Variables reflect the household mean unless stated otherwise. Peer group variables are based on both single-adult and couple households and are the leave-one-out mean. All NOK values are in real terms (2017 values). 10 NOK \approx 1 EUR

Research design

Main model specification

First stage:

$$\overbrace{\text{BEV share peers}_{t,p}}^{\text{endogenous variable}} = \overbrace{\alpha_1 \text{road toll peers}_{t,r,w}}^{\text{instrument}} + \sigma_2 \text{road toll}_{t,r,w} + \alpha_r + \theta_{w_1} + \theta_{w_2} + \eta_t + \gamma' \mathbf{X}_{t,h,r,w} + \delta Z_{t,p,r,w} + \mu_{ht}$$

Second stage:

$$\Pr(\text{BEV})_{t+1,h} = \beta_1 \widehat{\text{BEV share peers}}_{t,p} + \sigma_2 \text{road toll}_{t,r,w} + \alpha_r + \theta_{w_1} + \theta_{w_2} + \eta_t + \gamma' \mathbf{X}_{t,h,r,w} + \delta Z_{t,p,r,w} + \varepsilon_{ht}$$

- ▶ h : household, p : peer group (colleagues or family)
- ▶ r : neighborhood residence, $w = w_1, w_2$: work neighborhood(s)
- ▶ α_r : residential neighborhood fixed effects
- ▶ $\theta_{w_1}, \theta_{w_2}$: workplace neighborhood fixed effects
- ▶ $\mathbf{X}_{t,h,r,w}$: vector of household characteristics (incl. work commute controls)
- ▶ $Z_{t,p,r,w}$: vector of peer group characteristic (incl. work commute controls)

Instrument needs to satisfy the following criteria

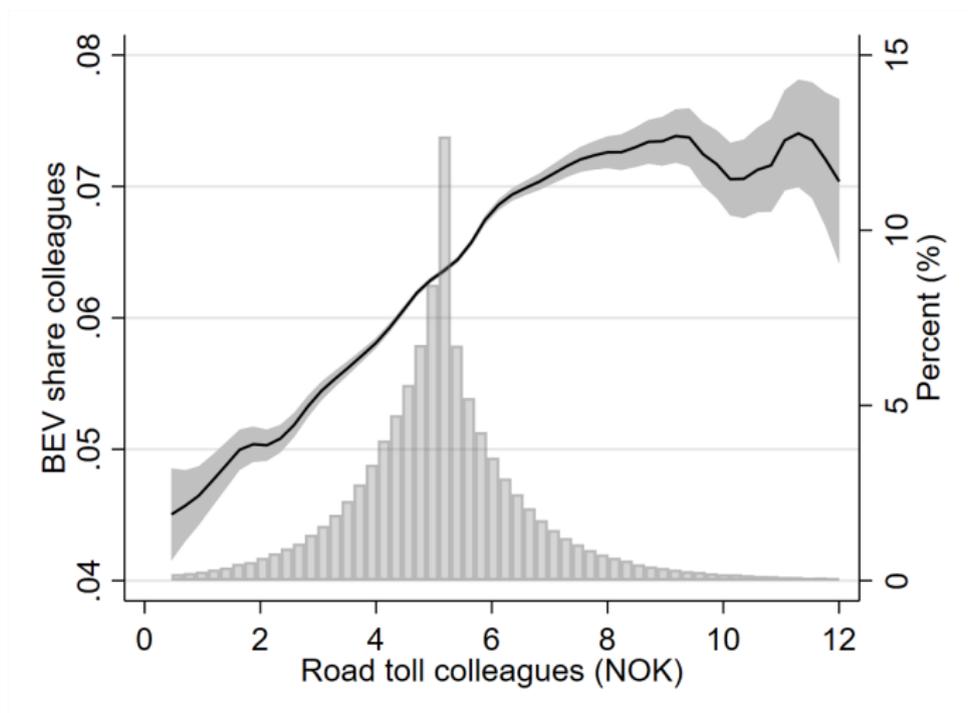
- ▶ Relevance (first stage)
- ▶ Exclusion restriction
- ▶ Monotonicity

Instrument needs to satisfy the following criteria

- ▶ Relevance (first stage)
- ▶ Exclusion restriction
- ▶ Monotonicity

First stage: road toll instrument

Figure 2: Residualized relationship between BEV share colleagues and road toll colleagues



Notes: Figure plots residualized BEV share against residualized road toll, where we absorb 3 fixed effects (neighborhood residence, work and work spouse). Line shows polynomial fit. Histogram shows the distribution of residualized road toll.

First stage: road toll instrument ▶ Skip

<i>Dep.var: BEV share colleagues</i>	(1)	(2)	(3)	(4)	(5)
Road toll colleagues (NOK)	0.00606*** (0.000070)	0.00260*** (0.000077)	0.00275*** (0.000109)	0.00251*** (0.000109)	0.00250*** (0.000109)
N (households)	365,804	363,447	307,444	307,444	307,444
Neighborhood FE		✓	✓	✓	✓
Own road toll	✓	✓	✓	✓	✓
Work commute controls			✓	✓	✓
Income and wealth controls				✓	✓
Other socioeconomic controls					✓
Mean BEV share colleagues	0.063	0.063	0.065	0.065	0.065
Mean road toll colleagues (NOK)	5.181	5.191	5.490	5.490	5.490
F statistic (excl. instrument)	7,540	1,136	637	531	530

- ▶ If colleagues' road toll increases by 1 NOK (~ 0.1 EUR) \rightarrow colleagues' probability of owning a BEV increases by 0.25 pp
- ▶ If colleagues' road toll increases by 10 % (~ 0.549 NOK) \rightarrow colleagues' probability of owning a BEV increases by 0.14 pp ($\sim 2\%$)

First stage: road toll instrument ▶ Skip

<i>Dep.var: BEV share colleagues</i>	(1)	(2)	(3)	(4)	(5)
Road toll colleagues (NOK)	0.00606*** (0.000070)	0.00260*** (0.000077)	0.00275*** (0.000109)	0.00251*** (0.000109)	0.00250*** (0.000109)
N (households)	365,804	363,447	307,444	307,444	307,444
Neighborhood FE		✓	✓	✓	✓
Own road toll	✓	✓	✓	✓	✓
Work commute controls			✓	✓	✓
Income and wealth controls				✓	✓
Other socioeconomic controls					✓
Mean BEV share colleagues	0.063	0.063	0.065	0.065	0.065
Mean road toll colleagues (NOK)	5.181	5.191	5.490	5.490	5.490
F statistic (excl. instrument)	7,540	1,136	637	531	530

- ▶ If colleagues' road toll increases by 1 NOK (~ 0.1 EUR) → colleagues' probability of owning a BEV increases by 0.25 pp
- ▶ If colleagues' road toll increases by 10 % (~ 0.549 NOK) → colleagues' probability of owning a BEV increases by 0.14 pp (~ 2%)

First stage: road toll instrument ▶ Skip

<i>Dep.var: BEV share colleagues</i>	(1)	(2)	(3)	(4)	(5)
Road toll colleagues (NOK)	0.00606*** (0.000070)	0.00260*** (0.000077)	0.00275*** (0.000109)	0.00251*** (0.000109)	0.00250*** (0.000109)
N (households)	365,804	363,447	307,444	307,444	307,444
Neighborhood FE		✓	✓	✓	✓
Own road toll	✓	✓	✓	✓	✓
Work commute controls			✓	✓	✓
Income and wealth controls				✓	✓
Other socioeconomic controls					✓
Mean BEV share colleagues	0.063	0.063	0.065	0.065	0.065
Mean road toll colleagues (NOK)	5.181	5.191	5.490	5.490	5.490
F statistic (excl. instrument)	7,540	1,136	637	531	530

- ▶ If colleagues' road toll increases by **1 NOK** (~ 0.1 EUR) \rightarrow colleagues' probability of owning a BEV increases by **0.25 pp**
- ▶ If colleagues' road toll increases by **10 %** (~ 0.549 NOK) \rightarrow colleagues' probability of owning a BEV increases by **0.14 pp** ($\sim 2\%$)

First stage: road toll instrument ▶ Skip

<i>Dep.var: BEV share colleagues</i>	(1)	(2)	(3)	(4)	(5)
Road toll colleagues (NOK)	0.00606*** (0.000070)	0.00260*** (0.000077)	0.00275*** (0.000109)	0.00251*** (0.000109)	0.00250*** (0.000109)
N (households)	365,804	363,447	307,444	307,444	307,444
Neighborhood FE		✓	✓	✓	✓
Own road toll	✓	✓	✓	✓	✓
Work commute controls			✓	✓	✓
Income and wealth controls				✓	✓
Other socioeconomic controls					✓
Mean BEV share colleagues	0.063	0.063	0.065	0.065	0.065
Mean road toll colleagues (NOK)	5.181	5.191	5.490	5.490	5.490
F statistic (excl. instrument)	7,540	1,136	637	531	530

- ▶ If colleagues' road toll increases by **1 NOK** (~ 0.1 EUR) \rightarrow colleagues' probability of owning a BEV increases by **0.25 pp**
- ▶ If colleagues' road toll increases by **10 %** (~ 0.549 NOK) \rightarrow colleagues' probability of owning a BEV increases by **0.14 pp** ($\sim 2\%$)

Instrument needs to satisfy the following criteria

- ▶ Relevance (first stage)
- ▶ Exclusion restriction
- ▶ Monotonicity

Conditional independence of instrument

While the **exclusion restriction** is inherently untestable

- ▶ Can verify its **plausibility** by examining whether our instrument is conditionally related to important household characteristics

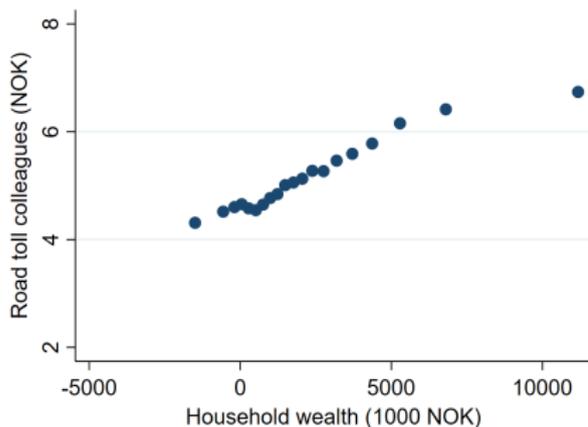
Conditional independence of instrument

While the **exclusion restriction** is inherently untestable

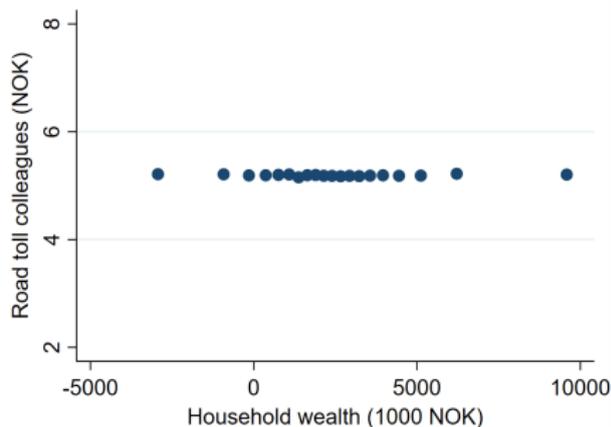
- ▶ Can verify its **plausibility** by examining whether our instrument is conditionally related to important household characteristics

Figure 3: Correlation between IV (road toll colleagues) and own household **wealth**

(a) Raw data



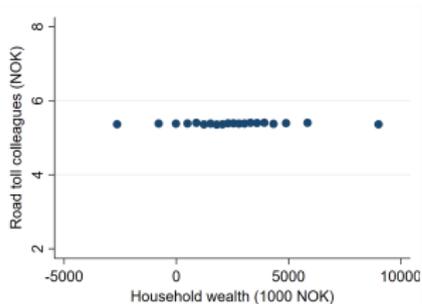
(b) Absorb neighborhood FE



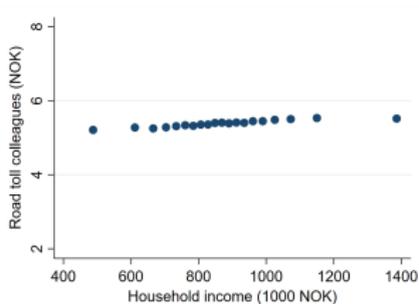
Conditional independence of instrument

Figure 4: Conditional correlation between IV (road toll colleagues) and household characteristics

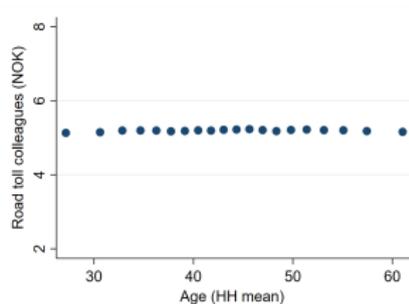
(a) Wealth



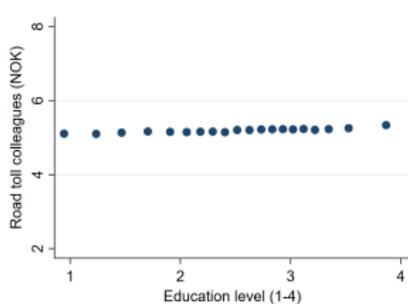
(b) Income



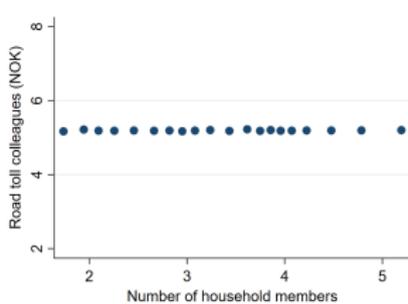
(c) Age



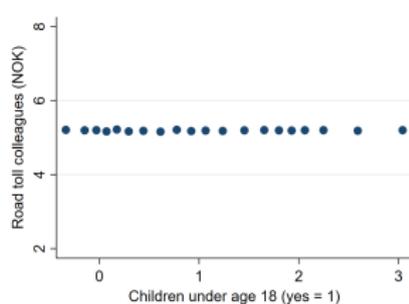
(d) Education



(e) Household members

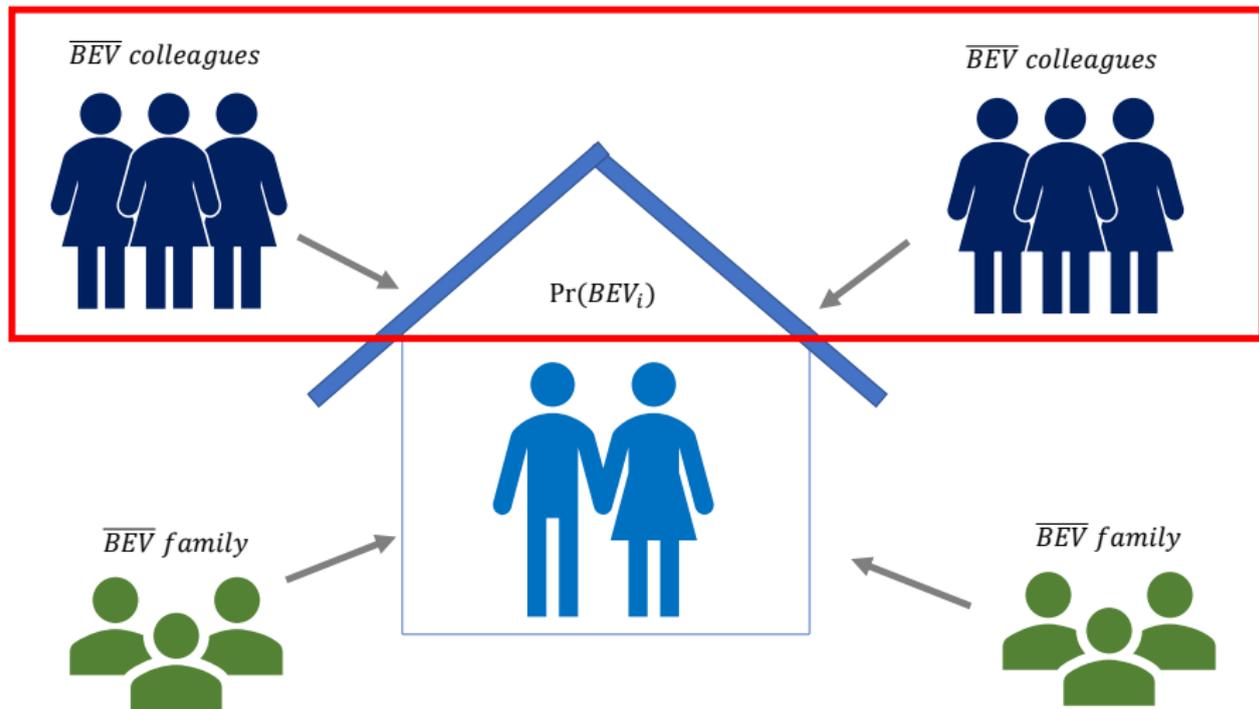


(f) Children under 18



Preliminary results

Colleagues



Results for colleagues

Table 2: Second stage results for peer effects at work, 2017

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
Panel A: Household-level effect				
BEV share colleagues	0.4453*** (0.10411)	0.5186*** (0.13907)	0.4142*** (0.15191)	0.3858** (0.15173)
Panel B: By household member				
BEV share female's colleagues	0.2848*** (0.08017)	0.2607** (0.10356)	0.2270** (0.11107)	0.2220** (0.11103)
BEV share male's colleagues	0.1377* (0.08177)	0.2631*** (0.09710)	0.1959* (0.10488)	0.1739* (0.10470)
N (households)	363,447	307,444	307,444	307,444
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.117	0.122	0.122	0.122
Mean BEV share colleagues	0.063	0.065	0.065	0.065

If the BEV share of both household members' colleagues increases by 1 pp
⇒ the household's probability of owning a BEV increases by 0.39 pp.

Results for colleagues

Table 2: Second stage results for peer effects at work, 2017

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
Panel A: Household-level effect				
BEV share colleagues	0.4453*** (0.10411)	0.5186*** (0.13907)	0.4142*** (0.15191)	0.3858** (0.15173)
Panel B: By household member				
BEV share female's colleagues	0.2848*** (0.08017)	0.2607** (0.10356)	0.2270** (0.11107)	0.2220** (0.11103)
BEV share male's colleagues	0.1377* (0.08177)	0.2631*** (0.09710)	0.1959* (0.10488)	0.1739* (0.10470)
N (households)	363,447	307,444	307,444	307,444
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.117	0.122	0.122	0.122
Mean BEV share colleagues	0.063	0.065	0.065	0.065

If the BEV share of both household members' colleagues increases by 1 pp
 ⇒ the household's probability of owning a BEV increases by 0.39 pp.

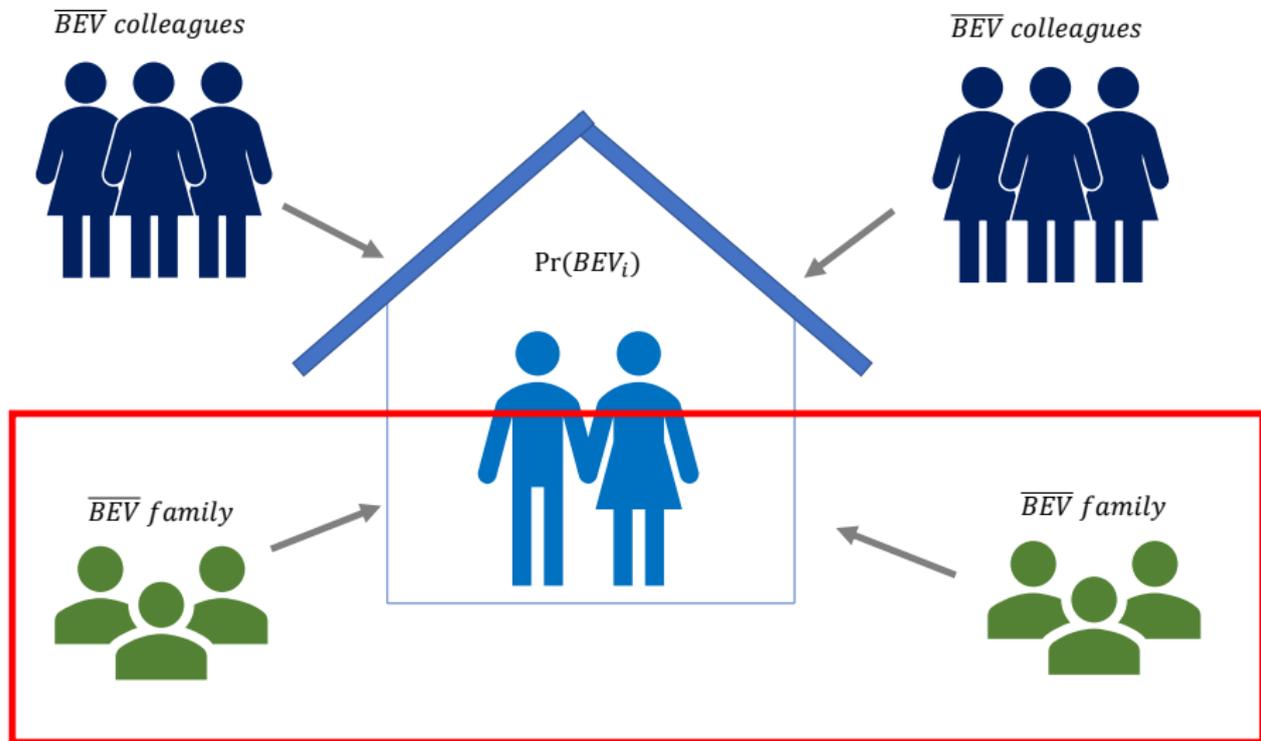
Results for colleagues

Table 2: Second stage results for peer effects at work, 2017

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
Panel A: Household-level effect				
BEV share colleagues	0.4453*** (0.10411)	0.5186*** (0.13907)	0.4142*** (0.15191)	0.3858** (0.15173)
Panel B: By household member				
BEV share female's colleagues	0.2848*** (0.08017)	0.2607** (0.10356)	0.2270** (0.11107)	0.2220** (0.11103)
BEV share male's colleagues	0.1377* (0.08177)	0.2631*** (0.09710)	0.1959* (0.10488)	0.1739* (0.10470)
N (households)	363,447	307,444	307,444	307,444
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.117	0.122	0.122	0.122
Mean BEV share colleagues	0.063	0.065	0.065	0.065

If the BEV share of both household members' colleagues increases by 1 pp
 ⇒ the household's probability of owning a BEV increases by 0.39 pp.

Family



Results for family

Table 3: Second stage results for peer effects in family networks, 2017

<i>Dep. var.: BEV (yes = 1)</i>	(2)	(3)	(4)	(5)
Panel A: Household-level effect				
BEV share family	0.1920*** (0.03310)	0.2205*** (0.05028)	0.1971*** (0.05373)	0.1891*** (0.05507)
Panel B: Female's and male's family				
BEV share female's family	0.1071*** (0.02871)	0.1123*** (0.03686)	0.1009*** (0.03913)	0.0985** (0.03968)
BEV share males's family	0.0979*** (0.02972)	0.1080*** (0.03821)	0.0959** (0.04067)	0.0900** (0.04145)
N (individuals)	287,601	194,563	194,563	194,563
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.121	0.126	0.126	0.126
Mean BEV share family	0.062	0.065	0.065	0.065
F-statistic (excl. instrument)	2,016	1,383	1,236	1,173

If the BEV share of both household members' family increases by 1 pp
⇒ the household's probability of owning a BEV increases by 0.19 pp.

Results for family

Table 3: Second stage results for peer effects in family networks, 2017

<i>Dep. var.: BEV (yes = 1)</i>	(2)	(3)	(4)	(5)
Panel A: Household-level effect				
BEV share family	0.1920*** (0.03310)	0.2205*** (0.05028)	0.1971*** (0.05373)	0.1891*** (0.05507)
Panel B: Female's and male's family				
BEV share female's family	0.1071*** (0.02871)	0.1123*** (0.03686)	0.1009*** (0.03913)	0.0985** (0.03968)
BEV share males's family	0.0979*** (0.02972)	0.1080*** (0.03821)	0.0959** (0.04067)	0.0900** (0.04145)
N (individuals)	287,601	194,563	194,563	194,563
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.121	0.126	0.126	0.126
Mean BEV share family	0.062	0.065	0.065	0.065
F-statistic (excl. instrument)	2,016	1,383	1,236	1,173

If the BEV share of both household members' family increases by 1 pp
⇒ the household's probability of owning a BEV increases by 0.19 pp.

Results for family

Table 3: Second stage results for peer effects in family networks, 2017

<i>Dep. var: BEV (yes = 1)</i>	(2)	(3)	(4)	(5)
Panel A: Household-level effect				
BEV share family	0.1920*** (0.03310)	0.2205*** (0.05028)	0.1971*** (0.05373)	0.1891*** (0.05507)
Panel B: Female's and male's family				
BEV share female's family	0.1071*** (0.02871)	0.1123*** (0.03686)	0.1009*** (0.03913)	0.0985** (0.03968)
BEV share males's family	0.0979*** (0.02972)	0.1080*** (0.03821)	0.0959** (0.04067)	0.0900** (0.04145)
N (individuals)	287,601	194,563	194,563	194,563
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.121	0.126	0.126	0.126
Mean BEV share family	0.062	0.065	0.065	0.065
F-statistic (excl. instrument)	2,016	1,383	1,236	1,173

If the BEV share of both household members' family increases by 1 pp
 ⇒ the household's probability of owning a BEV increases by 0.19 pp.

Heterogeneous peer effects

- ▶ **Heterogeneous peer effects at work** [▶ Table](#)
 - ▶ A high **female share** at work lowers peer effects ↓
 - ▶ A high share of **university-educated** workers increases peer effects ↑
 - ▶ A higher **income level** among workers increases peer effects ↑
 - ▶ Estimated peer effects do not vary systematically with **firm size**

Additional results and robustness checks

1. IV vs. OLS ▶ Work ▶ Family
2. Annual effects 2016-2019 ▶ Work ▶ Family
3. Panel data (2017-2019) with neighborhood \times year FE ▶ Work ▶ Family
4. Drop households that owned a BEV in the previous year ▶ Work ▶ Family
5. Δ BEV as the outcome variable ▶ Work ▶ Family
6. Colleagues and family in the same regression ▶ Work+Family
7. Alternative IV (based on colleagues' spouses') ▶ Work

Charging stations do not explain peer effects at work

Table 4: Second stage results for peer effects at work, 2017

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(2)
BEV share colleagues	0.3858*** (0.15173)	0.4449*** (0.13786)	0.4348*** (0.13887)
Charging stations in work neighborhood			0.0027*** (0.0.00111)
Neighborhood FE (8 digit)	✓		
Neighborhood FE (6 digit)		✓	✓
Own road toll	✓	✓	✓
Work commute controls	✓	✓	✓
Income and wealth controls	✓	✓	✓
Other socioeconomic controls	✓	✓	✓

Notes: The number of charging stations are measured at the 8 digit neighborhood level.

Charging stations do not explain peer effects at work

Table 4: Second stage results for peer effects at work, 2017

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(2)
BEV share colleagues	0.3858*** (0.15173)	0.4449*** (0.13786)	0.4348*** (0.13887)
Charging stations in work neighborhood			0.0027*** (0.0.00111)
Neighborhood FE (8 digit)	✓		
Neighborhood FE (6 digit)		✓	✓
Own road toll	✓	✓	✓
Work commute controls	✓	✓	✓
Income and wealth controls	✓	✓	✓
Other socioeconomic controls	✓	✓	✓

Notes: The number of charging stations are measured at the 8 digit neighborhood level.

Policy spillovers (from peer groups' road toll)

Table 5: Reduced form results for peer effects, 2017

<i>Dep.var: BEV (yes=1)</i>	(1)	(2)	(3)	(4)
Road toll (NOK)	0.00351*** (0.000128)	0.00247*** (0.000188)	0.00245*** (0.000188)	0.00245*** (0.000188)
Road toll colleagues (NOK)	0.00146*** (0.000315)	0.00165*** (0.000515)	0.00120** (0.000515)	0.00110** (0.000512)
Road toll family (NOK)	0.00064*** (0.000112)	0.00079*** (0.000193)	0.00066*** (0.000193)	0.00061*** (0.000192)
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓

Total effect = direct effect (road toll) + indirect effects (road toll colleagues and road toll family)

Policy spillovers (from peer groups' road toll)

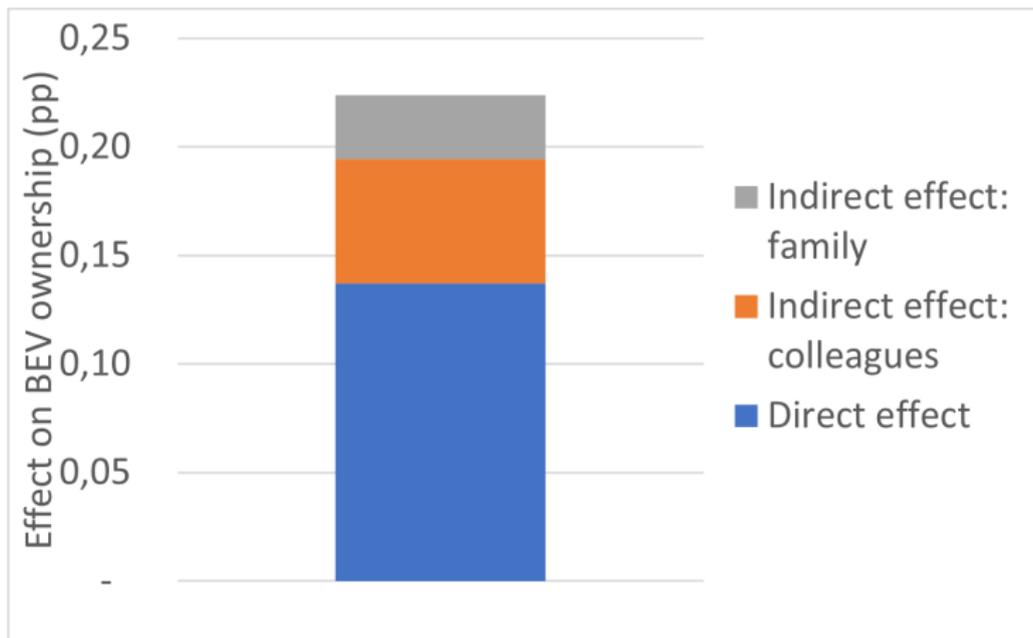
Table 5: Reduced form results for peer effects, 2017

<i>Dep.var: BEV (yes=1)</i>	(1)	(2)	(3)	(4)
Road toll (NOK)	0.00351*** (0.000128)	0.00247*** (0.000188)	0.00245*** (0.000188)	0.00245*** (0.000188)
Road toll colleagues (NOK)	0.00146*** (0.000315)	0.00165*** (0.000515)	0.00120** (0.000515)	0.00110** (0.000512)
Road toll family (NOK)	0.00064*** (0.000112)	0.00079*** (0.000193)	0.00066*** (0.000193)	0.00061*** (0.000192)
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓

Total effect = **direct effect** (road toll) + **indirect effects** (road toll colleagues and road toll family)

Total effect of increasing road toll by 10%

Spillovers increase the effect of the policy by $\sim 60\%$



Direct effect: $(10\% \times 5.6 \text{ NOK}) \times 0.245 \text{ pp} = 0.1372$.

Spillovers from colleagues: $(10\% \times 5.2 \text{ NOK}) \times 0.110 \text{ pp} = 0.0572$.

Spillovers from family: $(10\% \times 4.9 \text{ NOK}) \times 0.061 \text{ pp} = 0,0299$.

Conclusion

Summary and concluding remarks

- ▶ Our aim has been to **better understand the magnitude and nature of peer effects in BEV adoption**
- ▶ **We find that both colleagues and family members influence BEV adoption**
 - ▶ Colleagues have a larger effect than family members
 - ▶ Peer effects at work are increasing in male share, education, and income
 - ▶ Estimated peer effects are not explained by charging stations
- ▶ **We find that the presence of social spillovers increases the effect of a BEV policy by $\sim 60\%$**
- ▶ **Policy relevance and contribution**
 - ▶ Get better estimates (and predictions) on the effectiveness of governmental policies
 - ▶ Enhance our understanding of what influences BEV adoption

Summary and concluding remarks

- ▶ Our aim has been to **better understand the magnitude and nature of peer effects in BEV adoption**
- ▶ We find that both colleagues and family members influence BEV adoption
 - ▶ Colleagues have a larger effect than family members
 - ▶ Peer effects at work are increasing in male share, education, and income
 - ▶ Estimated peer effects are not explained by charging stations
- ▶ We find that the presence of social spillovers increases the effect of a BEV policy by $\sim 60\%$
- ▶ Policy relevance and contribution
 - ▶ Get better estimates (and predictions) on the effectiveness of governmental policies
 - ▶ Enhance our understanding of what influences BEV adoption

Summary and concluding remarks

- ▶ Our aim has been to **better understand the magnitude and nature of peer effects in BEV adoption**
- ▶ **We find that both colleagues and family members influence BEV adoption**
 - ▶ Colleagues have a larger effect than family members
 - ▶ Peer effects at work are increasing in male share, education, and income
 - ▶ Estimated peer effects are not explained by charging stations
- ▶ We find that the presence of social spillovers increases the effect of a BEV policy by $\sim 60\%$
- ▶ Policy relevance and contribution
 - ▶ Get better estimates (and predictions) on the effectiveness of governmental policies
 - ▶ Enhance our understanding of what influences BEV adoption

Summary and concluding remarks

- ▶ Our aim has been to **better understand the magnitude and nature of peer effects in BEV adoption**
- ▶ **We find that both colleagues and family members influence BEV adoption**
 - ▶ Colleagues have a larger effect than family members
 - ▶ Peer effects at work are increasing in male share, education, and income
 - ▶ Estimated peer effects are not explained by charging stations
- ▶ **We find that the presence of social spillovers increases the effect of a BEV policy by $\sim 60\%$**
- ▶ **Policy relevance and contribution**
 - ▶ Get better estimates (and predictions) on the effectiveness of governmental policies
 - ▶ Enhance our understanding of what influences BEV adoption

Summary and concluding remarks

- ▶ Our aim has been to **better understand the magnitude and nature of peer effects in BEV adoption**
- ▶ **We find that both colleagues and family members influence BEV adoption**
 - ▶ Colleagues have a larger effect than family members
 - ▶ Peer effects at work are increasing in male share, education, and income
 - ▶ Estimated peer effects are not explained by charging stations
- ▶ **We find that the presence of social spillovers increases the effect of a BEV policy by $\sim 60\%$**
- ▶ **Policy relevance and contribution**
 - ▶ Get better estimates (and predictions) on the effectiveness of governmental policies
 - ▶ Enhance our understanding of what influences BEV adoption

Thank you!

e.t.isaksen@frisch.uio.no
sites.google.com/site/elisabethisaksen

References I

- Allcott, H. and Kessler, J. B. (2019). The welfare effects of nudges: A case study of energy use social comparisons. *American Economic Journal: Applied Economics*, 11(1):236–76.
- Bailey, M., Johnston, D. M., Kuchler, T., Stroebel, J., and Wong, A. (2019). Peer effects in product adoption. Technical report, National Bureau of Economic Research.
- Bento, A., Kaffine, D., Roth, K., and Zaragoza-Watkins, M. (2014). The effects of regulation in the presence of multiple unpriced externalities: Evidence from the transportation sector. *American Economic Journal: Economic Policy*, 6(3):1–29.
- Beshears, J., Choi, J. J., Laibson, D., Madrian, B. C., and Milkman, K. L. (2015). The effect of providing peer information on retirement savings decisions. *The Journal of finance*, 70(3):1161–1201.
- Bollinger, B., Burkhardt, J., and Gillingham, K. T. (2020). Peer effects in residential water conservation: Evidence from migration. *American Economic Journal: Economic Policy*, 12(3):107–33.
- Bollinger, B. and Gillingham, K. (2012). Peer effects in the diffusion of solar photovoltaic panels. *Marketing Science*, 31(6):900–912.
- Bollinger, B., Gillingham, K., Kirkpatrick, A. J., and Sexton, S. (2019). Visibility and peer influence in durable good adoption. Available at SSRN 3409420.
- Brandon, A., List, J. A., Metcalfe, R. D., Price, M. K., and Rundhammer, F. (2019). Testing for crowd out in social nudges: Evidence from a natural field experiment in the market for electricity. *Proceedings of the National Academy of Sciences*, 116(12):5293–5298.

References II

- Clinton, B. C. and Steinberg, D. C. (2019). Providing the spark: Impact of financial incentives on battery electric vehicle adoption. *Journal of Environmental Economics and Management*, 98:102255.
- Cornelissen, T., Dustmann, C., and Schönberg, U. (2017). Peer effects in the workplace. *American Economic Review*, 107(2):425–56.
- Dahl, G. B., Løken, K. V., and Mogstad, M. (2014). Peer effects in program participation. *American Economic Review*, 104(7):2049–74.
- De Giorgi, G., Frederiksen, A., and Pistaferri, L. (2020). Consumption network effects. *The Review of Economic Studies*, 87(1):130–163.
- Gallagher, K. S. and Muehlegger, E. (2011). Giving green to get green? incentives and consumer adoption of hybrid vehicle technology. *Journal of Environmental Economics and management*, 61(1):1–15.
- Grinblatt, M., Keloharju, M., and Ikäheimo, S. (2008). Social influence and consumption: Evidence from the automobile purchases of neighbors. *The review of Economics and Statistics*, 90(4):735–753.
- Halse, A., Hauge, K. E., Isaksen, E. T., Johansen, B. G., and Raaum, O. (2022). Local incentives and electric vehicle adoption. Available at SSRN 4051730.
- Li, S., Tong, L., Xing, J., and Zhou, Y. (2017). The market for electric vehicles: Indirect network effects and policy design. *Journal of the Association of Environmental and Resource Economists*, 4(1):89–133.

References III

- Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The Review of Economic Studies*, 60(3):531–542.
- Muehlegger, E. and Rapson, D. (2018). Subsidizing mass adoption of electric vehicles: Quasi-experimental evidence from California. NBER Working Paper 25359.
- Sexton, S. E. and Sexton, A. L. (2014). Conspicuous conservation: The prius halo and willingness to pay for environmental bona fides. *Journal of Environmental Economics and Management*, 67(3):303 – 317.

Appendix

Road toll on the work commute

Toll calculator

From: 

To: 

Via:

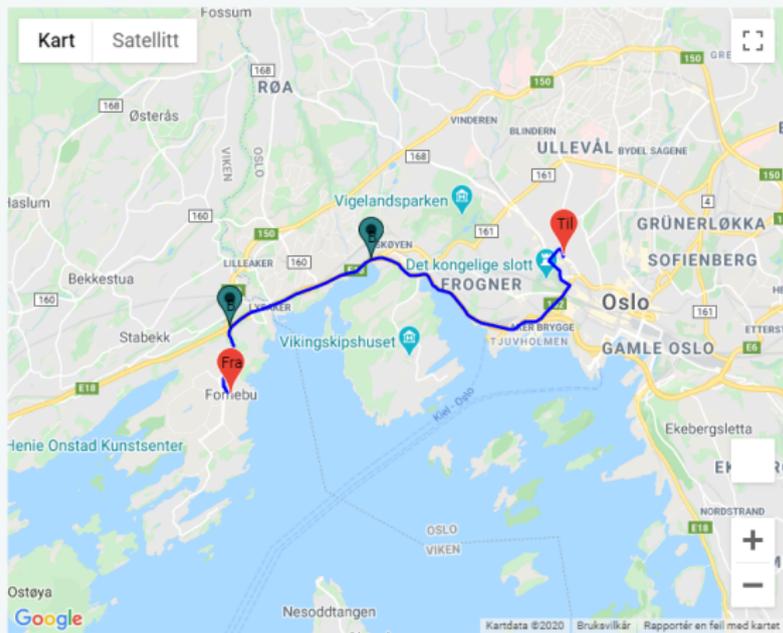
Show prices with AutoPASS contract

Date and time for departure:

If no time is filled in, the calculations of the toll road fees will not take into account higher fees during rush hour. The calculator can do calculations from June 1st, 2019.

Tolls

Distance	Tolls
9.3 km	50.00 kr
✓ Rampe Fornebu til E18	25.00 kr
✓ E18 Maritim	25.00 kr

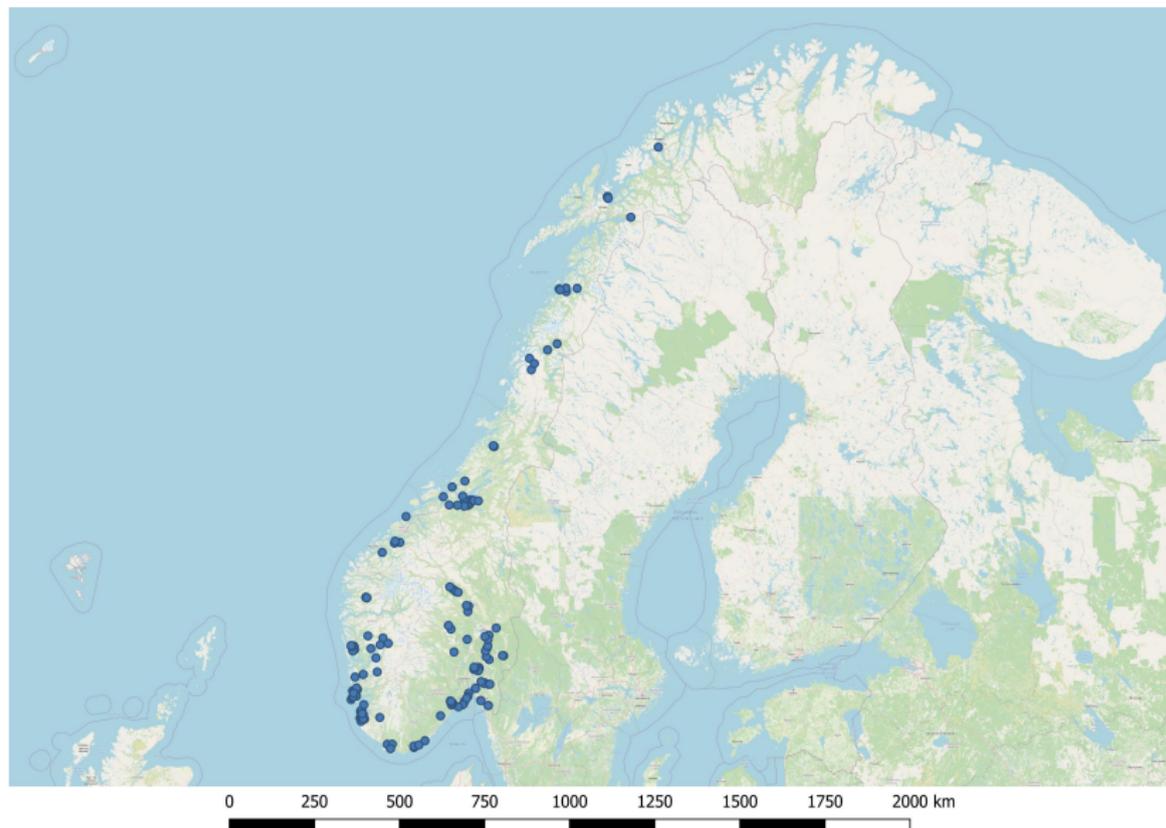


The discount in the toll calculator is 20 % on all toll stations, but in some places the discount deviates from this. All toll fees outside Oslo and Bærum are imposed from the

Source: fjellinjen.no. *Notes:* Road toll in the paper is calculated based on the time minimizing travel route between neighborhood centroids.

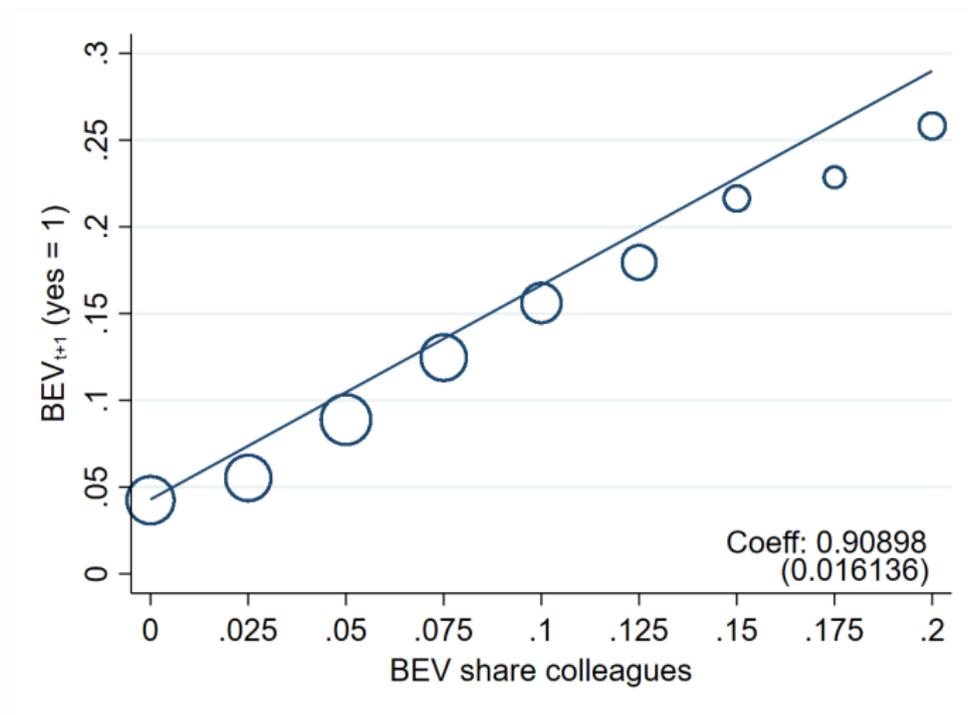
Road toll

Road toll in Norway, 2016 [▶ Back](#)



Colleagues: Naive peer effects (correlations)

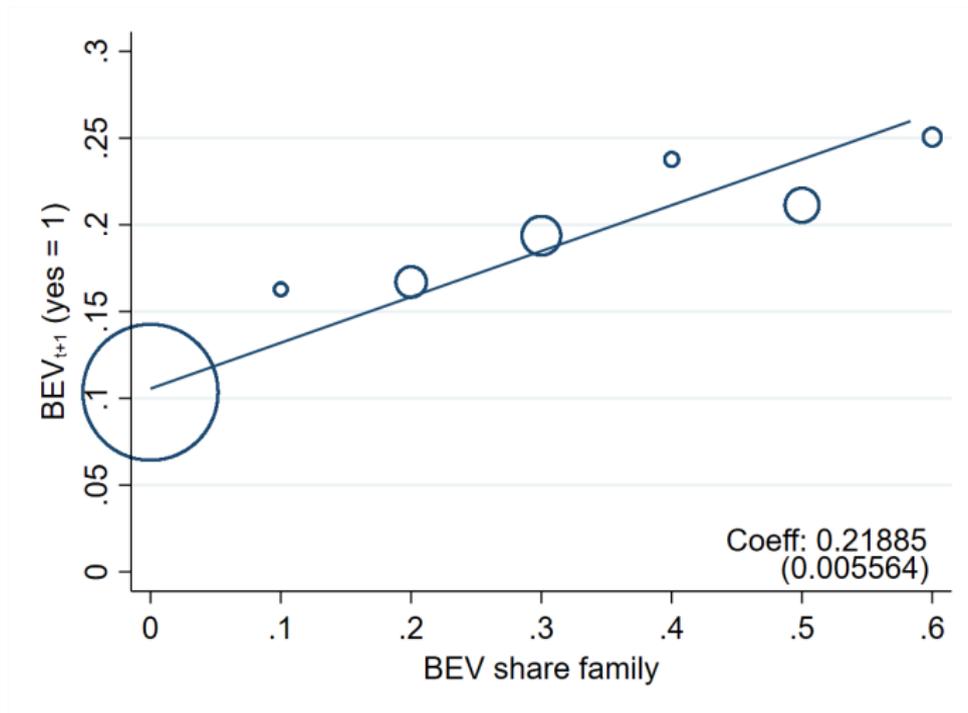
Figure 5: Binscatter: BEV share against BEV share colleagues



Notes: Figure shows own BEV ownership for 0.025 intervals of colleagues' BEV ownership. Each circle reflects the average BEV share within a given interval. Circle size indicates the size of the population (i.e., households). Line shows linear fit.

Family: Naive peer effects (correlations)

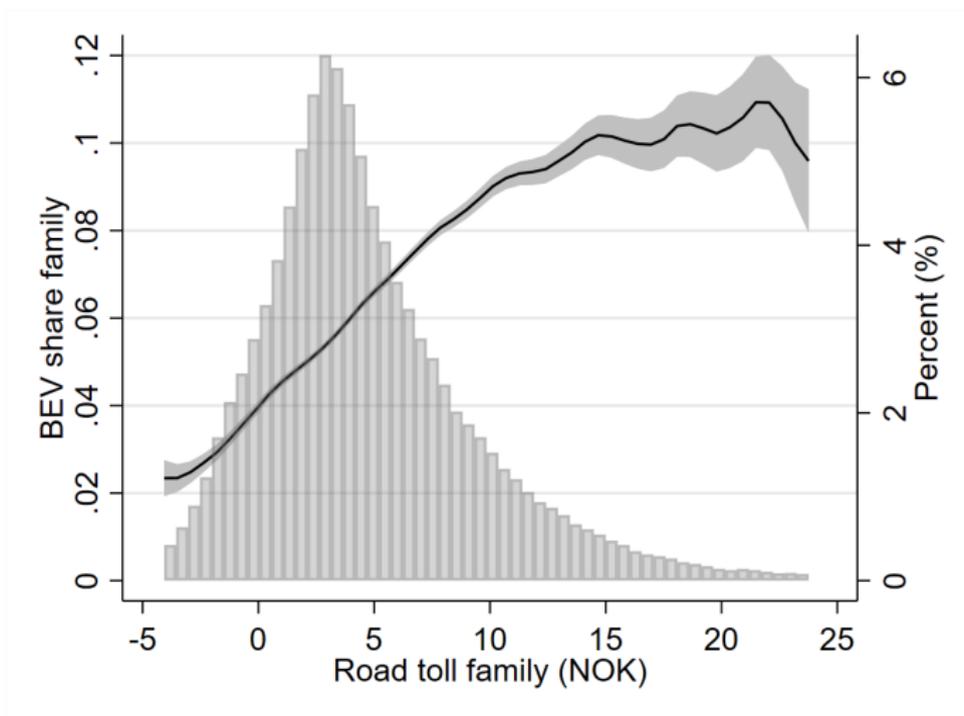
Figure 6: Binscatter: BEV share against BEV share family



Notes: Figure shows own BEV ownership for 0.01 intervals of family's BEV ownership. Each circle reflects the average BEV share within a given interval. Circle size indicates the size of the population (i.e., households). Line shows linear fit.

First stage: road toll instrument (family) [▶ Back](#)

Figure 7: Residualized relationship between BEV share family and road toll family



Notes: Figure plots residualized BEV share against residualized road toll, where we absorb 3 fixed effects (neighborhood residence, work and work spouse). Line shows polynomial fit. Histogram shows the distribution of residualized road toll.

First stage: road toll instrument (family)

[▶ Back](#)

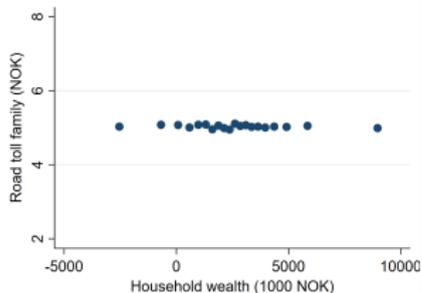
<i>Dep.var: BEV share family</i>	(1)	(2)	(3)	(4)	(5)
Road toll family (NOK)	0.00378*** (0.000074)	0.00336*** (0.000075)	0.00367*** (0.000099)	0.00343*** (0.000098)	0.00335*** (0.000098)
N (individuals)	290,164	287,601	194,563	194,563	194,563
Neighborhood FE		✓	✓	✓	✓
Own road toll	✓	✓	✓	✓	✓
Work commute controls			✓	✓	✓
Income and wealth controls				✓	✓
Other socioeconomic controls					✓
Mean BEV share	0.121	0.121	0.126	0.126	0.126
Mean BEV share family	0.062	0.062	0.065	0.065	0.065
Mean road toll (NOK)	5.520	5.537	5.687	5.687	5.687
Mean road toll family (NOK)	4.939	4.943	5.054	5.054	5.054
F statistic (excl. instrument)	2,598	2,016	1,383	1,236	1,173

If road toll family increases by 1 NOK →
family's' probability of owning a BEV increases by 0.34 pp

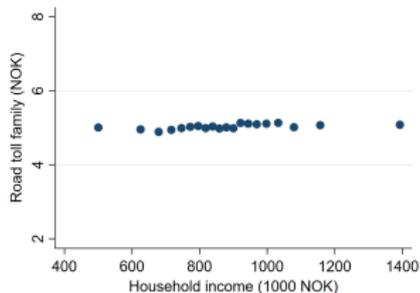
Conditional independence of instrument (family) [▶ Back](#)

Figure 8: Conditional correlation between IV (road toll family) and household characteristics

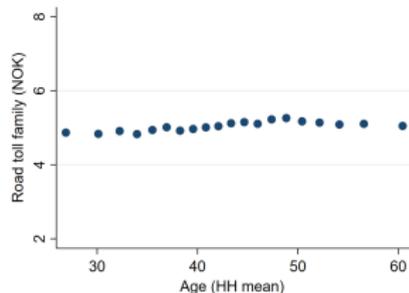
(a) Wealth



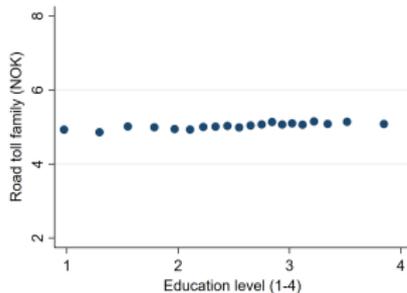
(b) Income



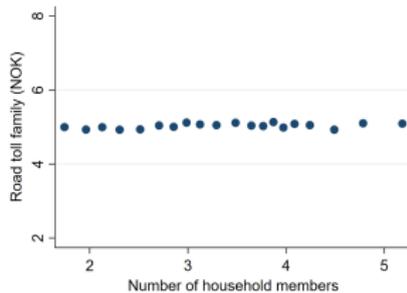
(c) Age



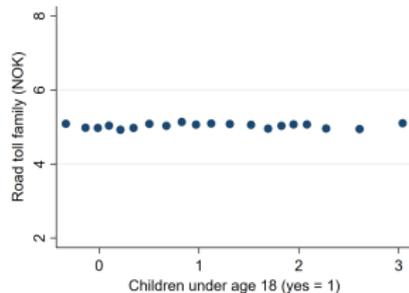
(d) Education



(e) Household members



(f) Children under 18



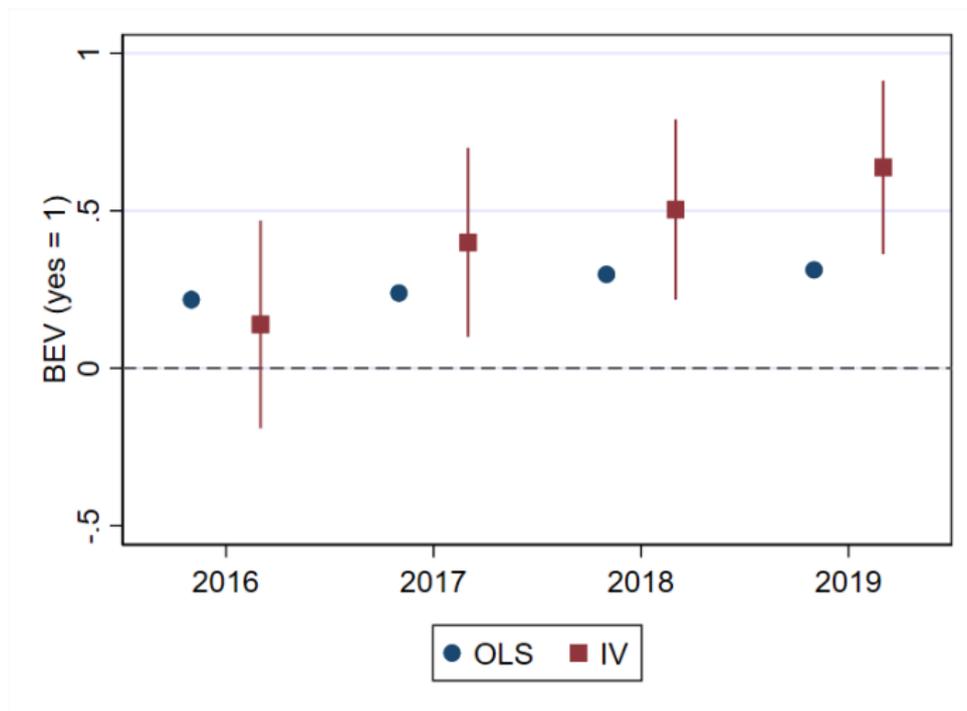
Heterogeneous effects

Table 6: Heterogeneous peer effects

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
BEV share colleagues	0.4208*** (0.15367)	0.6175*** (0.16412)	0.1023 (0.20139)	0.0305 (0.22026)
BEV share colleagues × firm size	-0.0006 (0.00046)			
BEV share colleagues × female share		-0.4707*** (0.14649)		
BEV share colleagues × share high-skilled			0.4134*** (0.14531)	
BEV share colleagues × income decile				0.0554*** (0.01421)

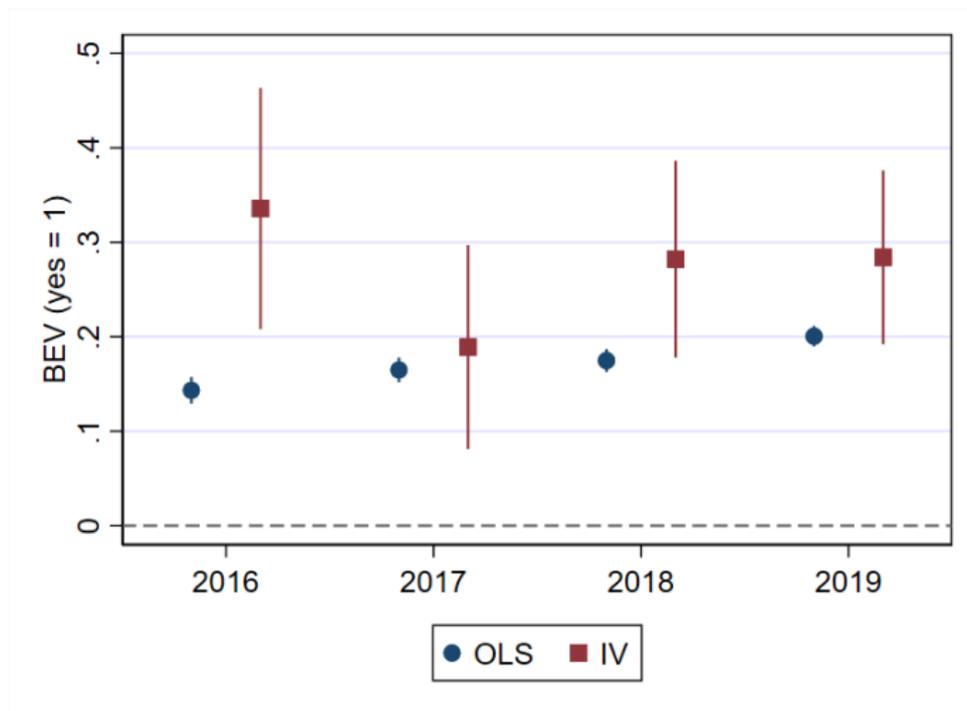
Peer effects colleagues: IV vs. OLS, 2016-2019

Figure 9: Effect of colleague's BEV ownership, by year



Peer effects family: IV vs. OLS, 2016-2019

Figure 10: Effect of family BEV ownership, by year



Peer effects colleagues: Panel data 2017–2019

Table 7: Second stage results for peer effects at work, 2017–2019 [▶ Back](#)

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
BEV share colleagues	0.5706*** (0.05825)	0.6586*** (0.08526)	0.5530*** (0.09982)	0.5366*** (0.09945)
N (households × year FE)	1,124,710	953,064	953,064	953,064
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.154	0.161	0.161	0.161
Mean BEV share colleagues	0.087	0.091	0.091	0.091

If BEV share of both household members' colleagues increases by 1 pp
⇒ the household's probability of owning a BEV increases by 0.54 pp.

Peer effects family: Panel data 2017–2019

Table 8: Second stage results for peer effects in family networks, 2017–2019 [▶ Back](#)

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
BEV share family	0.2224*** (0.02109)	0.2988*** (0.03421)	0.2787*** (0.03639)	0.2673*** (0.03730)
N (households × year FE)	882,504	596,971	596,971	596,971
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.160	0.166	0.166	0.166
Mean BEV share family	0.087	0.091	0.091	0.091
F statistic (excl. instrument)	4,592	2,800	2,420	2,290

If BEV share of both household members' family increases by **1 pp**
⇒ the household's probability of owning a BEV increases by **0.27 pp**.

Peer effects colleagues: Drop households that owned a BEV the previous year

Table 9: Second stage results for peer effects at work, 2017 [▶ Back](#)

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
BEV share colleagues	0.1999*** (0.06335)	0.2447*** (0.08898)	0.2151** (0.10244)	0.2031** (0.10315)
N (household × year)	331,300	278,822	278,822	278,822
Neighborhood × year FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.036	0.038	0.038	0.038
Mean BEV share colleagues	0.060	0.062	0.062	0.062

If BEV share of both household members' colleagues increases by 1 pp
⇒ the household's probability of adopting a BEV by next year increases by 0.2 pp.

Peer effects family: Drop households that owned a BEV the previous year

Table 10: Second stage results for peer effects at work, 2017–2019 [▶ Back](#)

<i>Dep.var: BEV (yes = 1)</i>	(1)	(2)	(3)	(4)
BEV share family	0.0706*** (0.01143)	0.0825*** (0.01859)	0.0751*** (0.01976)	0.0789*** (0.02029)
N (household × year)	771,135	518,074	518,074	518,074
Neighborhood × year FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.046	0.048	0.048	0.048
Mean BEV share family	0.078	0.081	0.081	0.081
F statistic (excl. instrument)	3,860	2,409	2,112	2,002

If BEV share of both household members' family increases by **1 pp**
⇒ the household's probability of adopting a BEV by next year increases by **0.08 pp**.

Peer effects colleagues: Change in BEV ownership from t-1 to t

Table 11: Second stage results for peer effects at work, 2017 [▶ Back](#)

Δ BEV (yes = 1)	(1)	(2)	(3)	(4)
BEV share colleagues	0.1592*** (0.05520)	0.1801** (0.07582)	0.1592* (0.08684)	0.1479* (0.08732)
N (household \times year)	363,447	307,444	307,444	307,444
Neighborhood \times year FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean Δ BEV	0.033	0.035	0.035	0.035
Mean BEV share colleagues	0.063	0.065	0.065	0.065

If BEV share of both household members' colleagues increases by 1 pp
 \Rightarrow the household's probability of adopting a BEV by next year increases by 0.15 pp.

Peer effects family: Change in BEV ownership from t-1 to t

Table 12: Second stage results for peer effects at work, 2017–2019 [▶ Back](#)

Δ BEV (yes = 1)	(1)	(2)	(3)	(4)
BEV share family	0.0458*** (0.00887)	0.0527*** (0.01469)	0.0491*** (0.01566)	0.0526*** (0.01609)
N (household \times year)	882,504	596,971	596,971	596,971
Neighborhood \times year FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Δ Mean BEV share	0.041	0.042	0.042	0.042
Mean BEV share family	0.087	0.091	0.091	0.091
F statistic (excl. instrument)	4,592	2,801	2,421	2,290

If BEV share of both household members' colleagues increases by 1 pp
 \Rightarrow the household's probability of adopting a BEV by next year increases by 0.05 pp.

Peer effects: Colleagues and family in same regression

Table 13: Second stage results for two peer groups (colleagues and family), 2017 [▶ Back](#)

Δ BEV (yes = 1)	(1)	(2)	(3)	(4)
BEV share colleagues	0.4921*** (0.11259)	0.5712*** (0.18499)	0.4760** (0.21005)	0.4377** (0.20936)
BEV share family	0.1853*** (0.03309)	0.2101*** (0.05192)	0.1910*** (0.05542)	0.1811*** (0.05674)
N (individuals)	287,600	180,233	180,233	180,233
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.121	0.129	0.129	0.129
Mean BEV share colleagues	0.064	0.066	0.066	0.066
Mean BEV share family	0.062	0.065	0.065	0.065

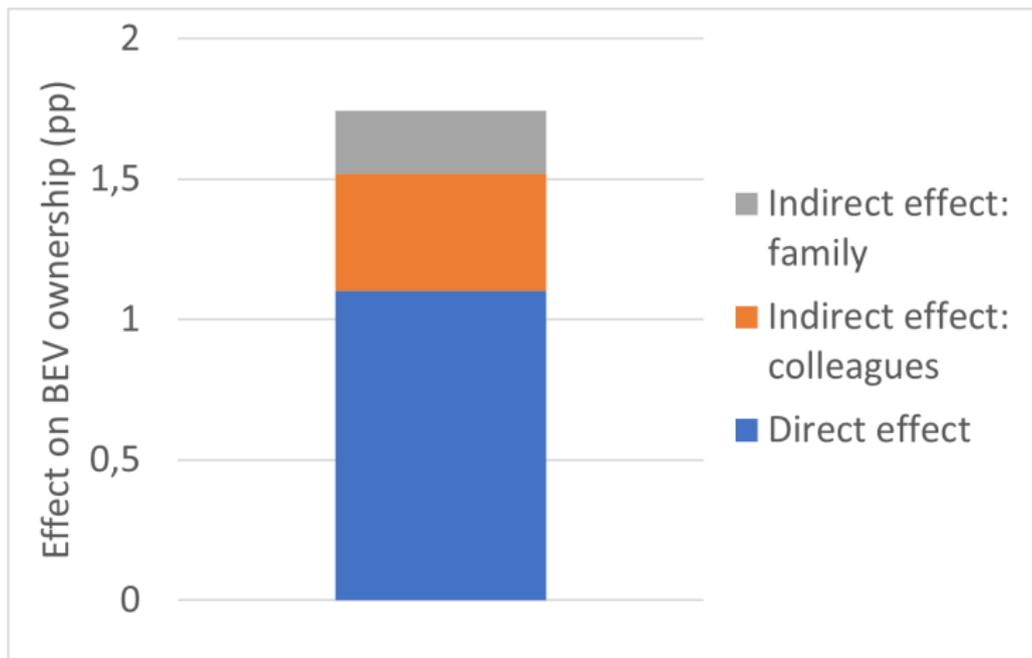
Results: Colleagues' spouses' road toll as IV

Table 14: Second stage results for peer effects at work, 2017 [▶ Back](#)

Δ BEV (yes = 1)	(1)	(2)	(3)	(4)
BEV share colleagues	0.7692*** (0.10674)	0.6689*** (0.12807)	0.5492*** (0.14363)	0.4725*** (0.14419)
N (households)	362,915	307,373	307,373	307,373
Neighborhood FE	✓	✓	✓	✓
Own road toll	✓	✓	✓	✓
Work commute controls		✓	✓	✓
Income and wealth controls			✓	✓
Other socioeconomic controls				✓
Mean BEV share	0.117	0.122	0.122	0.122
Mean BEV share colleagues	0.063	0.065	0.065	0.065
F-statistic (excl. instrument)	980	716	579	569

Total effect of increasing road toll by 10 NOK

Spillovers increase the effect of the policy by $\sim 60\%$



Direct effect: $10 \text{ NOK} \times 45 \% \text{ (share exposed to road toll)} \times 0.245 \text{ pp} = 1.1025$.

Spillovers from colleagues: $10 \text{ NOK} \times 38 \% \times 0.110 \text{ pp} = 0.418$.

Spillovers from family: $10 \text{ NOK} \times 37 \% \times 0.061 \text{ pp} = 0,222$.