Green subsidies with credit constraints

Susanna B. Berkouwer[1] (they/them) Joshua T. Dean[2] (he/him)

[1]The Wharton School, University of Pennsylvania and NBER
[2]The Booth School of Business, University of Chicago

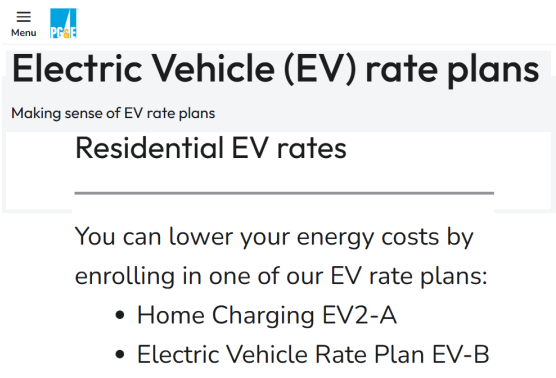
December 2025

Green technology subsidies: US, EU

Green technology subsidies: US, EU

Marginal cost subsidy

Lowering the electricity cost of charging your EV:



Menu

Electric Vehicle (EV) rate plans

Making sense of EV rate plans

Residential EV rates

You can lower your energy costs by enrolling in one of our EV rate plans:

- Home Charging EV2-A
- Electric Vehicle Rate Plan EV-B

Volvo Offers Swedish Buyers A Year Of Free Charging To Spark EV Sales

The pilot program will serve as a test for broader rollout across Europe and beyond.

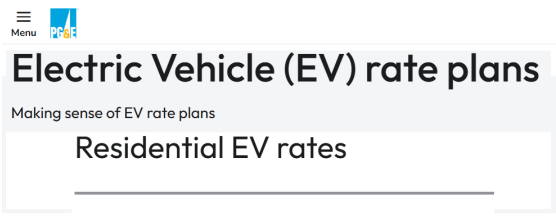
BY NATALIE NEFF

PUBLISHED: OCT 22, 2025 9:00 AM EDT

Green technology subsidies: US, EU

Marginal cost subsidy

Lowering the electricity cost of charging your EV:


Menu

Electric Vehicle (EV) rate plans

Making sense of EV rate plans

Residential EV rates

You can lower your energy costs by enrolling in one of our EV rate plans:

- Home Charging EV2-A
- Electric Vehicle Rate Plan EV-B


Volvo Offers Swedish Buyers A Year Of Free Charging To Spark EV Sales

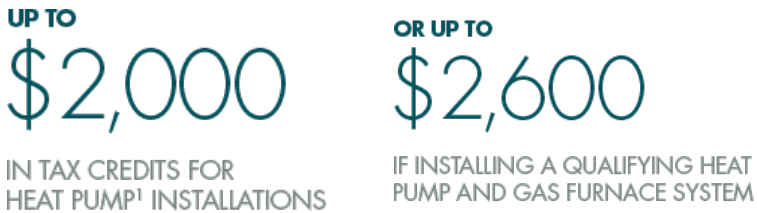
The pilot program will serve as a test for broader rollout across Europe and beyond.

BY NATALIE NEFF

PUBLISHED: OCT 22, 2025 9:00 AM EDT

Fixed cost subsidy

Lowering the cost of buying an EV or a heat pump:


UP TO

$2,000

IN TAX CREDITS FOR HEAT PUMP[1] INSTALLATIONS

OR UP TO

$2,600

IF INSTALLING A QUALIFYING HEAT PUMP AND GAS FURNACE SYSTEM

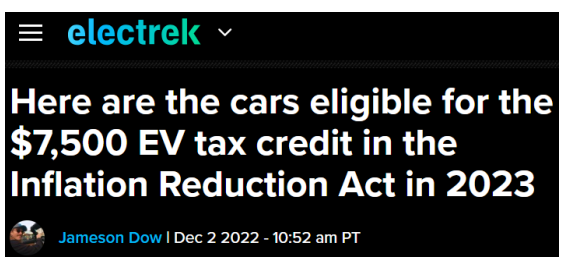

Heat pump grant increased to £7,500 by government in efforts to lower pollution and bills

Heat pumps emit far less pollution than gas boilers and can lower bills, but are expensive upfront. The government hopes the scheme will bring the cost of installing a new heat pump in line with that of a gas boiler.

Victoria Seabrook

Climate reporter @SeabrookClimate

Monday 23 October 2023 11:33, UK


electrek

Here are the cars eligible for the $7,500 EV tax credit in the Inflation Reduction Act in 2023

Jameson Dow | Dec 2 2022 - 10:52 am PT

Green technology subsidies: East Africa

Marginal cost subsidy

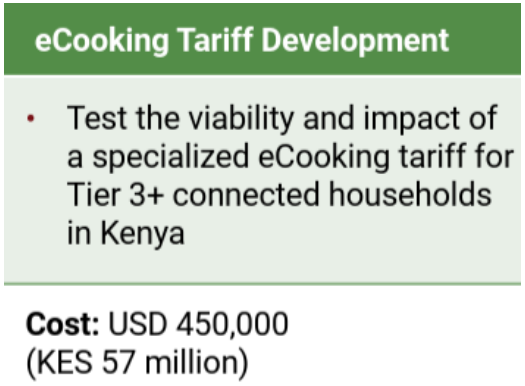
Business Daily

How new special power tariff has spurred electric vehicle uptake

THURSDAY, DECEMBER 26, 2024 — UPDATED ON MAY 28, 2025 - 5

UMEME Customers Enjoy Cheaper Cooking Tariff Set By ERA

Christopher Kiiza • November 14, 2022 3 minutes read



eCooking Tariff Development

- Test the viability and impact of a specialized eCooking tariff for Tier 3+ connected households in Kenya

Cost: USD 450,000
(KES 57 million)

Green technology subsidies: East Africa

Marginal cost subsidy

Business Daily

How new special power tariff has spurred electric vehicle uptake

THURSDAY, DECEMBER 26, 2024 — UPDATED ON MAY 28, 2025 - 5

UMEME Customers Enjoy Cheaper Cooking Tariff Set By ERA

Christopher Kiiza • November 14, 2022 3 minutes read

eCooking Tariff Development

- Test the viability and impact of a specialized eCooking tariff for Tier 3+ connected households in Kenya

Cost: USD 450,000
(KES 57 million)

Fixed cost subsidy

Tax waivers on eCooking

- A dedicated study to define a suitable tax waiver regime to reduce upfront appliances costs to locally manufactured appliances, components and/or accessories, which will increase demand.
- Determine the economic and financial impact of these waivers on government revenues and household affordability.

Cost: USD 125,000
(KES 16 Million)

PROJECT TYPE: Biogas SCALE: Large
LOCATION: Kenya
VINTAGES: 2023

1 ADD TO CART

How do demand wedges affect subsidy efficacy?

- **Demand wedge:** $wtp_{observed} < wtp_{efficient}$

How do demand wedges affect subsidy efficacy?

- **Demand wedge:** $wtp_{observed} < wtp_{efficient}$
- Examples:
  - Inattention to future benefits (myopia): $wtp_o = (1 - \theta) \cdot wtp_e$
    Dellavigna (2009)

How do demand wedges affect subsidy efficacy?

- **Demand wedge:** $wtp_{observed} < wtp_{efficient}$

- Examples:
  - Inattention to future benefits (myopia): $wtp_o = (1 - \theta) \cdot wtp_e$
    Dellavigna (2009)
  - Credit constraints: $wtp_o = \frac{1}{1+r} \cdot wtp_e$ (our setting: $r = 90\%$) Credit
    Hausman (1979): 18%

How do demand wedges affect subsidy efficacy?

- **Demand wedge:** $wtp_{observed} < wtp_{efficient}$

- Examples:
  - Inattention to future benefits (myopia): $wtp_o = (1 - \theta) \cdot wtp_e$
    Dellavigna (2009)
  - Credit constraints: $wtp_o = \frac{1}{1+r} \cdot wtp_e$ (our setting: $r = 90\%$) Credit
    Hausman (1979): 18%

- **Demand wedges often make marginal cost subsidies less effective:** each \$1 in subsidy spending increases wtp_o by less than \$1
  Hausman 1979; Allcott and Wozny 2014; Allcott, Mullainathan, Taubinsky 2014; Palmer, Walls 2015; Allcott, Taubinsky 2015; DeGroote, Verboven 2019; Grigolon, Reynaert, Verboven 2018; Gillingham, Houde, van Benthem 2021

How do demand wedges affect subsidy efficacy?

- **Demand wedge:** $wtp_{observed} < wtp_{efficient}$
- Examples:
  - Inattention to future benefits (myopia): $wtp_o = (1 - \theta) \cdot wtp_e$
    Dellavigna (2009)
  - Credit constraints: $wtp_o = \frac{1}{1+r} \cdot wtp_e$ (our setting: $r = 90\%$) Credit
    Hausman (1979): 18%
- **Demand wedges often make marginal cost subsidies less effective:** each \$1 in subsidy spending increases wtp_o by less than \$1
  Hausman 1979; Allcott and Wozny 2014; Allcott, Mullainathan, Taubinsky 2014; Palmer, Walls 2015; Allcott, Taubinsky 2015; DeGroote, Verboven 2019; Grigolon, Reynaert, Verboven 2018; Gillingham, Houde, van Benthem 2021
- Fixed cost subsidies don't target the externality or incentivize usage
- Does this mean demand wedges shift technologies to the right in the abatement cost curve?

This paper: Demand wedges **increase** fixed cost subsidy efficacy

1. If private benefits (wtp_e) and social benefits are positively correlated, a uniform demand wedge will increase the marginal adopter's positive externality

2. If the demand wedge increases demand elasticity, this reduces subsidy expenditure per marginal adoption

This paper: Demand wedges **increase** fixed cost subsidy efficacy

1. If private benefits (wtp_e) and social benefits are positively correlated, a uniform demand wedge will increase the marginal adopter's positive externality

2. If the demand wedge increases demand elasticity, this reduces subsidy expenditure per marginal adoption

3. Can this outweigh the shortcoming of fixed cost subsidies: no intensive margin incentive, no targeting on the externality?

This paper: Induction stoves in Kenya

Kenyan charcoal Jiko

Induction stove

This paper: Randomized Controlled Trial

1. **Sample:** 2,134 Kenyan households
2. **Randomized treatments:**
   - **Credit condition:** pay with loan or pay up front
   - **Fixed cost subsidies:** 10% or 86% off the standard price of $82
   - **Marginal cost subsidies:** 0, 25%, or 75% off the cost of electricity used to cook with the induction stove
3. **Measurement:**
   - 2min-frequency temperature monitors on charcoal stoves
   - 15min-frequency remote collection of induction stove usage
   - In-person 1-month follow up survey

Results I: Impacts

1. The induction stoves reduces total monthly energy spending by \$8.9 per month (126% annual IRR)
   - Monthly charcoal spending down \$10 (62%)
   - Monthly electricity spending up \$2.7 (87%), approx. 14 kWh

2. Net abatement of 3.1 tCO_2e per year
   - For comparison: an EV abates between 0.1–1.5 tCO_2e per year
     Hahn et al., 2024; Muehlegger and Rapson, 2023

Results II: Subsidy efficacy

- Positively correlated private and social benefits: $r = 0.76$
  Heterogeneous charcoal, electricity, LPG, wood consumption bundles
- Inelastic intensive margin response to MC subsidies: $\mathcal{E}_d = -0.18$
- Inelastic extensive margin response to MC subsidies: $\Delta wtp \leq 0.2 \cdot \Delta NPV$

Results II: Subsidy efficacy

- Positively correlated private and social benefits: $r = 0.76$
  Heterogeneous charcoal, electricity, LPG, wood consumption bundles
- Inelastic intensive margin response to MC subsidies: $\mathcal{E}_d = -0.18$
- Inelastic extensive margin response to MC subsidies: $\Delta wtp \leq 0.2 \cdot \Delta NPV$

How do demand wedges affect the efficacy of fixed cost subsidies?

	Loan	**Pay up front**
Annual abatement per marginal adopter	2.6 tCO_2e	3.2 tCO_2e
Extensive margin elasticity to fixed cost subsidy	$\mathcal{E}_d = -0.7$	$\mathcal{E}_d = -2.0$
Fixed cost subsidy expenditure per marginal adoption	\$99	\$63

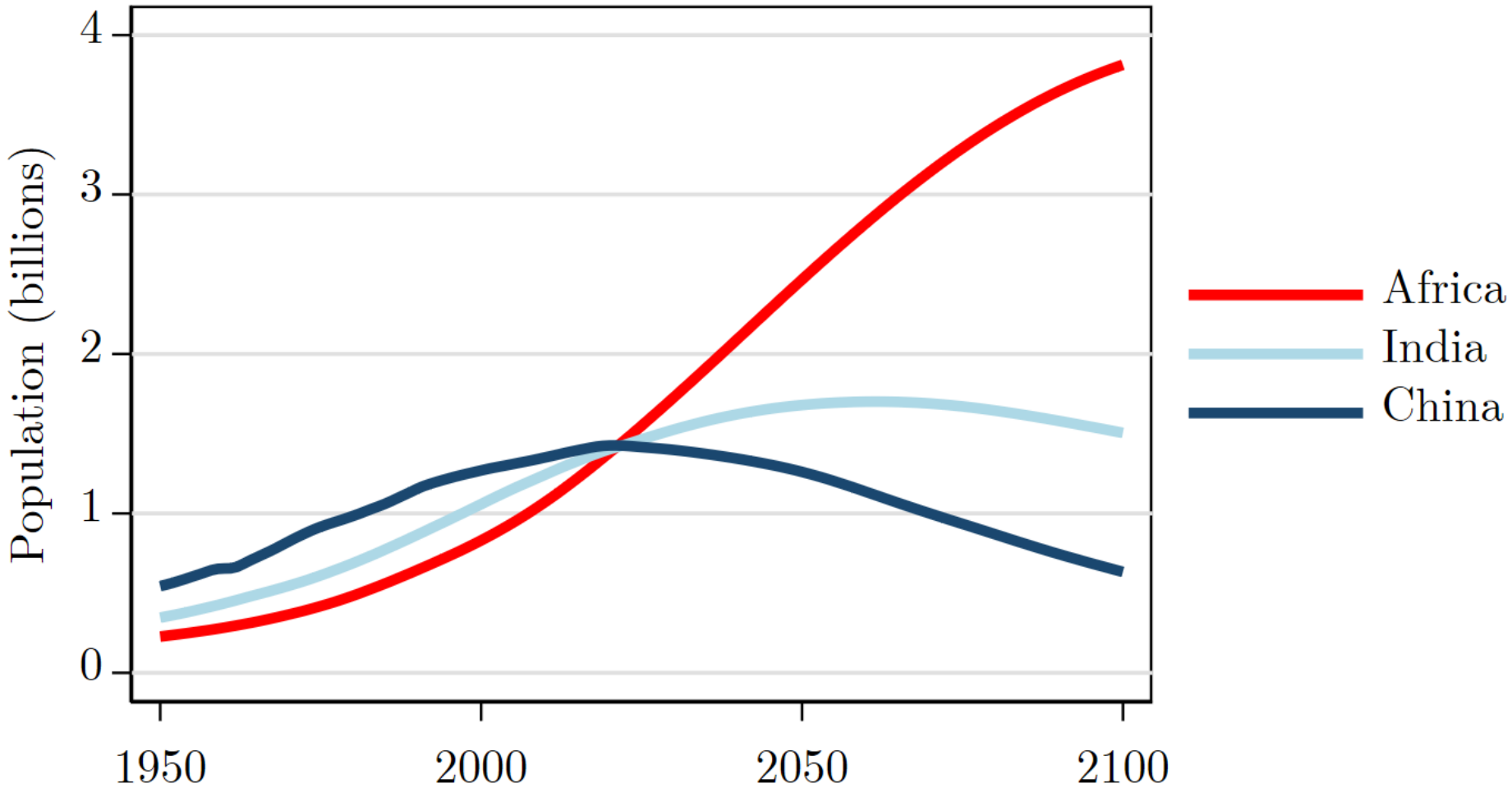
Results II: Subsidy efficacy

- Positively correlated private and social benefits: $r = 0.76$
  Heterogeneous charcoal, electricity, LPG, wood consumption bundles
- Inelastic intensive margin response to MC subsidies: $\mathcal{E}_d = -0.18$
- Inelastic extensive margin response to MC subsidies: $\Delta wtp \leq 0.2 \cdot \Delta NPV$

How do demand wedges affect the efficacy of fixed cost subsidies?

	Loan	**Pay up front**
Annual abatement per marginal adopter	2.6 tCO_2e	3.2 tCO_2e
Extensive margin elasticity to fixed cost subsidy	$\mathcal{E}_d = -0.7$	$\mathcal{E}_d = -2.0$
Fixed cost subsidy expenditure per marginal adoption	\$99	\$63
Abatement cost per tCO_2e after 3 years	**\$12.2**	**\$5.7**

Population in China, India, Africa



Source: UN, World Population Prospects (2024), medium scenario

Back of the envelope applications

- Larger demand wedge *e.g. credit constraints*
- Positively correlated private and social benefits, *e.g. fuel efficiency*
- Inelastic intensive margin *e.g. daily routines*

Where are these assumptions reasonable?

Back of the envelope applications

- Larger demand wedge *e.g. credit constraints*
- Positively correlated private and social benefits, *e.g. fuel efficiency*
- Inelastic intensive margin *e.g. daily routines*

Where are these assumptions reasonable?

- 2 billion people cook with biomass, emitting **10+ billion tCO_2e** per year
  $\Rightarrow$ Induction stoves: \$6 per tCO_2e
  $\Rightarrow$ Improved charcoal stoves: \$8 per tCO_2e
- 700 million people use kerosene lighting, emitting **1+ billion tCO_2e** per year
  $\Rightarrow$ Solar lamps: \$10 per tCO_2e

Back of the envelope applications

- Larger demand wedge *e.g. credit constraints*
- Positively correlated private and social benefits, *e.g. fuel efficiency*
- Inelastic intensive margin *e.g. daily routines*

Where are these assumptions reasonable?

- 2 billion people cook with biomass, emitting **10+ billion tCO$_2$e** per year
  $\Rightarrow$ Induction stoves: \$6 per tCO$_2$e
  $\Rightarrow$ Improved charcoal stoves: \$8 per tCO$_2$e
- 700 million people use kerosene lighting, emitting **1+ billion tCO$_2$e** per year
  $\Rightarrow$ Solar lamps: \$10 per tCO$_2$e
- 20 million diesel irrigation pumps in India; 25 million ICE motorcycles in Africa

Back of the envelope applications

- Larger demand wedge *e.g. credit constraints*
- Positively correlated private and social benefits, *e.g. fuel efficiency*
- Inelastic intensive margin *e.g. daily routines*

Where are these assumptions reasonable?

- 2 billion people cook with biomass, emitting **10+ billion tCO_2e** per year
  $\Rightarrow$ Induction stoves: \$6 per tCO_2e
  $\Rightarrow$ Improved charcoal stoves: \$8 per tCO_2e
- 700 million people use kerosene lighting, emitting **1+ billion tCO_2e** per year
  $\Rightarrow$ Solar lamps: \$10 per tCO_2e
- 20 million diesel irrigation pumps in India; 25 million ICE motorcycles in Africa

For comparison:

- **100 million tCO_2e** voluntary carbon credits sold in 2023
- 40 million electric vehicles globally abate $\sim$**100 million tCO_2e** per year
- EV subsidies cost >\$1,000 per tCO_2e *IEA 2024; Muehlegger, Rapson 2023; Hahn, Hendren, Metcalfe, Sprung-Keyser 2025. In U.S., 80% of new cars sold with financing.*

Today

Background

Theory

RCT Design

CO_2 Abatement

Intensive margin: Usage among marginal adopters

Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

Energy efficiency adoption: Short version of model

Building on Allcott, Mullainathan, Taubinsky (2012, 2014);

Pared down version—more sophisticated version has similar results

- Agent i consumes perfectly inelastic energy services θ_i
- At $t = 1$ they decide whether to buy the greener technology
- Market price of the greener tech relative to the dirty tech is $p_m - s_1$

Energy efficiency adoption: Short version of model

Building on Allcott, Mullainathan, Taubinsky (2012, 2014);

Pared down version—more sophisticated version has similar results

- Agent i consumes perfectly inelastic energy services θ_i
- At $t = 1$ they decide whether to buy the greener technology
- Market price of the greener tech relative to the dirty tech is $p_m - s_1$
- At $t = 2$ they choose what fraction $d \in [0, 1]$ of θ_i to consume using the greener substitute
- Substituting with the greener tech generates private savings $b_i = d\theta_i(\bar{b} + s_2)$ and positive externality, $\phi_i = d\theta_i\bar{\phi}$

Energy efficiency adoption: Short version of model

Building on Allcott, Mullainathan, Taubinsky (2012, 2014);

Pared down version—more sophisticated version has similar results

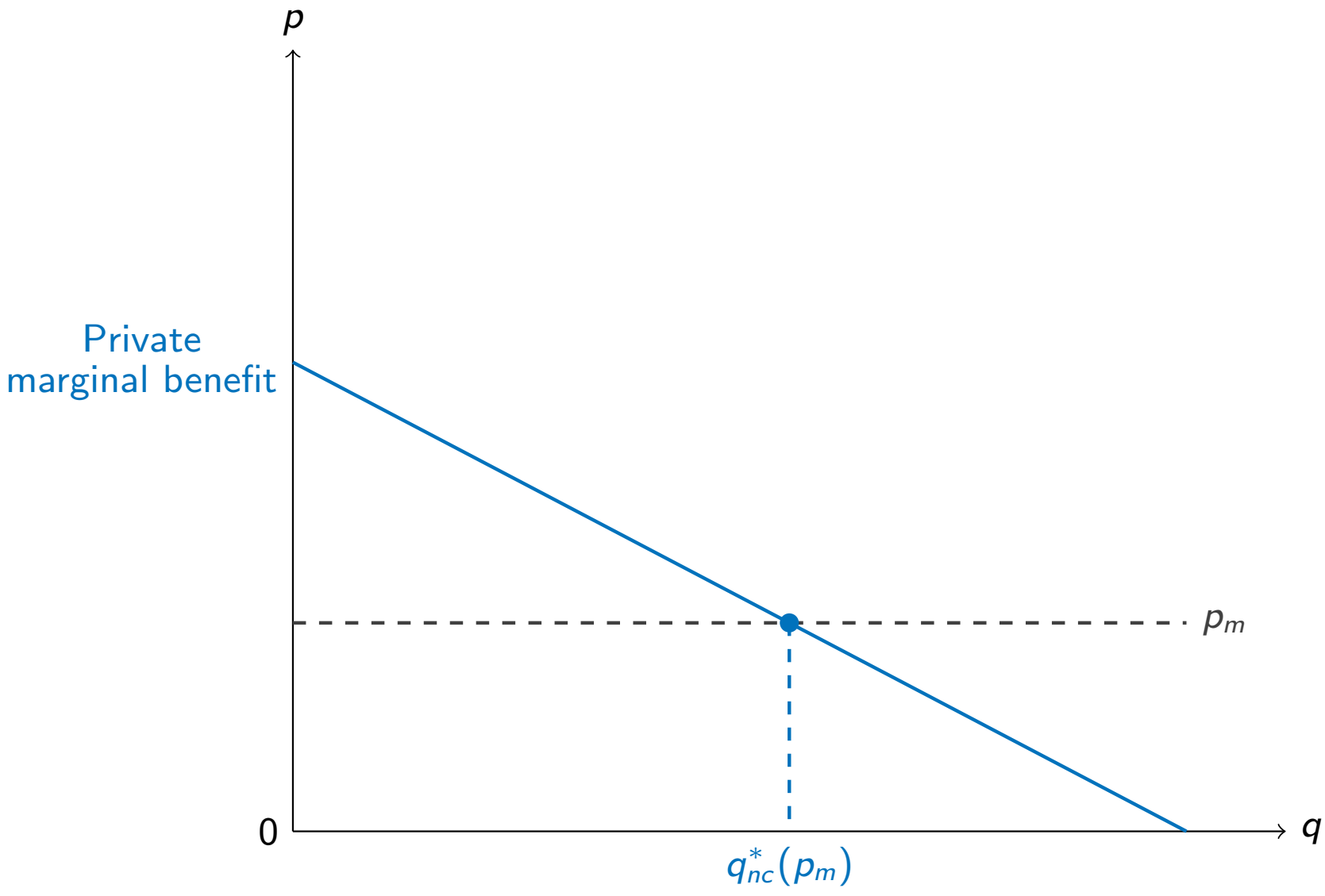
- Agent i consumes perfectly inelastic energy services θ_i
- At $t = 1$ they decide whether to buy the greener technology
- Market price of the greener tech relative to the dirty tech is $p_m - s_1$
- At $t = 2$ they choose what fraction $d \in [0, 1]$ of θ_i to consume using the greener substitute
- Substituting with the greener tech generates private savings $b_i = d\theta_i(\bar{b} + s_2)$ and positive externality, $\phi_i = d\theta_i\bar{\phi}$
- An agent facing an implied interest rate of r has maximum willingness to pay:

$$wtp_i = \frac{1}{1+r} \cdot b_i$$

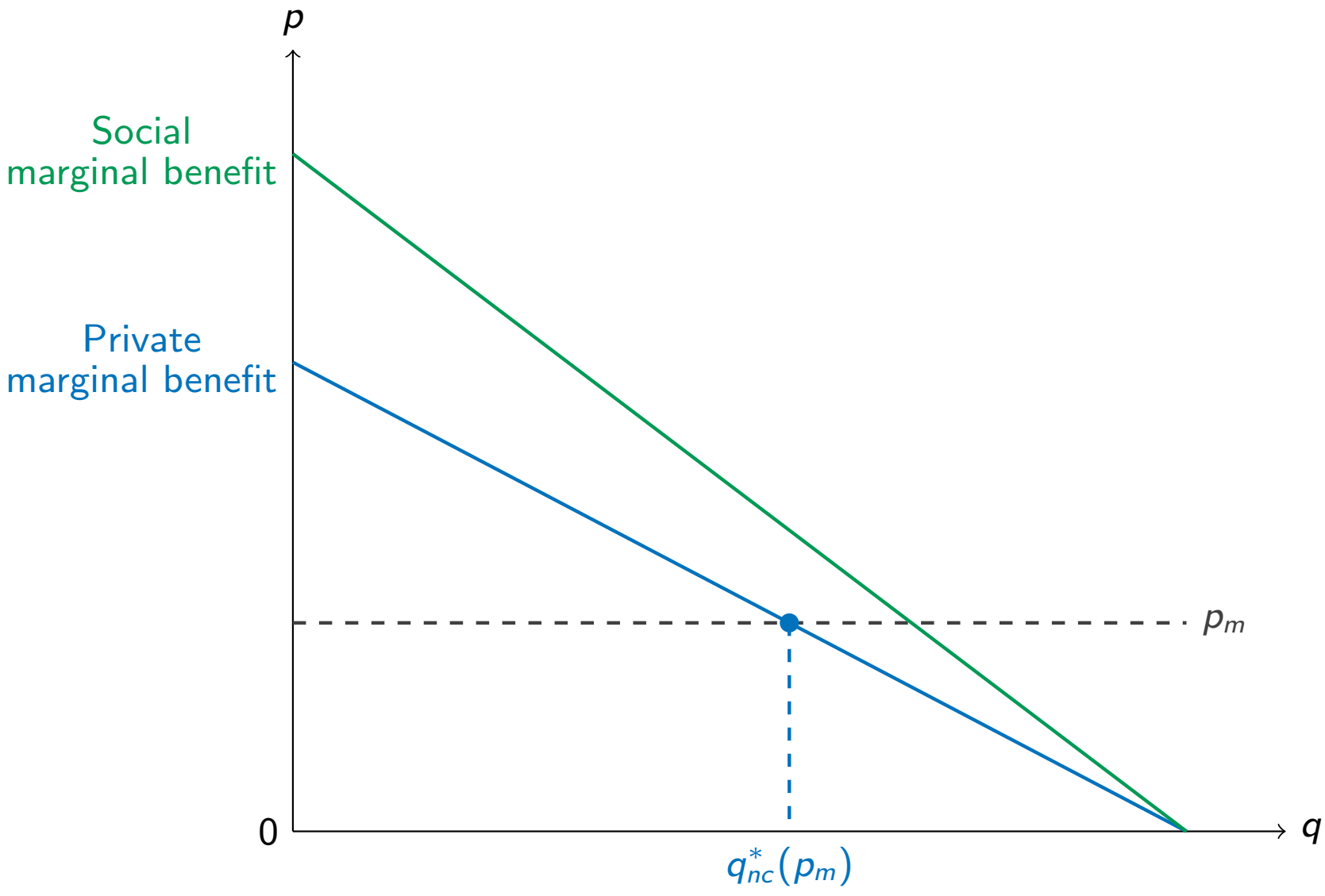
- Market demand is given by:

$$Q(P) = \sum_i P \leq wtp_i$$

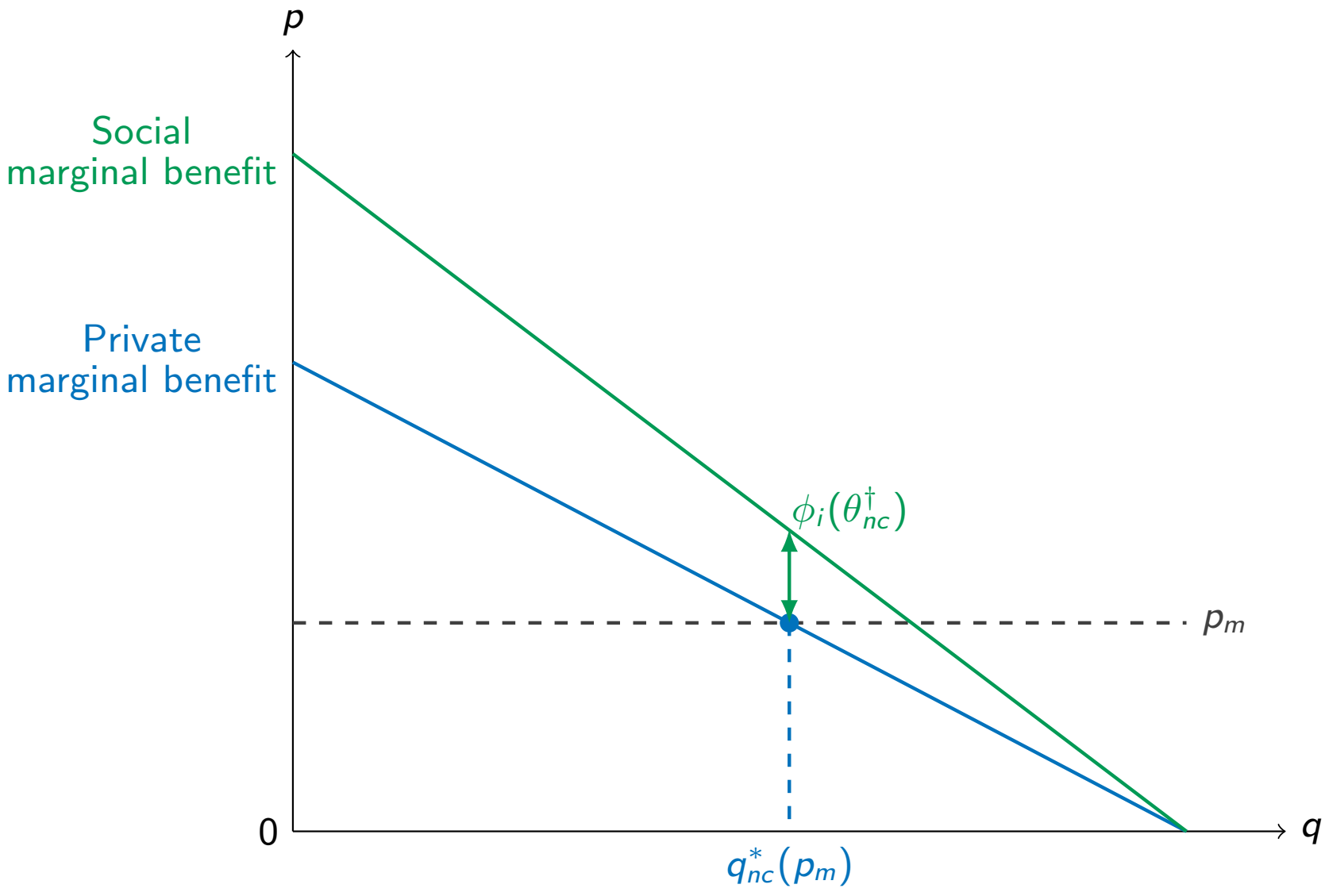
Graphical intuition: Marginal externality



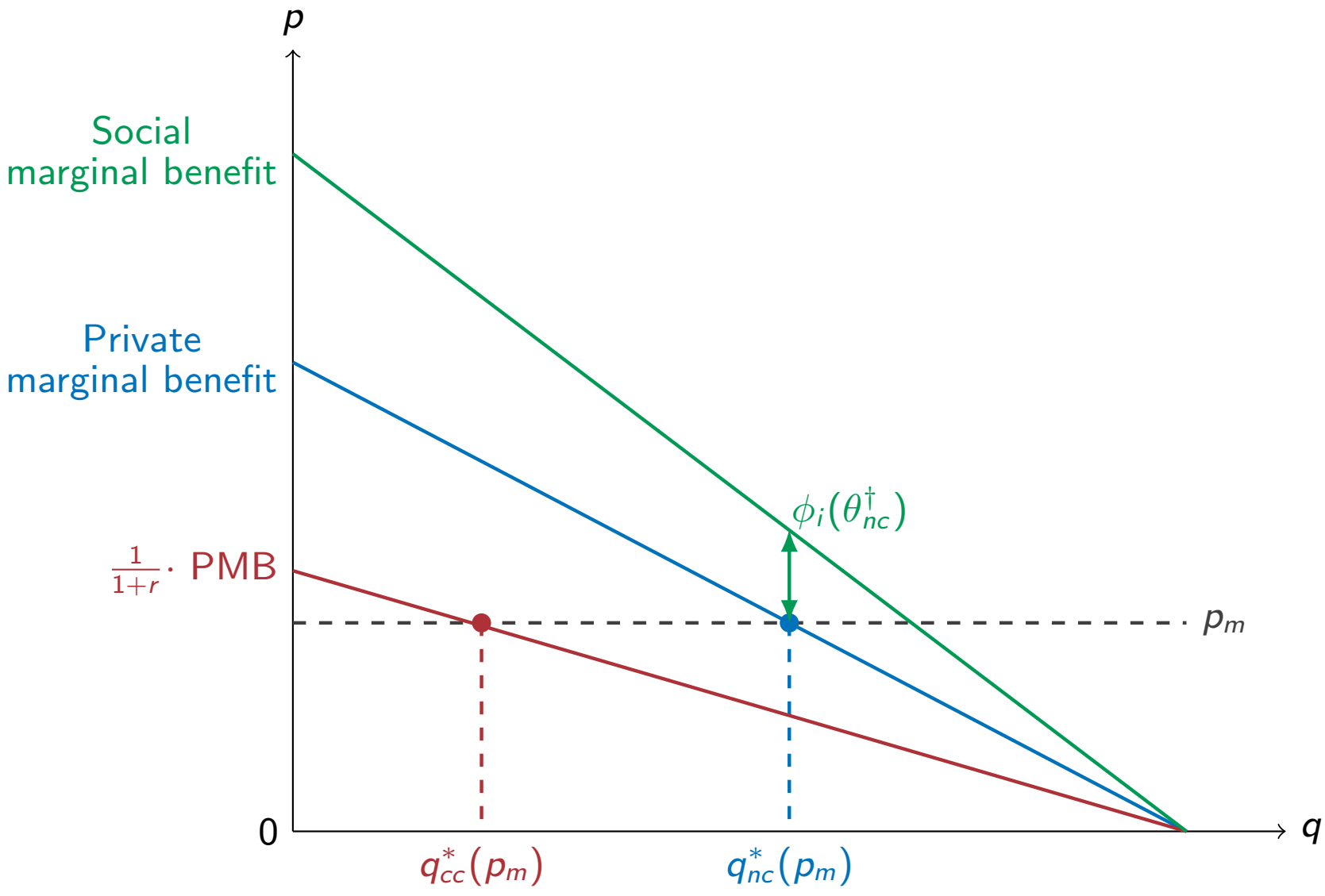
Graphical intuition: Marginal externality



Graphical intuition: Marginal externality

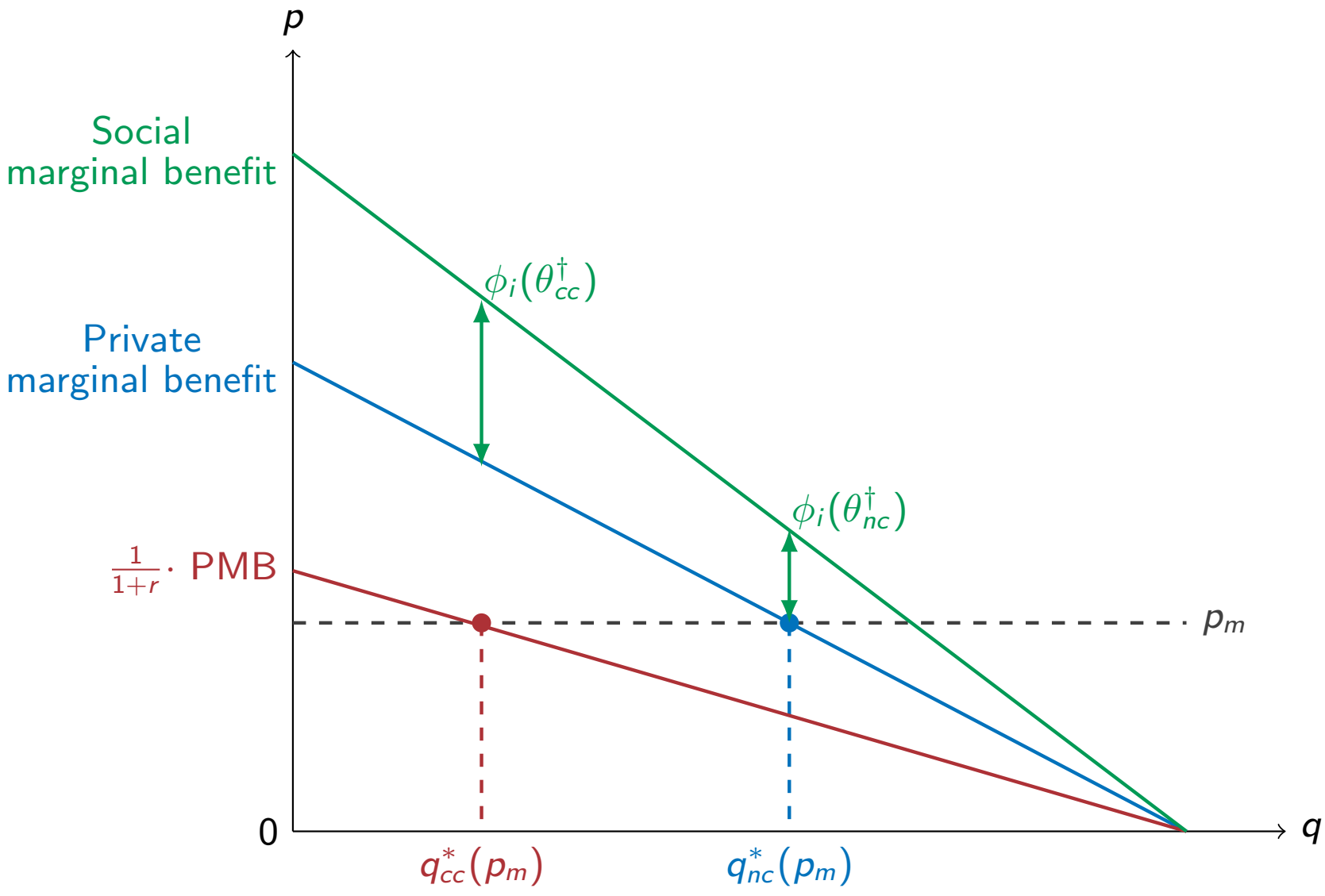


Graphical intuition: Marginal externality



Graphical intuition: Marginal externality

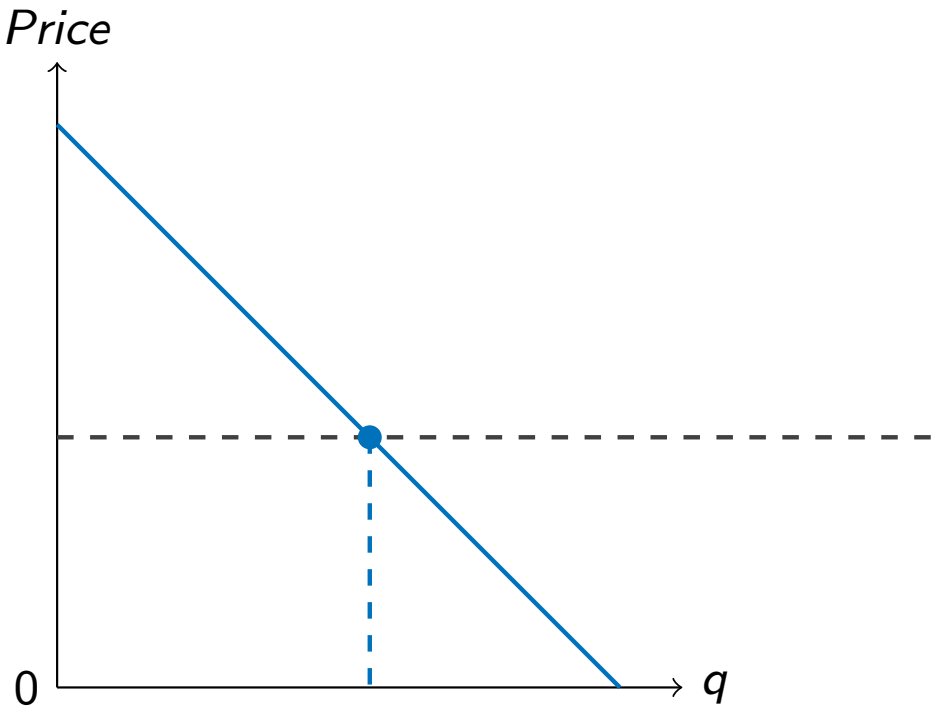
Result 1: Demand wedges increase the marginal adopter's positive externality



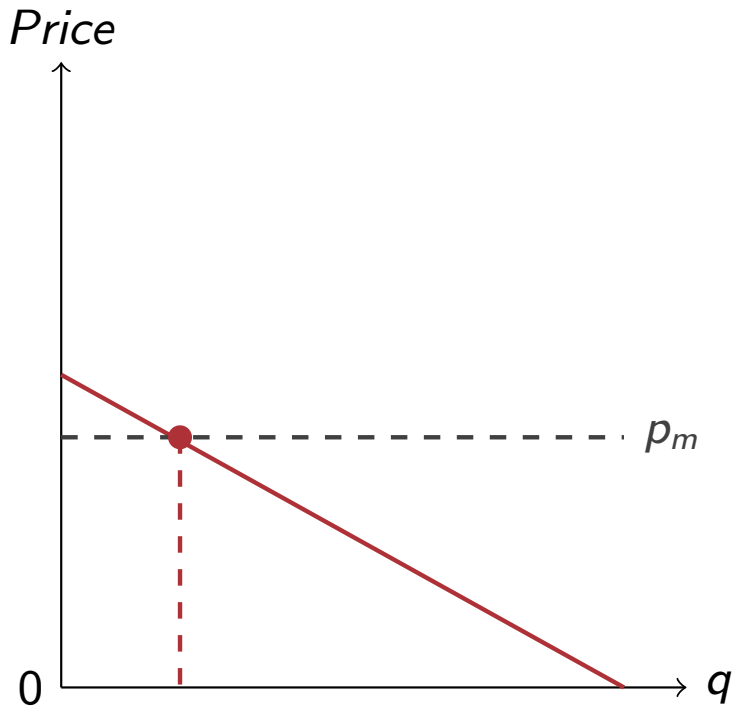
Graphical intuition: Cost per marginal adopter

Result 2: Demand wedges increase demand elasticity

(*a*) No wedge

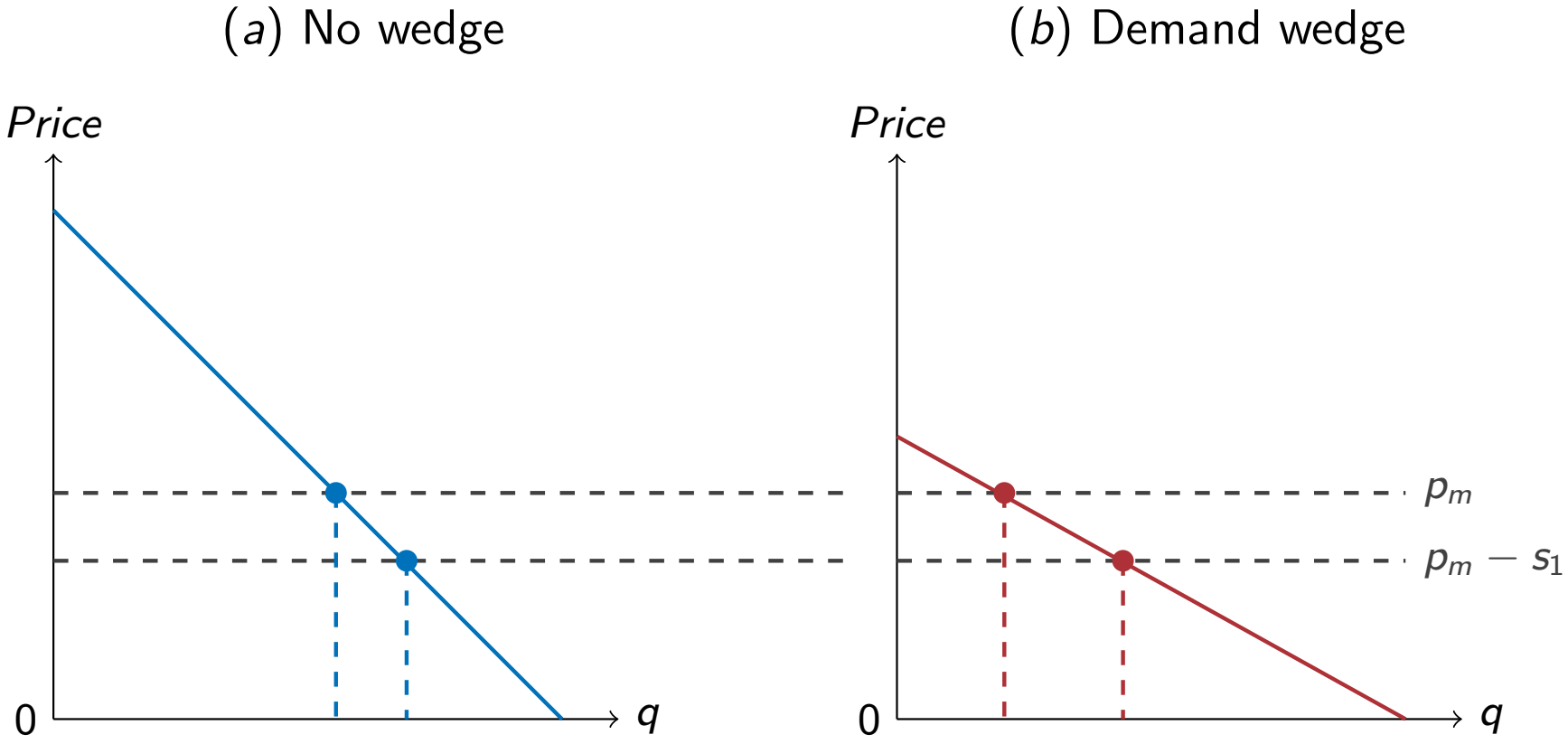


(*b*) Demand wedge



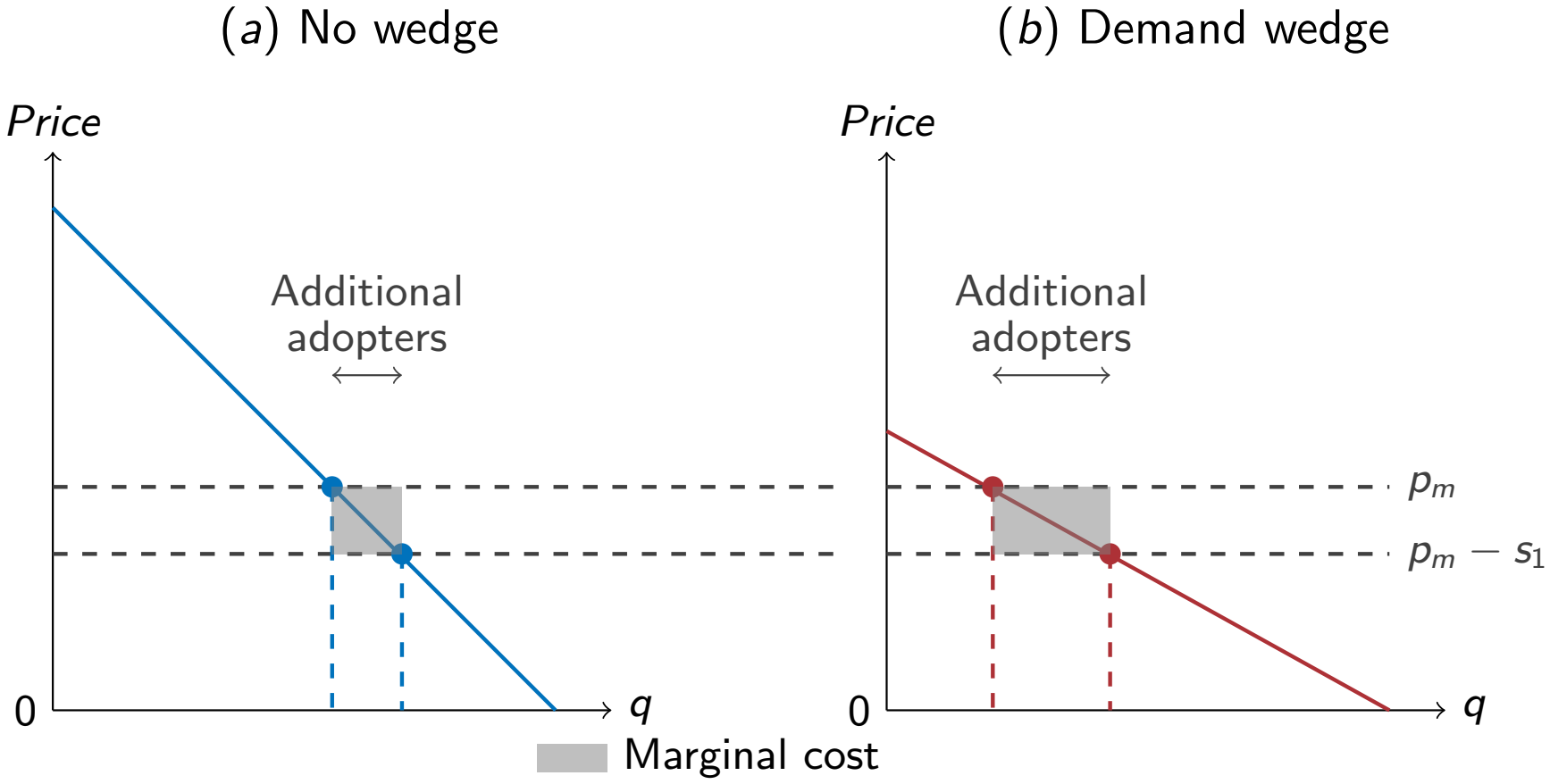
Graphical intuition: Cost per marginal adopter

Result 2: Demand wedges increase demand elasticity



Graphical intuition: Cost per marginal adopter

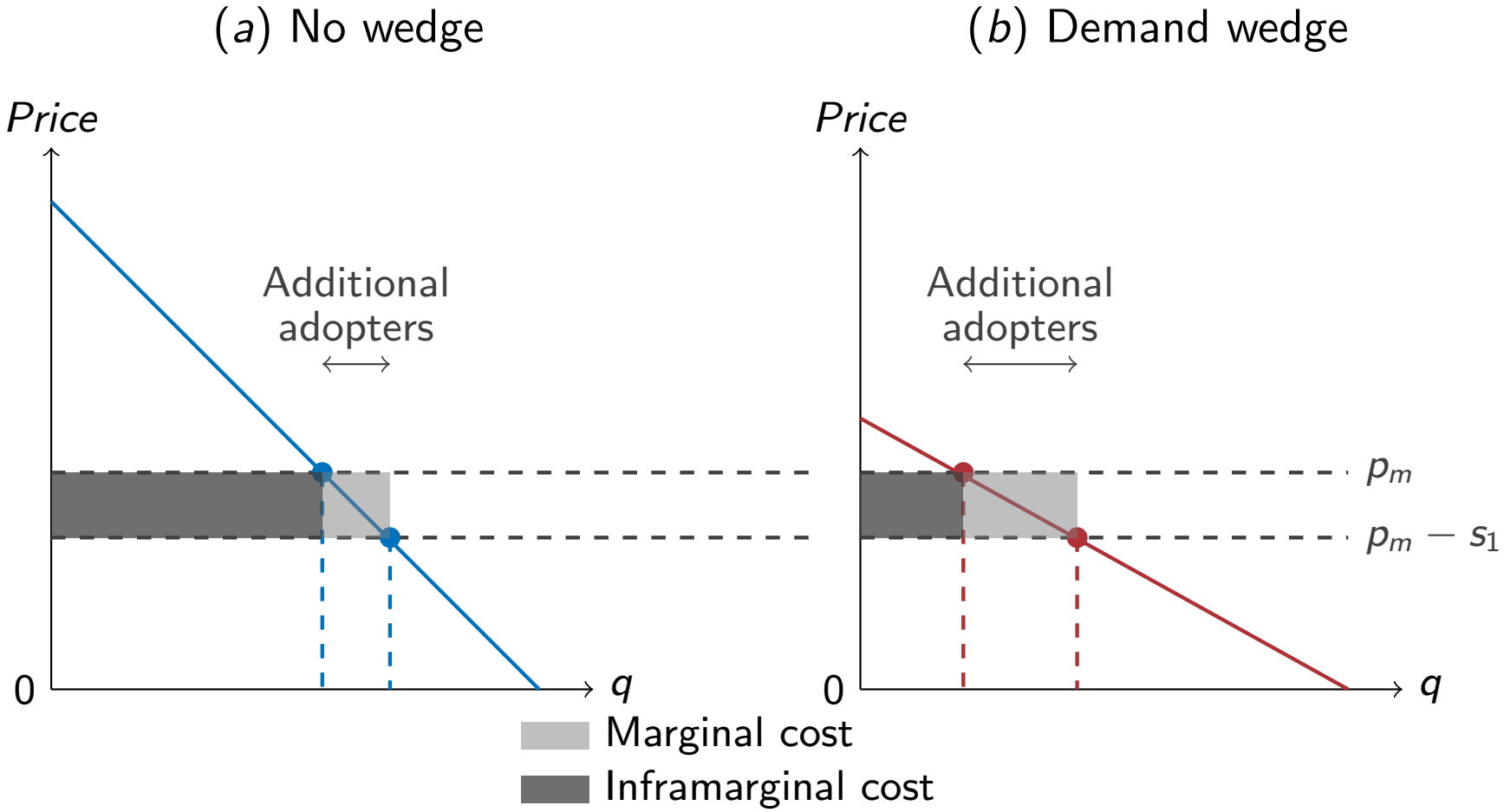
Result 2: Demand wedges increase demand elasticity



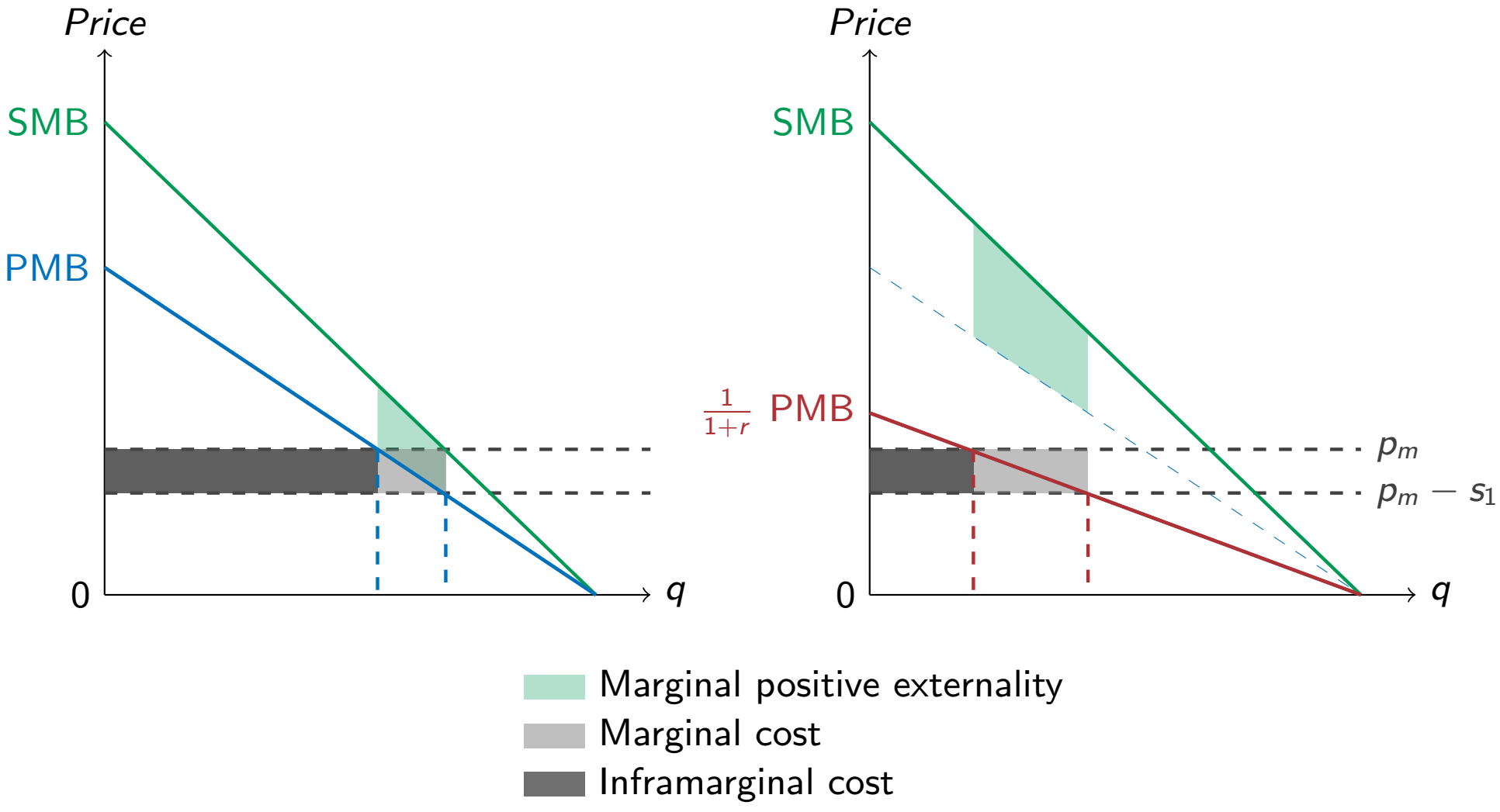
Graphical intuition: Cost per marginal adopter

Result 2: Demand wedges increase demand elasticity

- Elastic demand decreases the cost per marginal adopter



Subsidy efficiency: tCO_2e per dollar



Today

Background

Theory

RCT Design

CO_2 Abatement

Intensive margin: Usage among marginal adopters

Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

RCT with 2,100 participants: ECOA induction stove

- Use traditional charcoal cookstove as primary cooking technology
- Have a pre-pay electricity meter

Kenyan Jiko
(instrumented with a SUM)

ECOA

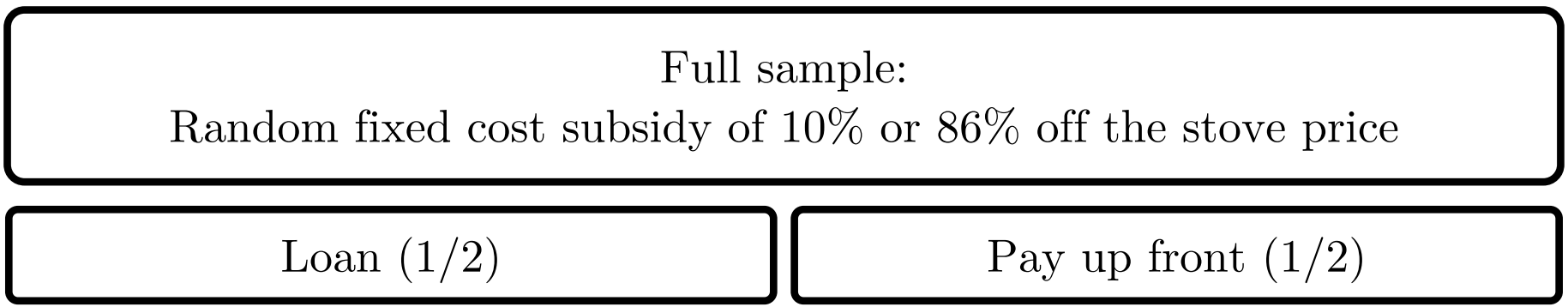
Randomly assigned credit, FC subsidies, MC subsidies

- **Fixed cost subsidies**, down from store price of $82:
  - 46% assigned a price of $20 (86% subsidy)
  - 49% assigned a price of $73 (10% subsidy)

Full sample:
Random fixed cost subsidy of 10% or 86% off the stove price

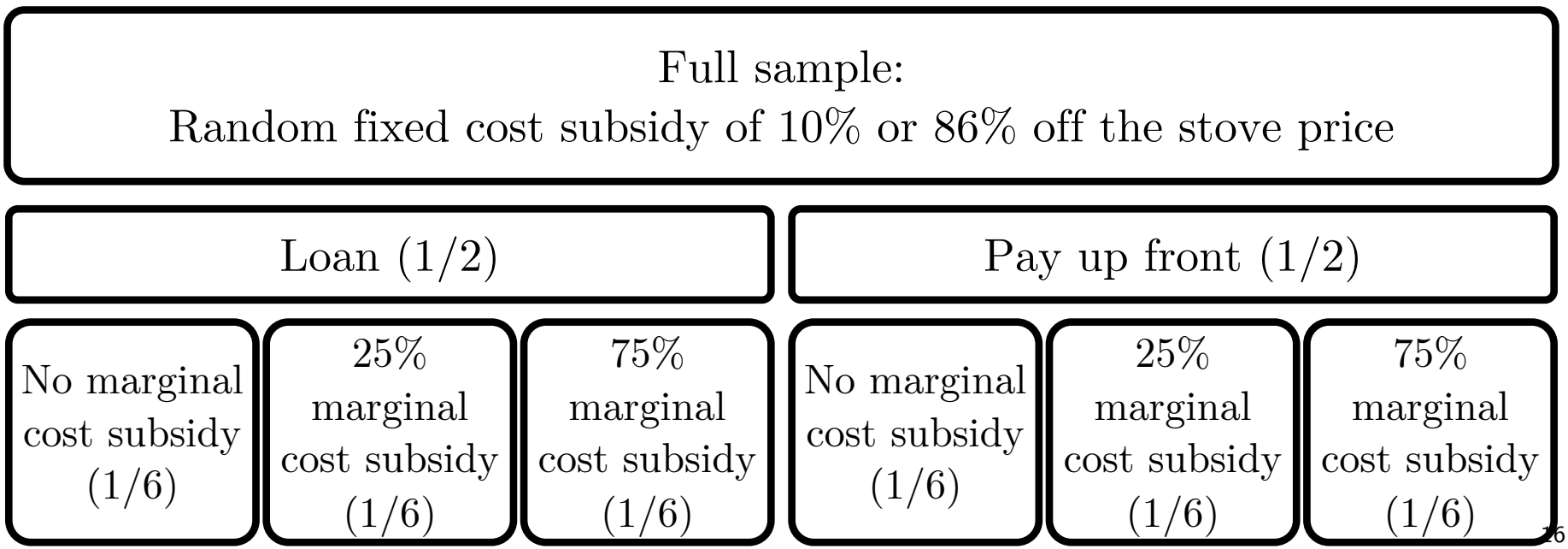
Randomly assigned credit, FC subsidies, MC subsidies

- **Fixed cost subsidies**, down from store price of \$82:
  - 46% assigned a price of \$20 (86% subsidy)
  - 49% assigned a price of \$73 (10% subsidy)
- **Two credit conditions:**
  - **Loan:** \$15 down downpayment, three deadlines 1, 2, 3 months later
  - **Upfront:** Pay full P_i today



Randomly assigned credit, FC subsidies, MC subsidies

- **Fixed cost subsidies**, down from store price of \$82:
  - 46% assigned a price of \$20 (86% subsidy)
  - 49% assigned a price of \$73 (10% subsidy)
- **Two credit conditions:**
  - **Loan:** \$15 down downpayment, three deadlines 1, 2, 3 months later
  - **Upfront:** Pay full P_i today
- **Marginal cost subsidies:** one-third each to 0%, 25%, 75%



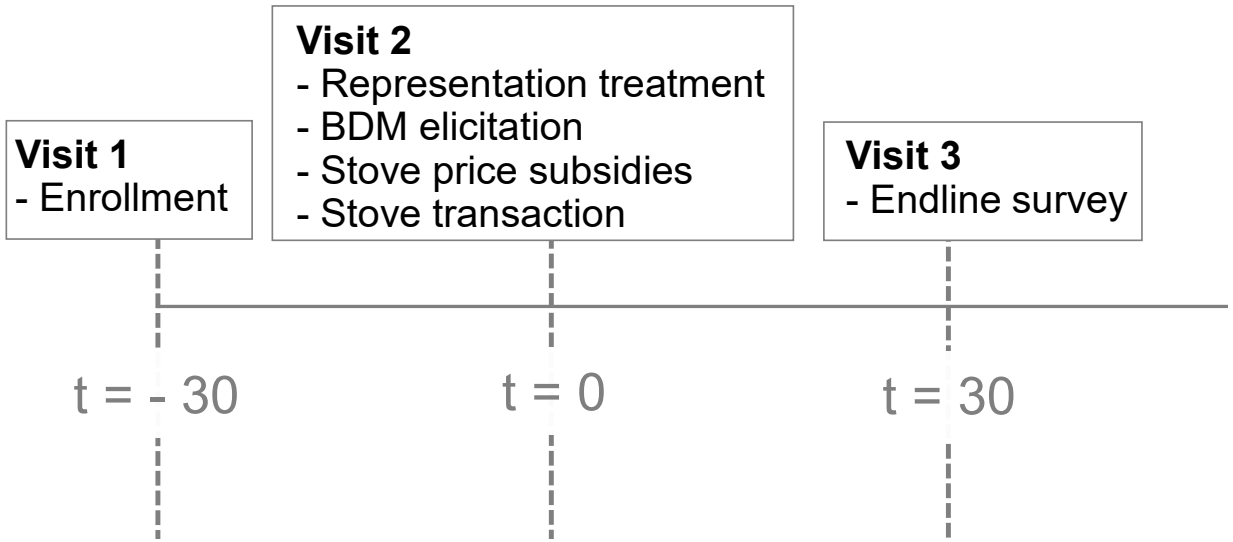
85% of sample gets information about marginal costs

Marginal cost subsidy control group:

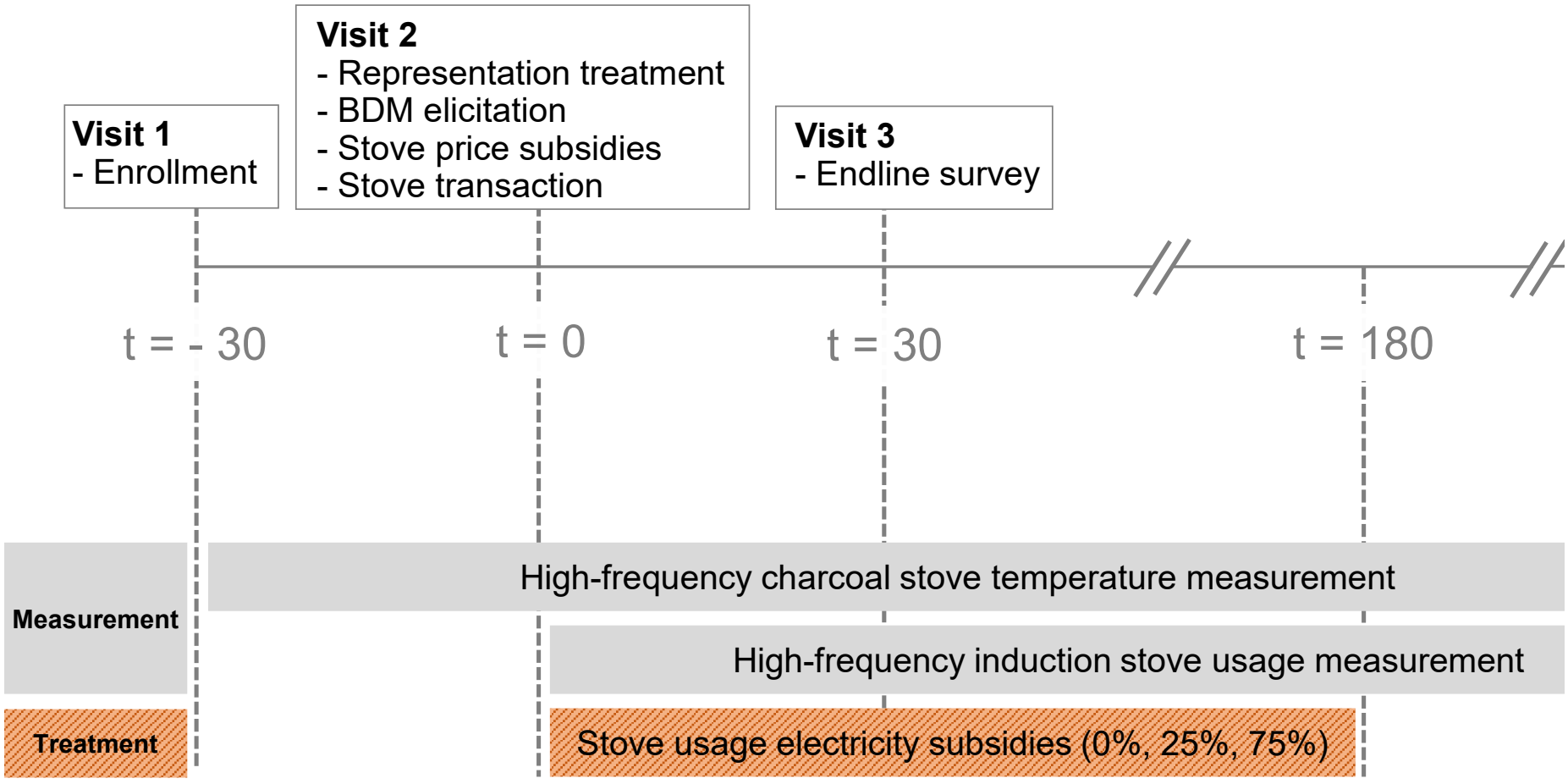
85% of sample gets information about marginal costs

Marginal cost subsidy treatment group:

Implementation Timeline



Implementation Timeline



Today

Background

Theory

RCT Design

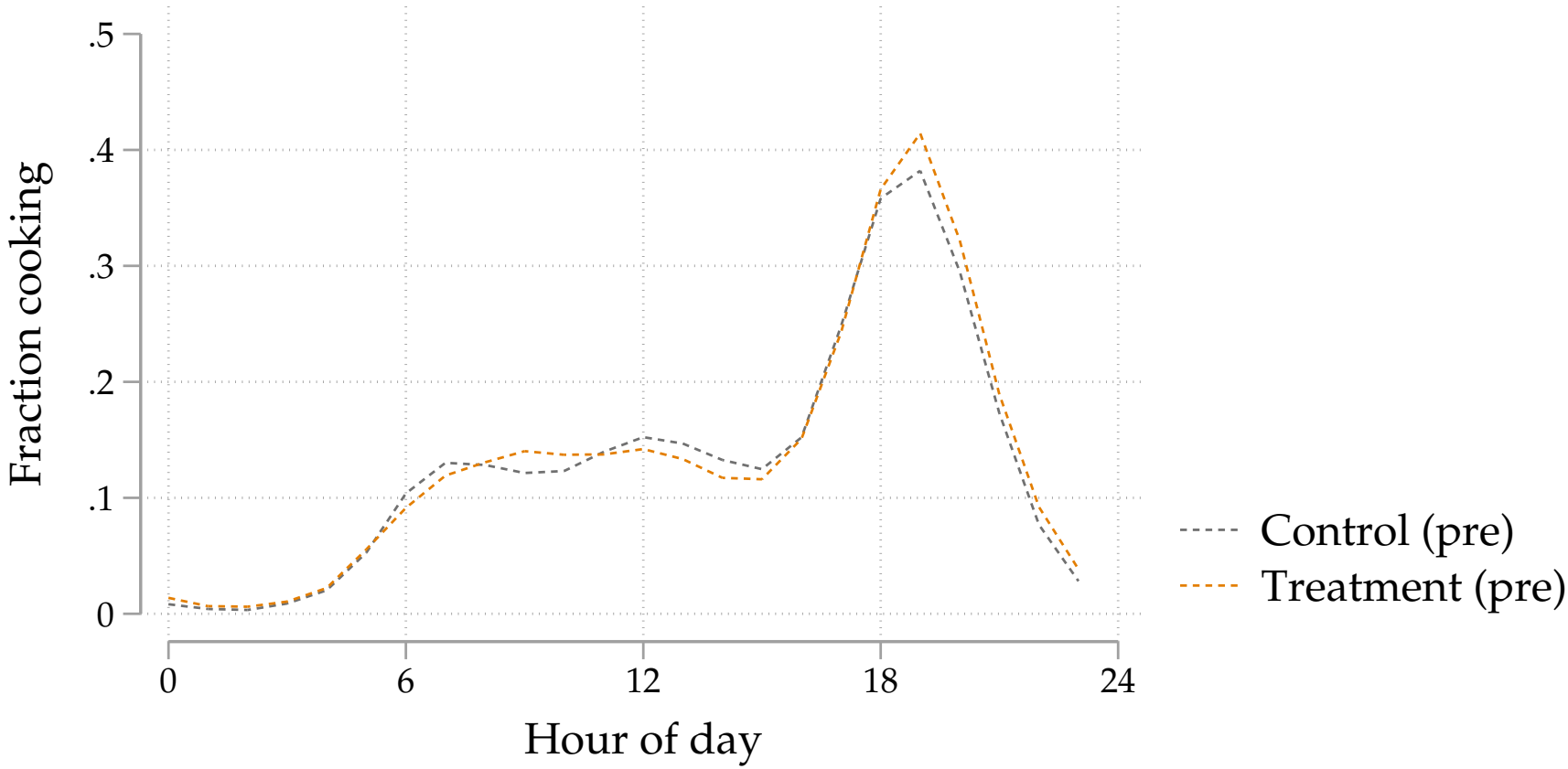
CO_2 Abatement

Intensive margin: Usage among marginal adopters

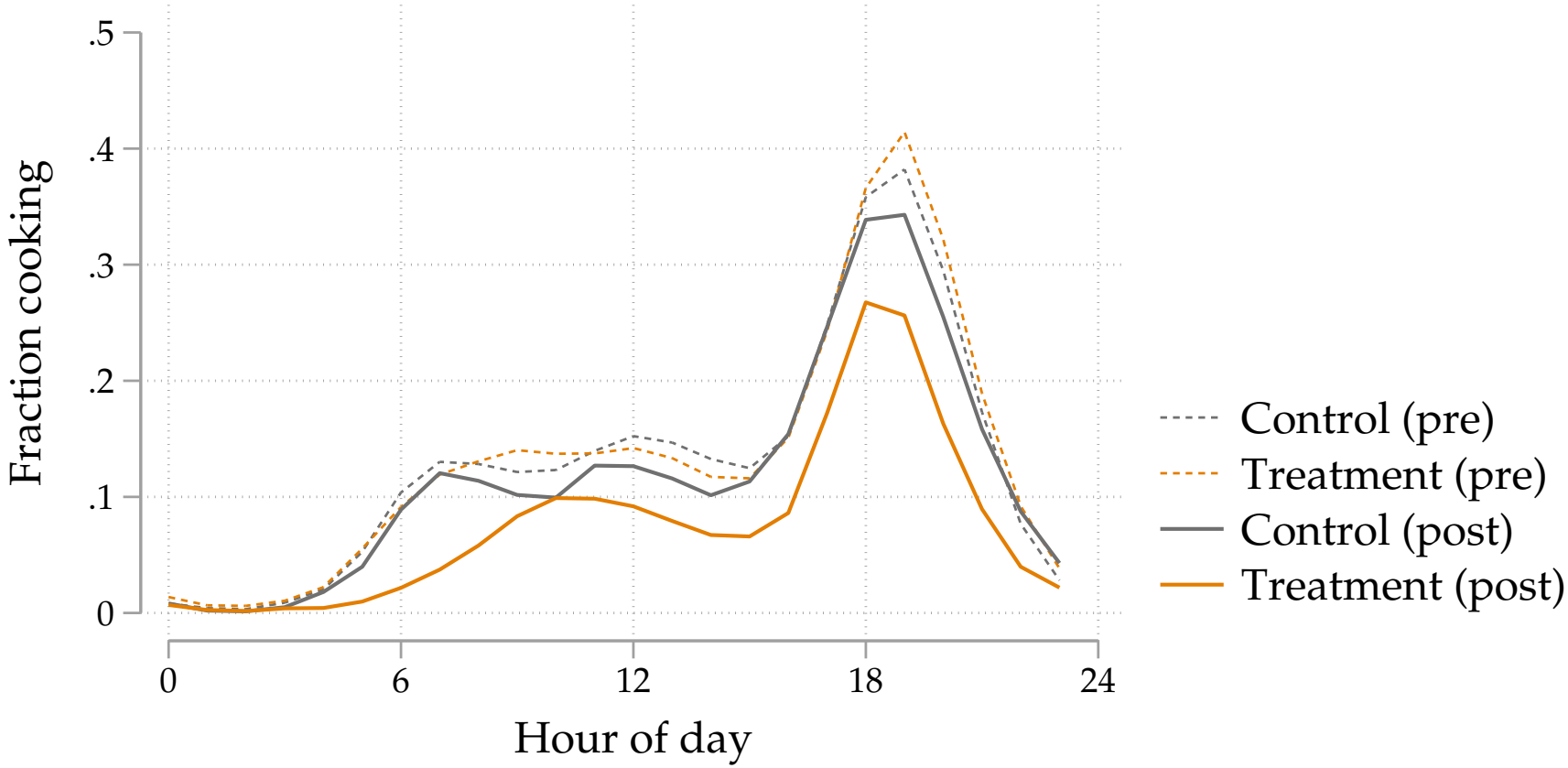
Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

Induction stove adopters use charcoal stoves less



Induction stove adopters use charcoal stoves less



Lower energy spending by $8.9 per month (24%)

Table: IV estimate of induction stove purchase on monthly energy spending (USD)

	Charcoal	LPG	Wood	Electricity	Total
Bought ECOA (=1)	-10.1***	-1.0	-0.4**	1.9***	-9.6***
	(0.9)	(0.6)	(0.2)	(0.4)	(1.1)
WTP (USD)	-0.0	0.0	0.0**	0.0***	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Observations	1724	1724	1724	1724	1724
Control Mean	16.2	5.2	0.5	3.1	25.0
F-Stat	93.98	38.78	2.94	60.20	44.32

Lower CO_2e emissions by 3 tCO_2e per year

Table: IV estimate of induction stove purchase on annual emissions (tCO_2e)

	Charcoal	LPG	Electricity	Total
Bought ECOA (=1)	-3.06***	-0.03	0.02***	-3.08***
	(0.27)	(0.02)	(0.00)	(0.27)
WTP (USD)	-0.00	0.00	0.00***	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	1724	1724	1724	1724
Control Mean	4.9	0.2	0.0	5.1
F-Stat	93.98	38.78	60.20	92.01

Today

Background

Theory

RCT Design

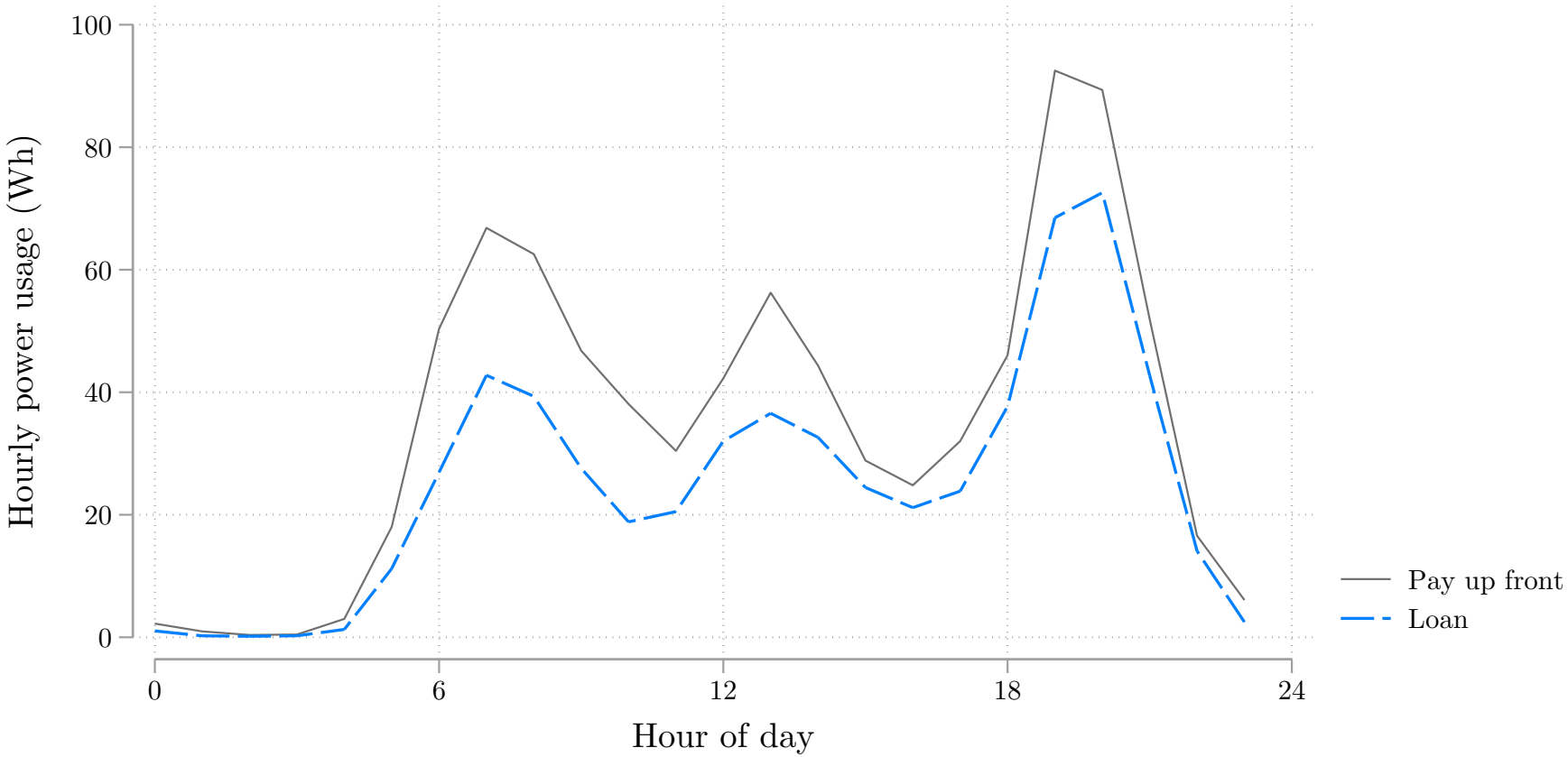
CO_2 Abatement

Intensive margin: Usage among marginal adopters

Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

Marginal adopters paying up front use new stoves more



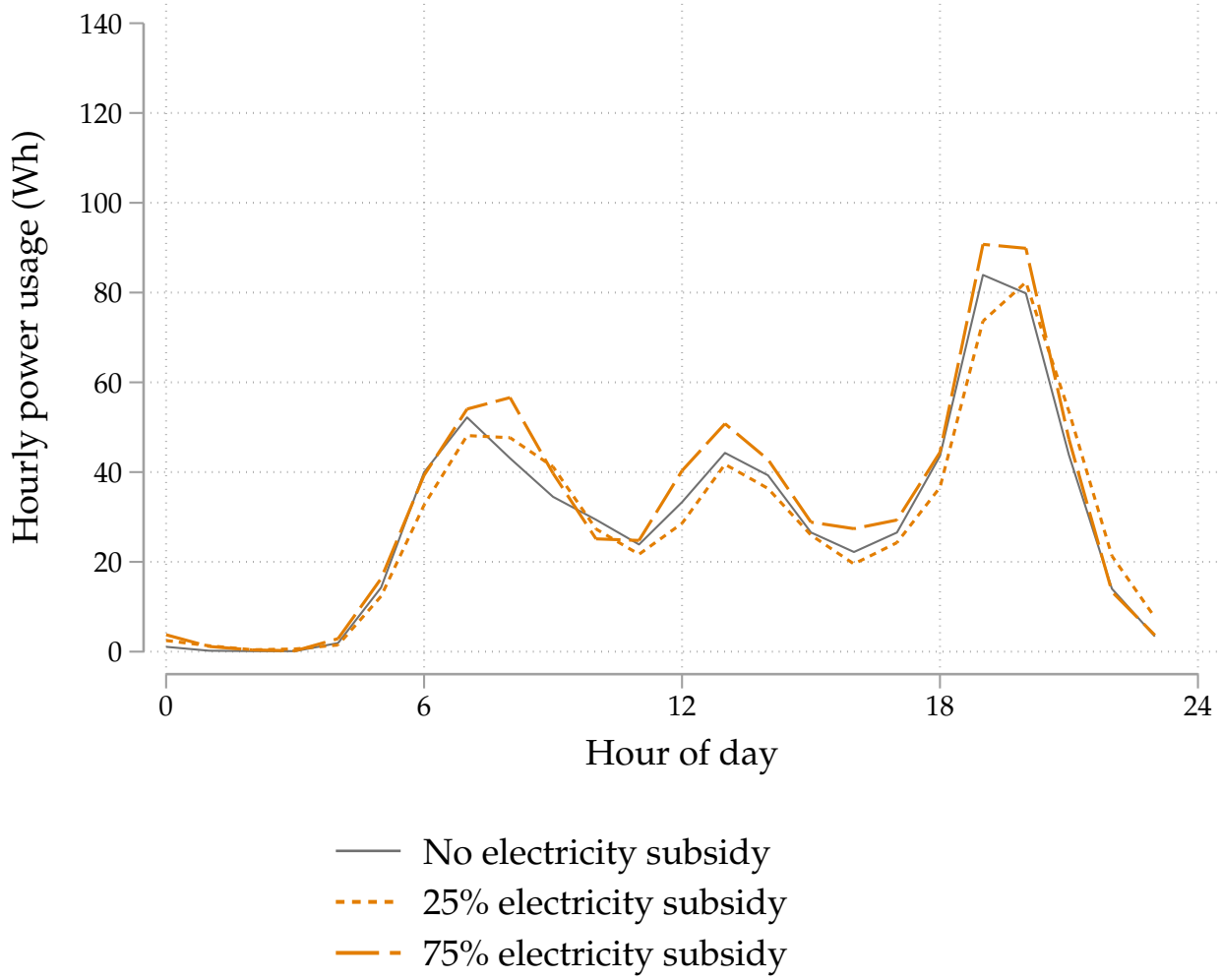
Marginal adopters paying up front abate more

	Charcoal (USD)		Charcoal (CO2)		Total (CO2)	
	(1)	(2)	(3)	(4)	(5)	(6)
Bought ECOA (=1)	-10.3***		-3.1***		-3.2***	
	(0.7)		(0.2)		(0.2)	
ECOA X No credit		-10.5***		-3.2***		-3.2***
		(0.7)		(0.2)		(0.2)
ECOA X Credit	1.6*	-8.7***	0.5*	-2.6***	0.5*	-2.6***
	(1.0)	(0.7)	(0.3)	(0.2)	(0.3)	(0.2)
Credit treatment (=1)	0.1	-0.5	0.0	-0.2	0.0	-0.1
	(1.6)	(1.6)	(0.5)	(0.5)	(0.5)	(0.5)
Observations	625	625	625	625	625	625
Control Mean	16.2	16.2	4.9	4.9	5.1	5.1
Controls	Some	Some	Some	Some	Some	Some
Sample	All	All	All	All	All	All
F-Stat	5.88	6.01	5.88	6.01	5.87	5.97

Note: Instrumental variables regression, with strata and treatment FE and SES controls

Conversely, intensive margin is very price inelastic

- Cannot distinguish between selection plus direct treatment effect
- Currently running another treatment to measure inattention



Today

Background

Theory

RCT Design

CO_2 Abatement

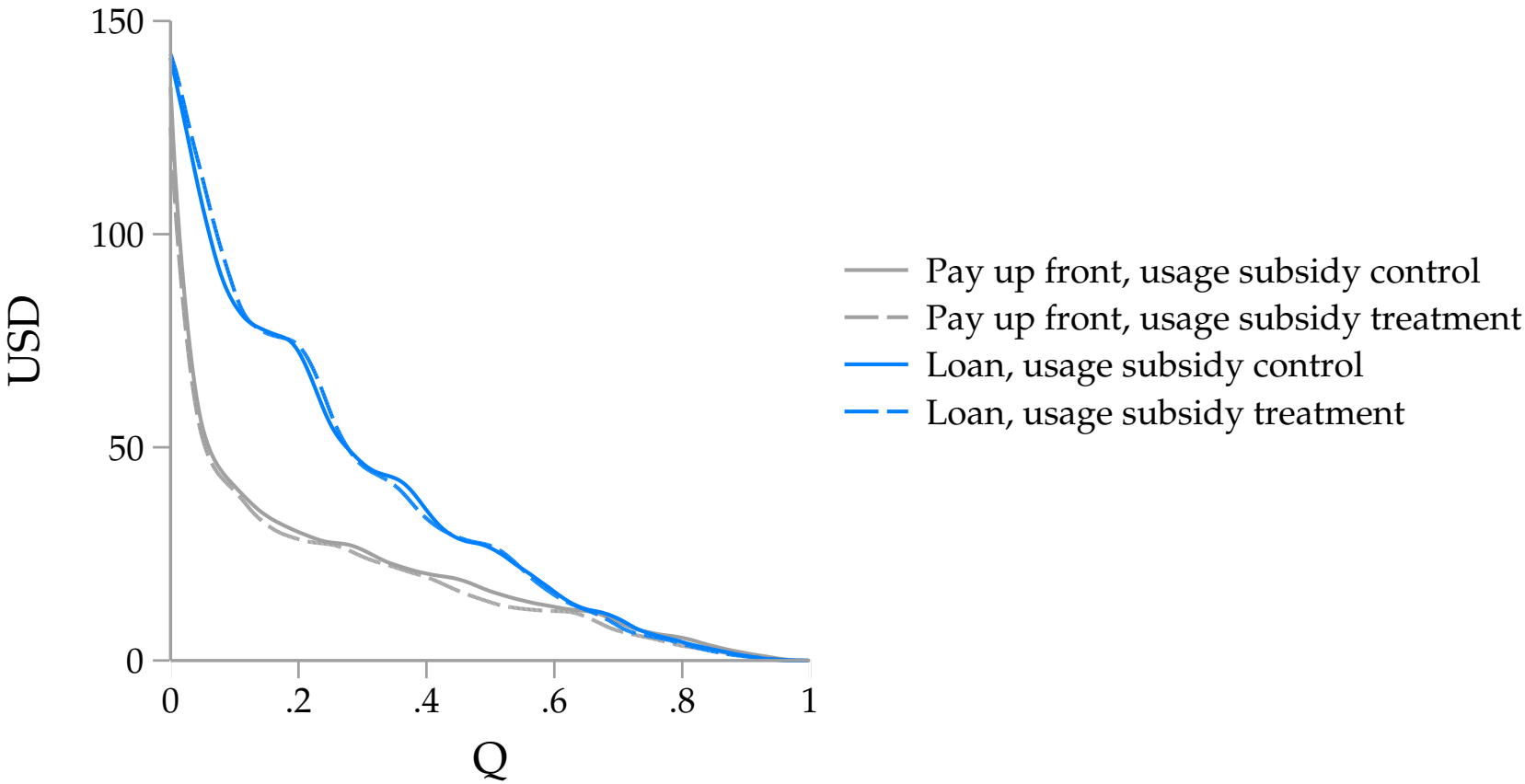
Intensive margin: Usage among marginal adopters

Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

Marginal cost subsidies have no impact on WTP

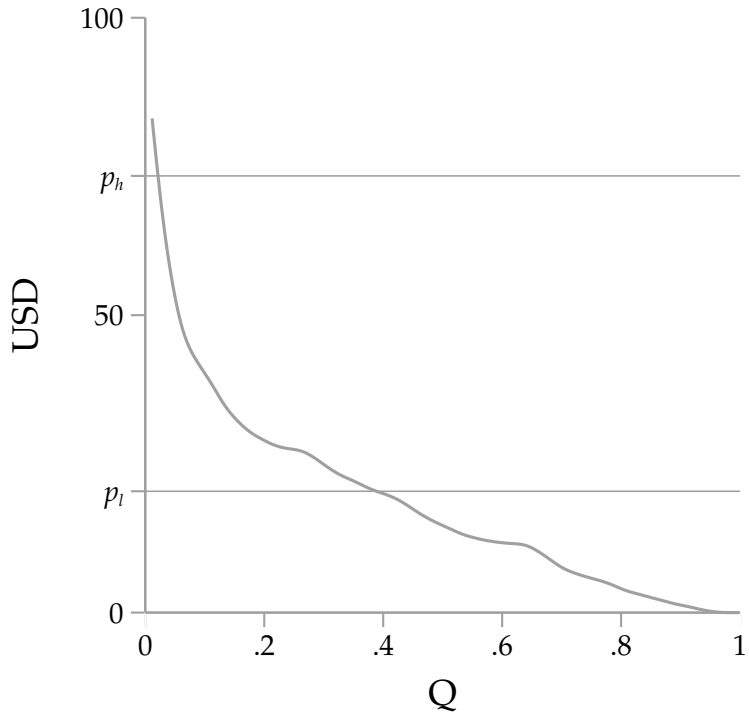
- Each \$1 of marginal cost subsidy increases WTP by no more than \$0.20



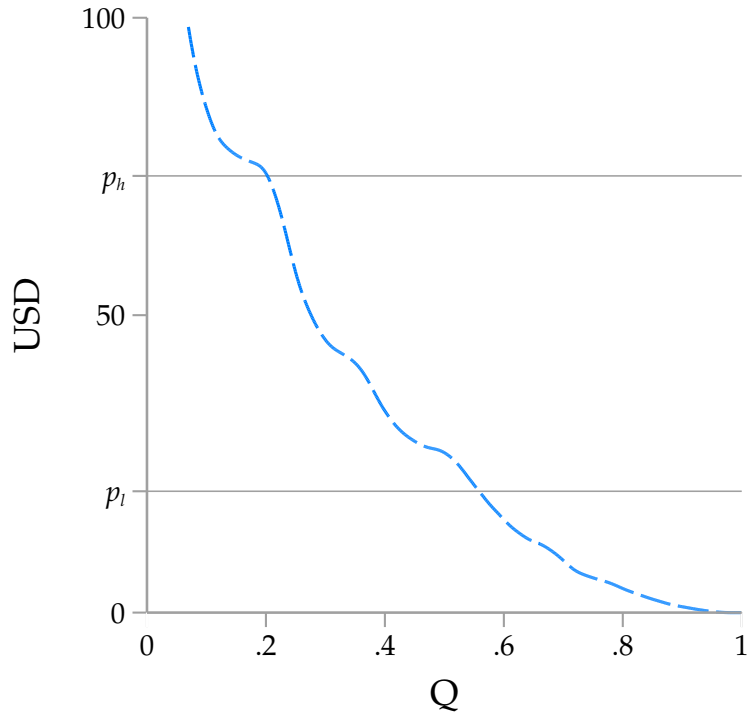
Credit constraints and demand elasticity

- Two subsidy points: $p_h = \$73$ and $p_l = \$20$

(a) Pay up front



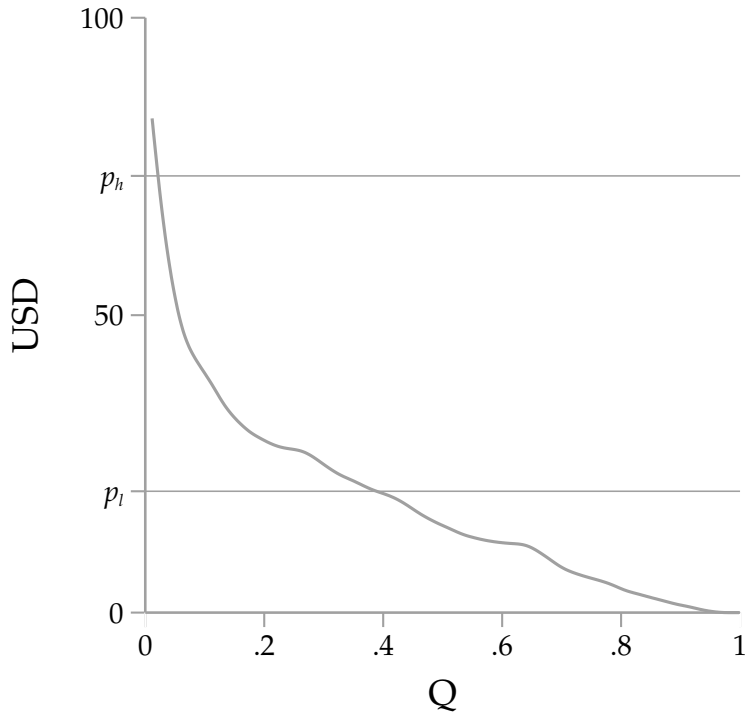
(b) Loan



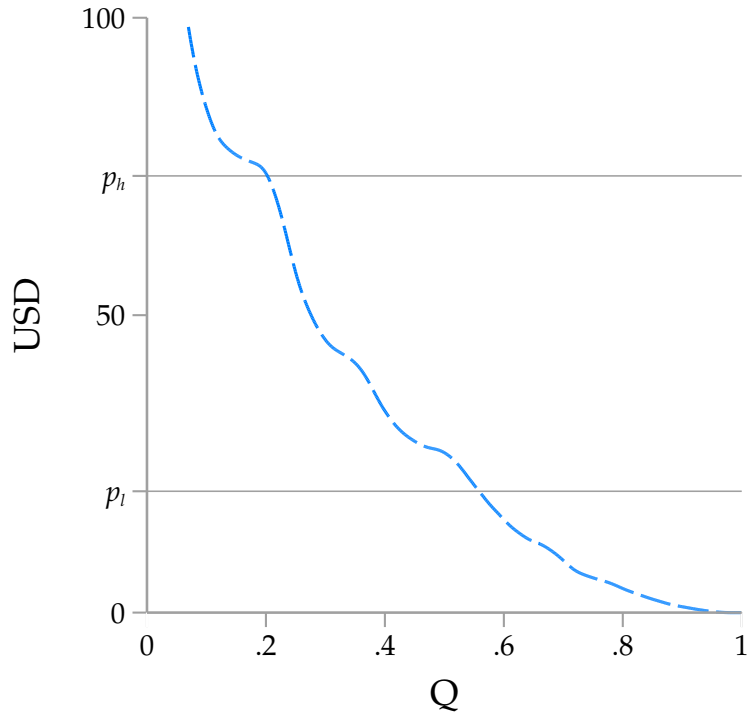
Credit constraints and demand elasticity

- Two subsidy points: $p_h = \$73$ and $p_l = \$20$
- Point: Loan $\mathcal{E}_D = -2.5$, Pay up front $\mathcal{E}_D = -30.8$
- Log-log: Loan $\mathcal{E}_D = -0.7$, Pay up front $\mathcal{E}_D = -2.0$

(a) Pay up front

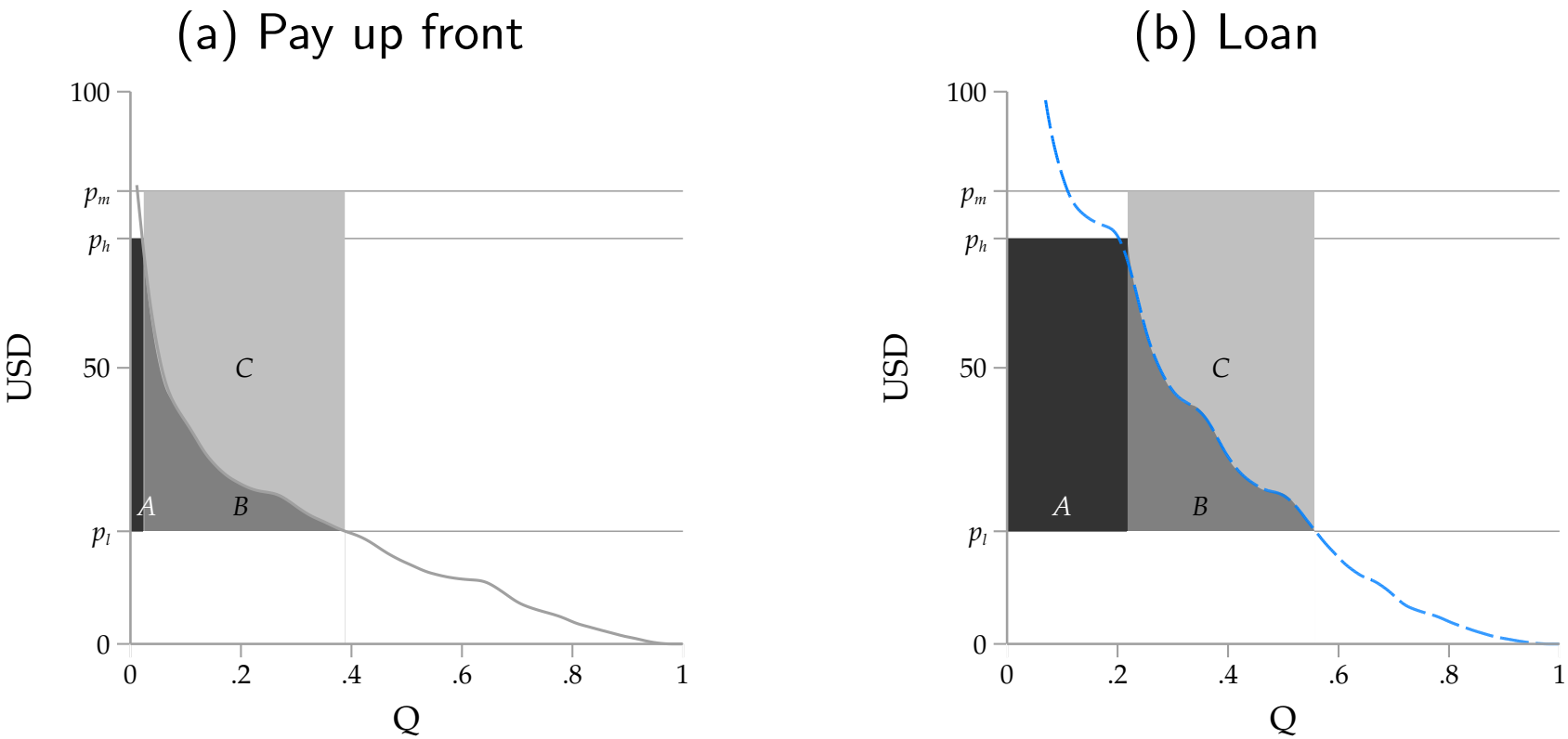


(b) Loan



Credit constraints and demand elasticity

- Two subsidy points: $p_h = \$73$ and $p_l = \$20$
- Point: Loan $\mathcal{E}_D = -2.5$, Pay up front $\mathcal{E}_D = -30.8$
- Log-log: Loan $\mathcal{E}_D = -0.7$, Pay up front $\mathcal{E}_D = -2.0$



Credit constraints increase marginality

	Loan	**Up front**
Extensive margin elasticity to fixed subsidy	$\mathcal{E}_d = -2.5$	$\mathcal{E}_d = -30.8$
Fraction of population that is marginal	34%	37%
Fraction of subsidies cost to inframarginal adopters	38%	6.3%
Subsidy spending per additional adoption	**$99**	**$63**

Today

Background

Theory

RCT Design

CO_2 Abatement

Intensive margin: Usage among marginal adopters

Extensive margin: Inframarginal and marginal subsidy expenditures

Aggregate subsidy efficacy

Aggregate subsidy efficacy by credit condition

	Loan	**Up front**
(a) Marginal cost subsidy efficacy		
Intensive margin elasticity to marginal subsidy	<0.3	<0.3
Extensive margin elasticity to marginal subsidy	<0.2	<0.2

Aggregate subsidy efficacy by credit condition

	Loan	**Up front**
(a) Marginal cost subsidy efficacy		
Intensive margin elasticity to marginal subsidy	<0.3	<0.3
Extensive margin elasticity to marginal subsidy	<0.2	<0.2
(b) Fixed cost subsidy efficacy		
Abatement per marginal adopter	2.6 tCO_2e	3.2 tCO_2e
Fixed cost subsidy expenditure per marginal adoption	\$99	\$63
Abatement cost per tCO_2e after 3 years	**\$12.2**	**\$5.7**

Conclusion

- We theorize that demand wedges increase the efficacy of fixed cost subsidies for green technologies
- We run a randomized trial to study induction stove adoption among 2,100 charcoal-using households in Nakuru County, Kenya

We generate four main findings:

1. Induction stoves abate 3 tCO_2e per year
2. Fixed cost subsidies abate at only \$6 per tCO_2e
3. Demand wedges increase fixed cost subsidy efficacy by:
   - Increasing the marginal adopter's positive externality
   - Decreasing the subsidy cost per marginal adopter
4. Marginal cost subsidies have minor extensive and intensive margin impacts

Our model and empirics suggest billions of tons of CO_2 emitted every year could be abated at less than \$10 per tCO_2e.

Additional slides

Credit market failures are pervasive and persistent

Moral hazard and adverse selection undermine credit markets:

- **Institutional constraints** $\Rightarrow$ lack of nationwide credit bureaus (e.g. FICO), asymmetric information about borrower quality
- **Institutional constraints** $\Rightarrow$ lack of insurance (e.g. FDIC), riskier savings
- **Informality** $\Rightarrow$ 1.7 billion people lack a bank or mobile money account
- **Relational economies** $\Rightarrow$ non-credible threat of punishment
- **Imperfect property rights** $\Rightarrow$ difficulty using or recovering collateral
- **Frictions in legal systems** $\Rightarrow$ poor debt recovery in case of default

Credit market failures are pervasive and persistent

Moral hazard and adverse selection undermine credit markets:

- **Institutional constraints** ⇒ lack of nationwide credit bureaus (e.g. FICO), asymmetric information about borrower quality
- **Institutional constraints** ⇒ lack of insurance (e.g. FDIC), riskier savings
- **Informality** ⇒ 1.7 billion people lack a bank or mobile money account
- **Relational economies** ⇒ non-credible threat of punishment
- **Imperfect property rights** ⇒ difficulty using or recovering collateral
- **Frictions in legal systems** ⇒ poor debt recovery in case of default

- Banks respond by increasing the pecuniary and non-pecuniary costs of credit ⇒ higher interest rates, shorter repayment periods, shorter grace periods, other-asset collateral, strict eligibility requirements

Quinn & Woodruff 2019; Banerjee & Duflo 2005, 2014; Field et al. 2013; Kaboski & Townsend 2012; Gertler, Green, Wolfram 2024; Jack et al. 2023; Fafchamps et al. 2014; Itskhoki & Moll 2019

Back

High LMIC interest rates increase subsidy efficiency

Source	Year	Country	Loan type	Monthly rate
Karlan, Mullainathan, Roth	2019	India	Moneylenders	141%[a]
Field, Pande	2008	India	Microfinance	44%
Fink, Jack, Masiye	2020	Malawi	Informal, stated	30–40%
Karlan, Mullainathan, Roth	2019	Philippines	Moneylenders	13%
Karlan, Zinman	2008	South Africa	Formal	8–12%
Mckenzie, Woodruff	2008	Mexico	Micro-lenders	10%
Angelucci, Karlan, Zinman[b]	2015	Mexico	Microlending	9%
Egger et al	2022	Kenya	Both	6%
Aleem	1990	Pakistan	Moneylenders	5%
Banerjee, Duflo	2007	India	Both	3–4%
Riley	2024	Uganda	Microfinance	3%
Mckenzie, Woodruff	2004	Sri Lanka	Informal	3%
Banerjee, Duflo	2004	India	Both	2.5–5%
Fafchamps	2000	Kenya, Zimbabwe	Both	2.5–5%
Attanasio et al[b]	2015	Mongolia	Microcredit	2%
Banerjee, Duflo, Glennerster, Kinnan[b]	2015	India	Microfinance	2%
Tarozzi, Desai, Johnson[b]	2015	Ethiopia	Microfinance	1%
Crepon, Devoto, Duflo, Pariente[b]	2015	Morocco	Microfinance	1%

[a]4.7% per day; [b]Part of the *AEJ: Applied Economics* special issue on microcredit

Back

Even higher unrealized **returns** across settings

Source	Year	Country	Monthly returns
Banerjee, Duflo	2012	India	89%
Berkouwer, Dean	2022	Kenya	82%
Mckenzie, Woodruff	2008	Mexico	20-33%
Anagol, Udry	2006	Ghana	20–25%
Crepon, Devoto, Duflo, Pariente	2015	Morocco	20%
Mckenzie, Woodruff	2004	Sri Lanka	15%
Field, Pande, Papp, Rigol	2013	India	11%
Kremer, Lee, Robinson, Rostapshova	2013	Kenya	8%
Banerjee, Duflo	2004	India	8%
Dupas, Robinson	2013	Kenya	6%
De Mel, McKenzie, Woodruff	2008	Pakistan	5%
Anagol, Udry	2006	Ghana	5%
Fink, Jack, Masiye	2020	Malawi	>4.5%
Banerjee & Duflo	2005	Growth theory: heterogeneous returns to the same factor	

Back