Search Costs and Diminishing Sensitivity

Heiko Karle
Frankfurt School of Finance & Management, CEPR

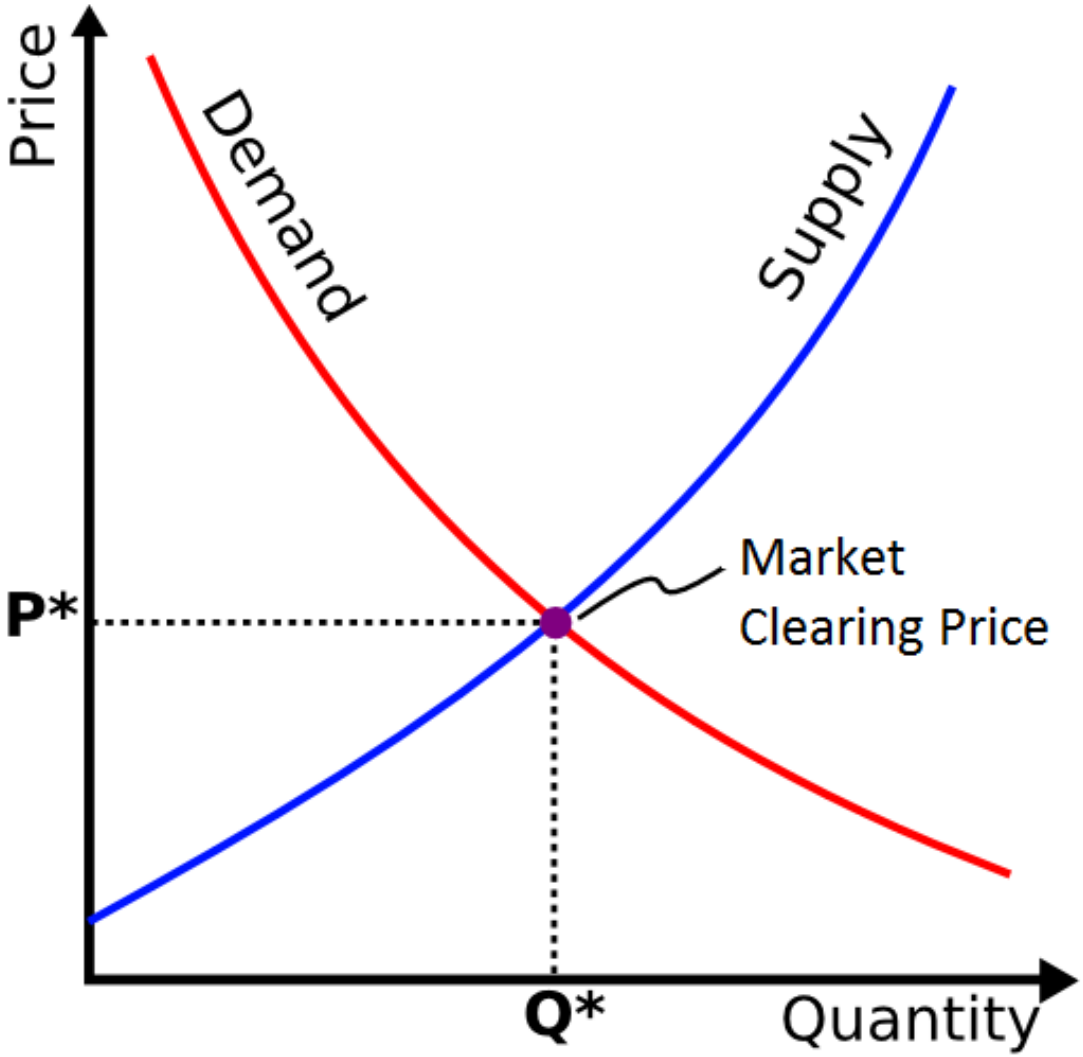
Florian Kerzenmacher
University of Innsbruck

Heiner Schumacher
KU Leuven, University of Innsbruck

Frank Verboven
KU Leuven, CEPR

EPoS Summer Summit 2022
April 8, 2022

Motivation



Motivation

- Economics: The competitive equilibrium maximizes welfare.

Motivation

- Economics: The competitive equilibrium maximizes welfare.
- Stigler (1961): When information is dispersed, search costs may limit competition and reduce welfare.

Motivation

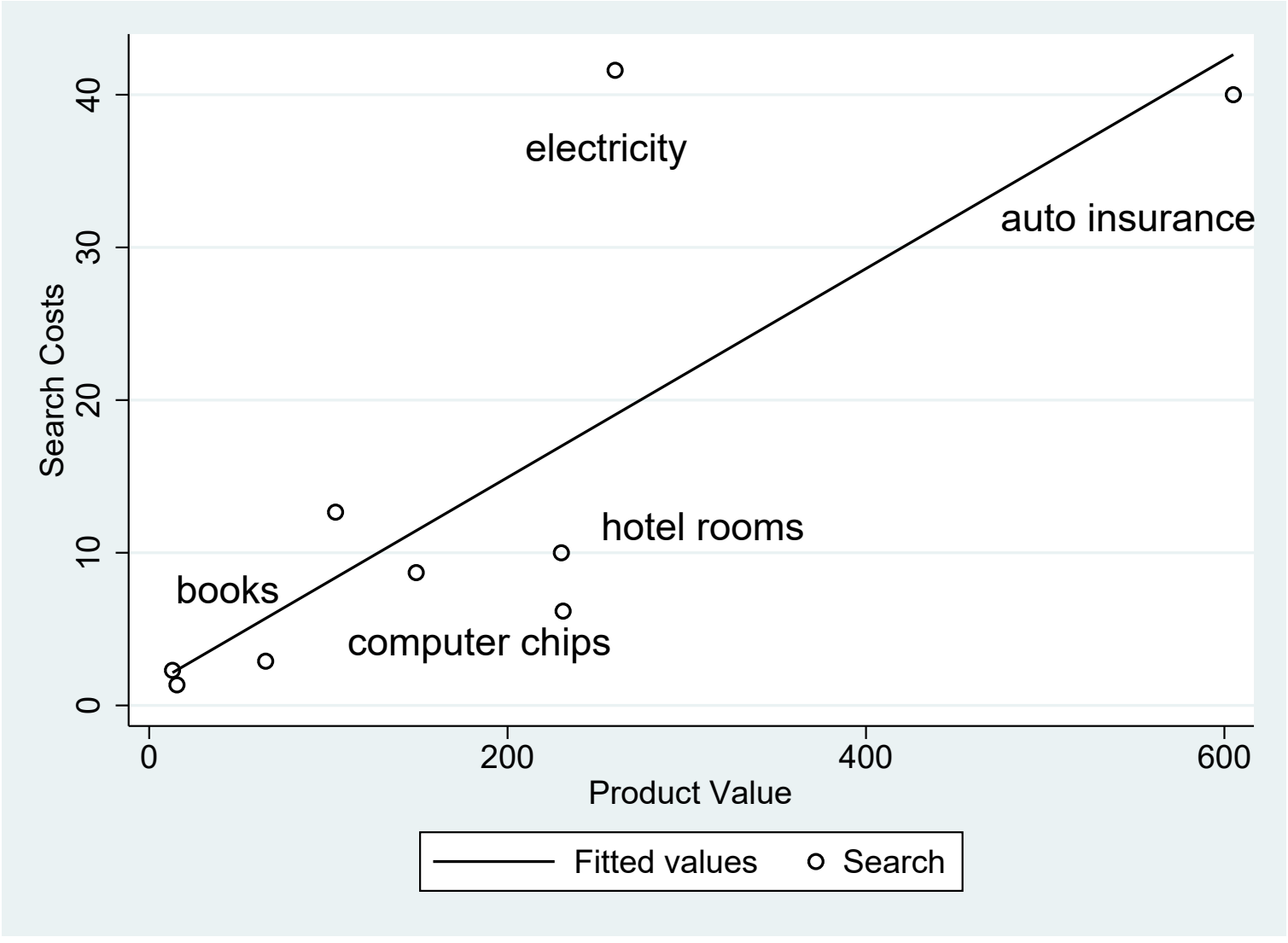
- Economics: The competitive equilibrium maximizes welfare.
- Stigler (1961): When information is dispersed, search costs may limit competition and reduce welfare.
- Beginning of 21st century: In digital markets, search costs should be low. Products and prices can easily be evaluated online with a few clicks.

Motivation

- Economics: The competitive equilibrium maximizes welfare.
- Stigler (1961): When information is dispersed, search costs may limit competition and reduce welfare.
- Beginning of 21st century: In digital markets, search costs should be low. Products and prices can easily be evaluated online with a few clicks.
- Privatization in markets for electricity, telecommunications, health-care, etc.

Motivation

- This prediction has not materialized.
- Large search cost estimates even when search is simple.
- Substantial price dispersion in online markets.
- Search costs increase in value of transaction.


Search Costs
0
10
20
30
40
0
200
400
600
Product Value
electricity
auto insurance
hotel rooms
books
computer chips
Fitted values
Search

Motivation

- Classic explanations:
  - Product complexity
  - Trust
- We demonstrate that there is a positive relationship between search costs and price scale.
- This produces large search costs in online environments.
- Further, we argue that this relationship can be explained by "diminishing sensitivity": Individuals' sensitivity to fixed price variations decreases in the price scale.

Motivation

Thaler (1980) “Toward a Positive Theory of Consumer Choice”:

- *You set off to buy a radio. When you arrive at the store, you find that the radio costs 25 USD, a price consistent with your priors. As you are about to make the purchase, a friend comes by and tells you that the same radio is selling for 20 USD at another store ten minutes away. Do you go to the other store? What is the minimum price differential which would induce to go to the other store?*

- *Now suppose that instead of a radio you are buying a television for 500 USD, and your friend tells you it is available at the other store for 495 USD. Same questions.*

Outline

- We build a search costs model that captures diminishing sensitivity.
- Next, we conduct an online search experiment. The treatment variation is the price scale.
- We jointly estimate search costs and the degree of diminishing sensitivity in our setting.
- Finally, we compare our search cost estimates to a direct cost measure that is derived from subjects' opportunity costs of time.

Search Cost Model

- A decision-maker (DM) can purchase "product A."
- In the classic model, if she purchases it at price p, her indirect utility equals

$$u - p.$$

Search Cost Model

- A decision-maker (DM) can purchase "product A."
- In the classic model, if she purchases it at price p, her indirect utility equals

$$u - p.$$

- If she exhibits diminishing sensitivity, her indirect utility equals

$$u - v(p),$$

where $v(p)$ is a concave function.

Diminishing Sensitivity

- We use the power utility function

$$v(p) = \frac{p^{1-\gamma} - 1}{1 - \gamma}.$$

- Parameter γ is the "degree of diminishing sensitivity."
- Standard case is $\gamma = 0$.
- We have $v(p) = \ln p$ for $\gamma = 1$. The DM is then equally sensitive to any given percentage price variation at all price levels (Weber-Fechner law of psychophysics).

Search Cost Model

- Large finite number of firms.
- Each firm chooses price p according to the distribution $F(p)$ with density $f(p)$ and support $[a, b]$.
- DM can only purchase the good from a searched firm.
- Each search reduces utility by a cost c.

Search Cost Model

- We consider optimal sequential search (McCall 1970).
- There is a reservation price $r \in [a, b]$ such that the DM continues search as long as $p > r$, and stops search if $p < r$.

Search Cost Model

- We consider optimal sequential search (McCall 1970).
- There is a reservation price $r \in [a, b]$ such that the DM continues search as long as $p > r$, and stops search if $p < r$.
- For $\gamma = 0$, we have

$$c = \int_a^r (r - p)\, f(p) dp.$$

- For $\gamma > 0$, we have

$$c = \int_a^r (v(r) - v(p))\, f(p) dp.$$

Search Cost Model

- We consider optimal sequential search (McCall 1970).
- There is a reservation price $r \in [a, b]$ such that the DM continues search as long as $p > r$, and stops search if $p < r$.
- For $\gamma = 0$, we have

$$c = \int_a^r (r - p)\, f(p) dp.$$

- For $\gamma > 0$, we have

$$c = \int_a^r (v(r) - v(p))\, f(p) dp.$$

- Our goal is to identify the distribution over c and γ.

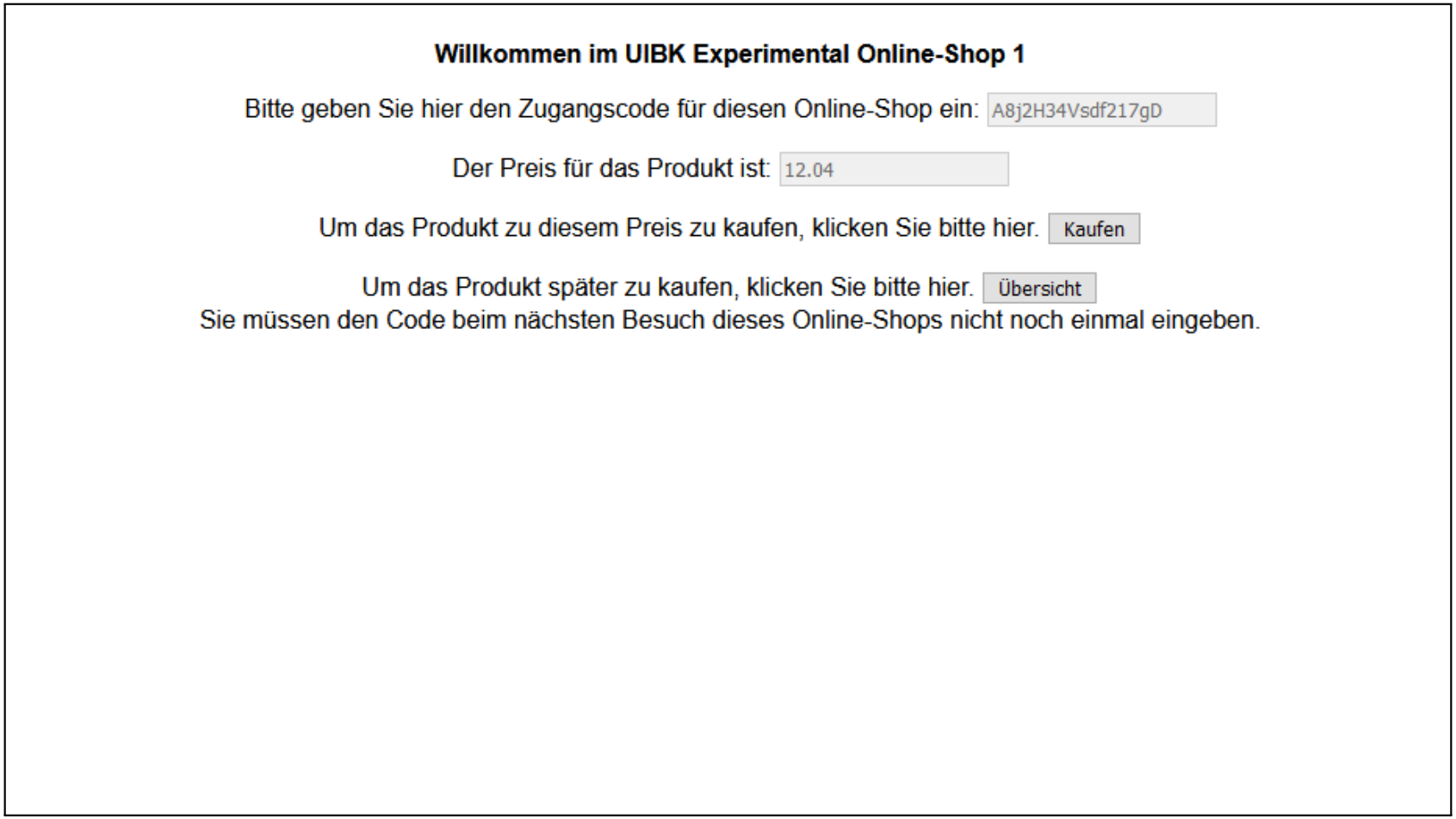
Experimental Design

- We invite subjects to participate in an online search experiment.
- Stage 1: Demographic information (age, gender, education), cognitive ability, risk tolerance.
- At the end of Stage 1, subjects are informed about the design of Stage 2.
- Stage 2: Subjects have to purchase “product A” and can search for the lowest price.
- The payoff in Stage 2 is the price saving (no actual product is sold).
- Stage 2 takes place a few days/right after Stage 1.

Experimental Design

- There are up to $N = 100$ online shops.
- At each shop, the prices are distributed uniformly on the interval $[a, b]$ with $b > a > 0$.
- Subjects can access online shops sequentially.
- To access an online shop, they have to insert a 16-digit key.
- The key creates hassle costs (copy-and-paste is disabled).

Experimental Design



Experimental Design

- Subjects have four days for search.
- If they purchase product A at price p, their payoff is $b - p$.
- If they do not search at all, they purchase product A at price $p = b$ and their payoff from Part 2 is zero.
- We run the experiment in two different subject populations: student subjects from the University of Innsbruck and workers on Amazon Mechanical Turk (AMT).

Experimental Design

- We run four treatments in each subject population.
- Price scales (in Euros) for student subjects:
  - Scale 1.0: $[a, b] = [4, 8]$.
  - Scale 3.0: $[a, b] = [12, 24]$.
  - Scale 5.0: $[a, b] = [20, 40]$.
  - Scale 7.0: $[a, b] = [28, 56]$.
- Price scales (in USD) for AMT workers:
  - Scale 0.5: $[a, b] = [2, 4]$.
  - Scale 1.5: $[a, b] = [6, 12]$.
  - Scale 2.5: $[a, b] = [10, 20]$.
  - Scale 3.5: $[a, b] = [14, 28]$.

Descriptive Statistics

- 581 student subjects, 490 (84.2 percent) conduct at least one search; average age = 23.5 years, 62 percent female.
- 626 AMT workers, 528 (83.0 percent) conduct at least one search; average age = 39.6 years, 44 percent female.
- They work on average 20.8 hours per week on AMT.
- We do not find selection into scale treatments based on observables.

Descriptive Statistics

Table: Descriptive Statistics – Average Search Behavior

	Price Scale	Share Searchers	Mean No. Searches if search	Median No. Searches if search	Gain Share if search
			Panel A: Student Subjects		
$S1.0$	[4.00, 8.00]	0.85	7.0 (6.6)	5	0.87
$S3.0$	[12.00, 24.00]	0.83	9.6 (15.1)	5	0.89
$S5.0$	[20.00, 40.00]	0.87	10.2 (12.1)	6	0.91
$S7.0$	[28.00, 54.00]	0.83	11.5 (17.2)	6	0.93
Observations		581	490	490	490
			Panel B: AMT Workers		
$S0.5$	[2.00, 4.00]	0.85	2.9 (4.1)	1	0.68
$S1.5$	[6.00, 12.00]	0.84	3.3 (9.0)	1	0.69
$S2.5$	[10.00, 20.00]	0.83	2.6 (3.3)	1	0.64
$S3.5$	[14.00, 28.00]	0.86	3.5 (6.8)	1	0.65
Observations		626	528	528	528

Search Cost Estimation

- How can we derive search costs from subjects' behavior?
- We make a parametric assumption on the distribution over search costs and then jointly estimate search costs and the degree of diminishing sensitivity in an ordered probit regression.

Search Cost Estimation

Table: Search Costs Estimates, $\gamma = 0$

	(1)	(2)	(3)
Panel A: Student Subjects			
$S1.0$		0.247***	0.379***
		(0.050)	(0.124)
$S3.0$		0.481***	0.731***
		(0.101)	(0.251)
$S5.0$		0.551***	0.846***
		(0.113)	(0.293)
$S7.0$		0.579***	0.872***
		(0.124)	(0.290)
Constant	0.458***		
	(0.066)		
Controls	No	No	Yes
σ	1.996***	1.826***	1.793***
	(0.502)	(0.447)	(0.439)
Observations	490	490	490

Search Cost Estimation

Table: Search Costs Estimates, $\gamma = 0$

	(1)	(2)	(3)
Panel B: AMT Workers			
$S0.5$		0.424***	0.449***
		(0.069)	(0.106)
$S1.5$		1.528***	1.564***
		(0.237)	(0.353)
$S2.5$		2.860***	2.816***
		(0.444)	(0.638)
$S3.5$		3.794***	3.702***
		(0.558)	(0.804)
Constant	2.296***		
	(0.270)		
Controls	No	No	Yes
σ	8.648***	4.486***	3.909***
	(1.779)	(0.739)	(0.633)
Observations	528	528	528

Search Cost Estimation

Table: Search Costs and γ Estimates

	(1)	(2)	(3)	(4)
	Panel A: Student Subjects		*Panel B: AMT workers*	
Constant	0.138***	0.209**	0.171***	0.191***
	(0.050)	(0.092)	(0.040)	(0.054)
σ	0.542**	0.547**	0.370***	0.373***
	(0.229)	(0.229)	(0.104)	(0.103)
γ	0.415***	0.408***	0.975***	0.937***
	(0.120)	(0.119)	(0.089)	(0.089)
Controls	No	Yes	No	Yes
Observations	490	490	528	528

Search Cost Estimation

Table: Search Costs Estimates, fixed γ

	(1)	(2)	(3)	(4)
	Panel A: Student Subjects		*Panel B: AMT Workers*	
	$\gamma = 0.415$:	$\gamma = 0$:	$\gamma = 0.975$:	$\gamma = 0$:
$S1.0/S0.5$	0.124***	0.247***	0.139***	0.424***
	(0.024)	(0.050)	(0.020)	(0.069)
$S3.0/S1.5$	0.155***	0.481***	0.169***	1.528***
	(0.032)	(0.101)	(0.023)	(0.237)
$S5.0/S2.5$	0.144***	0.551***	0.190***	2.860***
	(0.029)	(0.113)	(0.026)	(0.444)
$S7.0/S3.5$	0.133***	0.579***	0.183***	3.794***
	(0.028)	(0.124)	(0.024)	(0.558)
σ	0.541***	1.826***	0.364***	4.486***
	(0.128)	(0.447)	(0.052)	(0.739)
Observations	490	490	528	528

Search Cost Estimation

- *For both subject groups, the classic search cost estimates increase in the price scale.*
- We find substantial degrees of diminishing sensitivity: Students $\gamma = 0.42$, AMT workers $\gamma = 0.98$.
- Taking diminishing sensitivity into account yields us average search costs of 0.14 EUR for students and 0.17 USD for AMT workers.
- Students: In treatment *S*7.0, 77 percent of the classic search cost estimates are due to scale-dependence.
- AMT workers: In treatment *S*3.5, even 95 percent of the classic search cost estimates are due to scale dependence.

Search Time

- We precisely record the time subjects need to insert a 16-digit code to get a price quote.
- Additionally, we elicit expected hourly earnings on AMT from AMT workers.
- We calculate "alternative search costs" as

$$\text{mean search duration} \times \frac{\text{expected hourly earnings}}{3600}.$$

- AMT workers expect to earn 7.30 USD per hour (sd = 7.60) on average.

Search Time

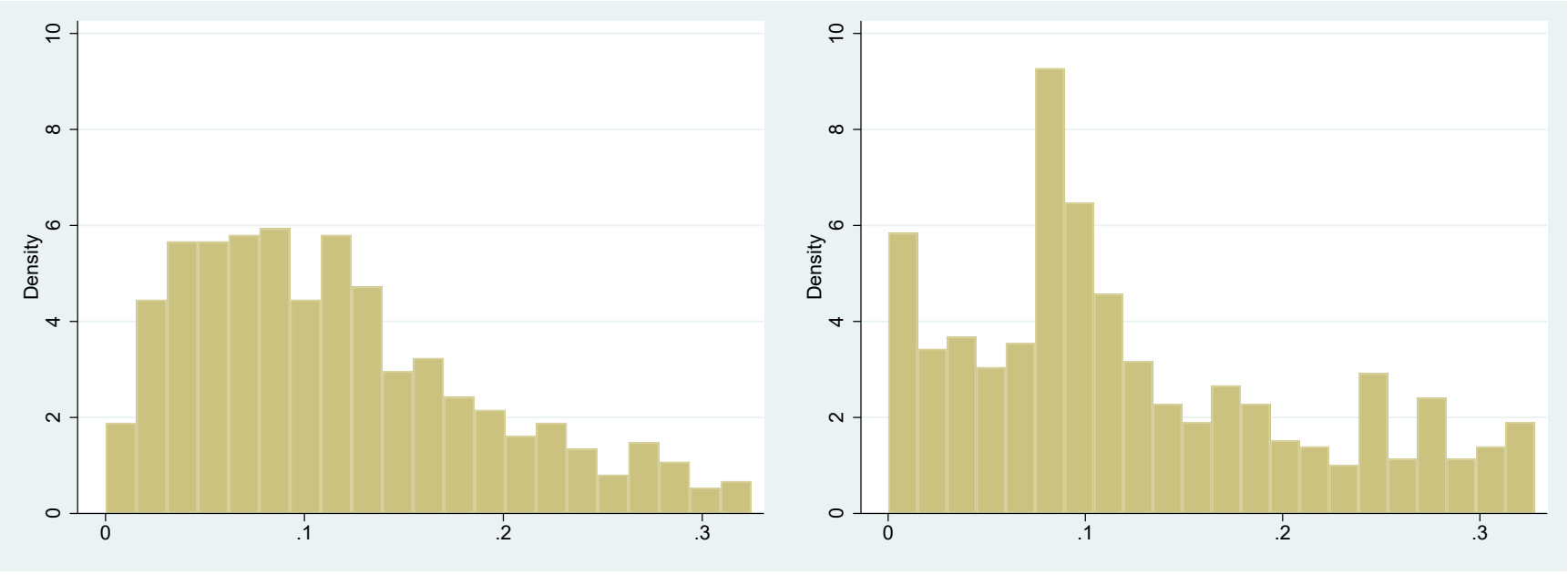


Figure: Alternative search costs (left graph) and individual search costs (right graph) of AMT workers.

Search Time

- Average estimated search costs of AMT workers are 0.17 USD per search.
- Average alternative search costs of AMT workers are 0.16 USD per search.
- *The two numbers are similar only if we allow for diminishing sensitivity in the search cost model.*
- There is a (weakly) significant positive association between estimated and alternative search costs.

Conclusion

- We showed that classic search cost estimates increase in the price scale.
- We updated the sequential search model and allowed for diminishing sensitivity.
- This generates “small” search cost estimates that correspond well to subjects’ true opportunity costs of time.
- *A large fraction of search costs are “psychological search costs.”*

Conclusion

- A standard recommendation in economics is to make markets more transparent.
- Healtcare, insurance, energy, mobile phones, internet,...
- Our results imply that this may not be enough to make these markets efficient or to reduce market power.

Conclusion

- A standard recommendation in economics is to make markets more transparent.
- Healtcare, insurance, energy, mobile phones, internet,...
- Our results imply that this may not be enough to make these markets efficient or to reduce market power.
- Open questions:
  - What influences the degree of diminishing sensitivity?
  - Does this behavioral tendency vary in the population?
  - Interventions that insipre more search/switching?

Thank you for your attention!