Measuring the Welfare Cost of Asymmetric Information in Consumer Credit Markets

Anthony A. DeFusco* **Huan Tang†** **Constantine Yannelis‡**

*Northwestern University and NBER
†London School of Economics
‡ University of Chicago and NBER

Motivation

- Asymmetric information has **theoretically** important effects on credit markets
  Akerlof (1970), Jaffee & Russel (1976), Stiglitz & Weiss (1981)

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- Information asymmetries documented **empirically** in many credit markets
  - Mortgages
    Stroebel (2016), Gupta & Hansman (2019)
  - Auto loans
    Adams, Einav & Levin (2009), Einav, Jenkins & Levin (2012)
  - Credit cards
    Ausubel (1999), Agarwal et al. (2010, 2018)
  - Payday and microcredit
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  - Fintech consumer loans
    Hertzberg, Liberman & Paravisini (2018)

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  - Fintech consumer loans
    Hertzberg, Liberman & Paravisini (2018)
- Less work linking **theory** + **empirics** to measure **welfare costs**

This Paper: Empirical Context

- Estimate welfare losses from asymmetric information in Chinese “fintech” market
  - Fintech $\equiv$ consumer lending facilitated by stand-alone online platforms
- Three features of this market motivate our focus on it
  - It is new $\longrightarrow$ scope for asymmetric information greater?
  - It is large $\longrightarrow$ China $\approx$ half of global fintech lending
  - Collaboration with specific lender $\longrightarrow$ clean identification
- But the approach we use is general and can be applied to any credit market...

This Paper: Measuring Welfare Losses

Step 1 — Adapt "cost curve" approach from insurance literature to credit markets

- Asymmetric information $\rightarrow$ lenders' marginal costs $\uparrow$ in interest rates
  - Adverse selection: higher rates attract riskier borrowers
  - Moral hazard: higher rates increase individual-level default risk

This Paper: Measuring Welfare Losses

Step 1 — Adapt "cost curve" approach from insurance literature to credit markets

- Asymmetric information $\rightarrow$ lenders' marginal costs $\uparrow$ in interest rates
- Link between price and marginal cost $\rightarrow$ inefficiently high pricing
    - In equilibrium, lenders set price $=$ average cost $>$ marginal cost $=$ social cost

This Paper: Measuring Welfare Losses

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- Key insight from insurance literature $\rightarrow$ Einav, Finkelstein, & Cullen (2010)
  - Demand, AC, and MC curves are sufficient statistics for welfare analysis

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  - Demand, AC, and MC curves are sufficient statistics for welfare analysis
- **An important distinction between credit and insurance markets**
  - Default $\rightarrow$ price you're quoted $\neq$ price you pay

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- An important distinction between credit and insurance markets
  - Default $\rightarrow$ price you're quoted $\neq$ price you pay
- Implication of this distinction
  - Demand $\neq$ willingness to pay $\rightarrow$ need to estimate willingness to pay curve

This Paper: Measuring Welfare Losses

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- Einav, Finkelstein, & Cullen (2010)
  - Demand, AC, and MC curves are sufficient statistics for welfare analysis
- Our contributions
  - Show how to construct WTP curve from these inputs
  - Show that under moral hazard estimated welfare losses = upper bound

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Step 2 — Estimate these curves using randomized experiment

- Large fintech lender randomized interest rates offered to applicants
- Use to trace out how demand and costs vary with interest rates

Summary of Main Results

Asymmetric information is present in this market

- Increasing interest rate by 10pp ↓ take-up rate by 4.3pp
- Increasing interest rate by 10pp ↑ charge-off rate by 1.0pp
- Borrowers who endogenously select in at higher rates have higher expected costs

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Large equilibrium price distortion, but small overall welfare losses

- Equilibrium interest rate (D = AC): 30%
- Efficient interest rate (D = MC): 9%
- Welfare loss: 0.8% of loan amount ($\approx$ $7.20 per applicant)
- Small welfare loss driven by relatively inelastic demand

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Larger welfare losses among observably riskier borrowers

- Welfare losses 2x larger among borrowers with low initial credit scores

Empirical Setting, Experimental Design, and Data

Empirical Setting

Our lender $\rightarrow$ "The Platform"

- Popular Chinese platform specializing in small-dollar installment loans
  - Typical loan size: ¥6300 ($\approx$ \$900)
  - Typical maturity: 12 months
  - Typical borrowing cost: 36%

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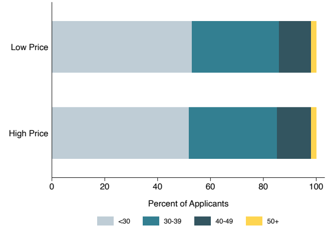
The experiment

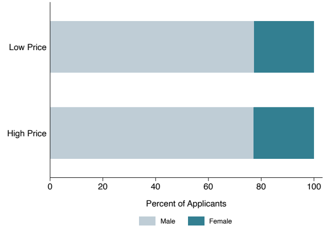
- Platform randomly selected $\approx$11K applicants in Q1 2018
- All had qualified for credit, but were offered different interest rates
- High-Price group: standard financing terms $\rightarrow \bar{r} = 36\%$
- Low-Price group: 40% reduction borrowing costs $\rightarrow \bar{r} = 21.5\%$

Covariate Balance Tests

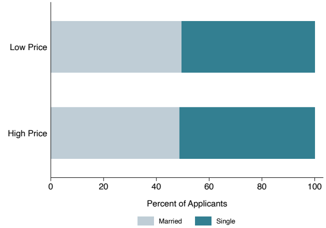
Age



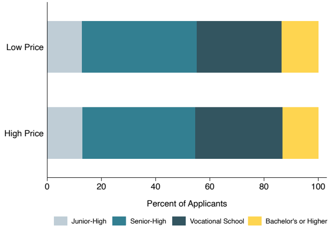
Sex



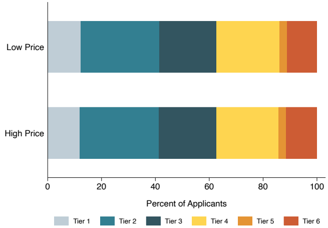
Marital Status



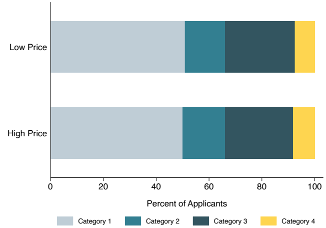
Education



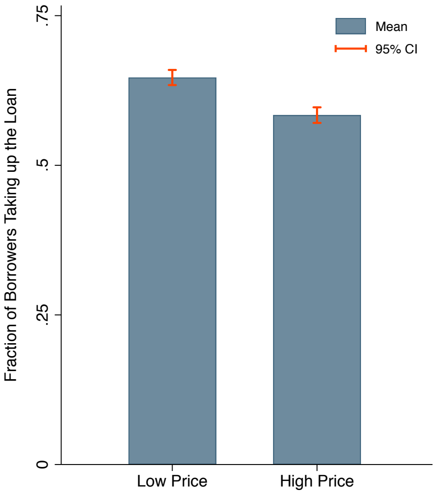
City Tier



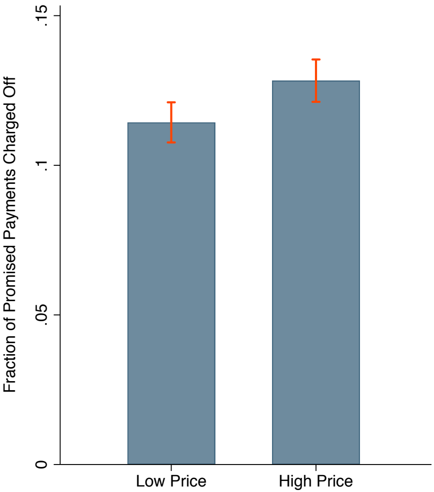
Credit Rating



Evidence of Asymmetric Information



Take-up Rate



Charge-off Rate

Conceptual Framework

Setup

- Contract space
  - One-period loans
  - Fixed loan size: L
- Lenders
  - Choose interest rate: r
  - $N \geq 2$, identical, risk-neutral
- Borrowers
  - Accept/reject loan offers at posted rate
  - Heterogeneous: $X \sim F(X)$
  - Expected default rate: $\delta(X_i)$
  - Expected charge-off rate: $\theta(X_i)$
  - Baseline: no moral hazard $\rightarrow \delta(X_i), \theta(X_i)$ independent of r

Borrower Demand

- Utility of accepting a loan: $u^L(X_i, r)$
- Outside option: $u^N(X_i)$
- Maximum acceptable rate

$$\rho(X_i) \equiv \max\{r : u^L(X_i, r) > u^N(X_i)\}$$

- Market demand curve

$$D(r) = \int \mathbb{1}(\rho(X) \geq r) dF(X)$$

Market Structure, Supply, and Equilibrium

- Expected profits

$$\Pi_j = \frac{L}{N} \times \int (r - \delta(X)\theta(X)(1+r) - c)\mathbb{1}(\rho(X) \geq r)dF(X) = 0$$

  - c: "fixed" costs (e.g. cost of funds, customer acquisition)

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- Average cost

$$AC(r) = \frac{1}{D(r)} \int c(X)\mathbb{1}(\rho(X) \geq r)dF(X) = \mathbb{E}\left[c(X) \mid \rho(X) \geq r\right]$$

  - $c(X) = c + \delta(X)\theta(X)$

Market Structure, Supply, and Equilibrium

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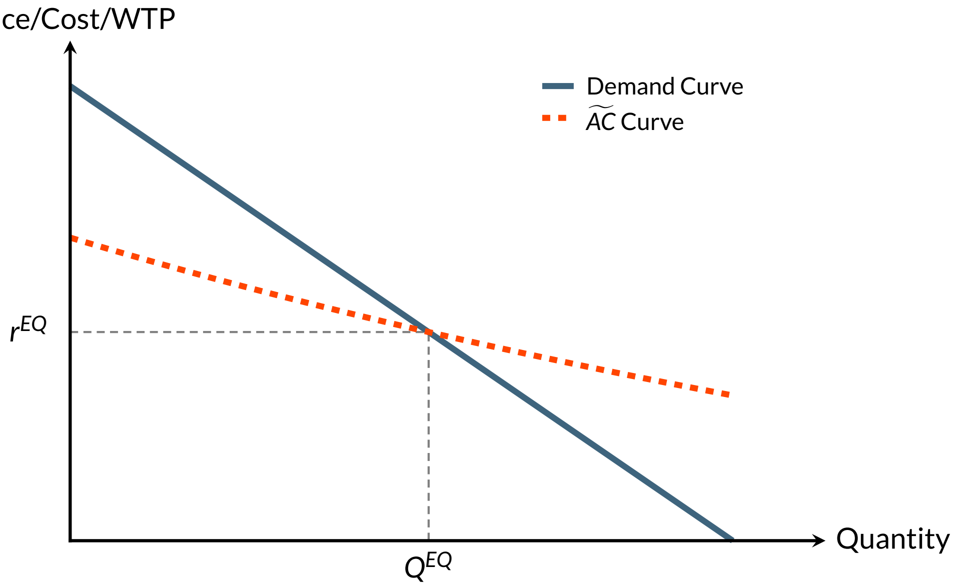
- Equilibrium pricing

$$r = \frac{\int c(X)\mathbb{1}(\rho(X) \geq r)dF(X)}{\int (1 - \delta(X)\theta(X))\mathbb{1}(\rho(X) \geq r)dF(X)} = \frac{AC(r)}{(1+c) - AC(r)} \equiv \widetilde{AC}(r)$$

Graphical Representation of Equilibrium Outcome



Welfare and Efficiency

- Consumer surplus

$$CS = \int \left[\left(m^L(X) - (1 - \delta(X)\theta(X))rL \right) \mathbb{1}(\rho(X) \geq r) + m^N(X)\mathbb{1}(\rho(X) < r) \right] dF(X)$$

  - $m^L(X_i)$: money-metric value of loan
  - $m^N(X_i)$: money-metric value of no loan
  - WTP = $m^L(X_i) - m^N(X_i) = (1 - \delta(X_i)\theta(X_i))\rho(X_i)L$

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- Producer surplus

$$PS = L \times \int (r - \delta(X)\theta(X)(1 + r) - c)\mathbb{1}(\rho(X) \geq r) dF(X)$$

Welfare and Efficiency

- Total surplus

$$TS = CS + PS = \int \Big[\Big(m^L(X) - c(X)L \Big) \mathbb{1}(\rho(X) \geq r) + m^N(X) \mathbb{1}(\rho(X) < r) \Big] dF(X)$$

- Constrained efficient allocation $\rightarrow$ borrower i receives a loan if and only if

$$\mathbb{E}[m^L(X) - m^N(X) \mid \rho(X) = \rho(X_i)] \geq \mathbb{E}[c(X)L \mid \rho(X) = \rho(X_i)]$$

Welfare and Efficiency

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$$\rho(X_i) \geq \frac{\mathbb{E}[c(X) \mid \rho(X) = \rho(X_i)]}{\mathbb{E}[1 - \delta(X)\theta(X) \mid \rho(X) = \rho(X_i)]} = \frac{MC(\rho(X_i))}{(1 + c) - MC(\rho(X_i))} \equiv \widetilde{MC}(\rho(X_i))$$

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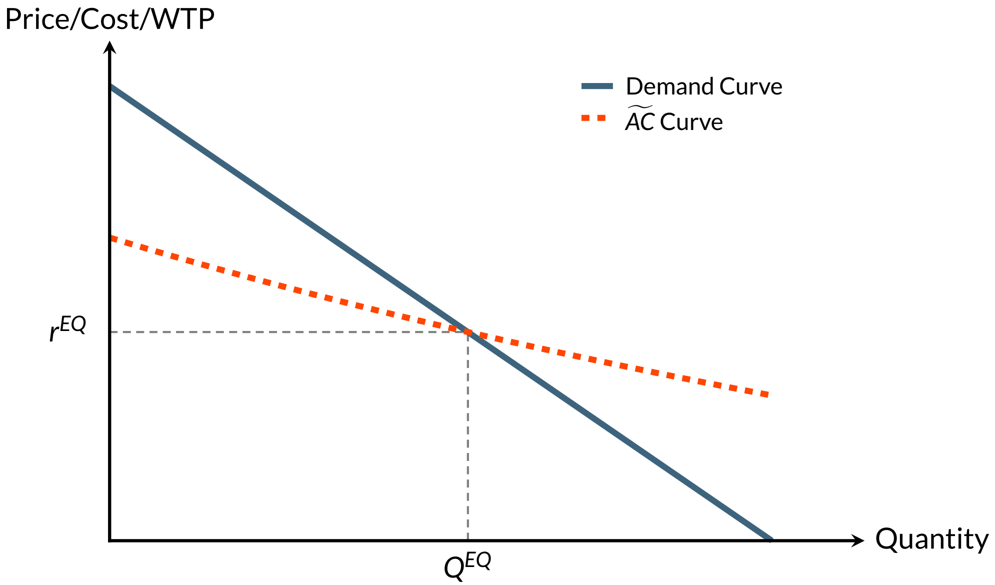
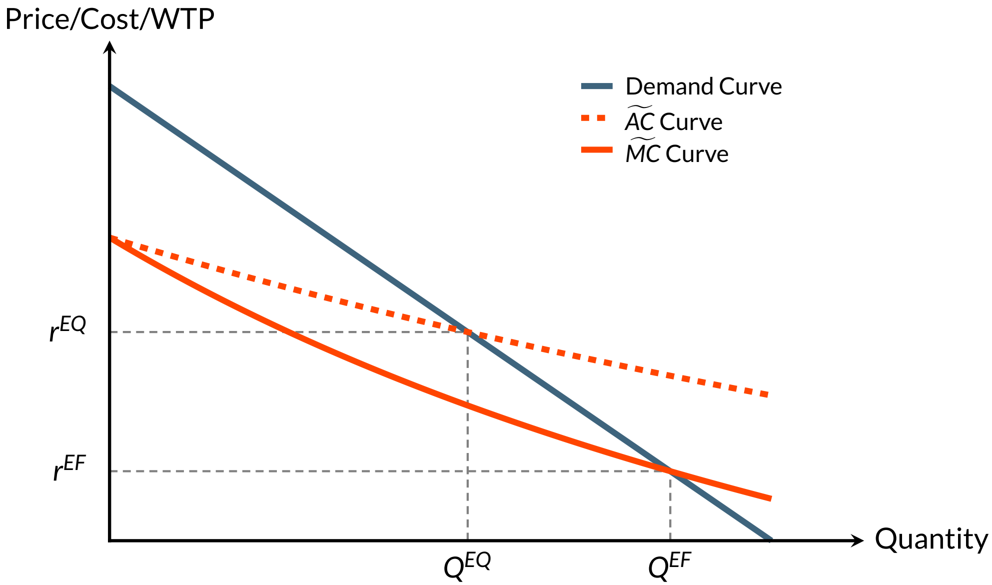


Graphical Representation of Equilibrium and Efficient Outcome



Measuring the Welfare Loss

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Measuring the Welfare Loss

- Constrained efficient allocation $\rightarrow$ borrower *i* receives a loan if and only if

$$\mathbb{E}[1 - \delta(X)\theta(X) \mid \rho(X) = \rho(X_i)] \times \rho(X_i) \geq \underbrace{\mathbb{E}[c(X) \mid \rho(X) = \rho(X_i)]}_{MC(\rho(X_i))}$$

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- Constrained efficient allocation $\rightarrow$ borrower i receives a loan if and only if

$$\underbrace{\mathbb{E}[1-\delta(X)\theta(X) \mid \rho(X)=\rho(X_i)] \times \rho(X_i)}_{WTP(\rho(X_i))} \geq \underbrace{\mathbb{E}[c(X) \mid \rho(X)=\rho(X_i)]}_{MC(\rho(X_i))}$$

- The **WTP curve** converts the demand curve into ex-ante willingness to pay

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- Measures **default-adjusted** borrower **maximum acceptable rate**

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- The WTP curve converts the demand curve into ex-ante willingness to pay
- Measures default-adjusted borrower maximum acceptable rate
- Easily constructed given knowledge of demand and marginal cost curves

$$WTP(\rho(X_i)) = (1 + c - \mathbb{E}[c(X) \mid \rho(X)=\rho(X_i)]) \times \rho(X_i)$$

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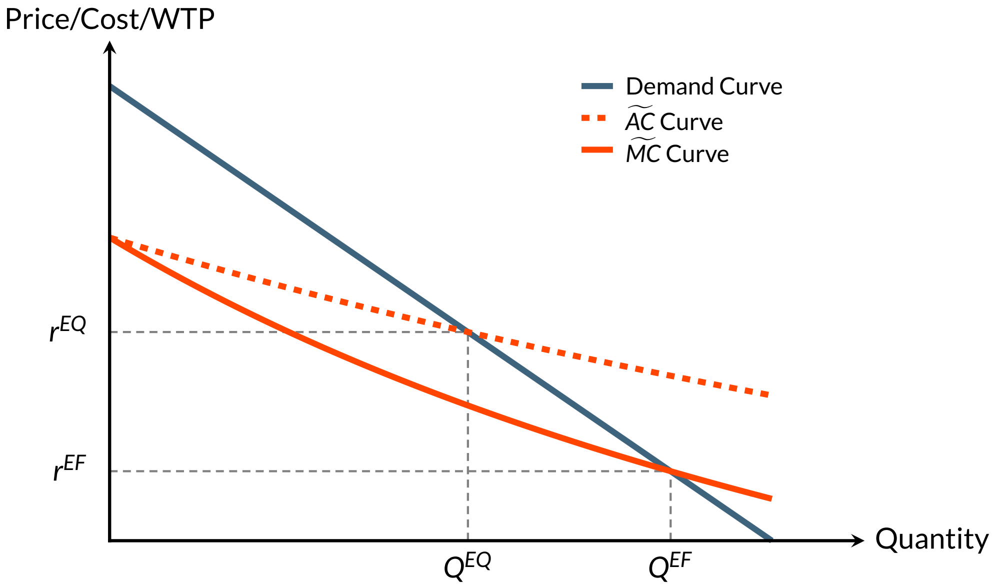
- Will over-estimate WTP under moral hazard $\rightarrow$ welfare estimates = upper bound

Moral Hazard

The Welfare Cost of Asymmetric Information



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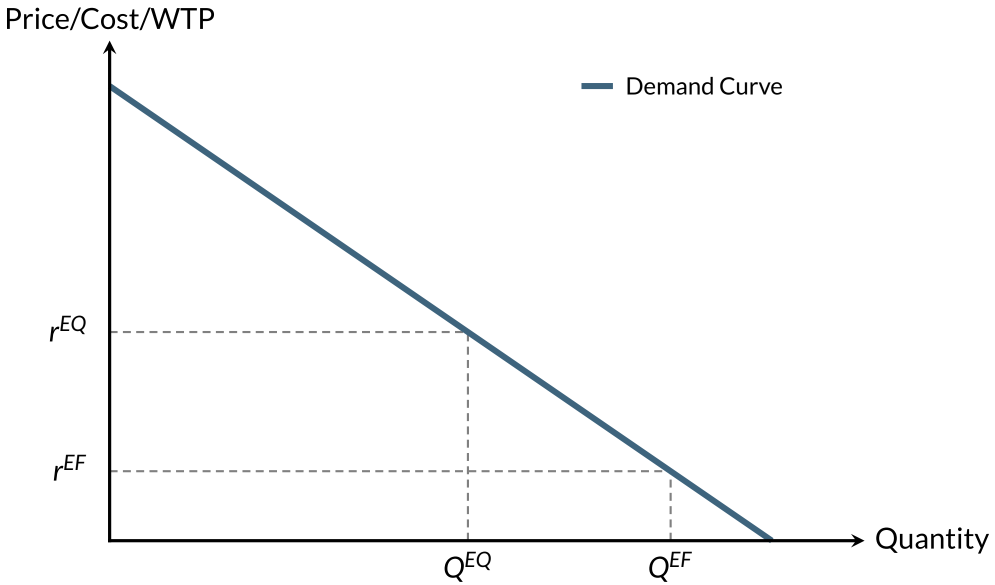

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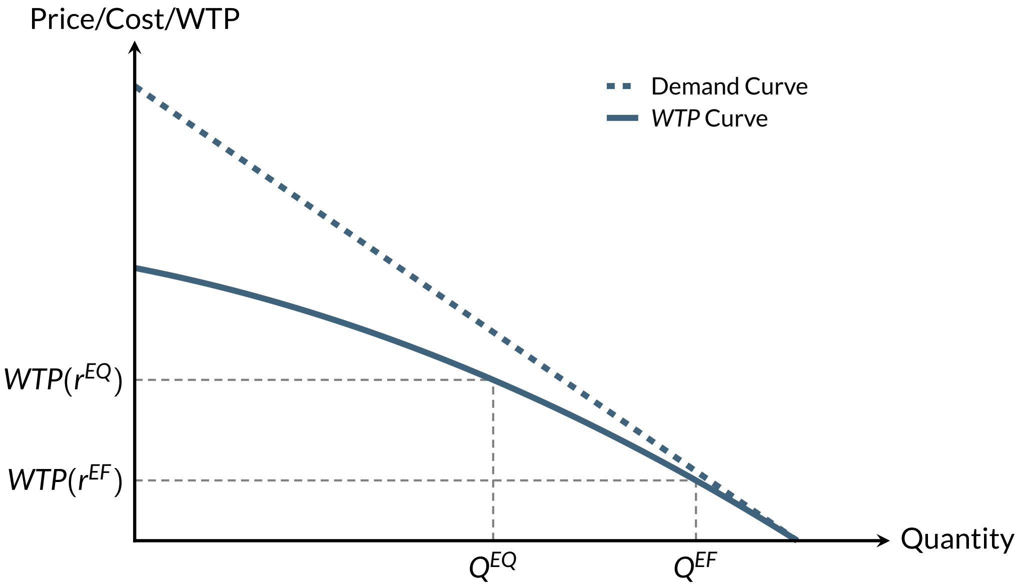

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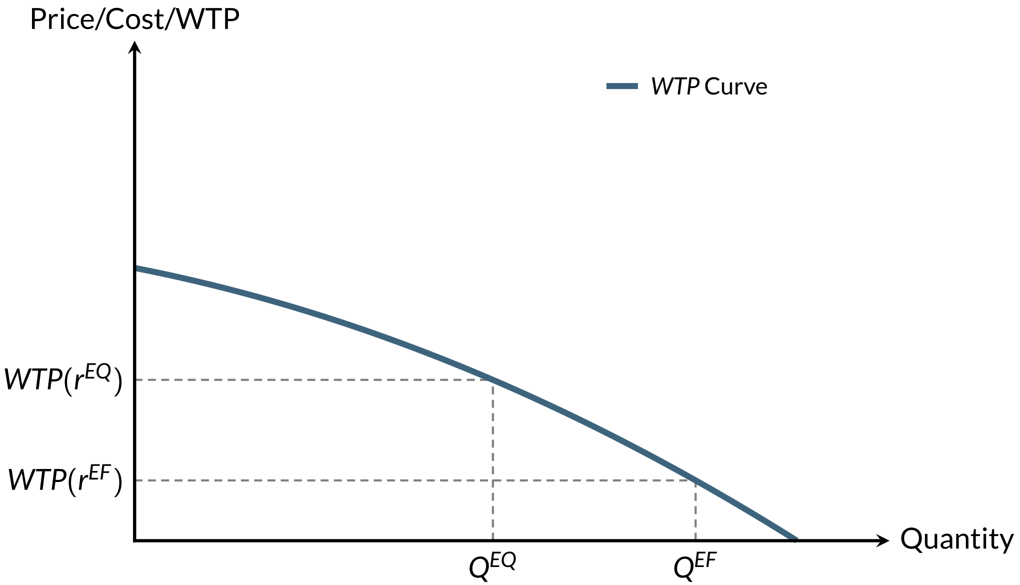

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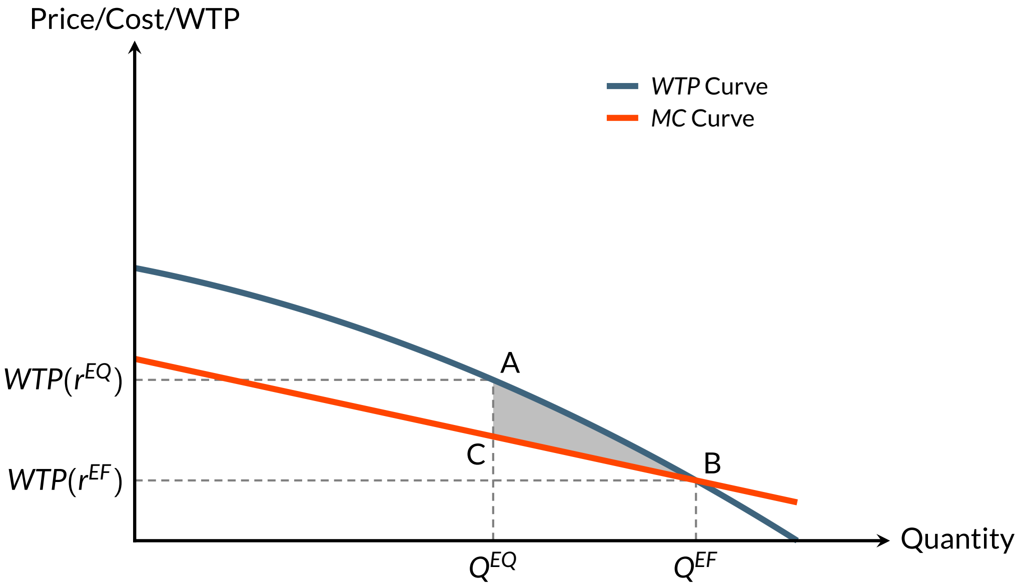

Estimation

Estimating the Demand and Cost Curves

- Demand curve

$$d_i = \alpha_d + \beta_d r_i + \epsilon_i$$

- Average cost curve

$$c_i = \alpha_c + \beta_c r_i + \nu_i$$

- Measurement
  - d_i: indicator for take-up
  - c_i: charge-off rate + fixed cost
    - Baseline: calibrate fixed cost
    - Extension: estimate to set $(r^{EQ}, Q^{EQ}) = (\bar{r}, \overline{Q})$
  - r_i: interest rate $\rightarrow$ instrumented using treatment assignment

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- Marginal cost curve

$$MC(r) = \frac{\partial TC(r)}{\partial D(r)} = \frac{\partial (AC(r) \times D(r))}{\partial D(r)} = \frac{\alpha_d \beta_c}{\beta_d} + \alpha_c + 2\beta_c r$$

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- $\widetilde{AC}(r)$ and $\widetilde{MC}(r)$ derived from these using definitions

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- $WTP(r)$ built from $D(r)$ and $MC(r)$

Main Results

Estimating the Demand and Cost Curves

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Estimating the Demand and Cost Curves

- **Demand curve**

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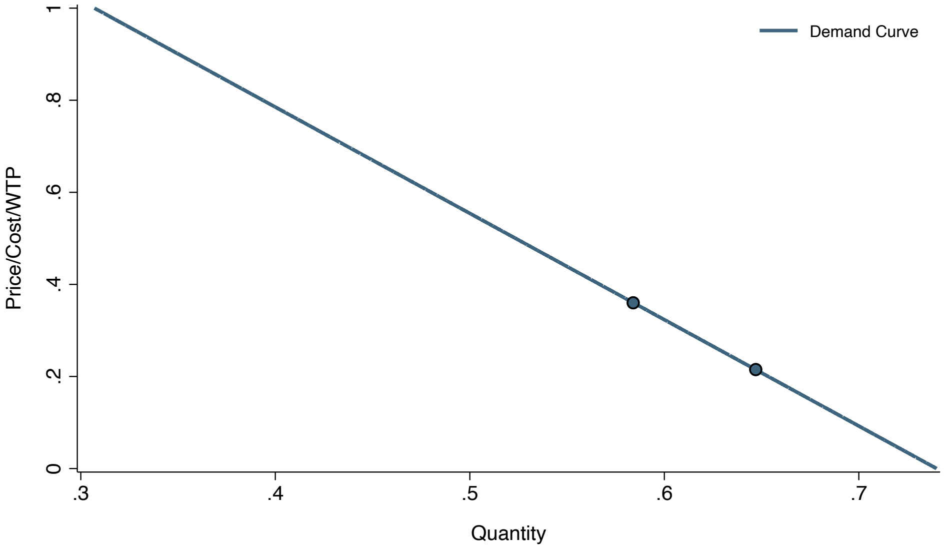
Demand Curve Estimates

	(1)	(2)	(3)	(4)
Interest Rate	-0.433***	-0.429***	-0.430***	-0.425***
	(0.064)	(0.063)	(0.063)	(0.063)
Constant	0.740***	0.739***	0.739***	0.737***
	(0.019)	(0.019)	(0.019)	(0.019)
Demographics		X	X	X
Geography			X	X
Loan Size and Rating				X
Number of Observations	10,991	10,991	10,991	10,991

First Stage

Demand Curve Estimates



Estimating the Demand and Cost Curves

- **Demand curve**

$$d_i = \alpha_d + \beta_d r_i + \epsilon_i$$

- Average cost curve

$$c_i = \alpha_c + \beta_c r_i + \nu_i$$

- Marginal cost curve

$$MC(r) = \frac{\partial TC(r)}{\partial D(r)} = \frac{\partial (AC(r) \times D(r))}{\partial D(r)} = \frac{\alpha_d \beta_c}{\beta_d} + \alpha_c + 2\beta_c r$$

- $\widetilde{AC}(r)$ and $\widetilde{MC}(r)$ derived from these using definitions
- $WTP(r)$ built from $D(r)$ and $MC(r)$

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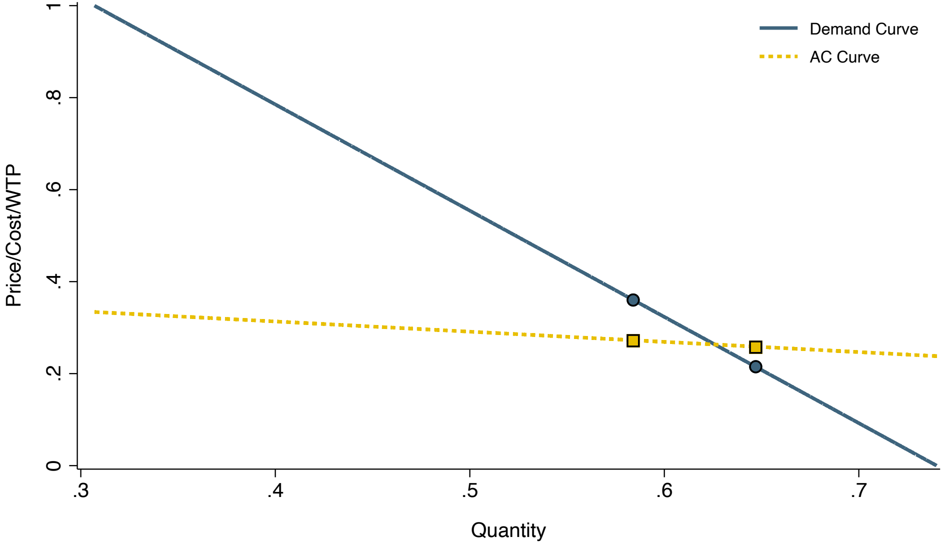
Average Cost Curve Estimates

	(1)	(2)	(3)	(4)	(5)
Interest Rate	0.096**	0.094**	0.093**	0.090**	0.090*
	(0.044)	(0.044)	(0.044)	(0.043)	(0.049)
Constant	0.238***	0.238***	0.238***	0.239***	0.227***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
Demographics		X	X	X	X
Geography			X	X	X
Loan Size and Rating				X	X
Estimated Fixed Cost					X
Number of Observations	6,761	6,761	6,761	6,761	6,761

First Stage Fixed Cost

Average Cost Curve Estimates



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Estimating the Demand and Cost Curves

- Demand curve

$$d = 0.740 - 0.433 \times r$$

- Average cost curve

$$c = 0.238 + 0.096 \times r$$

- **Marginal cost curve**

$$MC(r) = \frac{\partial TC(r)}{\partial D(r)} = \frac{\partial (AC(r) \times D(r))}{\partial D(r)} = \mathbf{0.074 + 0.192 \times r}$$

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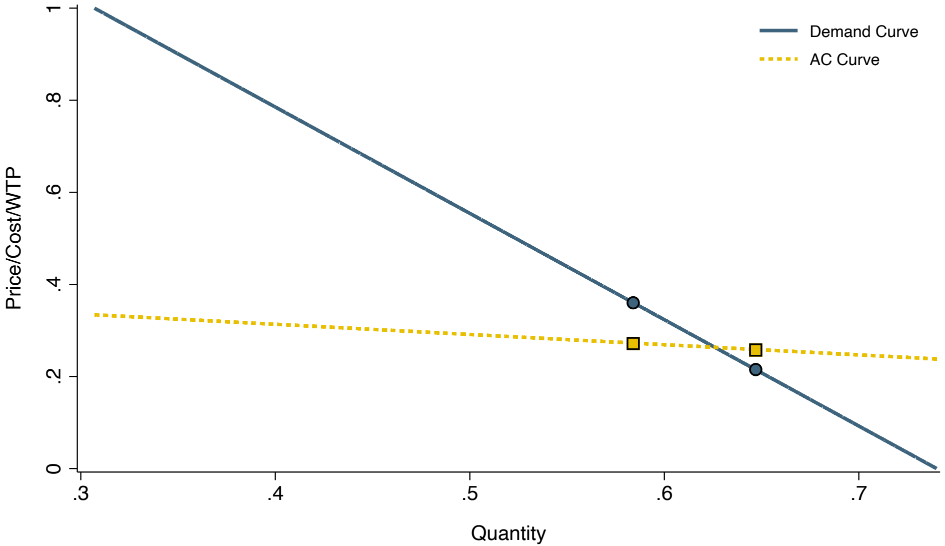
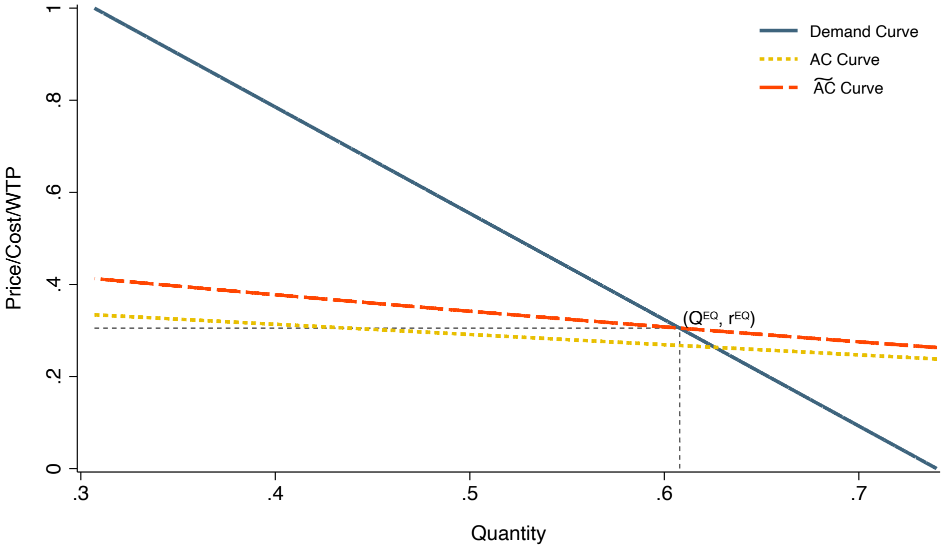
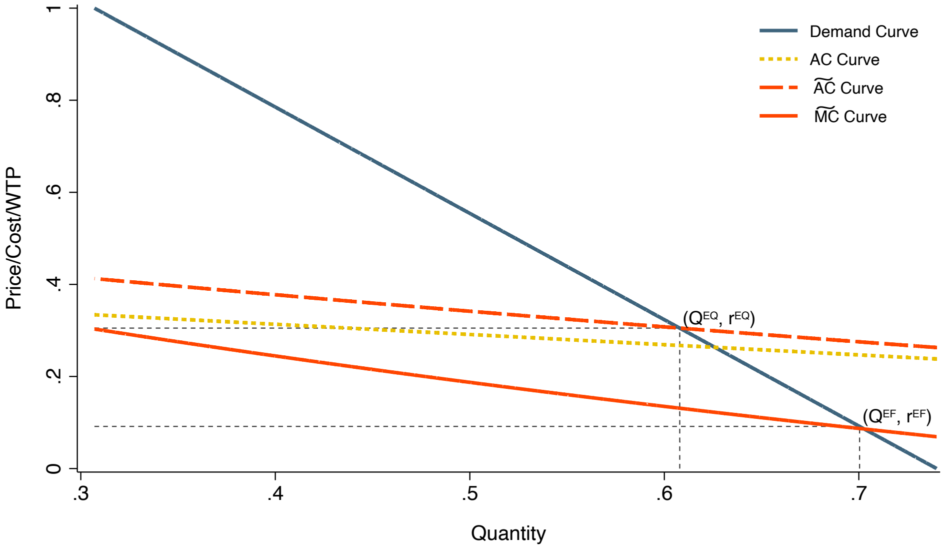
Implied $\widetilde{AC}$ and $\widetilde{MC}$ Curves



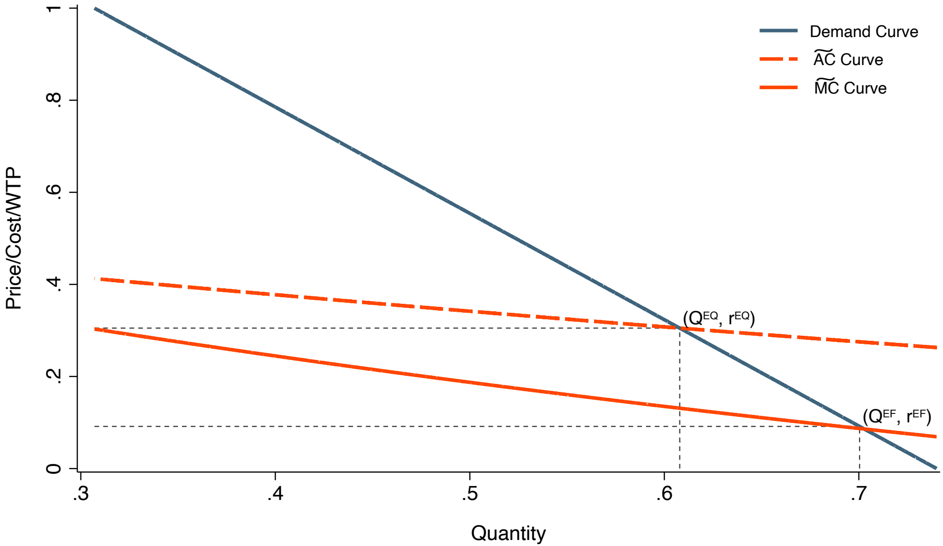
Implied $\widetilde{AC}$ and $\widetilde{MC}$ Curves



Implied $\widetilde{AC}$ and $\widetilde{MC}$ Curves



Empirical Estimates of Equilibrium and Efficient Outcomes



Estimating the Demand and Cost Curves

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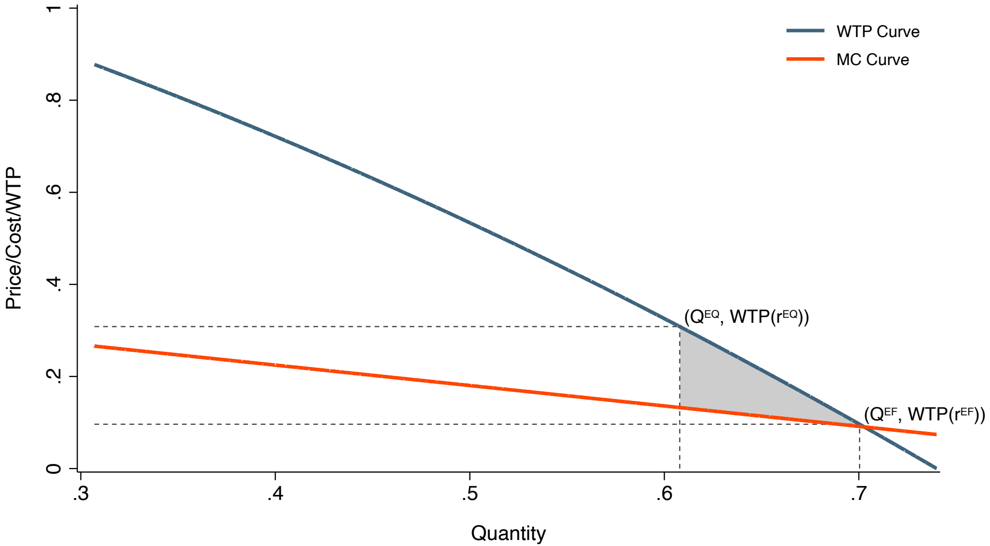
The Welfare Cost of Asymmetric Information



Implied Quantities of Interest

	(1)	(2)	(3)	(4)	(5)
Equilibrium Price	0.304	0.304	0.304	0.304	0.288
Equilibrium Quantity	0.608	0.608	0.608	0.608	0.615
Efficient Price	0.085	0.088	0.091	0.095	0.081
Efficient Quantity	0.703	0.701	0.700	0.697	0.703
Welfare Loss (per ¥100): Approximate	0.835	0.806	0.787	0.750	0.743
Welfare Loss (per ¥100): Exact	0.849	0.820	0.800	0.762	0.754
Demographics		X	X	X	X
Geography			X	X	X
Loan Size and Rating				X	X
Estimated Fixed Cost					X

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Demographics		X	X	X	X
Geography			X	X	X
Loan Size and Rating				X	X
Estimated Fixed Cost					X

Asymmetric information $\rightarrow$ Large equilibrium price distortion

Bootstrap CIs Heterogeneity

Implied Quantities of Interest

	(1)	(2)	(3)	(4)	(5)
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Demographics		X	X	X	X
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Loan Size and Rating				X	X
Estimated Fixed Cost					X

Inelastic demand → Small equilibrium quantity distortion

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Geography			X	X	X
Loan Size and Rating				X	X
Estimated Fixed Cost					X

Welfare loss = 0.8% of loan amount $\approx$ \$7.20 per applicant

Bootstrap CIs Heterogeneity

Conclusion

Estimate welfare losses from asymmetric information in new and growing market

- Large price distortion
- Small quantity distortion
- Surprisingly small welfare losses
- Hard to argue for strong policy interventions in this market

Illustrate how methods from insurance can be adapted to credit markets

- Key required inputs
  - Data on borrower take-up (demand)
  - Data on lender charge-offs (costs)
  - Exogenous variation in interest rates
- Hopefully useful for studies of other credit markets!

Thanks!

Covariate Balance Tests

	Low Price	High Price	Difference	*t*-statistic
	(1)	(2)	(3)	(4)
Loan terms				
Interest Rate (%)	21.5	36.0	-14.5	-291.45***
Loan size (¥100's)	62.7	62.5	0.2	0.24
Basic Demographics				
Age	30.4	30.5	-0.1	-0.61
Male (%)	77.3	77.2	0.1	0.08
Single (%)	50.4	51.3	-0.8	-0.86
Highest Degree Completed (%)				
Junior-High School	12.8	13.0	-0.2	-0.31
Senior-High School	42.4	41.6	0.8	0.85
Vocational School	31.2	32.2	-0.9	-1.06
Bachelor's or Higher	13.5	13.2	0.3	0.52
City Tier (%)				
Tier 1	12.4	11.9	0.5	0.76
Tier 2	29.1	29.4	-0.3	-0.38
Tier 3	21.2	21.4	-0.2	-0.28
Tier 4	23.4	23.1	0.4	0.44
Tier 5	2.8	2.8	-0.1	-0.18
Tier 6	11.1	11.4	-0.2	-0.37
Credit Rating (%)				
Category 1	50.8	50.0	0.8	0.87
Category 2	15.3	16.0	-0.8	-1.12
Category 3	26.4	25.8	0.6	0.66
Category 4	7.5	8.1	-0.6	-1.19
Number of Observations	5,479	5,512	10,991	10,991

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Incorporating Moral Hazard

- Moral hazard $\rightarrow$ borrower-level costs depend on the interest rate

$$c(X_i, r) = c + \delta(X_i, r)\theta(X_i, r)$$

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- The marginal cost curve now has two components

$$MC(r) = \underbrace{\mathbb{E}[c(X, r) \mid \rho(X) = r]}_{\text{Adverse Selection (>0)}} + \underbrace{\frac{1}{D'(r)} \int \frac{\partial c(X, r)}{\partial r} \mathbb{1}(\rho(X) \geq r) dF(X)}_{\text{Moral Hazard (< 0)}}$$

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- Constructing WTP as before will **overestimate** consumer surplus

$$WTP(\rho(X_i)) = (1 + c - \mathbb{E}[c(X,r) \mid \rho(X) = \rho(X_i)]) \times \rho(X_i) < (1 + c - MC(\rho(X_i))) \times \rho(X_i)$$

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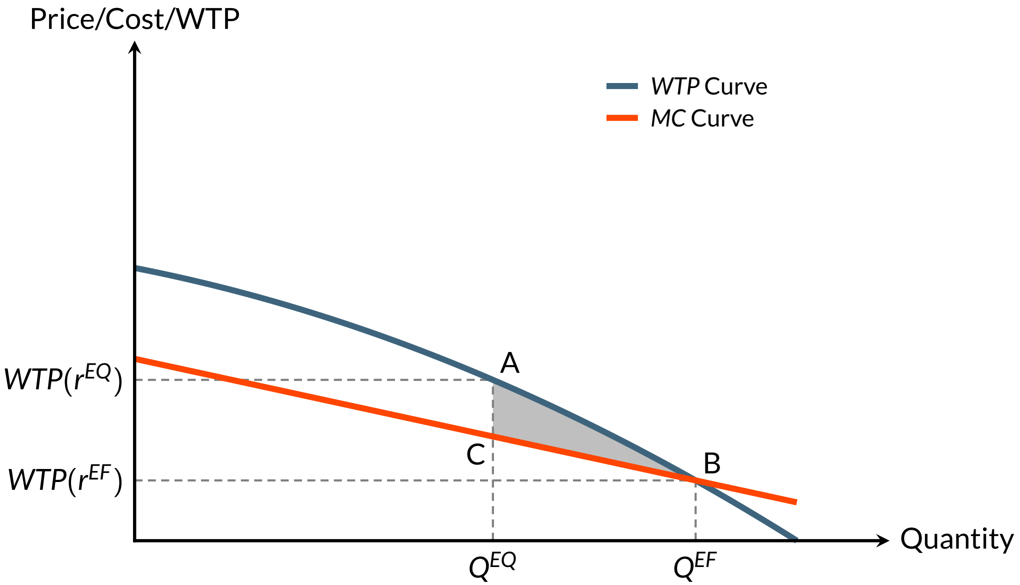
- We estimate an **upper bound** on pooled welfare losses

The Welfare Cost of Asymmetric Information



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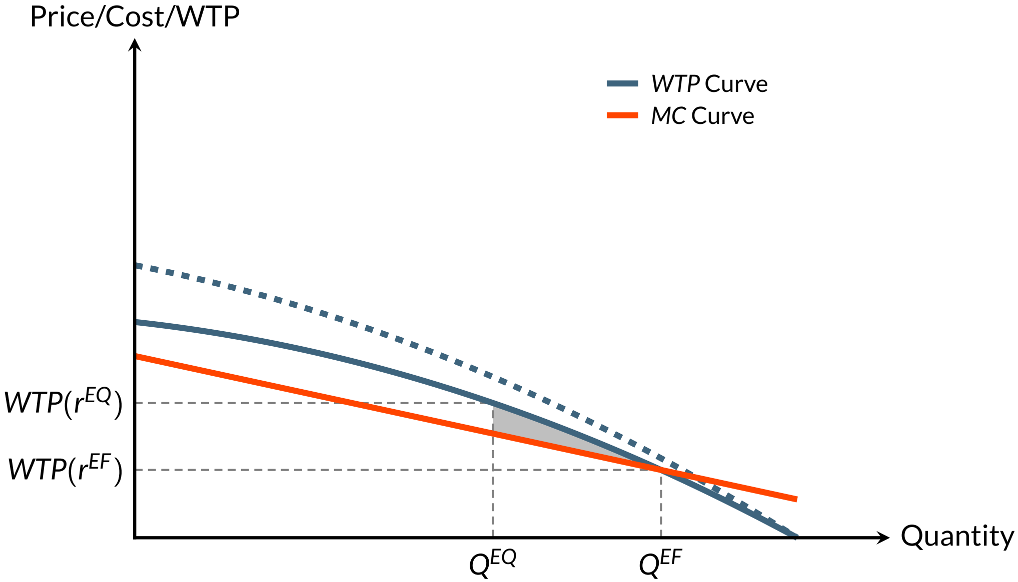
The Welfare Cost of Asymmetric Information



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First Stage Results: Demand Curve

	(1)	(2)	(3)	(4)
	Interest Rate			
High-Price Group	0.145***	0.145***	0.145***	0.145***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.215***	0.215***	0.215***	0.215***
	(0.000)	(0.000)	(0.000)	(0.000)
Demographics		X	X	X
Geography			X	X
Loan Size and Rating				X
F-statistic	84,945	84,945	85,015	87,371
Number of Observations	10,991	10,991	10,991	10,991

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First Stage Results: Average Cost Curve

	(1)	(2)	(3)	(4)
	Interest Rate			
High-Price Group	0.145***	0.145***	0.145***	0.145***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.211***	0.211***	0.211***	0.211***
	(0.000)	(0.000)	(0.000)	(0.000)
Demographics		X	X	X
Geography			X	X
Loan Size and Rating				X
F-statistic	59,143	59,083	59,092	60,439
Number of Observations	6,761	6,761	6,761	6,761

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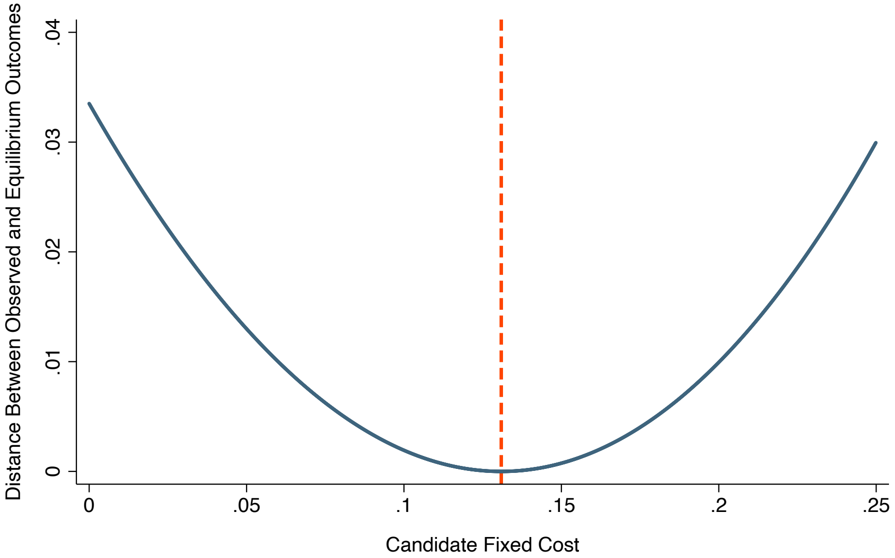
Confidence Intervals for Implied Quantities of Interest

	(1)	(2)	(3)	(4)	(5)
Equilibrium Price	0.304	0.304	0.304	0.304	0.288
	[0.294, 0.317]	[0.294, 0.317]	[0.294, 0.316]	[0.294, 0.317]	[0.278, 0.299]
Equilibrium Quantity	0.608	0.608	0.608	0.608	0.615
	[0.597, 0.618]	[0.598, 0.618]	[0.598, 0.618]	[0.597, 0.618]	[0.605, 0.625]
Efficient Price	0.085	0.088	0.091	0.095	0.081
	[-0.131, 0.286]	[-0.133, 0.294]	[-0.128, 0.294]	[-0.129, 0.299]	[-0.141, 0.285]
Efficient Quantity	0.703	0.701	0.700	0.697	0.703
	[0.614, 0.781]	[0.612, 0.782]	[0.612, 0.780]	[0.608, 0.777]	[0.615, 0.783]
Welfare Loss (per ¥100): Approximate	0.835	0.806	0.787	0.750	0.743
	[0.025, 2.684]	[0.012, 2.647]	[0.009, 2.625]	[0.004, 2.555]	[0.005, 2.547]
Welfare Loss (per ¥100): Exact	0.849	0.820	0.800	0.762	0.754
	[0.006, 3.306]	[0.001, 3.291]	[0.001, 3.202]	[0.000, 3.127]	[0.000, 3.066]
Demographics		X	X	X	X
Geography			X	X	X
Loan Size and Rating				X	X
Estimated Fixed Cost					X

Objective Function Value for Fixed Cost Estimation



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Demand Curve Estimates by Credit Rating

	Category 1		Category 2-4	
	(1)	(2)	(3)	(4)
Interest Rate	-0.448***	-0.448***	-0.417***	-0.402***
	(0.088)	(0.088)	(0.091)	(0.091)
Constant	0.746***	0.778***	0.733***	0.722***
	(0.026)	(0.026)	(0.028)	(0.029)
Demographics		X		X
Geography		X		X
Loan Size		X		X
Number of Observations	5,543	5,543	5,448	5,448

Demand equally sensitive to interest rates across credit scores

Average Cost Curve Estimates by Credit Rating

	Category 1		Category 2-4	
	(1)	(2)	(3)	(4)
Interest Rate	0.056	0.060	0.133**	0.122*
	(0.056)	(0.056)	(0.068)	(0.067)
Constant	0.230***	0.227***	0.247***	0.237***
	(0.016)	(0.016)	(0.020)	(0.021)
Demographics		X		X
Geography		X		X
Loan Size		X		X
Number of Observations	3,432	3,432	3,329	3,329

Costs more sensitive to interest rates among observably riskier borrowers

Implied Quantities of Interest by Credit Rating

	Category 1		Category 2-4	
	(1)	(2)	(3)	(4)
Equilibrium Price	0.272	0.270	0.344	0.317
Equilibrium Quantity	0.624	0.657	0.590	0.594
Efficient Price	0.156	0.140	0.016	0.019
Efficient Quantity	0.676	0.715	0.727	0.714
Welfare Loss (per ¥100): Approximate	0.256	0.325	1.725	1.425
Welfare Loss (per ¥100): Exact	0.258	0.327	1.790	1.468
Demographics		X		X
Geography		X		X
Loan Size		X		X

Welfare losses substantially larger among observably riskier borrowers

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