Credit Constraints in the Market for Consumer Durables: Evidence from Micro Data on Car Loans

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Contents

1. Introduction

- a novel approach for testing for borrowing constraints using micro data on car loans from Consumer Expenditure Survey (1984-1995)
- borrowing constraints have specific implications for interest rate and maturity elasticities of the demand for loans

Main goal

- estimate elasticities of car loan demand with respect to interest rate and maturity
- examine how these elasticities differ across different groups in population
- examine whether consumers who are more likely to be constrained exhibit a larger maturity and a lower interest rate elasticity than the other groups

2. Data

Consumer Expenditure Survey (CES), 1984-95

- rotating panel in which each household is interviewed four consecutive times over a one year period

Data strengths

- substantial time variation in interest rates and maturities
- ability to test for existence of borrowing constraints separately in various subgroups (young or low income households)
- compare the relative sizes of interest rate and maturity elasticities across groups

2. Data

Data challenges

- selection bias- observations on financing are available only for consumers who purchased a car and decided to finance such a purchase
- financing a car purchase is bounded between 0 and the value of the car
- endogeneity issues: observed interest rate and maturity of a loan are likely to be endogenous
- normality assumptions seem inappropriate: observed loan variables would not be distributed normally

3. A Theoretical Framework

- Why elasticities of loan demand with respect to interest rate and maturity are informative about the significance of liquidity constraints?

- Two definitions of Liquidity Constraints:

A consumer is liquidity constrained if

1. she cannot borrow as much as she would like in order to finance present consumption using resources that would accrue to her in the future
2. if interest rate is increasing in the amount borrowed

3.1 The Demand for Loans With Liquidity Constraints

Interest rate sensitivity of loan demand

$$A = f(r(A) + \bar{r}, z)$$

A demand for loans

z includes, among other things, current and future income

$\bar{r}$ exogenous part of r

3.1 The Demand for Loans With Liquidity Constraints

$$\frac{dA}{d\bar{r}} = f_1(r(A))r'(A)\frac{dA}{d\bar{r}} + f_1(r(A)) \Leftrightarrow$$

$$\frac{dA}{d\bar{r}} = \frac{f_1(r(A))}{1 - f_1(r(A))r'(A)}$$

$f_1(r)$ derivative of f with respect to 1st argument

If $r'(A) < 0$ (interest rate is a decreasing function of net asset position) and $f_1(r) > 0$ (lending is an increasing function of interest rate), then

$$\left|\frac{dA}{d\bar{r}}\right| = \left|\frac{f_1(r(A))}{1 - f_1(r(A))r'(A)}\right| < f_1(r)$$

Loan demand of liquidity constrained consumers will be less responsive to exogenous changes in interest rate than demand of liquidity unconstrained consumers

3.1 The Demand for Loans With Liquidity Constraints

Maturity sensitivity of loan demand

- Increase in maturity, by reducing monthly payments, will effectively allow the consumer to borrow more.
- These payments will depend on interest rate (since lower interest rates decrease payments for a given loan), but they will depend much more on maturity.
- This applies to consumer loans only, which are typically short-term (3-5 years).

3.2 The Demand for Loans Without Liquidity Constraints

Interest rate sensitivity of loan demand

- If offered car loan interest rate > individual expected after-tax interest rate → consumer will not finance any amount.
- If offered car loan interest rate < individual expected after-tax interest rate → consumer will finance full amount.

Loan demand is highly sensitive to the interest rate

3.1 & 3.2 The Demand for Loans With and Without Liquidity Constraints

In sum**, liquidity constrained consumers** will fall into two categories**:**

- Some will be rationed out of car market, in which case they will show no sensitivity to either loan interest rate or maturity.
- Others will buy and finance a car, in which case their loan demand will be <u>highly sensitive to loan maturity</u>, but <u>less sensitive to interest rate</u>.

and **liquidity unconstrained consumers** will fall into two categories:

- Some may find it optimal to never finance, in which case they will show no sensitivity to either loan interest rate or maturity.
- Others will find it optimal to finance, in which case their loan demand will exhibit <u>high sensitivity to interest rate</u>.

Limitation: liquidity constraints cannot be identified among consumers who did not buy or finance a car.

4. Empirical specification and econometric issues

- Loan demand equation

$$l^* = \ln(L^*) = x\theta_l + f(r.m) + \varepsilon$$

L^*: desired loan amount

x: vector of exogenous variables that capture demographic, life cycle and macroeconomic effects on loan amount

r: interest rate of the loan

m: maturity of the loan

ε: unobserved error term

- Exogeneity assumption of interest rate and maturity is invalid

- Exploit two developments to construct instruments for interest rate and maturity

4. Empirical specification and econometric issues

1st development: tax reform of 1986

Gradual phase out of interest deductibility that changes the after-tax interest rate of consumer loans

$$r_t = r_p * \underbrace{(1 - t_f * \alpha_t * I - t_s * \alpha_t * I + t_f * t_s * \alpha_t * I)}_{tax\ price\ of\ debt}$$

r_t after-tax nominal rate in year t

r_p pre-tax consumer loan rate

t_f marginal federal tax rate

t_s marginal state tax rate

I dummy that takes the value of 1 if consumer itemizes deductions on his/her tax return

α_t proportion of consumer interest that is deductible from income

4. Empirical specification and econometric issues

1st development: tax reform of 1986

Instrument: tax price of debt

Construction of instrument

- compute tax price of debt
  - run NBER tax simulation program that matches CES data with tax rate data
- instrument is valid
  - use CES and tax information from year prior to car purchase
  - compute average (across regions) tax price of debt in each year
  - use these averages as instruments

Identification assumption: tax reform affects loan demand only through its effect on the after-tax interest rate and does not have any direct effects on loan demand.

4. Empirical specification and econometric issues

2nd development: increased durability of cars

- Increased durability (slower depreciation) implies that lenders can offer longer maturities as cars retain their collateral value for a longer time period.

- Instruments: Depreciation rates

Depreciation rates can explain a substantial proportion of the time variation of maturity

4. Empirical specification and econometric issues

2nd development: increased durability of cars

Construction of instruments

- use information on vehicle stock (model year and estimated value of car) provided by each household in CES
- construct depreciation rates going forward: 1-year, 2-year until 4-year depreciation rates
- deflate all car prices using CPI deflator
- compute mean for all cars of a particular cohort (that is model-year) in each year in sample
- construct depreciation rates based on means of car prices

4. Empirical specification and econometric issues

Sample selection issues:

- loans are observed only for households who decide to buy and finance a car
- finance is available up to 100% of car value

Sample selectivity model

y_i decision to buy vs. not buy (dependent variable)

f_i finance share (ratio of car loan to car value)

y_i is correlated with f_i

4. Empirical specification and econometric issues

- y_i^o and f_i^0 are two latent variables, generated by bivariate process

$$\begin{bmatrix} y_i^o \\ f_i^0 \end{bmatrix} = \begin{bmatrix} Z_i\beta \\ X_i\gamma \end{bmatrix} + \begin{bmatrix} u_i \\ v_i \end{bmatrix} \sim N\left[0, \begin{pmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{pmatrix}\right]$$

ρ correlation between u_i and v_i

σ standard deviation of u_i

- y_i and f_i are observed and they are related to y_i^o and f_i^0 as follows:

$$y_i = \begin{cases} y_i^o & if\ f_i^0 \leq 0 \\ unobserved & if\ f_i^0 > 0 \end{cases}$$

$$f_i = \begin{cases} 1\ if\ f_i^0 \leq 0 \\ 0\ if\ f_i^0 > 0 \end{cases}$$

4. Empirical specification and econometric issues

Ordered discrete choice model

- derived from latent/unobserved variable model

$$d^0 = Z\beta_d + u_d$$

Relation between d^0 and d

$$d = \begin{cases} 0 \quad if\ Z\beta_d + u_d < \widetilde{\alpha_1}\ (not\ buy/finance) \\ 1 \quad if\ \widetilde{\alpha_1} < Z\beta_d + u_d < \widetilde{\alpha_2}\ (\text{finance less than 100\% of car value}) \\ 2 \quad if\ Z\beta_d + u_d > \widetilde{\alpha_2}\ (finance\ 100\%\ of\ car\ value) \end{cases}$$

$\widetilde{\alpha_1}$ and $\widetilde{\alpha_2}$ fixed unknown thresholds

Z vector includes:

- all exogenous variables in x,
- all exogenous variables that affect r and m, and
- controls that may affect decision to buy a car, but not loan amount such as population size of residence town and vehicle stock variables (number of cars in the stock, dummy for not currently owning a car, average age of the stock)

4. Empirical specification and econometric issues

- Reduced form interest rate and maturity equations:

$$r^* = x\theta_r + W\delta_r + u_r = X\beta_r + u_r$$
$$m^* = x\theta_m + W\delta_m + u_m = X\beta_m + u_m$$

$$X \equiv [x \quad W], \beta_r \equiv \begin{bmatrix} \theta_r \\ \delta_r \end{bmatrix}, \; \beta_m \equiv \begin{bmatrix} \theta_m \\ \delta_m \end{bmatrix}$$

W: instruments that affect interest rate and maturity, but which can be excluded from loan demand equation (e.g. average tax price of debt and depreciation rates)

- Observed interest rate r, and observed maturity m:

$$r = 1\{d > 0\} \times r^*$$
$$m = 1\{d > 0\} \times m^*$$

4. Empirical specification and econometric issues

- Assume linear $f\ (r, m)$:

$$l^* = \ln(L^*) = x\theta_l + f(r.m) + \varepsilon$$

$$l^* = \ln(L^*) = x\theta_l + \gamma_1 r + \gamma_2 m + \varepsilon$$

$$l^* = X\beta_l + u_l$$

$$\beta_l = \begin{bmatrix} \theta_l + \gamma_1\theta_r + \gamma_2\theta_m \\ \gamma_1\delta_r + \gamma_2\delta_m \end{bmatrix}$$

$$u_l = \gamma_1\ u_r + \gamma_2 u_m + \varepsilon$$

- Reduced form system with unknown parameters: $\beta_d, \beta_l, \beta_r, \beta_m$

4.1. Estimation: Semiparametric approach

Semiparametric approach (Powell, 2001)

Multi-step procedure:

1st step: estimate election equation assuming u_d is normally distributed (ordered probit model) and obtain $\widehat{\beta_d}$

- r^* and m^* are observed if $d > 0$, or equivalently

$$Z\beta_d + u_d < \widetilde{\alpha_1} \quad \Leftrightarrow \quad u_d > \widetilde{\alpha_1} - Z\beta_d$$

$$E(r|X, Z, d > 0) = X\beta_r + E(u_r|X, Z, u_d > \widetilde{\alpha_1} - Z\beta_d)$$

$$E(m|X, Z, d > 0) = X\beta_m + \underbrace{E(u_m|X, Z, u_d > \widetilde{\alpha_1} - Z\beta_d)}_{sample\ selection\ bias\ term\ or\ selection\ effect}$$

4.1. Estimation: Semiparametric approach

- Assumption:

$$E(u_r | X, Z, u_d > \widetilde{\alpha_1} - Z\beta_d) = \lambda_r(Z\beta_d)$$

$$E(u_m | X, Z, u_d > \widetilde{\alpha_1} - Z\beta_d) = \lambda_m(Z\beta_d)$$

$Z\beta_d$ selection index

$\lambda_r(\,)$ and $\lambda_m(\,)$ are unknown functions

4.1. Estimation: Semiparametric approach

2nd step: Estimate β_r, β_m by weighted least squares on the pairwise differenced selected sample

$$Min \sum_{i<j} 1\{d_i > 0\} 1\{d_j > 0\} K\left((Z_i - Z_j)\,\widehat{\beta_d}\right)\left[\left(r_i - r_j\right) - (X_i - X_j)\beta_r\right]^2$$

$$Min \sum_{i<j} 1\{d_i > 0\} 1\{d_j > 0\} K\left((Z_i - Z_j)\,\widehat{\beta_d}\right)\left[\left(m_i - m_j\right) - (X_i - X_j)\beta_m\right]^2$$

i , j households

$K(\ )$ is a weighting function that equals to 1 if $Z_i = Z_j$

Households with same selection indices have approximately equal selection bias terms. Hence pairwise differencing eliminates the sample selection bias.

4.1. Estimation: Semiparametric approach

- Estimate reduced form equation: $l^* = X\beta_l + u_l$ for $d = 1$ by minimizing

$$Min \sum_{i<j} 1\{d_i = 1\}\, 1\{d_j = 1\}\, K\left(\left((Z_i - Z_j)\,\widehat{\beta_d}\right)\right) \left[\left(l_i - l_j\right) - (X_i - X_j)\beta_l\right]^2$$

- Having obtained $\widehat{\beta_d}, \widehat{\beta_l}, \widehat{\beta_r}, \widehat{\beta_m}$, estimate structural parameters γ_1 and γ_2 by minimizing the quadratic form

$$Q = \left(\hat{\pi} - h(\theta)\right)' \widehat{V^{-1}} (\hat{\pi} - h(\theta))$$

$\theta = (\theta_l, \gamma_1, \gamma_2, \theta_r, \delta_r, \theta_m, \delta_m)$ vector of structural parameters

$\hat{\pi}$: vector of estimated reduced form parameters $(\beta_d, \beta_l, \beta_r, \beta_m)$

$h(\,)$: function that maps structural parameters into reduced form parameters

$\hat{V}$: consistent estimator of variance-covariance matrix of reduced form parameters

5. Empirical Results
5.1 Results Based on the Full Sample

Full Sample

Dependent variable: Log of Loan Size

Number of Obs. Financing: 4323

	Specification	r-Derivative		m-derivative	
[1]	*DNV*, Only r	−0.82	(0.25)	–	–
[2]	*DNV*, r and m	−0.09	(0.25)	7.38	(1.33)
[3]	*DNV*, cubic polynomial in r and m	−0.27	(0.26)	7.45	(1.39)
[4]	P, r and m	−0.05	(0.37)	8.77	(2.69)

- **Consumers are highly sensitive to changes in the loan maturity, but unresponsive to changes in the interest rate**.
- **This is strongly suggestive of the existence of liquidity constraints in the population.**

5.2. Results Based on Subgroups

Dependent variable: Log of Loan Size

	Age Gr. 1		Age Gr. 2		Age Gr. 3	
Specification	r	m	r	m	r	m
DNV, r and m	−0.49	4.03	−0.61	4.26	0.27	7.46
	(0.24)	(0.73)	(0.32)	(2.11)	(1.00)	(4.32)

Notes:

Age groups are defined as follows:

Age Gr. 1: Age of Household Head ≤ 35

Age Gr. 2: $35 <$ Age of Household Head < 55

Age Gr. 3: Age of Household Head ≥ 55

Younger consumers do not appear to be more constrained than middle-aged consumers

5.2. Results Based on Subgroups

Dependent variable: Log of Loan Size

	Income Gr. 1		**Income Gr. 2**		**Income Gr. 3**	
Specification	r	m	r	m	r	m
DNV, r and m	−0.24	6.04	−0.68	3.62	−1.34	−0.04
	(0.17)	(1.48)	(0.37)	(1.49)	(0.79)	(1.84)

Notes:

Groups are defined as follows:

Inc. Gr. 1: $0 <$ Per-Capita Income ≤ 10000

Inc. Gr. 2: $10000 <$ Per-Capita Income < 20000

Inc. Gr. 3: Per-Capita Income ≥ 20000

Lower income groups are highly sensitive to maturity extensions, while the high income group is not. In contrast, the high income group exhibits the highest sensitivity to interest rate changes.

5. Empirical Results

Empirical results are consistent with the existence of liquidity constraints :

- Consumer groups that are more likely to be liquidity constrained (e.g. low income households) are highly sensitive to maturity changes, but less sensitive to interest rate changes
- Consumer groups that are more likely to be liquidity unconstrained (e.g. high income consumers) exhibit significant interest rate, but no maturity sensitivity.