

A Quantitative Theory of Information and Unsecured Credit*

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Abstract

Over the past three decades four striking features of aggregates in the unsecured credit market have been documented: (1) rising availability of credit along both the intensive and extensive margins, (2) rising debt accumulation, (3) rising bankruptcy rates and discharge in bankruptcy, and (4) rising dispersion in interest rates across households. We provide a quantitative theory of unsecured credit that is consistent with these facts. Specifically, we show that all four outcomes mentioned above are consistent with improvements in the ability of lenders to observe more components of individual income now than in earlier periods. A novel feature is that we allow for individualized loan pricing under asymmetric information. In addition, the paper makes a methodological contribution: an algorithm to locate equilibria with asymmetric information, a task that is complicated by the requirements that (i) lenders must use all information revealed by household choices and (ii) off-equilibrium beliefs and prices matter for equilibrium outcomes.

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1 Introduction

Over the past three decades there have been dramatic changes in the unsecured credit market. First, the availability of unsecured credit has increased both along the extensive and intensive margin; Narajabad (2007) documents that the fraction of US households with positive credit card limits increased by 17 percentage points between 1989 and 2004, while the average credit limit more than doubled over the same time period. In addition to the increase in availability of credit, Krueger and Perri (2006) measure that unsecured debt (utilized credit) as a fraction of disposable income has risen from 2 percent to 9 percent from 1980 to 2005. Several researchers have documented the significant rise in Chapter 7 bankruptcies over the same time period, including Livshits, MacGee, and Tertilt (2006) and Sullivan, Warren, and Westbrook (2000). Athreya (2004) notes explicitly that this increase continued over the entire 1990s; quantitatively, the filing rate per 1000 households went from 2 in 1980 to 9 in 2002; see Figure (1).¹ Finally, Sullivan, Warren, and Westbrook (2000) also notes that defaults are not only more common but also much larger; median non-mortgage debt-to-income ratio for households filing for bankruptcy doubled *from* 0.75 *to* 1.54 over the period 1981-1997 (see Figure 2, taken from Sullivan, Warren, and Westbrook 2000).

Recent empirical work on the functioning of consumer credit markets has also documented striking changes in the sensitivity of credit terms to borrower characteristics. A summary of this work is that credit terms, especially for unsecured loans, exhibited little variation across US households as recently as 1990, even though in the cross-section these households exhibited substantial heterogeneity in income, wealth, and default risk.² In the subsequent period, from 1990 to the present, a variety of financial contracts, ranging from credit card lines to auto loans to insurance, now exhibit terms that depend nontrivially on regularly updated measures of default risk, particularly a household's credit score. Three related findings stand out from the literature. First, the sensitivity of credit card loan rates to the conditional bankruptcy probability grew substantially after the mid-1990's (Edelberg 2006). Second, credit scores themselves became more informative. Furletti (2003), for example, finds that the spread between the rates paid by highest and lowest risk classifications grew from zero in 1992 to 800 basis points by 2002. Third, the distribution of interest rates for unsecured credit was highly concentrated in 1983 and very diffuse by 2004 (Livshits, MacGee, and Tertilt 2007b and Figure 3); furthermore, the distribution of interest rates for delinquent households was indistinguishable from nondelinquent ones in 1983 but shifted significantly to the right by 2004. Each of the preceding three findings relates to the amount of information available to lenders at the time of extending and pricing credit. In a world without default risk, changes in the information available to lenders would have little or no bearing on the availability or terms for credit. However, if default is a possibility, then the changes summarized above can be expected to alter the behavior of both households and lenders.

A good deal of recent attention has been given over to the task of accounting for the rapid growth and relatively high incidence of unsecured indebtedness and bankruptcy seen among US households, including Gross and Souleles (2003), Athreya (2004), Livshits, MacGee, and Tertilt (2006), and Narajabad (2007). The candidate explanations for the rise in debts and default fall into two (non-exclusive) categories. First, there is the possibility that the personal costs incurred by defaulters have fallen substantially, either as a result of improved bankruptcy filing procedures, the learning by households from each other about navigating the bankruptcy process, or even lower psychic costs (stigma). Gross and Souleles (2003) argue households did appear to be more willing to default in the late 1990's than in earlier periods, all else equal. Unfortunately, these explanations

¹The data is taken from the Statistical Abstract of the United States, various issues. We acknowledge cribbing the actual figure from Zagorsky and Lupica (2008).

²A survey of these empirical findings can be found in Hunt (2005).

tend to produce rising default rates combined with declining discharges on average, as households become less able to borrow and therefore default on less debt.

A second class of explanations for rising debt and default hinges on the extent to which transactions costs associated with lending are likely to have fallen as a result of improved information storage and processing technologies available to lenders. Athreya (2004) and Livshits, MacGee, and Tertilt (2006) explore this possibility; unlike changes in costs at the individual level, falling risk-free rates or transactions costs can produce both an increase in default rates and an increase in the amount of debt discharged in bankruptcy, making this mechanism a more promising candidate than lower individual default costs for the time series observations in the credit market. However, this mechanism cannot produce the increased dispersion in credit terms discussed above, because the changes treat all households essentially the same. Since both of these explanations fail within the context of specific models, we reexamine them here and find the same results – falling costs do not generate changes that match the data along all dimensions. That is, while they could be part of the reason the credit market has undergone such dramatic changes, they cannot be the only reason.

A common feature of the models that underlie the preceding explanations is full information: the information available to lenders always includes the entire relevant household state vector. In a highly stylized framework, Narajabad (2007) analyzes the effects of an increase in the informativeness of a signal received by lenders on a borrower’s long term income level, showing that such a change is qualitatively consistent with the increased indebtedness, increased default, and increased dispersion in loan terms observed. Importantly, Narajabad (2007) does not address changes in the degree of asymmetric information but rather changes in the quality of symmetric information; in contrast, this paper focuses on changes in the extent to which information is asymmetric between borrowers and lenders.³ In particular, we interpret the facts above as reflecting improved information about borrowers that is available for use by lenders.

Our goal in this paper is to provide a quantitative theory of how improved information changes the unsecured credit market and the ability of households to smooth consumption over the life-cycle (intertemporal smoothing) and across states (intra-temporal smoothing). We provide a model that allows for the quantitatively-serious measurement of how unsecured credit markets operate under asymmetric information and how changes in information alter outcomes when loan pricing is individualized. As is well known, equilibria under asymmetric information require a specification of the precise interaction of borrowers and lenders, which we model as a signalling game.⁴ We are guided in our choice of market microstructure by the requirement that households perceive a price function for loans as a function of default risk; thus, we need to solve for prices for arbitrary borrowing levels, including those not observed in equilibrium. A second complication that must be dealt with under asymmetric information is the extent to which information is revealed by household decisions. In particular, in a conjectured equilibrium, the information conveyed by a borrower’s chosen debt level must not provide incentives for a lender to deviate in the terms offered, given the information available to the intermediary; in our economy, this requirement states that the beliefs used to construct default rates (on the equilibrium path) must be consistent with the stationary distribution produced by the model.

To understand how improvements in information affect outcomes in the credit market, we study two equilibria. First, we allow lenders to observe all relevant aspects of the state vector necessary to predict default risk. We then compare this allocation to one where lenders are no longer able

³Narajabad (2007) features only *ex post* asymmetric information; all contracts are executed under symmetric information. Strong commitment assumptions ensure that the *ex post* asymmetric information does not alter equilibrium outcomes.

⁴Hellwig (1990) makes this point clearly.

to observe all of these variables. We follow the literature’s preferred specification of household labor income over the life-cycle. In this formulation, households draw stochastic incomes that are the sum of four components: a permanent shock realized prior to entry into the labor market (representing formal education), a deterministic age-dependent component with a peak several years before retirement, a persistent shock, and a purely transitory shock.⁵ Thus, information changes alter the observability of the components of household labor income; specifically, we prohibit the lenders from observing total income and the two stochastic components while the permanent shock is always observable. The difference across these allocations is a quantitative measure of the effect of improved information about shocks in unsecured credit markets.

Our first set of results focuses on the full information economy, where the pricing of debt incorporates all relevant information from the model. In this model bankruptcy is largely an intertemporal-smoothing phenomenon and not an inter-state smoothing one. That is, the bulk of borrowing occurs for life cycle purposes, and the bulk of default occurs when income expectations indicate that future borrowing capacity is not very valuable. As a result, default occurs among the unlucky young, and after age 50 is very low, both of which are features of the data. Under full information, our model matches the default rate and median borrowing on the unsecured credit market, but fails to match the unconditional mean of debt discharged through bankruptcy. However, given that we abstract from shocks to net worth that generate large involuntary defaults the appropriate target for discharged debt is smaller than that measured in the data (net worth shocks play an important role in Livshits, MacGee, and Tertilt 2006 and Chatterjee *et al.* 2007).

Once we depart from the full information setting we find that the equilibrium levels of debt and default fall dramatically. In other words, the model produces outcomes similar to those obtaining in a period (before 1990) that observers have characterized as one with limited information. We show first constructively that an allocation in which all households can borrow large amounts at the risk-free rate is not an equilibrium: those households with weak future income prospects (high-risk households) have a strong incentive to default at high levels of debt, generating nontrivial default risk and necessitating a default premium. In turn, as the premium for borrowing is raised, the low-risk households refuse to borrow as much, revealing the type of all those who do; the market then requires a further increase in the interest rate, which reduces borrowing by the high-risk types until they pool again with the low-risk types. This process continues until the incentives to deviate for low-risk borrowers are offset by the need to smooth consumption. As a quantitative matter, this pooling equilibrium occurs at a low enough debt level to sustain risk-free lending to every borrower. Thus, a natural method for modelling the reduction of information leads to an outcome qualitatively consistent with the salient aspects of unsecured credit markets prior to 1990.

In policymaking circles there is a debate regarding the effects of more information in the credit market. It is often asserted that better information in the credit market would harm disadvantaged groups, such as racial minorities, that benefit from pooling.⁶ Our model predicts that all agents are better off under full information, as every individual can borrow more at lower rates. We also show that better information will lead to both “democratization” and “intensification” of credit – that is, we obtain increases in both the extensive and intensive margins of the unsecured credit market. In terms of welfare, the intensification is quantitatively more significant: high school agents benefit less than college agents under full information, mainly because they are less-

⁵Some representative citations include Hubbard, Skinner, and Zeldes (1994) and Krueger and Perri (2006).

⁶Specifically, Section 215 of FACT Act directs the Federal Reserve Board, the Federal Trade Commission, and the Office of Fair Housing and Equal Opportunity (a department of HUD) to study “the consideration or lack of consideration of certain factors...could result in negative treatment of protected classes under the Equal Credit Opportunity Act.” Report to Congress on Credit Scoring and Its Effects on the Availability and Affordability of Credit,” Board of Governors of the Federal Reserve System, August 2007.

constrained by low information since their desire to borrow is limited by relatively-flat expected income profiles. Thus, information is not redistributing credit from bad to good borrowers, it is expanding it for everyone (as in the classic lemons problem). The key policy implication we derive from the model is that the runup in bankruptcies is not a problem; instead, it is the result of welfare-improving improvements in the information available to credit markets. However, all agents in the economy would be willing to rid themselves of the bankruptcy option *ex ante*; thus, policymakers should focus on how to make the bankruptcy option less attractive not because it has recently gotten more prevalent but because it has always been welfare-reducing.

Our paper is closely related to theoretical work of Chatterjee, Corbae, and Ríos-Rull (2006b), which attempts to provide a theory of reputation in unsecured borrowing; relative to that paper we simplify matters by limiting the dynamic aspects of credit terms. Our justification for this approach is that under full information credit scores are irrelevant, while our interpretation of the period of partial information as the 1980s implies that credit scores were not used even though they were collected; in turn, a key payoff of this assumption is quantitative tractability. Our paper is also related to Sánchez (2008), who studies a screening model of unsecured credit but abstracts from life-cycle considerations. Given the clear life-cycle aspect of both unsecured borrowing and bankruptcy, we focus on precisely capturing the interaction of information asymmetries with life-cycle earnings growth. Lastly, our work is complementary to Livshits, MacGee, and Tertilt (2007b) and Drozd and Nosal (2007), who offer theories of increased differentiation of borrowers based on declining contracting costs.⁷

The remainder of the paper is organized as follows. The next section introduces the model, followed by the algorithm used to compute equilibria, and then results of the quantitative model. The final section concludes.

2 A Model with Default

Households in the model economy live for a maximum of $J < \infty$ periods. There are two classes of households – “normals”, who face uninsurable risk, save and borrow via costly financial intermediaries, and occasionally choose to file for bankruptcy, and “specials”, who do not face idiosyncratic risk, do not default, and earn higher rates of return arising from direct ownership of physical capital.

2.1 Normal Households

Each normal household of age j has a probability $\psi_j < 1$ of surviving to age $j + 1$ and has a pure time discount factor $\beta < 1$. Households value consumption and attach a negative value λ_j (in utility terms) to all nonpecuniary costs of filing for bankruptcy. Their preferences are represented by the expected utility function

$$\sum_{j=1}^J \sum_{s^j} \left(\prod_{i=0}^j \beta \psi_{j,y} \right) \Pi(s^j) \left[\frac{n_j}{1-\sigma} \left(\frac{c_j}{n_j} \right)^{1-\sigma} - \lambda_j \mathbf{1}(d_j = 0) \right], \quad (1)$$

where d_j is 0 if the household chooses to default. $\Pi(s^j)$ is the probability of a given history of events s^j . $\sigma \geq 0$ is the Arrow-Pratt coefficient of relative risk aversion. We assume that households retire exogenously at age $j^* < J$, and n_j is the number of household members at age j .⁸

⁷Similar to Narajabad (2007), both papers also assume strong *ex post* commitment to contracts on the part of lenders.

⁸We assume that labor is supplied inelastically. Many studies of rising inequality assert that changes in labor hours are a critical source of insurance (Storesletten, Telmer, and Yaron 2004 or Heathcote, Storesletten, and Violante

The presence of nonpecuniary costs of bankruptcy is standard in the literature (see Livshits, MacGee, and Tertilt 2007); these costs reflect the calculations in Fay, Hurst, and White (1998) that a large measure of households would have "financially benefited" from filing for bankruptcy but did not. Furthermore, Gross and Souleles (2002) and Fay, Hurst, and White (1998) document significant unexplained variability in the probability of default across households, even after controlling for a large number of observables. These papers suggest the presence of implicit unobserved collateral that is heterogeneous across households; λ reflects any such unobserved collateral, including (but not limited to) the stigma associated with bankruptcy. However, it also reflects a large number of other costs that are not explicitly pecuniary in nature (as in Athreya 2002), such as the added search costs associated with renting apartments when one does not have clean credit.

The household budget constraint during working age is given by

$$c_j + q(b_j, I) b_j + \Delta \mathbf{1}(d_j = 0) \leq a_j + (1 - \tau) W \omega_{j,y} y e \nu, \quad (2)$$

where q is an individual-specific bond price that depends on bond issuance b_j and a vector of individual characteristics I , a is net worth, Δ is the pecuniary cost of filing for bankruptcy, and the last term is after-tax current income. Log labor income is the sum of five terms: the aggregate wage index W , a permanent shock y realized prior to entry into the labor market, a deterministic age term $\omega_{j,y}$, a persistent shock e that evolves as an AR(1)

$$\log(e') = \rho \log(e) + \epsilon', \quad (3)$$

and a purely transitory shock $\log(\nu)$. Both ϵ and $\log(\nu)$ are independent mean zero normal random variables with variances that are y -dependent. The budget constraint during retirement is

$$c_j + q(b_j, I) b_j \leq a + \theta W \omega_{j^*-1, y} y e_{j^*-1} \nu_{j^*-1} + \Theta W, \quad (4)$$

where for simplicity we assume that pension benefits are composed of a fraction $\theta \in (0, 1)$ of income in the last period of working life plus a fraction Θ of average income (which is normalized 1). Because bankruptcy is not a retiree phenomenon, we deliberately keep the specification of retirees simple. There do not exist markets for insurance against income or survival risk and we abstract from any sources of long-run growth.

The survival probabilities $\psi_{j,y}$ and the deterministic age-income terms $\omega_{j,y}$ differ according to the realization of the permanent shock. We interpret y as differentiating between non-high school, high school, and college education levels, as in Hubbard, Skinner, and Zeldes (1994), and the differences in these life-cycle parameters will generate different incentives to borrow across types. In particular, college workers will have higher survival rates and a steeper hump in earnings; the second is critically important as it generates a strong desire to borrow early in the life cycle, exactly when default is highest. We abstract away from any connection between type and family size.⁹ The lifecycle aspect of our model is key – in the data, defaults are skewed toward young households (who borrow at least in part for purely intertemporal reasons).

2006) and abstracting away from it will bias the outcomes in the model. We do not introduce elastic labor supply into the model because the actual ability of households to use variations in labor hours to smooth consumption is unclear.

⁹Stochastic mortality and age-dependent family size do not play an important role in our model, but we keep them so as not to bias our estimates of the parameters of the model in systematic ways.

2.1.1 Recursive Formulation

The recursive version of the household problem is useful for understanding the default decision. A household of age j with good credit $m = 0$ solves the dynamic problem

$$v(a, y, e, \nu, \lambda, j, m = 0) = \max_{b, d(e', \nu', \lambda') \in \{0, 1\}} \left\{ \begin{array}{l} \frac{n_j}{1-\sigma} \left(\frac{c_j}{n_j} \right)^{1-\sigma} + \beta \psi_{j,y} \sum_{e', \nu', \lambda'} \pi_e(e'|e) \pi_\nu(\nu') \pi_\lambda(\lambda'|\lambda) \\ \times \left[\begin{array}{l} (1-d(b, e', \nu', \lambda')) v(b, y, e', \nu', \lambda', j+1, m'=0) + \\ d(b, e', \nu', \lambda') v^D(0, y, e', \nu', \lambda', j+1, m'=1) \end{array} \right] \end{array} \right\} \quad (5)$$

where

$$v^D(0, y, e', \nu', \lambda', j+1, m'=1) = \left\{ \begin{array}{l} \frac{n_j}{1-\sigma} \left(\frac{c_j}{n_j} \right)^{1-\sigma} - \lambda + \beta \psi_{j,y} \sum_{e', \nu', \lambda'} \pi_e(e'|e) \pi_\nu(\nu') \pi_\lambda(\lambda'|\lambda) \\ \times \left[\begin{array}{l} \xi v(a', y, e', \nu', \lambda', j+1, m'=0) + \\ (1-\xi) v(a', y, e', \nu', \lambda', j+1, m'=1) \end{array} \right] \end{array} \right\} \quad (6)$$

is the value of default; note that households cannot borrow or save during the period in which they declare bankruptcy. A household that is currently flagged with bad credit $m = 1$ solves the problem

$$v(a, y, e, \nu, \lambda, j, m = 1) = \max_{b, d(e', \nu', \lambda') \in \{0, 1\}} \left\{ \begin{array}{l} \frac{n_j}{1-\sigma} \left(\frac{c_j}{n_j} \right)^{1-\sigma} + \beta \psi_{j,y} \sum_{e', \nu', \lambda'} \pi_e(e'|e) \pi_\nu(\nu') \pi_\lambda(\lambda'|\lambda) \\ \times \left[\begin{array}{l} \xi \left[\begin{array}{l} (1-d(b, e', \nu', \lambda')) v(b, y, e', \nu', \lambda', j+1, m'=0) + \\ d(b, e', \nu', \lambda') v^D(0, y, e', \nu', \lambda', j+1, m'=1) \end{array} \right] + \\ (1-\xi) \left[\begin{array}{l} (1-d(b, e', \nu', \lambda')) v(b, y, e', \nu', \lambda', j+1, m'=1) + \\ d(b, e', \nu', \lambda') v^D(0, y, e', \nu', \lambda', j+1, m'=1) \end{array} \right] \end{array} \right] \end{array} \right\} \quad (7)$$

In each period the household initially makes a consumption-savings decision (c, b) , where b is the amount of borrowing/saving. The household also makes a conditional default decision $d(b, e', \nu', \lambda')$ that equals 1 if the household declares bankruptcy in the event that next period's shocks are (e', ν', λ') and 0 otherwise. The parameter $\xi \in (0, 1)$ governs the likelihood of the bad credit market disappearing tomorrow. Under partial information, the price charged a household for issuing debt will in general depend on m , so that households with recent defaults will receive different credit terms than households with 'clean' credit. The probabilistic removal of this marker captures the effect of current regulations requiring that a bankruptcy filing disappear from one's credit score after 10 years and agents are prohibited from declaring Chapter 7 bankruptcy more than once every 7 years.¹⁰

2.2 Loan Pricing

We focus throughout on competitive lending. There exists a competitive market of intermediaries who offer one-period debt contracts and utilize available information to offer individualized credit pricing. Let I denote the information set for a lender and $\hat{\pi}^b: b|I \rightarrow [0, 1]$ denote the function that assigns a probability of default to a loan of size b given information I . $\hat{\pi}^b$ is identically zero for positive levels of net worth and is equal to 1 for some sufficiently large debt level. The break-even

¹⁰Some households in our model will declare bankruptcy more than once every 7 years. Since households in the US economy also have the option to declare Chapter 13 and typically do not have many assets to be seized, we do not think that this outcome is too unreasonable. Keeping track of the number of periods since a filing is too computationally burdensome.

pricing function must satisfy

$$q(b, I) = \begin{cases} \frac{1}{1+r} & \text{if } b \geq 0 \\ \frac{(1-\hat{\pi}^b)\psi_j}{1+r+\phi} & \text{if } b < 0 \end{cases} \quad (8)$$

given $\hat{\pi}^b$. r is the exogenous risk-free saving rate and ϕ is a transaction cost for lending, so that $r + \phi$ is the risk-free borrowing rate; the pricing function takes into account the automatic default by those households that die at the end of the period. With full information, a variety of pricing arrangements will lead to the same price function. However, as is well known (Hellwig 1990), under asymmetric information settings outcomes often depend on the particular “microstructure” being used to model the interaction of lenders and borrowers. Under full information our approach is completely standard (see Chatterjee *et al.* 2007 or Livshits, MacGee, and Tertilt 2006), as we employ a setting that delivers to households a function $q(b, y, e, \nu, j, m) : b \rightarrow \left[0, \frac{1}{1+r}\right]$ that they can take parametrically when optimizing; the compactness of the range for q implies that the household problem has a compact opportunity set and therefore possesses a solution.

We now detail explicitly the microstructure that underlies our pricing function, which we model as a two-stage game between borrowers and lenders. In the first stage, borrowers name a level of debt b that they wish to issue. Second, a continuum of lenders compete in an auction where they simultaneously post a price for the desired debt issuance of the household and are committed to delivering the amount b in the event their ‘bid’ is accepted; that is, the lenders are engaging in Bertrand competition for borrowers. In equilibrium borrowers choose the lender who posts the lowest interest rate (highest q) for the desired amount of borrowing. Thus, households view the pricing functions as schedules and understand how changes in their desired borrowing will alter the terms of credit (that is, they know $D_b q(b, I)$) because they compute the locus of Nash equilibria under price competition. Exactly how the pricing function depends on the components in I will be specified next. We defer a formal statement of equilibrium until after our discussion of q .

2.2.1 Full Information

In the full information case, I includes all components of the household state vector: $I = (a, y, e, \nu, \lambda, j, m)$. Zero profit for the intermediary requires that the probability of default used to price debt must be consistent with that observed in the stationary equilibrium, implying that

$$\hat{\pi}^b = \sum_{e', \nu', \lambda'} \pi_e(e'|e) \pi_\nu(\nu') \pi_\lambda(\lambda'|\lambda) d(b(a, y, e, \nu, \lambda, j, m), e', \nu', \lambda'). \quad (9)$$

Since $d(b, e', \nu', \lambda')$ is the probability that the agent will default in state (e', ν', λ') tomorrow at debt level b , integrating over all such events *tomorrow* is the relevant default risk. This expression also makes clear that knowledge of the persistent component e is critical for predicting default probabilities; the more persistent e is, the more useful it becomes in assessing default risk.¹¹ With partial information we will need to integrate over current states as well as future ones, since pieces of the state vector will not be observable.

2.2.2 Partial Information

The main innovation of this paper is to take a first step in evaluating the consequences of changes in the information available for predicting default risk on one-period debt. Default risk, in turn, arises

¹¹We leave as future work the case where neither borrowers nor lenders know how to decompose their income changes, as in the original permanent income model of Friedman (1957).

from a combination of indebtedness and the risk associated with future income. Under asymmetric information, we make an anonymous markets assumption: no past information about an individual (other than their current credit market status m) can be used to price credit. This assumption rules out the creation of a credit score that encodes past default behavior through observed debt levels; since income shocks are persistent, past borrowing would convey useful information, although it is an open question how much. Given the difficulties encountered by other researchers in dealing with dynamic credit scoring, we think it useful to consider an environment for which we can compute equilibria.¹²

Partial information in our economies will manifest itself through the observability of the stochastic elements of the household state vector. We maintain the assumption throughout that age and education are observable and that total income and the transitory and persistent components of income are not.¹³ In addition, we do not let lenders observe the current net worth of the borrower, total current income, and the current stigma cost. Therefore, we have $I = (y, j, m)$ (with (a, e, ν, λ) not observed).¹⁴ Since the observables (age and education) are slow-moving components of the individual state vector, our assumptions avoid overstating the power of adverse selection to unravel credit market arrangements.¹⁵

The first concern for solving the partial information economy is that lenders must hold beliefs over the probability of an individual being in a particular state (e, ν, λ) given *whatever* is observed, knowing also that what is observed is a function of lenders' *a priori* beliefs; that is, beliefs must satisfy a fixed point condition. Let $\Pr(e, \nu, \lambda | b, y, j, m)$ denote the probability that an individual's shock vector in any period takes a given value (e, ν, λ) , conditional on observing the size of borrowing, the permanent shock, age, and credit status. Given this assessment, the lender can compute the likelihood of default on a loan of size b :

$$\hat{\pi}^b = \sum_{e, \nu, \lambda} \left[\sum_{e', \nu', \lambda'} \pi_e(e' | e) \pi_\nu(\nu') \pi_\lambda(\lambda' | \lambda) d(b, e', \nu', \lambda') \right] \Pr(e, \nu, \lambda | b, y, j, m). \quad (10)$$

In a stable environment with a small number of creditors, or one with an efficient technology for information sharing, intermediaries must form beliefs that incorporate everything they either know or can infer from observables; competitors who exploit this information may be able to 'cream-skim' the best borrowers away from those who form beliefs in any other way.¹⁶ We view the partial information setting as a natural analogue to the conditions that prevailed in the early 1980s, for reasons that will become clear later. Figure (4) illustrates the inference problem of the intermediary – for a given level of borrowing there may exist several different individuals who could be issuing that b . $\Pr(e, \nu, \lambda | b, y, j, m)$ assigns a probability to each of these types based on knowledge of the decision rules of agents.

In the partial information environment the calculation of $\Pr(e, \nu, \lambda | b, y, j, m)$ is nontrivial, because it involves the distribution of endogenous variables. First, let the invariant distribution

¹²See Chatterjee, Corbae, and Ríos-Rull (2006b).

¹³Again, we note that regulatory restrictions prohibit the use of age in determining credit terms, at least in the unsecured credit market, along with race and gender. We study the possibility that types are unobserved in a companion paper, which focuses on estimating the costs of such regulations.

¹⁴We separate b from I even though b is observable because the borrower takes the derivative of q with respect to b and it is therefore more convenient to make it a separate argument.

¹⁵We briefly examined a case where total indebtedness is also not observed; since the game underlying that arrangement is considerably more difficult to specify, we leave a complete study of that economy to future work. Our preliminary results suggest that default actually rises under partial information, making that setup inconsistent with empirical observations.

¹⁶This point is related to the extensive survival literature, which investigates whether agents who form beliefs that deviate from rational expectations can survive in asset markets.

over states be denoted by $\Gamma(a, y, e, \nu, \lambda, j, m)$. In a stationary equilibrium the joint conditional probability density over shocks (e, ν, λ) must be given by

$$\Pr(e, \nu, \lambda | b, y, j, m) = \int_a \Gamma(a = f(b, y, e, \nu, \lambda, j, m), y, e, \nu, \lambda, j, m), \quad (11)$$

where f is the inverse of g with respect to the first argument wherever $\Gamma(a, y, e, \nu, \lambda, j, m) > 0$; that is,

$$a = f(b, y, e, \nu, \lambda, j, m)$$

and

$$b = g(a, y, e, \nu, \lambda, j, m).$$

Thus, the decision rule of the household under a given pricing scheme is inverted to infer the state conditional on borrowing. Using this function the intermediary then integrates over the stationary distribution of net worth, conditional on observables, and uses this density to formulate beliefs.

It is possible that intermediaries in the partial information world would find it profitable to offer a menu of contracts and separate types (meaning agents with different realizations of the shocks (e, ν, λ)) in this manner. We restrict attention to the pure signaling model, which is not only tractable but also consistent with the relative homogeneity of unsecured loan contracts prior to 1990, and thus do not permit screening through multiple contracts.¹⁷

2.2.3 Off-Equilibrium Beliefs

In addition to ensuring that pricing reflects equilibrium information transmission, the second key complication present under asymmetric information is how to assign beliefs about a household's state for values of the state *not* observed in equilibrium. That is, how should lenders assign beliefs regarding repayment by households where $\Gamma(a, y, e, \nu, \lambda, j, m) = 0$? This issue matters because a household's decision on the equilibrium path depends on its understanding of lender behavior at *all* feasible points in the state space, including those that never arise. Our theory does not restrict off-equilibrium beliefs in a clear way, since we require only zero profit on the equilibrium path, so we must specify a rule for off-equilibrium outcomes. Given the proliferation of equilibria typically present in signaling models, we want to discipline this choice as tightly as possible.

The assignment of off-equilibrium beliefs turns out to be closely related to the algorithm we use to compute equilibria. Our algorithm is iterative – we guess pricing functions, compute implied default rates, recompute pricing functions based on the new default rates, and iterate to convergence. The critical choice of the algorithm is therefore the initial pricing function and the rule for updating. We assign the initial off-equilibrium beliefs in order to minimize the effects on equilibrium outcomes; specifically, we begin by guessing a pricing function q^0 with the following properties: it is constant at the risk-free borrowing rate $\frac{1}{1+r+\phi}$ over the range $[0, b_{\min})$, where b_{\min} is a debt level such that no agent could prevent default if they borrowed that much, and then drops to 0 discontinuously. The implied beliefs for the intermediary are such that default never occurs except when it *must* in every state of the world; this assumption has the appeal that it is very weak requirement, as no equilibrium pricing function could possibly permit more borrowing.

¹⁷Modelling the game as signaling rather than screening is significantly easier. In a screening game the uninformed players (the lenders) move first, and then we would need to check deviations in the infinite-dimensional space of alternative pricing functions. Here the informed players (the borrowers) move first and we only need to check deviations in the space of borrowing levels. Because we let the borrower solve out for the schedule of prices faced for any given borrowing amount, these deviations are checked implicitly by simply solving the household optimization problem. Sánchez (2008) models the screening game; he obtains some homogeneity by assuming that the cost of a screening contract is too high in the earlier period for it to be used.

Since our algorithm will generate a monotone mapping over pricing functions, it is imperative that we begin with this function if we are to avoid limiting credit opportunities unnecessarily. It is useful to compare our initial pricing function with the natural borrowing limit, the limit implied by requiring consumption to be positive with probability 1 in the absence of default. Our initial debt limit is larger than the natural borrowing limit, as agents can use default to keep consumption positive in some states of the world; we only require that they not need to do this in every state of the world.¹⁸ We also restrict attention to weakly monotone functions, for reasons to be detailed below.

2.2.4 Equilibrium

We now formally define an equilibrium for the game between borrowers and lenders. We denote the state space for households by $\Omega = \mathcal{B} \times \mathcal{Y} \times \mathcal{E} \times \mathcal{V} \times \mathcal{L} \times \mathcal{J} \times \{0, 1\} \subset \mathcal{R}^4 \times \mathcal{Z}_{++} \times \{0, 1\}$ and space of information as $\mathcal{I} \subset \mathcal{Y} \times \mathcal{E} \times \mathcal{V} \times \mathcal{L} \times \mathcal{J} \times \{0, 1\}$.

Definition 1 *A Perfect Bayesian Equilibrium for the credit market consists of (i) household strategies for borrowing $b^* : \Omega \rightarrow \mathcal{R}$ and default $d^* : \Omega \times \mathcal{E} \times \mathcal{V} \rightarrow \{0, 1\}$ and intermediary strategies for lending $q^* : \mathcal{R} \times \mathcal{I} \rightarrow \left[0, \frac{1}{1+r}\right]$ and (ii) beliefs about the borrower state Ω given borrowing $\mu^*(\Omega|b)$, that satisfy*

1. **Lenders optimize:** *Given beliefs $\mu^*(\Omega|b)$, q^* is the pure-strategy Nash equilibrium under price competition.*
2. **Households optimize:** *Given prices $q^*(b, I)$, b^* solves the household problem.*
3. **Beliefs are consistent with Bayes' rule:** *The stationary joint density of Ω and b , $\Gamma_{\mu^*}(\Omega, b)$, that is induced by (i) lender beliefs and the resultant optimal pricing, (ii) household optimal borrowing strategies, and (iii) the exogenous process for earnings shocks and mortality, is such that the associated conditional distribution of Ω given b , denoted $\Gamma_{\mu^*}^b(b)$, is $\mu^*(\Omega|b)$.*
4. **Off-Equilibrium Beliefs:** *$q^*(b, I) = 0 \forall b$ such that $\Gamma_{\mu^*}^b(b) = 0$ and $q^*(b, I)$ is weakly decreasing in b .*

If our shocks are continuous random variables, the debt levels that get zero weight in the stationary distribution are those above and below any levels that get positive weight (Γ has a connected support); with discrete random variables we do not get connectedness, but we solve the model as if it obtained. Obviously, for default decisions the upper limit is irrelevant; thus, as noted above, we are imposing a belief about the behavior of agents who borrow more than *any* agent would in equilibrium, no matter what unobserved state they are currently in. Given that q is weakly decreasing in b , the natural assumption is that this agent intends to default with probability one.

2.2.5 Computing Partial Information Equilibria

The imposition of conditions on beliefs off-the-equilibrium path makes the computational algorithm we employ relevant for outcomes, and in this section we therefore discuss in some detail our algorithm for computing partial information competitive equilibria. The computation of the full information equilibrium is straightforward using backward induction; since the default probabilities

¹⁸This point is also made in Chatterjee *et al.* (2007).

are determined by the value function in the next period, we can solve for the entire equilibrium, including pricing functions, with one pass. The partial information equilibrium is not as simple, since the lender beliefs regarding the state of borrowers influence decisions and are in turn determined by them; an iterative approach is therefore needed.

1. Guess the initial function $q^0(b, y, j, m)$ discussed above;
2. Solve household problem to obtain $g(a, y, e, \nu, \lambda, j, m)$, $f(b, y, e, \nu, \lambda, j, m)$, and $d(e', \nu', \lambda' | a, y, e, \nu, \lambda, j, m)$;
3. Compute $\Gamma(a, y, e, \nu, \lambda, j, m)$ and $P(b, y, e, \nu, \lambda, j, m) = \Gamma(f(b, y, e, \nu, \lambda, j, m), y, e, \nu, \lambda, j, m)$;
4. Locate $b_{\min}(y, e, \nu, \lambda, j, m)$, the minimum level of debt observed conditional on the other components of the state vector;
5. Set $q^*(b \leq b_{\min}, y, j, m) = 0$ (that is, borrowing that exceeds any observed triggers default with probability 1);

6. Compute

$$\pi^d(b, y, e, \nu, \lambda, j, m) = \sum_{e'} \sum_{\nu'} \sum_{\lambda'} \pi_e(e'|e) \pi_\nu(\nu') \pi_\lambda(\lambda'|\lambda) d(e', \nu', \lambda'); \quad (12)$$

7. Compute $\Pr(e, \nu, \lambda | b, y, j, m)$ from $P(b, y, e, \nu, \lambda, j, m)$ for each (b, y, j, m) , the probability that an individual is in (e, ν, λ) given observed (b, y, j, m) ;

8. Compute

$$\hat{\pi}^d(b, y, j, m) = \sum_e \sum_\nu \sum_\lambda \pi^d(b, y, e, \nu, \lambda, j, m) \Pr(e, \nu, \lambda | b, y, j, m), \quad (13)$$

the expected probability of default for an individual in observed state (b, y, j, m) ;

9. Set

$$q^*(b, y, j, m) = \frac{(1 - \hat{\pi}^d(b, y, j, m)) \psi_j}{1 + r + \phi} \quad \text{for all } b \geq b_{\min}(b, y, j, m); \quad (14)$$

10. Set

$$q^1(b, y, j, m) = \Xi q^0(b, y, j, m) + (1 - \Xi) q^*(b, y, j, m)$$

and repeat until the pricing function converges, where Ξ is set very close to 1.

Because the household value function is continuous but not differentiable or concave, we solve the household problem on a finite grid for a , using linear interpolation to evaluate it at points off the grid. Similarly, we use linear interpolation to evaluate q at points off the grid for b . To compute the optimal savings behavior we use golden section search (see Press *et al.* 1993 for details of the golden section algorithm) after bracketing with a coarse grid search; we occasionally adjust the brackets of the golden section search to avoid the local maximum generated by the nonconcave region of the value function. To calibrate the model we use a derivative-free method to minimize the sum of squared deviations from the targets; the entire program is implemented using OpenMP instructions over 8 processors.

Let \mathcal{Q} denote the compact range of the pricing function q ; as noted above, \mathcal{Q} is a compact subset of the unit interval. Our iterative procedure maps the lattice of weakly-monotone continuous functions over \mathcal{Q} back into itself. To ensure the existence of a unique fixed point for this mapping,

we would want to establish the contraction property for this mapping; however, once the price at a particular point reaches zero it can never become positive, so the contraction property will not hold. As a result, both the initial condition and the updating scheme could matter for outcomes (since the equilibrium pricing function may not be unique). We have detailed above our approach for selecting the initial condition and the updating procedure; we then set Ξ close enough to 1 that the iterative procedure defines a monotone mapping, ensuring the existence of at least one fixed point.¹⁹ $q = 0$ is also an equilibrium under certain restrictions on lender beliefs – if no agent receives any current consumption for issuing debt no debt is issued and intermediaries therefore make zero profit; provided that their off-equilibrium beliefs are that any debt will be defaulted upon with probability 1 optimality of lender decisions is also satisfied – and is a fixed point of our iterative procedure. The key advantage of our initial condition is that it guarantees convergence to the competitive equilibrium which supports the largest amount of borrowing – formally, it generates a descending Kleene chain on the lattice.²⁰

Our interest in the equilibrium which permits the most borrowing at the lowest rates arises from the fact that such an equilibrium Pareto-dominates all the others (conditional on the monotonicity restriction). In our economy all pricing is individualized and r is effectively exogenous, meaning that the decisions of one type do not impose pecuniary externalities on any other type. Thus, we can analyze the efficiency of an allocation individual-by-individual (in an *ex ante* sense). For any individual, the outcome under q^0 dominates any other, whether they exercise the default option or not, because it maximizes the amount of consumption-smoothing that an individual could achieve. Since q is a monotone-decreasing function of b , it follows that any allocation which generates higher q for each b dominates one with lower q ; that is, $q_1 \succeq q_2$ implies that allocation 1 Pareto-dominates allocation 2. Since $q = 0$ is the “worst” equilibrium in the sense that no borrowing is permitted at all, any equilibrium with positive borrowing at finite rates must yield higher *ex ante* social welfare.

2.3 Special Households

It is well known (e.g. Budría Rodríguez *et al.* 2002) that within a very broad class on consumption-savings models, labor income processes estimated from panel data are incapable of generating the extremely high degree of wealth concentration observed in the data. Specifically, parameters that allow the model to match average wealth will typically lead to counterfactually high wealth levels for most households. Because we wish to accurately accommodate debt use and the general equilibrium effects arising from changes in information, we require our model to capture both wealth concentration *and* overall wealth levels. We therefore posit a class of ‘special’ households of measure μ_s who face neither idiosyncratic risk nor financial market frictions and therefore earn a higher rate of return on savings. In equilibrium, these households will generate high concentrations of wealth and will never default. Their present-value budget constraint is

$$\sum_{j=1}^J \left(\frac{1}{1 + MPK - \delta} \right)^{j-1} c_j = A_1$$

¹⁹Our results are the same if we set $\Xi \in [0.95, 0.999]$. Due to the slow updating the program typically takes several days to converge.

²⁰We know of no conditions that guarantee the existence of a fixed point other than $q = 0$; because $\Delta > 0$, our equilibria always satisfy $q > 0$. Kleene chains are discussed in Kleene (1952).

where lifetime wealth is given by

$$A_1 = k_1 + \sum_{j=1}^{j^*-1} \left(\frac{1}{1+MPK-\delta} \right)^{j-1} (1-\tau) wy\omega_{j,y} + \left(\frac{1}{1+MPK-\delta} \right)^{j^*-1} \sum_{j=j^*}^J \left(\frac{1}{1+MPK-\delta} \right)^{j-j^*-1} (\theta wy\omega_{j^*-1,y} + \Theta);$$

we assume that special households are drawn from the measure of college types only. We set preferences to logarithmic for these households. These assumptions imply that we can solve for their decisions analytically:

$$\begin{aligned} c_1 &= \frac{1-\beta_s}{1-\beta_s^J} A_1 \\ c_j &= \beta_s^j (1+MPK-\delta)^{j-1} c_1. \end{aligned}$$

Capital holdings are then given by the budget constraint at each age:

$$k_{j+1} = (1+MPK-\delta)k_j + (1-\tau)wy\omega_{j,y} - \frac{1-\beta_s}{1-\beta_s^J} \beta^{j-1} (1+MPK-\delta)^j A_1.$$

The presence of the special households means that the risk-free rate is almost independent of bankruptcy policy.

2.4 Government

The only purpose of government in this model is to fund pension payments to retirees. The government budget constraint is

$$\begin{aligned} & \tau(1-\mu_s)W \int y\omega_{j,y} e\nu\Gamma(a,y,e,\nu,\lambda, j < j^*, m) + \tau \frac{\mu_s}{J} W \sum_{j=1}^{j^*-1} y\omega_{j,y} \\ &= (1-\mu_s)W \int (\theta\omega_{j^*-1,y} ye_{j^*-1} \nu_{j^*-1} + \Theta) \Gamma(a,y,e,\nu,\lambda, j \geq j^*, m) + \frac{\mu_s}{J} W \sum_{j=1}^{j^*-1} (\theta\omega_{j^*-1,y} y + \Theta). \end{aligned}$$

2.5 Production Firms

A continuum of production firms rent capital and labor to produce output using the technology

$$Y = K^\alpha N^{1-\alpha} - \delta K.$$

Due to constant returns to scale these firms earn zero profit and we can normalize the number of firms to 1.

2.6 Market Clearing

The market for loans clears when the risk-free saving rate equals the marginal product of capital net of depreciation δ :

$$r = \alpha K^{\alpha-1} N^{1-\alpha} - \delta - \vartheta,$$

where ϑ is an intermediation cost that applies to both saving and borrowing. Total capital is the unique positive solution to

$$K = \frac{1 - \mu_s}{1 + \alpha K^{\alpha-1} N^{1-\alpha} - \delta - \vartheta} \int b(a, y, e, \nu, \lambda, j, m) \Gamma(a > 0, y, e, \nu, \lambda, j, m) + \frac{1 - \mu_s}{1 + \alpha K^{\alpha-1} N^{1-\alpha} - \delta - \vartheta + \phi} \int \left(1 - \pi^b(a, y, e, \nu, \lambda, j, m)\right) b(a, y, e, \nu, \lambda, j, m) \Gamma(a < 0, y, e, \nu, \lambda, j, m) + \frac{\mu_s}{J} \sum_{j=1}^J k_j$$

where

$$N = (1 - \mu_s) \int y \omega_{j,y} e \nu \Gamma(a, y, e, \nu, \lambda, j, m) + \frac{\mu_s}{J} \sum_{j=1}^{j^*-1} y \omega_{j,y}$$

is total labor input and $\alpha \in (0, 1)$ is the elasticity of output with respect to capital. The labor market clears when the aggregate wage index equals the marginal product of labor:

$$W = (1 - \alpha) K^\alpha N^{-\alpha}.$$

Finally, the goods market clears when total consumption plus total transactions costs equals total output less depreciation:

$$\begin{aligned} C &= (1 - \mu_s) \int c \Gamma(a, y, e, \nu, \lambda, j, m) + \frac{\mu_s}{J} \sum_{j=1}^J c_j \\ T &= (1 - \mu_s) \int [\phi \mathbf{1}(b < 0) b + \Delta \mathbf{1}(m = 0, m' = 1) + \vartheta b] \Gamma(a, y, e, \nu, \lambda, j, m) \\ C + T &= K^\alpha N^{1-\alpha} - \delta K, \end{aligned}$$

where $\mathbf{1}(A)$ is the indicator function for set A . This expression can be obtained by summing over the budget constraints and imposing the optimality conditions for intermediaries and production firms; by Walras' law we can ignore it.

3 Calibration

We set $\sigma = 2$. We set $\theta = 0.35$ at an exogenous retirement (model) age of 45 and $\Theta = 0.2$, yielding an overall replacement rate around 55 percent. The income process is taken from Hubbard, Skinner, and Zeldes (1994), which estimates separate processes for non-high school, high school, and college-educated workers for the period 1982-1986. Figure (5) displays the path for $\omega_{j,y}$ for each type; the large hump present in the profile for college-educated workers implies that they will want to borrow early in life to a greater degree than the other types will (despite their effective discount factor being somewhat higher due to higher survival probabilities). The process is discretized with 15 points for e and 3 points for ν . The resulting processes are

$$\begin{aligned} \log(e') &= 0.95 \log(e) + \epsilon' \\ \epsilon &\sim N(0, 0.033) \\ \log(\nu) &\sim N(0, 0.04) \end{aligned}$$

for non-high school agents,

$$\begin{aligned}\log(e') &= 0.95 \log(e) + \epsilon' \\ \epsilon &\sim N(0, 0.025) \\ \log(\nu) &\sim N(0, 0.021)\end{aligned}$$

for high school agents, and

$$\begin{aligned}\log(e') &= 0.95 \log(e) + \epsilon' \\ \epsilon &\sim N(0, 0.016) \\ \log(\nu) &\sim N(0, 0.014)\end{aligned}$$

for college agents; the measures of the three groups are 15, 58, and 22 percent, respectively, and the measure of special agents is $\mu_s = 0.05$.²¹ We set $\phi = \vartheta = 0.03$ to generate a 6 percent spread between risk-free saving rates received by normal households and the risk-free borrowing rate.²² Δ is set equal to 0.03; if one unit of model output is interpreted as \$40,000 – roughly median income in the US – then the filing cost is equal to \$1200.²³ Finally, $\xi = 0.25887$ implies that 95 percent of households who do not file for bankruptcy again will have clean credit after 10 years.

For λ , we employ a two-state Markov chain for the non-pecuniary cost of default with realizations $\{\lambda_1, \lambda_2\}$ and transition matrix

$$\Pi_\lambda = \begin{bmatrix} \pi & 1 - \pi \\ 1 - \pi & \pi \end{bmatrix}.$$

If $\pi > 0.5$, the underlying stigma cost is persistent; symmetry implies that the measure of households with each value of λ is 50 percent.

We calibrate the parameters $(\beta, \lambda_1, \lambda_2, \beta_s, \pi, \alpha, \delta)$ to match seven targets: a measure of borrowers equal to 12.5 percent, an aggregate negative net worth to GDP ratio of 1.41 percent, a bankruptcy filing rate of 1.2 percent, a median discharge to median income ratio for filers of 56 percent, a risk-free saving rate of 1 percent, a 70 percent labor income share, and an annual depreciation rate of 10 percent. We identify debt with negative net worth in the model, an assumption which requires some defense. As noted above, in the data (as well as in the model), defaults are largely the province of the young (Sullivan, Warren, and Westbrook 2000); young households also have few gross assets, implying that negative net worth and unsecured debt largely coincide. Thus, our target captures the financial position of those households who are important for default empirically. The value for the ratio of negative net worth to GDP is taken from Sánchez (2008); we exclude the self-employed and consider both credit cards and installment loans as unsecured debt. For the measure of borrowers, we roughly average the numbers from Chatterjee *et al.* (2007) – 6.7 percent – and Wolff (2004) – 17.6 percent to get a ballpark measure of 12.5 percent.

Our target for bankruptcy is consistent with a model in which only income is uncertain; that is, there are no shocks to expenses. Expense shocks create involuntary creditors that allow households to suddenly acquire very large debts with no corresponding change in measured consumption. The difficulties in measuring rare “catastrophic” shocks, their true “uninsurability” (for example, Medicare and emergency rooms are always available to deal with medical shocks), and their persistence can lead to a serious mismeasurement of the role of credit use and bankruptcy for managing income

²¹Recall that all special agents are college-educated types, so the total measure of college agents is 20 percent. We normalize units of measurement such that $N = 1$.

²²The spread between saving rates and capital returns is thus equal to 3 percent, consistent with transactions costs measured by Evans and Schmalensee (1999).

²³This cost is an estimate inclusive of filing fees, lawyer costs, and the value of time.

risk. Furthermore, White (2007) casts some doubt on the evidence that such shocks contribute significantly to observed bankruptcy rates, and Sullivan, Warren, and Westbrook (2000) report that at most one-fifth of filers report that health played *some* role in their decision to file. We therefore calibrate the model’s bankruptcy target to be net of this measure. Using an overall filing rate of 1.5 percent, our target becomes 1.2 percent. The median discharge to median income ratio that we use identifies negative net worth with discharged debt and is taken from Sullivan, Warren, and Westbrook (2000).

The resulting calibrated parameter values are listed in Table (1), along with all other parameters for the convenience of the reader. Special households are marginally more patient than normal ones; they hold almost 20 percent of total wealth based largely on their comparative advantage in savings returns. λ is fairly persistent – importantly, because households only borrow in the unsecured credit market for a relatively short period early in their life, their λ rarely changes over the relevant horizon. Highly-persistent λ values generate significant discharge in the model, and indicate the presence of highly persistent characteristics that implicitly collateralize borrowing. We discuss the role of λ more completely below.

4 Results

This section is divided into four subsections. The first two examine the equilibria under full and partial information, with particular attention devoted to the facts regarding debt, bankruptcy, and discharge. The third and fourth compute measures of consumption smoothing and welfare and compare them across information settings.

4.1 Full Information

4.1.1 Aggregates

Table (1) presents the aggregate unsecured credit market statistics from the model under full information. The calibration procedure is quite successful, with one exception – the ratio of median discharge to median income is too small. We do not find this prediction to be worrisome, because we have ignored defaults driven by large expense shocks. As noted above, these shocks have only modest effects on filing rates, and we are able to target a default rate net of such considerations. Neither point holds with respect to discharge – defaults driven by large expense shocks will necessarily be large and the data that separates discharge according to the reason for filing does not exist. Furthermore, some Chapter 7 filings are for self-employed agents and these defaults tend to be large. Thus, relative to the model the data measure is biased upward.

Figure (6a) displays the pricing functions for college types at age 29 given the low value of λ ; as would be expected the higher the realization of e the more credit is available (at any given interest rate).²⁴ For low realizations of e the pricing functions look like credit lines – borrowing can occur at a fixed rate (in this case, the risk-free rate) up to some specified level of debt, after which the interest rate goes to ∞ . For higher realizations the increase in the interest rate is more gradual, meaning that some risky borrowing will occur in equilibrium; for some borrowers, the marginal gain from issuing debt is sufficiently high that they are willing to pay a default premium to do it. The pricing functions for noncollege types look similar but involve higher interest rates at any given level of debt. Similar pictures arise for older agents – they are weakly decreasing in debt with more gradual increases in interest rates for luckier agents. However, middle-aged agents (say,

²⁴The top panel plots the price functions for the lowest 5 realizations of e , the middle panel the middle 5, and the bottom panel the highest 5. ν is set to the mean value, since it plays only a limited role in the default decision.

age 45) can borrow significantly more than their younger counterparts, although they choose not to do so in equilibrium. In Figure (6b), we plot the pricing functions for the high value of λ – again as expected, high λ agents can borrow a lot more than low λ ones.

As noted above, λ plays an important role in generating empirically-reasonable median discharge to median income ratios. There are two key aspects to this process – the coefficient of variation and the persistence. If one assumes that λ is constant, uniform across households, and chosen to match the observed filing rate, the model produces only a 5 percent of discharge-income ratio and does not display the unobserved heterogeneity of filers suggested by Fay, Hurst, and White (1998); the model predicts low discharge because the uniform λ turns out to be quite small, leading to frequent but small bankruptcies. If λ differs across households but is iid, discharge rates remain too low as the average λ needs to be small. Without persistence, no household’s implicit collateral is expected to be particularly valuable in the next period and thus cannot support large debts. Thus, our calibration produces high cross-sectional dispersion and high persistence in λ in order to support relatively large discharges.

We now discuss the effects of the two main transactions costs, Δ and ϕ . As noted in Livshits, MacGee, and Tertilt (2007) and Athreya (2004), dropping transactions costs can potentially deliver the trends in the default rates and debts observed in the data, so these changes are worth examining as competitor stories. No household in the model would default on any debt $b > -\Delta$, so higher values of Δ can support larger debts in general. Changes in Δ only alter the length of the initial flat segment where risk-free borrowing is sustained (see Figure 7a). Changes in ϕ only shift the pricing functions up and down (see Figure 7b). Thus, neither change will alter the variance of interest rates that agents receive, as they affect all agents symmetrically. To get a change in the distribution of interest rates, one needs to generate changes in the slope of the pricing functions. As a result, stories that place falling transactions costs at the heart of the changes in the unsecured credit market cannot account for the homogeneity observed in the earlier period.

If we change the average λ in the economy, the effect is to move default rates and discharge levels in opposite directions (see Athreya 2004). Furthermore, changing merely the average λ delivers little change in the dispersion in the terms – it plays the same role as Δ in that it shifts the pricing left and right. Thus, changes in stigma can also be dismissed as the force driving all of the changes in the unsecured credit market.

4.1.2 Distributions

With respect to the distribution of unsecured debt, we show in Figure (8) that debts are incurred largely by college types – if they borrow, they borrow more than other groups. This larger borrowing reflects two aspects. First, college types have the most humped-shape average earnings profile. For purely intertemporal reasons they desire borrowing early in life in order to redistribute consumption. Given that the other two groups expect smaller rises in their average earnings over their lifetime, their intertemporal borrowing demand is much smaller. The second reason is that the credit market is simply more willing to permit college types to borrow, as shown in the pricing functions in Figure (6a-b) discussed above.

Figure (9) plots the lifecycle density of default for the model; consistent with empirical observations (Sullivan, Warren, and Westbrook 2000, Figure 2), default occurs mainly in the early periods of economic life because those are the periods in which agents are borrowing. Specifically, more than 70 percent of defaults are accounted for by households in which the primary petitioner is under the age of 45. In the model, default by the young is driven primarily by the hump-shape in average earnings; contrasting the non-high-school and college types shows clearly that large humps in average earnings generate a distribution of default skewed towards the young. If we remove

the hump in earnings for the college type, we observe a very low and nearly-uniform distribution of defaults over the life cycle. The model predicts that filing rates are increasing in education, so that we overstate filings by college types and underpredict those for high school types.²⁵ These anomalies suggest that the nonpecuniary costs may covary positively with education.²⁶

In addition to the age-distribution of default rates, the model predicts that the largest defaults occur in middle age. Intuitively, defaults among the very young must involve relatively small debt levels; these households will choose not to borrow large amounts if they experience good earnings shocks, will have not have had time to accumulate large debts if they have experienced moderate earnings shocks, and would not have been able to borrow large amounts had they experiences relatively bad earnings shocks. By contrast, by middle age, purely intertemporal borrowing by those who had experienced mean earnings realizations will have had time to accumulate. Therefore, if such households experience poor earnings outcomes, and choose to default, they will do so on relatively large amounts of debt.

Figure (10) shows the default distribution over the income shocks – default occurs mainly among the low to middle values for e .²⁷ Very high e households do not default because they are saving and they expect a relatively-flat profile for future income. Very low e households would default if they could manage to acquire debt; however, given the pricing functions in Figure (6), acquiring this debt is difficult because future income is flat and low so that borrowing will be followed by default under most circumstances. Because filers are generally younger households the income level for bankrupts is well below average, as in the data, even though they are not generally drawing the lowest shocks. Figure (10) also shows that the vast majority of defaults are done by low λ types. This feature is consistent with the evidence in Fay, Hurst, and White (1998) that documents a large number of individuals who would benefit *financially* from declaring bankruptcy but, for some reason, do not file. However, it also raises an important empirical issue – having results that depend critically on unobserved shocks to preferences is generally viewed suspiciously by quantitative economists (ourselves included), so some future work is being allocated to pinning down what costs λ is capturing and how they could be expected to vary over time.

4.1.3 Dispersion and Credit Sensitivity

Figure (11) is a plot of the variance of borrowing rates over the lifecycle. The dispersion in interest rates is fairly flat, despite the strong age dependence of default rates; the variance is systematically higher for the higher educated groups, since those groups are the ones who borrow and default on the equilibrium path. In the model, agents are willing to pay fair premiums for the option to default and do so. Furthermore, since all pricing is actuarially-fair with respect to default risk, agents who pose higher risk will pay higher prices to borrow. Both observations are consistent with the relatively high dispersion and sensitivity found in recent data; we show below that the partial information setting will display neither characteristic.

We now discuss the role of the credit marker m under full information, where it reveals nothing about the household beyond what is contained in the rest of the state vector. We partition the population into $m = 0$ (no record of past bankruptcy) and $m = 1$ (record of past bankruptcy)

²⁵Linfield (2006) shows that college types constitute 24 percent of households and 15.5 percent of filers, while high school types are 56 percent of households and 78 percent of filers. Sullivan, Warren, and Westbrook (2000) argue that the distribution is roughly uniform over education groups, except for the group that reports 'Some College' is overrepresented in filers (as of 1991).

²⁶That interpretation would be consistent with stigma being a primary component of λ .

²⁷The presence of the very large spike in the central panel is due to the fact that the density for ν is $\{0.167, 0.667, 0.167\}$. The defaulters in the high ν panel are have recently switched from high to low λ , accounting for the absence of high ν , high λ defaulters.

types. Table (2) displays the moments of agents conditional on having $m = 1$. Our model under full information predicts that credit scores will be correlated with credit terms – those who carry defaults on their record will pay more on average to borrow and borrow less.

Crucially, we deliver this result without resorting to exclusion. Exclusion is ex post inefficient for lenders under full information, so it cannot be justified on theoretical grounds, and the data available only show that households borrow a lot less after bankruptcy, not whether they could not borrow or could and chose not to due to unfavorable terms.²⁸ Again, we will show below that the partial information setting will not have this property.

Finally, our model predicts an average "bad borrower" cost of 3 percentage points, very close to the differences in the modal interest rates across delinquent and nondelinquent households in Figure (??). We did not target this moment in the data, so matching it is additional confirmation that our model is reasonably consistent with current facts about the credit market. We do overstate the borrowing of households after bankruptcy.

4.2 Partial Information

4.2.1 Aggregates

We now report results for the economy under partial information – to remind the reader, partial information means that the lender is not able to observe (a, e, ν, λ) nor total income. A central implication of our model is that partial information nearly eliminates the market for unsecured credit. At the level of credit aggregates, Table (3) shows our two central findings: the default rate drops to zero and unsecured borrowing declines precipitously-to nearly zero. Thinking qualitatively, the partial information setting is consistent with the early 1980s – default rates and debt were low.

Why does the credit market collapse in the economy with partial information? Consider our function q^0 above – that is, a pricing function that allows risk-free borrowing out to a level of debt that would generate default in every state of the world tomorrow; Chatterjee *et al.* (2007) refer to this level of debt as the endogenous borrowing constraint driven by a lack of commitment to repay. This pricing function cannot be an equilibrium, as high risk borrowers with debt near this level would default in at least some states of the world, creating a risk premium in lending. At the new higher interest rates low risk borrowers will borrow less, meaning that the high risk borrowers will now face even higher rates as their type is revealed. As a result, the high risk borrowers reduce their borrowing as well. This process, which is exactly the insight that we use to compute equilibria, apparently continues until the market reaches very low levels of debt and default – essentially, the bad risk types chase the good risk types all the way to zero. The thing that distinguishes good and bad credit risks in our model is the amount of borrowing they desire. Bad risk borrowers would like to borrow a lot, provided they can do so cheaply, and then default; the only way to get cheap credit is to pool with the good risk borrowers. But good risk borrowers are unwilling to pay high prices to borrow, so their borrowing is low and, ultimately, so is the borrowing of the bad risks. That is, our model displays a very strong ‘lemons’ effect.

Our main result is robust to changes in parameter values (such as the ratio of the variances of persistent and transitory shocks to income, the variance and persistence of the stigma shocks, the transactions costs for borrowing, and the risk aversion parameter) – better information always leads to more debt, more default, and more dispersion in terms. Furthermore, for settings where the partial information economy actually displays some equilibrium default – one such setting has $\Delta = 0$ – we also find that more information leads to an increase in debt discharged through bankruptcy. In no case is the size of the unsecured credit market significant.

²⁸Chatterjee *et al.* (2007) rely on the government to enforce exclusion through a moral suasion argument.

It is natural to ask what features would be needed to sustain pooling at a high level of debt; that is, what would a model need to produce in order for the partial information world to lead to more debt and default than the full information one? In a sense, this question asks whether a model such as ours is preordained to produce a strong lemons effect. What the model would need to produce is homogeneity in the “value of default” across the agents who are being pooled together; unfortunately, in a model with unobservable income shocks that homogeneity is hard to produce. Agents with good income prospects do not want to pay a premium to borrow, meaning that they are generally unwilling to remain pooled with households who value the default option highly. We admit to being uncertain precisely how to generate this homogeneity, though, and it clearly does not arise in our calibrated model.

4.2.2 Distributions

Our model makes predictions for the distribution of the increased debt arising from a move from PI to FI. Specifically, we see that it is the college educated whose behavior changes most in terms of both borrowing and bankruptcy. These households borrow most when young, and default most frequently. By contrast, the equilibrium behavior of the non-college-educated changes very little in the move from PI to FI. These predictions of the model are both supported by recent work. Sanchez (2008) shows that distribution of unsecured debts, as measured by negative net worth, changed substantially between 1983 and 2004. Specifically, he shows that the bottom 30% of the earnings distributions saw its share of total debt *shrink*. For example, the bottom decile held 24.9% of all unsecured debt in 1983, but held just 10% in 2004. Similarly, the bottom quintile’s share of debts fell by one-fourth (from 32.7% to 25%) over the same period. Moreover, given the large absolute increase in unsecured debt levels, most of the new debt was acquired by households in higher quantiles of the earnings distribution.

The intuition for the differential response across education levels to changes in information is as follows. Under PI, adverse selection limits borrowing by all groups, but this restriction on credit access affects the college-educated the most, as their mean age-earnings profiles contains the most pronounced hump across all education levels. Under FI, college-educated households access’ to credit grows, as adverse selection is mitigated, resulting in a large increase in indebtedness when young. By contrast, the nearly flat mean age-earnings profile for those without a high-school education makes them relatively less interested in borrowing under either PI or FI, except if they intend to default. Under either PI or FI, however, they will find themselves unable to borrow; in the former due to the strength of adverse selection, and in the latter, due to the pricing behavior of lenders who observe the entire household state vector.

4.2.3 Dispersion and Credit Sensitivity

With respect to dispersion in credit terms, our main finding is that under PI, every agent ends up borrowing at essentially the same interest rate. Thus, dispersion goes down as information gets worse. Figure (13) shows the pricing function across different values of (e, ν, λ) , compared to the ones obtained under full information. One clearly sees that all agents, not merely the low risk ones, are subjected to higher interest rates and lower effective credit limits under partial information. Almost all borrowing that does occur is done at the risk-free rate; since the low levels of debt observed in equilibrium are very close to the pecuniary filing cost Δ , it is almost never cost effective to exercise the option to default. Thus, at a qualitative level improvements in information appear consistent with observed trends in the credit market for both debt and default – with less information in the earlier period one would observe lower debt levels, fewer defaults, less

debt discharged per default, and more uniform terms for credit. Our quantitative model agrees with the more-stylized model in Narajabad (2007) – the better the information about the income prospects of borrowers the more default will occur. The key difference in our model relative to Narajabad (2007) is the extent to which lenders are committed to the contract. In his model borrowing may reveal information about a borrower’s type but lenders cannot alter the contract to incorporate it; in contrast, in our model lenders incorporate current borrowing into their assessment of default risk. We now show that the ability of lenders to use information revealed by borrowing decisions is critical for understanding how asymmetric information unravels the credit market.

Turning next to the sensitivity of terms to individual credit history, notice that unlike the FI settings, changes in credit status m reveal information about the borrower. However, how much information any such change contains, and in turn its effect on credit terms, depends endogenously on the strength of the adverse selection problem. Given the strong lemons problem our model displays, agents with $m = 0$ and $m = 1$ (under settings in which the PI model does have equilibrium default) end up borrowing at rates very similar to each other – both groups effectively borrow at the risk-free rate. Thus, the model under PI delivers credit terms that are insensitive to measures of credit worthiness, as documented by Edelberg (2006), Furletti (2003), and Livshits, MacGee, and Tertilt (2008). As noted above, alternative theories of rising default rates do not deliver increased dispersion of terms and increased sensitivity to individual circumstances.

4.3 Consumption Smoothing

We now turn to some of the consequences of improved information for objects that agents care about. In Figure (12) we plot the mean of log consumption over the lifecycle under the two assumptions about information. Mean consumption is lower under full information than partial information due to the transactions costs of borrowing ϕ and defaulting Δ ; when agents borrow and default more, they destroy more resources and leave themselves less wealth to finance lifetime consumption (since the risk-free rate and wage rate are basically unchanged, the present value of lifetime earnings is not affected to any significant degree). One can thus interpret ϕ and Δ as insurance premia paid for the right to borrow and introduce limited state-contingency into returns. The drop in consumption is mainly concentrated among older households.²⁹ Under FI transactions costs destroy 9.34 percent of output, while under PI this number falls to 8.88 percent; in contrast, under NBK transactions costs destroy 9.82 percent of output.

Turning to consumption volatility, we find it helpful to decompose volatility into two components:

$$V(\log(c)) = E[V(\log(c)|j)] + V(E[\log(c)|j]); \tag{15}$$

the total variance of consumption is the mean of the variances of consumption conditional on being age j plus the variance of mean consumption conditional on being age j . The first term yields a measure of *intra-temporal* smoothing – it is the average dispersion of consumption occurring within households of any given age and so provides a natural measure of “risk sharing”. The second term measures *inter-temporal* smoothing by capturing the extent to which mean consumption – which is precisely what would obtain for *all* households under complete insurance markets – evolves over the lifecycle. In Table (4) we present the aggregates for these two measures.

The variance of consumption is high early in the lifecycle because households are restricted in their ability to borrow when young, inhibiting consumption smoothing. Consumption smoothing becomes less effective for most ages under partial information because borrowing is essentially im-

²⁹A more complete discussion of consumption smoothing effects can be found in Athreya, Tam, and Young (2008).

possible; thus, the young in particular experience significant consumption fluctuations.³⁰ However, households that borrow early in life must repay debts as they age, leaving them exposed to income risk later in life. Because the partial information economy does not permit borrowing, these older households are able to smooth their consumption effectively using buffer stocks of savings accumulated earlier in life; of course, the fact that they can smooth their consumption effectively when old does not mean that they are better off in an *ex ante* sense.

This result makes clear that the tradeoff discussed in Livshits, MacGee, and Tértilt (2007) based on aggregate numbers is misleading – bankruptcy does not necessarily improve the ability to smooth consumption across states of the world at the expense of smoothing over time.³¹ Instead, it improves smoothing for some households – older ones – at the expense of younger households who cannot borrow. It also suggests that evaluating the costs of bankruptcy reform may require more general preferences that permit disentangling risk aversion from the elasticity of intertemporal substitution in consumption; we are planning a companion paper in which we extend our model to households with preferences from Epstein and Zin (1989).³²

4.4 Welfare

We conclude this section of the paper with two simple welfare calculations – how valuable was the gain in information and how does this number compare to the gain from eliminating the default option? In Table (5), the consumption equivalent C_{eq} is the percentage that consumption must be increased in each period to make newborn households indifferent between two economies, conditional on the newborn observing their permanent shock y .³³ The model suggests that the welfare costs of pooling can be significant – these costs are orders of magnitude larger than the welfare cost of business cycles, for example, even in models with incomplete markets (Krusell and Smith 2002). It is important to stress that these calculations are not the welfare gains generated by a change in policy; that calculation would require computing the transitional dynamics between steady state distributions. Given that there are only very weak general equilibrium effects at play (other than the individual pricing functions), we do not think that paying the costs of computing a transition are worth it; fortunately, the same consideration suggest that our welfare calculations will not be too inaccurate.

All newborn households are better off under full information – because the model does not feature any cross-subsidization under partial information, there is no type that suffers when information is revealed. But college types benefit much more than the other types, largely due to their desire to borrow against the much-higher income they expect later in life. Since adverse selection completely disrupts borrowing, these types gain quite a lot. It also explains why college types gain even more from the elimination of bankruptcy, since that setting permits borrowing out to the natural debt limit. Our numbers in this section, when combined with those in Table (4), show that consumption variance is a misleading indicator of welfare. While the intertemporal measure gets the right welfare ranking, the intratemporal measure does not – partial information would appear to generate the highest welfare. Thus, one needs to be careful when extrapolating from measurements of consumption volatility to measurements of welfare.³⁴

³⁰See Athreya (2008) for more details.

³¹In Athreya, Tam, and Young (2008) we provide two-period examples in which bankruptcy can inhibit or improve intertemporal smoothing and inhibit or not affect intratemporal smoothing. We find that the expected value and expected variance of income tomorrow plays an important role.

³²Nakajima (2008) considers the welfare implications of bankruptcy reform in a model with temptation preferences of the sort axiomatized by Gul and Pesendorfer (2001).

³³The welfare cost before observing y would just be the weighted average of the costs for the different types.

³⁴We are not the first to note this point; Krueger and Perri (2004) contains a long discussion of the welfare changes

Welfare gains from eliminating bankruptcy are larger when bankruptcy rates are low (partial information), because the gains of bankruptcy elimination include the gains from better information – indeed, the welfare gains are essentially additive. If bankruptcy is not an option, the information problem disappears. If a borrower cannot discharge debts, the lender does not need to know anything about them. One lesson that we take from this observation, combined with the fact that all newborns gain from information improvements, is that the recent runup in default rates should not be a public policy concern; rather than reflecting the bad faith attempts by borrowers to rid themselves of debt they should not have been able to take on in the first place, high default rates reflect the fairly-priced gambles taken by young households in an attempt to shield themselves from bad shocks early in the lifecycle.³⁵

5 Conclusion

This paper has evaluated the role played by information for the functioning of unsecured credit markets; a key technical contribution is an algorithm to compute equilibria with individualized pricing and asymmetric information. We find that the big trends in unsecured credit markets – rising debt, rising default, rising discharge, increasing dispersion of interest rates, and increasing good borrower discounts – are all consistent with an improvement in the ability of the market to observe characteristics about borrowers. Furthermore, our model makes a clear welfare statement – more information in the unsecured credit market is better for all types – and strongly suggests that the recent runup in bankruptcies is not something that policymakers should be concerned about.

In two companion papers we make use of our model and algorithm to study two questions. First, we are studying how regulatory conditions that constrain information in the credit market affect the economy; for example, the Equal Credit Opportunity Act explicitly bans the use of age, race, and gender for the determination of credit. Such bans may serve noneconomic goals, but they may also impose costs on the economy by pooling different types of borrowers together.³⁶ Second, in Athreya, Tam, and Young (2008) we ask how the dramatic increase in labor income risk impacted the use and efficiency of the unsecured credit market; as the title of that paper suggests, our key finding is that unsecured credit markets cannot function as insurance markets no matter which information regime prevails.³⁷

A feature of recent work on consumer default, including the present paper, is that it imposes a type of debt product that does not mimic all the features of a standard unsecured contract offered by the credit market. In our model, as in nearly all extant quantitative studies of bankruptcy and endogenous credit markets, individuals issue one-period bonds in the credit market. As a result, any bad outcome is immediately reflected in the terms of credit, making consumption smoothing in response to bad shocks difficult (credit tightens exactly during the period in which it is most

that rising income volatility has caused.

³⁵There is a large law and economics literature on the welfare implications of bankruptcy options; Porter and Thorne (2006) is one example with many references for the interested reader. Since those papers lack a formal model their measures of welfare commit the sin of conflating current economic condition with utility, precisely the approach we identify here as being fraught with danger.

³⁶Inference in a model with regulatory constraints is subject to more restrictions than those discussed here. Intermediaries want to form beliefs about the unobserved characteristics of borrowers, but if those inferences prove too accurate they can be fined by the regulator; that is, if the equilibrium reveals that a banned characteristic is informative about credit terms the intermediary is subject to penalties, even if the characteristic is not explicitly used, limiting the value of the sophisticated inference procedure considered here.

³⁷Empirical support for the changing variance of shocks can be found in Gottschalk and Moffitt (1994), among others. See Athreya, Tam, and Young (2008) for more references.

needed); this arrangement would seem to artificially increase the incentive for default.³⁸ In our defense, credit contracts explicitly permit repricing by the lender at will, but it is an open question the extent to which they use this option. Given that credit conditions are typically only adjusted by two events – default or entering the market to either purchase more credit or to retire existing lines – credit lines may be a more appropriate abstraction. Whether it makes a significant difference for consumption smoothing is the subject of future work.³⁹

³⁸We discuss this point in detail in Athreya, Tam, and Young (2008), as it forms the basis of our argument that credit markets cannot provide effective insurance against increased income risk.

³⁹Matteos-Planas (2007) is a recent attempt to model credit lines with homogeneous interest rates and lender commitment; Athreya (2002) is an early contribution to the same literature but with less detail. Matteos-Planas and Ríos-Rull (2007), relax the stringent requirements of commitment and homogeneity imposed in the previous papers, although their model is not yet quantitative.

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Table 1: Parameters/Calibration

Parameters				
$\sigma = 2.0000$	$\vartheta = 0.0300$	$\Delta = 0.0300$	$\lambda_2 = 0.0358$	$\Theta = 0.2000$
$\beta = 0.9823$	$\beta_s = 1.0024$	$\xi = 0.2589$	$\pi_{HH} = \pi_{LL} = 0.8668$	$\alpha = 0.3000$
$\phi = 0.0300$	$\mu_s = 0.0500$	$\lambda_1 = 1.6715$	$\theta = 0.3500$	$\delta = 0.1000$
Calibration		Model	Target	
Discharge/Income Ratio		0.2760	0.5600	
Fraction of Borrowers		0.1259	0.1250	
Debt/GDP Ratio		0.0208	0.0141	
Default Rate		1.366%	1.200%	

Parameters defined in text.

Table 2:

	$b < 0, m = 0$		$b < 0, m = 1$	
Mean	b	q	b	q
<i>Coll</i>	0.2769	0.9038	0.1243	0.8703
<i>HS</i>	0.0842	0.8490	0.0440	0.8233
<i>NHS</i>	0.0332	0.8034	0.0278	0.7306

Table 3: Unsecured Credit Market Aggregates

	FI	PI
Discharge/Income Ratio	0.2760	0.1379
Fraction of Borrowers	0.1259	0.0479
Debt/GDP Ratio	0.0208	0.0011
Default Rate	1.366%	0.000%

Table 4: Consumption Smoothing

	FI			PI		
	Coll	HS	NHS	Coll	HS	NHS
Intra	0.1134	0.1539	0.2112	0.1005	0.1518	0.2120
Inter	0.0260	0.0220	0.0221	0.0306	0.0243	0.0232
Total	0.1394	0.1759	0.2333	0.1311	0.1761	0.2352

Table 5: Change in Welfare

	Coll	HS	NHS
$PI \rightarrow FI$	0.86%	0.32%	0.13%

Figure 1: Chapter 7 Filings Per Capita

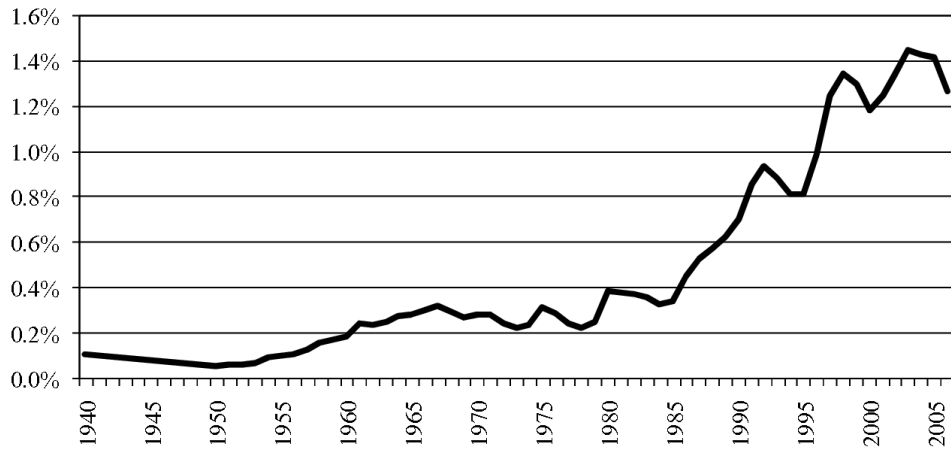


Figure 2:

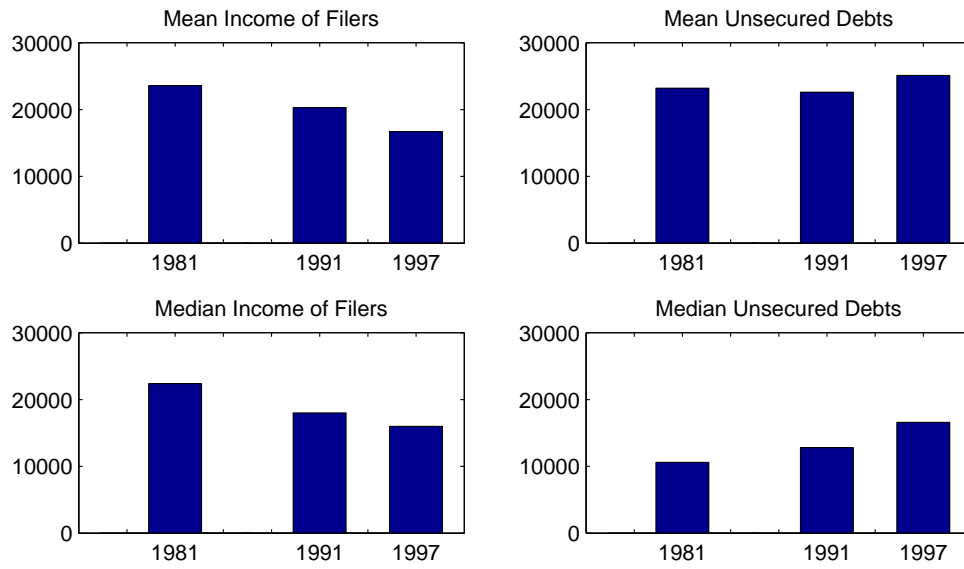


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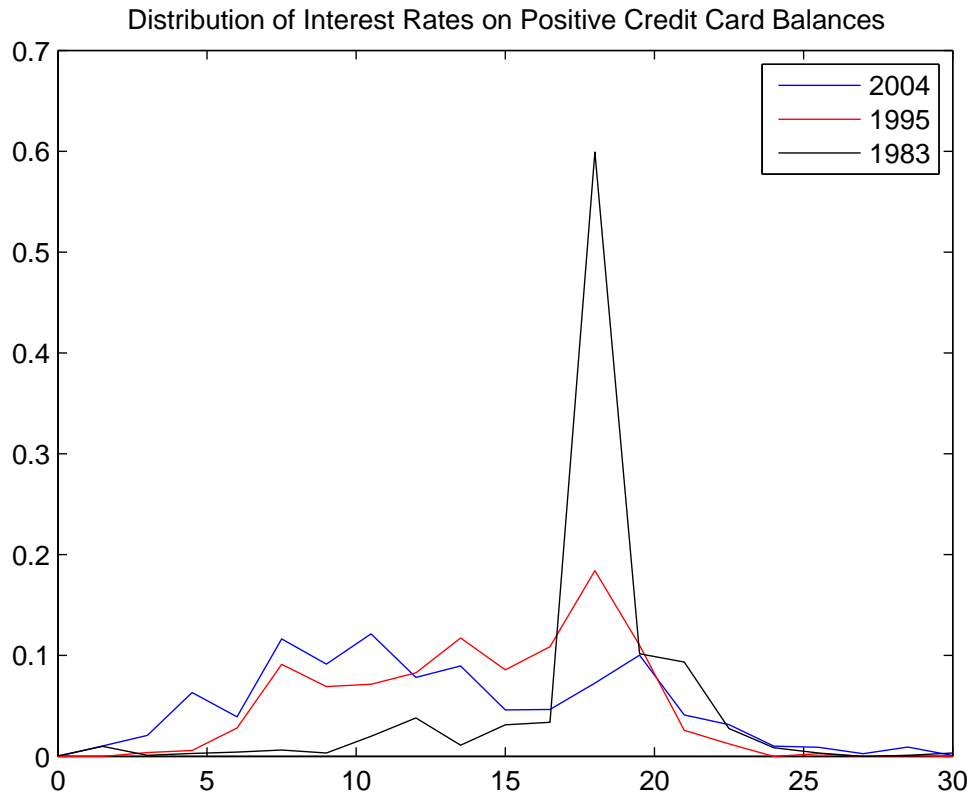


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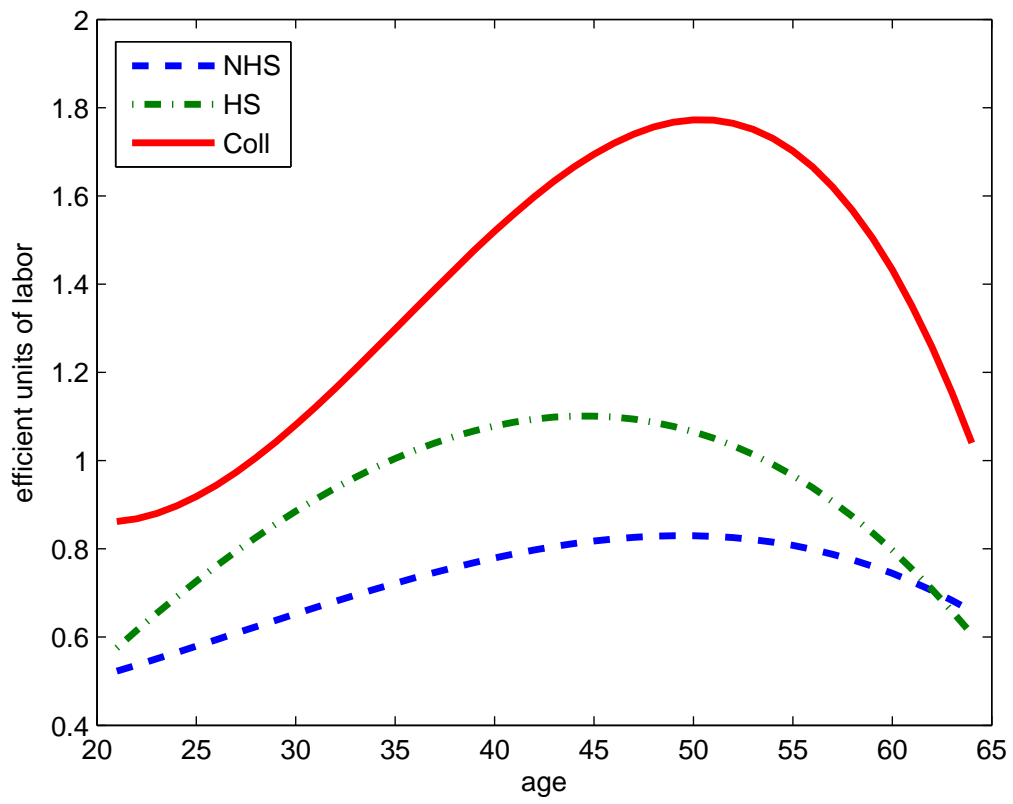
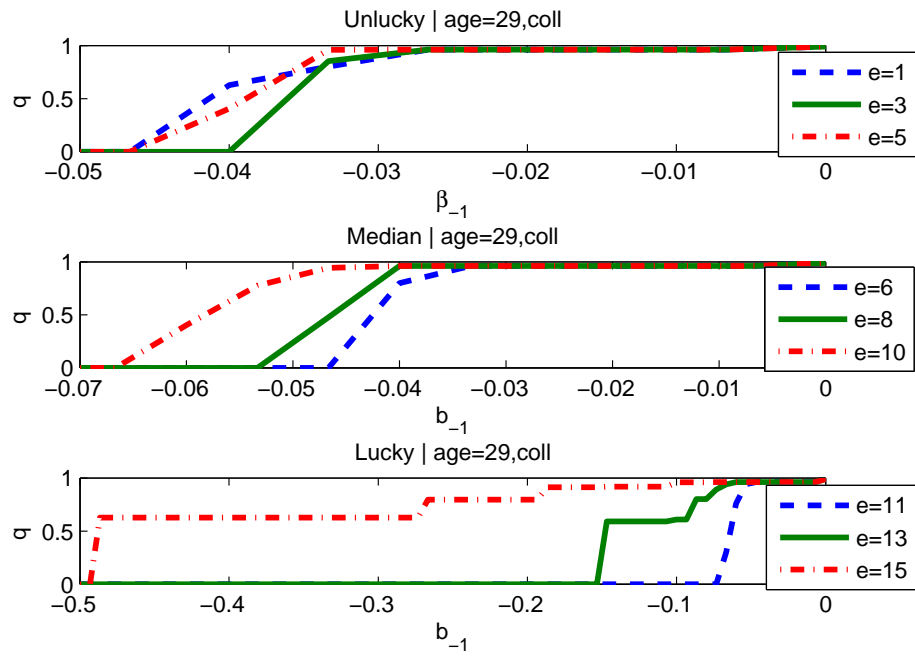
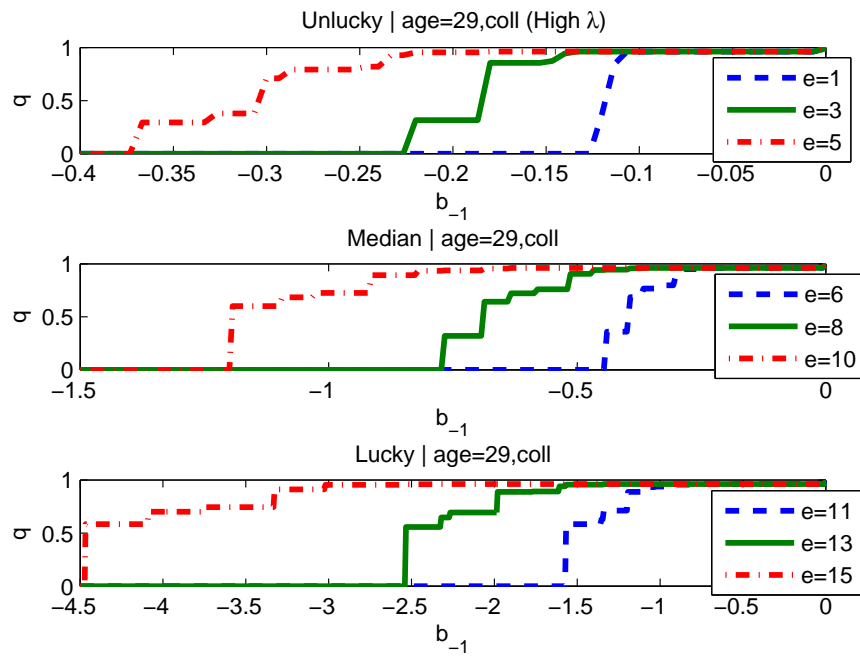


Figure 6: (a), (b)

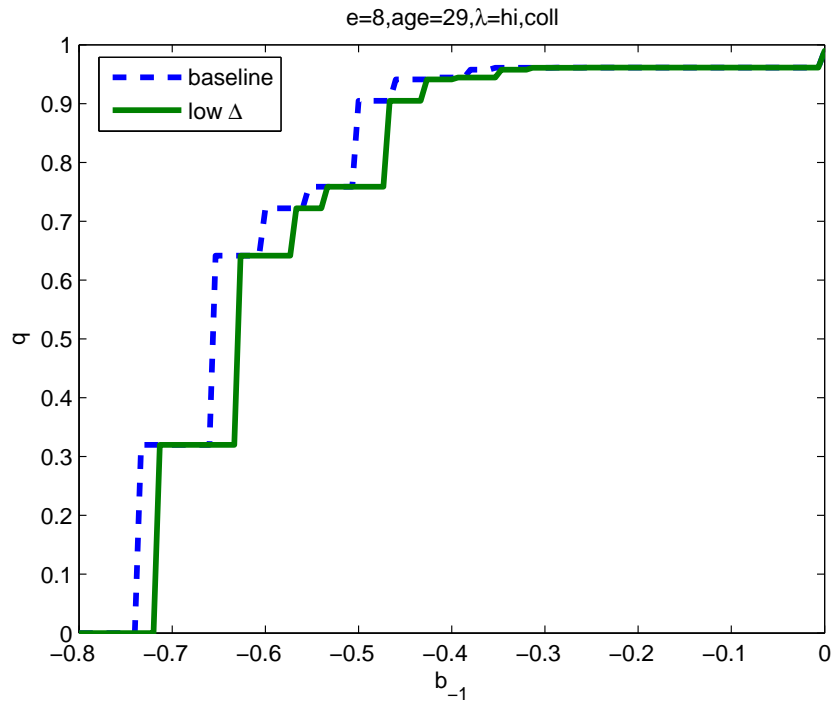


(a) Low λ

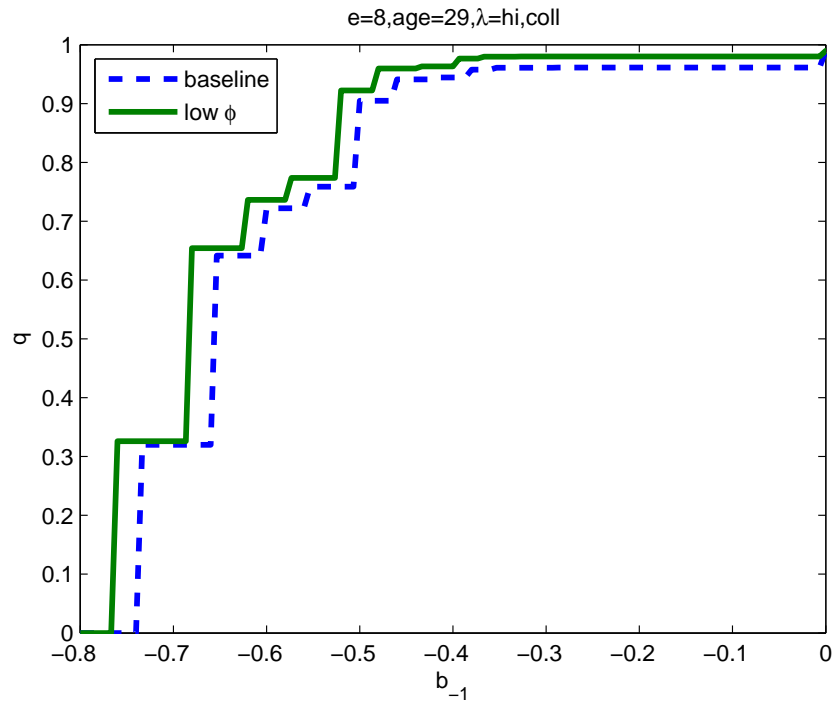


(b) High λ

Figure 7: (a), (b)



(a) Low Δ



(b) Low ϕ

Figure 8:

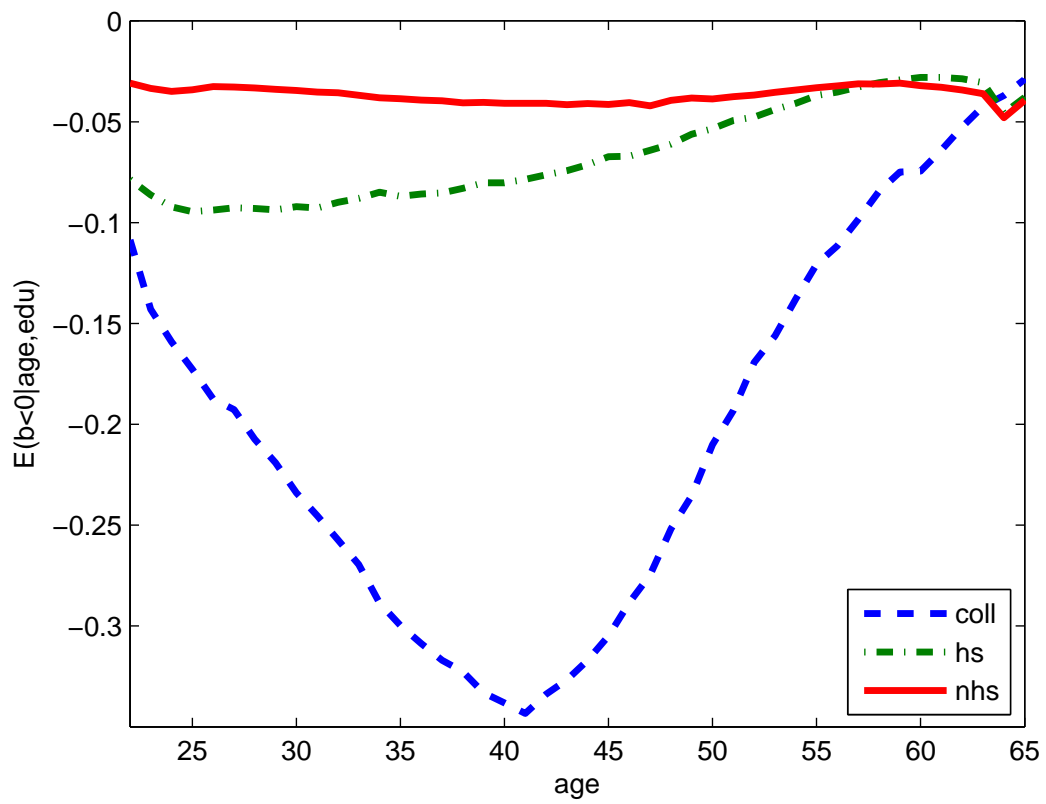


Figure 9:

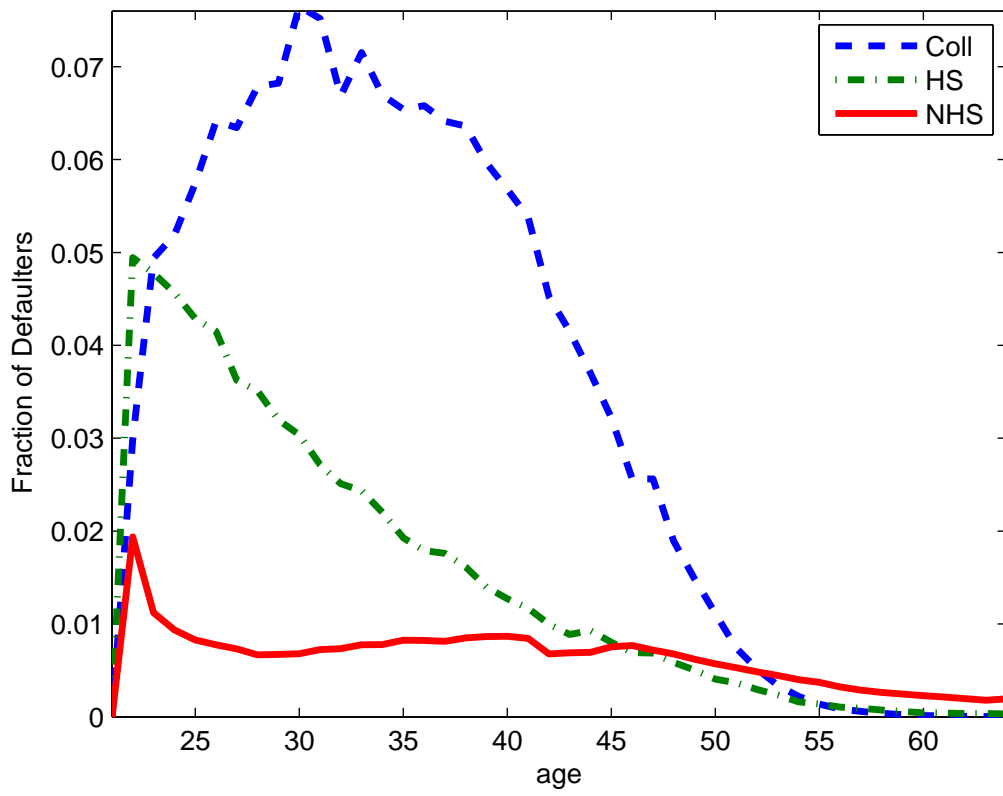


Figure 10:

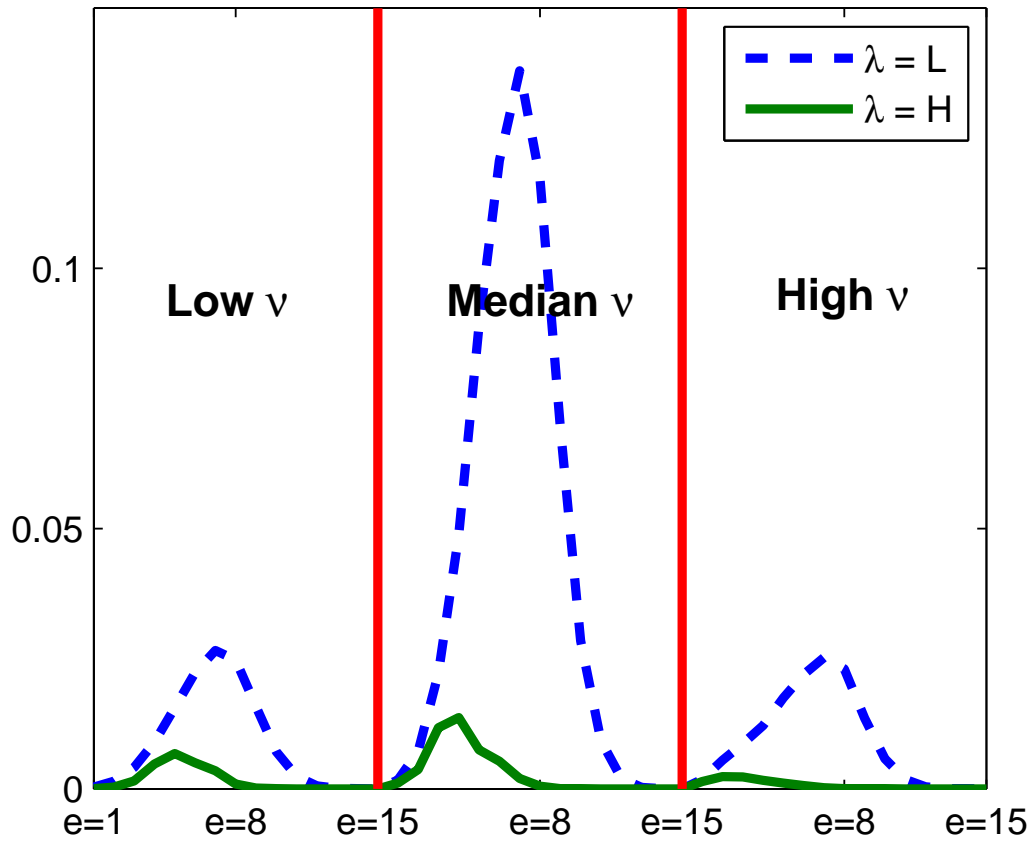


Figure 11:

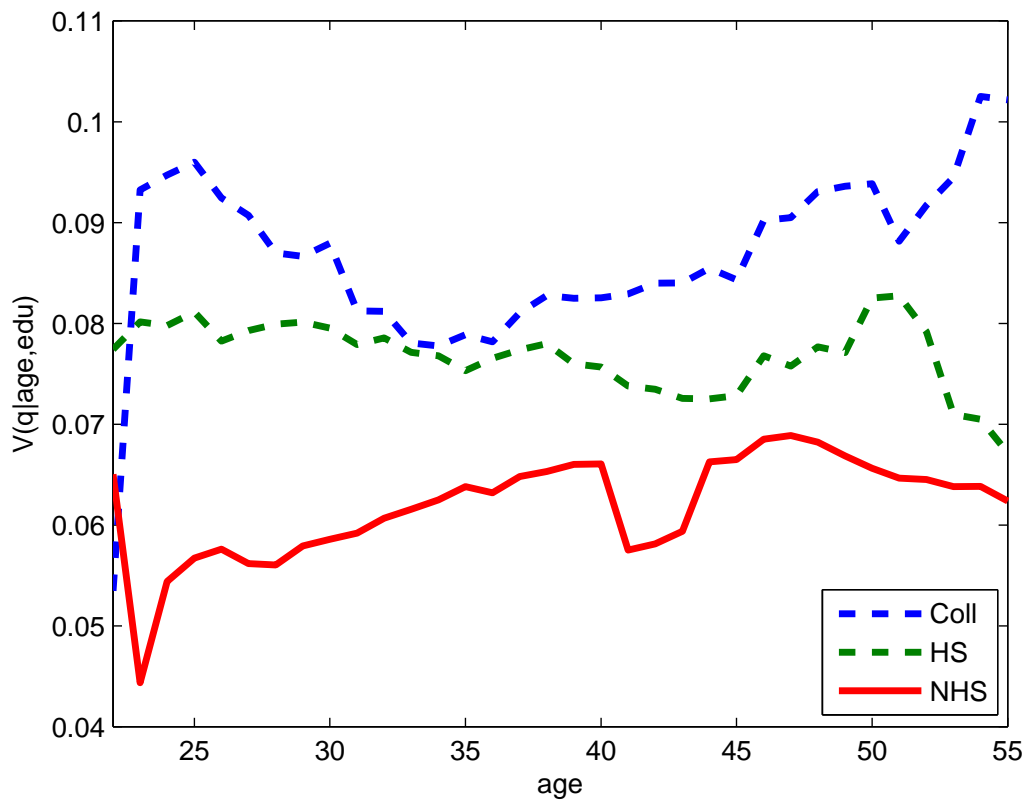


Figure 12:

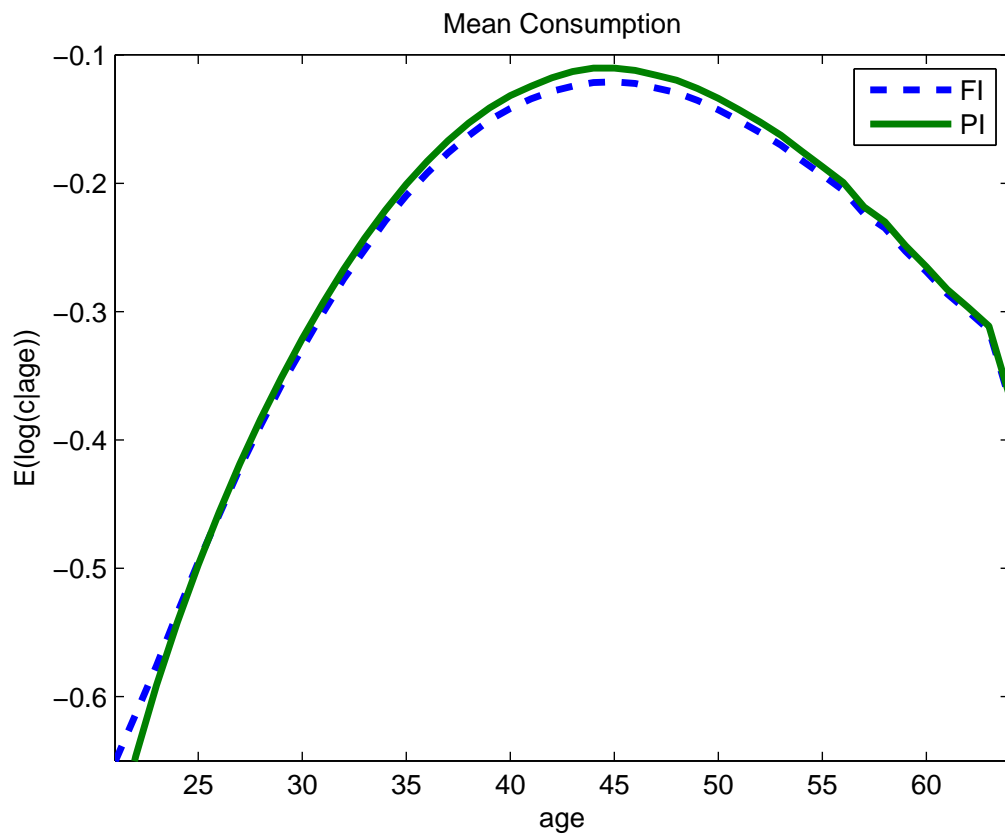


Figure 13:

