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Loan Guarantees for Consumer Credit Markets*

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Abstract

Loan guarantees are arguably the most widely used policy intervention in credit markets, especially for consumers. This may be natural, as they have several features that, a priori, suggest that they might be particularly effective in improving allocations. However, despite this, little is actually known about the *size* of their effects on prices, allocations, and welfare.

In this paper, we provide a quantitative assessment of loan guarantees, in the context of unsecured consumption loans. Our work is novel as it studies loan guarantees in a rich dynamic model where credit allocation is allowed to be affected by both limited commitment frictions and private information.

Our findings suggest that consumer loan guarantees may be a powerful tool to alter allocations that, if carefully arranged, can improve welfare, sometimes significantly. Specifically, our key findings are that (i) under both symmetric and asymmetric information, guaranteeing small consumer loans nontrivially alters allocations, and strikingly, yields welfare improvements even *after* a key form of uncertainty—one's human capital level—has been realized, (ii) larger guarantees change allocations very significantly, but lower welfare, sometimes for all household-types, and (iii) *substantial* further gains are available when guarantees are restricted to households hit by large expenditure shocks.

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1. Introduction

In the US and many other developed nations, arguably the most important class of interventions in household credit markets are publicly-funded guarantees issued to private lenders to defray losses from default. In the U.S., the most obvious of these are the loan guarantee programs for home loans. Currently, for example, the FHA and the Veterans Administration both offer loan guarantees to private lenders that are explicitly backed by the "full faith and credit" of the Federal government to qualified home buyers, and in both 2009 and 2010, the FHA alone originated over \$300 billion in new guaranteed loans. Similarly, the US Student Loan Administration (Sallie Mae) is active in arranging guaranteed loans, with recent flows on the order of \$100 billion annually, and a stock of approximately \$500 billion. Loan-guarantees also play a role in credit aimed at the self-employed, with the U.S. Small Business Administration's (SBA) 7a loan program guaranteeing roughly \$100 billion in credit per decade since 1990.[1][2]

Beyond their sheer size, the *scope* of activities receiving guarantees is noteworthy. Endeavors ranging from nuclear and solar power plant construction, trade credit, micro-enterprises, and support for female-entrepreneurs are all ones that have received, or currently receive, guaranteed loans. In some instances, the guarantees are motivated by the premise of externalities. Others, such as the guarantees on student loans, are motivated by additional considerations, especially a quantitative presumption over the strength of limited commitment problems (such as those arising from the private sector's statutory inability to attach human capital, in the case of student loans), as well as the desire to alleviate "rationing" induced by private information.

The goal of this paper is to provide a quantitative assessment of the price-, allocation-, and welfare-related consequences of guaranteeing loans for household credit. Our focus will be on the ability of loan guarantees to productively alter allocations when credit markets are affected by limited commitment, and sometimes asymmetric information as well; we will not presuppose the presence of any externalities.

Our results can be summarized as follows. First, under symmetric information we find that loan guarantees can, strikingly, generate improvements for households even *after* all uncertainty

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[1] See Weinberg and Walter (2002) and Li (2002) for more details. Both show that the overall contingent-liabilities of the US government have grown substantially over time.

[2] In addition to these officially-guaranteed loan programs, there is one that dwarfs them all, and this is the one operated by the two main government-sponsored enterprises (GSEs), Fannie Mae, Freddie Mac. These entities issue securities to investors that come with a guarantee against default risk. The ultimate originators of mortgage credit to home buyers thereby receive, in essence, a loan guarantee. While historically not explicitly backed by the Treasury—but now clearly so—MBS investors receive Fannie and Freddie guarantees on loans with face value of approximately \$5 trillion, nearly half of the value all household mortgage debt.

over their final human capital level — which fully pins down their expected lifetime income — has resolved itself. However, this is true only as long as they are not too generous (whereby only small loans qualify). This welfare gain is disproportionately experienced by low-skilled households who face flat average income paths and relatively-large shocks. Higher-skilled types rapidly begin to experience welfare losses as loan guarantees are made more generous. These results arise because loan guarantees induce a transfer from skilled to unskilled, which can be substantial, while the gains to the skilled from improved loan pricing as a result of guarantees are relatively small. Second, we find that allocations are quite sensitive to the size of qualifying loans whereby even modest limits on qualifying loan size invite very large borrowing – as perhaps intended by proponents. However, these same limits also bring very large increases in default rates relative to a world without guarantees, and as a result, transfer resources in significant amounts from the *ex post* lucky to the *ex post* unlucky, in addition to transferring wealth across education types.

Under asymmetric information, we find that guarantees can, once again, yield ex-ante improvements for households of all human capital levels. Moreover, the welfare gains are larger than under symmetric information because the loan guarantee to some extent mitigates the information asymmetry problem. This is because the reduction in the sensitivity of loan interest rates to default risk that accompanies loan guarantees also reduces relatively high-risk borrower-types' incentives to reduce their borrowing inefficiently simply to mimic those with lower risk. This incentive effect contributes positively to the welfare impact. Finally, targeted guarantees that focus entirely on households hit by large expenditure shocks dominate unrestricted programs.

Taken as a whole, our results suggest that loan guarantees can be quite powerful, but that care must be taken if policymakers intervene in credit markets through them. They can improve outcomes and do so in ways that are robust to the informational frictions present, but they can also rather quickly alter private incentives to borrow and default, which in turn can redistribute resources in ways that leave most worse off. This finding is particularly important from a policy perspective, as it does not matter for our model whether the loan guarantees received by lenders are explicitly part of a program, or simply arise from *implicit promises* to creditors. As long as lenders act as competitors, the effects on household budget sets and default behavior will be the same, as the latter will receive cheaper, less-sensitive loan terms.[3]

Our paper is novel along two dimensions. We are the first, to our knowledge, to analyze loan-guarantees in the presence of both voluntary default (default when it is feasible to repay debt)

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[3] Notice also that loan-guarantees may well be politically feasible — obtaining the support of all newly-entering households, of all human capital levels, requires no complex forms of ex-post compensation of losers by winners.

and asymmetric information. Second, we are the first to assess these effects quantitatively. Our work enables us to measure, for the first time, the ability of loan guarantees to alleviate credit constraints when the latter arise from the presence of both asymmetric information and the force that makes such a friction relevant at all: limited commitment to loan repayment. Moreover, the extent of asymmetric information in our model will be *endogenous* as well; it depends on how heterogeneous borrowers are, not only in terms of both exogenous shocks, but also in terms of endogenously determined and unobservable, net asset positions. Loan guarantees therefore alter the importance of asymmetric information not just directly, but also indirectly via their influence on asset accumulation.

Our work contributes to the understanding of how credit markets are altered by the predominant form of intervention aimed at them in modern economies, through a model that explicitly accommodates the two central frictions—limited commitment and asymmetric information—routinely deemed most culpable in these markets' dysfunction. At a more specific level, our work contributes by evaluating the likely outcome of the *introduction* of loan guarantees in a specific market that, for several a priori reasons, makes them a good candidate for improving outcomes (to be detailed below), but where they currently are not employed. The complete absence of loan guarantees on unsecured consumer credit is striking: the young and poor have long been identified as facing both borrowing constraints and income risk (see Jappelli (1990) and Hubbard, Skinner, and Zeldes (1994), respectively, for important early references), and they generally lack any meaningful form of collateral. Therefore, to the extent that the unsecured market is the one most relevant for improving the consumption smoothing efforts of a nontrivial group of US households, the provision of guaranteed loans to this sector appears, *a priori*, likely to be consequential.[4]

While we focus our quantitative analysis on consumer credit markets where only intangible collateral arising from the perception of reputational costs or changes in future credit terms is "posted," our approach applies to credit markets where more tangible forms of collateral are pledged. This is because even when a loan guarantee program is nominally targeted at a secured form of lending, such as mortgage loan guarantees, they can only alter allocations because there is a positive probability of the loan becoming at least partially unsecured, ex-post. That is, the value of the guarantee

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[4] Relatedly, although beyond the scope of our inquiry, it should be noted that loan guarantees are often seen as a viable and essential part of macroeconomic/financial public policy remedies to get credit markets "unstuck" in crises. Prominent efforts include the Emergency Loan Guarantee Act of 1971, and more recently the guarantees offered by Federal Reserve System to member banks to allow the latter continued access to relatively inexpensive wholesale funding. An extremely recent examples relates to the suggestion that loan guarantees be used to alleviate fallout from Greek sovereign default. (http://www.nytimes.com/2011/09/24/business/us-pressures-europe-to-act-with-force-on-debt-crisis.html?_r=1).

necessarily emerges from the existence of states of nature in which ex post, repayment becomes less attractive than paying the costs of default. Sometimes, these costs are primarily those arising from the surrender of tangible collateral that, ex-post, becomes less valuable than reneging on the repayment obligation. In other cases, default implies the destruction of intangible collateral, as described above. Thus, in either case, loan guarantees fundamentally concern unsecured lending.

There are at least three a priori reasons to study the potential for consumer loan guarantees. First, loan guarantees decouple loan pricing from credit risk. This is relevant in light of a growing body of work showing that in the absence of complete insurance markets, risk averse households can benefit from the state-contingency introduced by the option to default, particularly in bad states of the world (these papers include Zame (1993), Dubey, Geanakoplos, and Shubik (2005), Livshits, MacGee, and Tertilt (2007), and Chatterjee *et al.* (2007)). Moreover, in existing work, consumers have been shown to benefit despite the presence of loan pricing that moves "against" the riskiest borrowers. However, these gains are not necessarily accessible in all *a priori* plausible environments. In recent quantitative work on the value of defaultable consumer debt, a variety of authors (such as Athreya, Tam, and Young (2009)) have found that in many cases, the ability of lenders to reprice loans at the same frequency as the arrival of new information on income risk undoes insurance benefits altogether. In other words, every time a consumer is hit by a persistent (but not permanent) bad shock, they find their ability to commit to loan repayment eroded and any borrowing they might attempt will become expensive. From the perspective of borrowers, if competitive lenders are made partially whole, they cannot "risk-adjust" interest rates as much, meaning that unsecured debt markets will be better able to assist households in consumption smoothing. Thus, policies which allow for default, but break the link between credit risk and credit pricing, are promising candidates to improve allocations—at least to borrowers.

A second reason to develop an assessment of loan guarantees is that the power of unsecured lenders to frequently re-price consumer debt has already led to policy changes. Most noticeably, the "CARD" Act of 2009 has responded by essentially *requiring* longer-term commitments from lenders in an attempt to deter frequent repricing. However, as studied by Tam (2009), such policies may carry serious side effects. In particular, average interest rates are predicted to rise substantially to offset the ability of a borrower to "dilute" their debt (much as in the sovereign debt literature). In contrast, loan guarantees will decouple risk and pricing, while at the same time reducing *average* interest rates. This channel may be important: Calem, Gordy and Mester (2006) show that many US households appear to use credit cards for relatively long-term financing, making the roughly ten-percentage-point cost differential between secured and unsecured interest rates quantitatively important.[5]

Lastly, loan guarantees may mitigate the consequences of asymmetric information at the *individual* level. This is because they lessen the incentive for a borrower to misrepresent and pretend to be a lower-risk individual. This is precisely the mechanism operative in Smith and Stutzer (1989). The costs of asymmetric information are *inextricably* linked to the strength of the limited commitment problem; if agents are unable to repudiate debt the asymmetric information problem is completely irrelevant for allocations. This link is an important feature of loan guarantees given that asymmetric information may be an important part of why credit constraints do affect many households. In particular, the larger the equilibrium amount of adverse selection, the more valuable loan guarantees are likely to be for households.

Despite these likely benefits, it should be clear that loan guarantees will create costs, particularly in two places. First, default rates are likely to rise, generating more deadweight loss (whether pecuniary or nonpecuniary in nature). The rise in default rates occurs for the very reason that loan-guarantees "work": they lead to the systematic underpricing of loans by lenders, given their risk. Relatively larger loans will now attract the attention of relatively high-risk borrowers. As a result, the more effective any loan-guarantee scheme is in spurring borrowing and consumption, the more prevalent will be default and deadweight losses on the equilibrium path. In the context of loan-guarantees for entrepreneurial ventures, the work of Lelarge et al. (2008) documents precisely this type of response in a near-natural French experiment. As they note, "it [loan guarantees] significantly increases their probability of default, suggesting that risk-shifting may be a serious drawback for such loan guarantee programs." This inevitable tradeoff means that the real questions are: "By how much?" and "Does risk-shifting happen, and if so, is it welfare-enhancing?"

Second, tax revenue must be raised to finance transfers to lenders *ex post*. Under incomplete markets, the taxes used to finance these transfers have two *opposing* effects on welfare. First, if, as was the case in the in study of Lelarge et al. (2008), a relatively large fraction faces a tax that a relatively small proportion benefit most significantly from, the introduction of a publicly-funded loan guarantee program will reduce the mean level of income for many households. In particular, if it is a *relatively* small measure of households who run up substantial debts that, absent the guarantee, would demand high interest rates, they then receive a transfer from all other households. Second, non-regressive taxes reduce the variance of after-tax income, especially when

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[5] Andolfatto (2002) develops a simple model to illustrate how government policies may induce changes in behavior that generate calls to change that policy. Athreya, Tam, and Young (2010b) discuss a similar issue with respect to bankruptcy costs.

one's *expected* lifetime income (as captured by *ex ante* uncertainty over one's eventual educational attainment) is uncertain. The second term, being second order, is necessarily dominated by the first, so the net effect is a welfare loss due to taxation. Thus, the choice of introducing a loan guarantee system boils down to the choice of whether or not to replace a world of relatively high average interest rates that, moreover, are highest in those states where a household's marginal valuation of wealth is highest, with one of low average interest rates that are relatively insensitive to personal circumstances, but where average after-tax income for most is lower and smoother.

Our paper is linked to three strands of research in public interventions in credit markets. First, our work is tied to an earlier, relatively stylized, class of papers that focused on the role of interventions, including loan guarantees, on outcomes for a general problem of risky-investment problem in static or near-static settings under asymmetric information. Key landmarks in this category are Chaney and Thakor (1985), Smith and Stutzer (1989), Innes (1990), Gale (1990), and Williamson (1994).[6] Most of this work abstracts from the financing of their programs as well while, as noted above, these costs will feature prominently in our analysis.

Second, our work is clearly connected to more recent work on *quantitative* analysis of the allocational consequences of loan guarantees. This work began, to our knowledge, with the work of Gale (1991), and was followed by the rich, fully dynamic, and relatively tractable incomplete-market models developed in Li (1998), and Jeske, Krueger, and Mitman (2010).[7] The last paper is the first to focus centrally on credit markets in a consumption smoothing context. However, with respect to modeling default, in all the preceding work, default is involuntary; it is forced to occur due to an extreme event. In Jeske, Krueger, and Mitman (2010), for example, default occurs whenever the value of the loan exceeds the value of the collateral initially pledged as the result of an exogenous change in asset prices; that is, loan guarantees alter allocations only because loans can become partially unsecured ex-post.[8]

Third, our focus on consumer credit under default risk in the latter kind of incomplete-market setting connects this paper closely to recent work of Chatterjee et al. (2007), Livshits et al (2007), and Athreya, Tam, Young(2010, 2011). In this line of work, guarantees are not studied, but both

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[6] In related work, Lacker (1994) investigates whether adverse selection problems necessarily justify government intervention in credit markets. When cross-subsidization between private contracts is not feasible, intervention is generally welfare-improving.

[7] See also recent work of Jia (2010), who studies loan guarantees as a form of insurance for small businesses in a setting similar to that of Li (1998).

[8] In future work, we aim to analyze the role of guarantees for mortgage lending. However, the central role of aggregate risk in driving home-loan default makes a full quantitative analysis that satisfactorily incorporates the forces we *do* allow for here–partially endogenously asymmetric information and limited commitment–currently infeasible. But that model would have the same fundamental structure as that developed here.

voluntary default and asymmetric information have been shown to matter for the allocation of consumer credit in the absence of guarantees, see e.g., Athreya, Tam, Young (2011) and Sanchez (2009).

2. Illustrative Model

In this section we discuss why loan guarantees are likely to be of particular interest, as opposed to any of the other myriad of interventions that governments could choose, using a simple two-period model for illustration. Smith and Stutzer (1989) provide a simple argument for the use of loan guarantees in unsecured commercial credit markets – compared to direct government loans or equity purchases, loan guarantees are the only option that does not worsen the private information problem. The interest rate reductions apply to all risk-types, so high-risk types do not find any particular advantage, beyond what they already have, for pretending to be low-risk. Other programs, such as direct loans to those unable to obtain credit (who are low-risk in their model), will lead to additional incentives by high-risk borrowers to claim the contracts intended for low-risk ones, a situation which is harmful to efficiency.

There are two important distinctions between our work and theirs – the nature of the commitment problem and the issue of government revenue balance. In Smith and Stutzer (1989), limited commitment is a trivial consideration: default occurs when the borrower receives zero income and is costless (in terms of direct costs). In contrast, US bankruptcy procedures are voluntary and clearly not costless: there is a filing fee in addition to substantial time costs and some form of stigma/nonpecuniary costs appear relevant as well (see Fay, Hurst, and White (1998) or Gross and Souleles (2002)). Two questions then emerge. First, do loan guarantees still have desirable welfare properties when commitment is not trivial and default is costly? Second, do these properties hinge on the presence of information asymmetries with costly signalling? The second aspect that casts some doubt about the efficacy of loan guarantees in more general environments is that they can be expensive. Smith and Stutzer (1989) do not consider the financing of such payments; any welfare gains from the guarantee could easily be wiped out by the cost of taxation. In contrast, a central aspect of our analysis is the requirement that transfers required to implement loan guarantees be paid for via taxes.

Before turning to the quantitative setting in the next section, we use a two-period variant of our model to identify the types of individuals who are harmed by risk-based pricing (and the nonwaivable right of default that makes it necessary) and who may therefore gain from loan guarantees.

Households have standard expected utility preferences

$$\max_{c_1,\{c_2(e_2),d_2(e_2)\}} \left\{u\left(c_1\right)+\beta E_{e_2}\left[u\left(c_2\left(e_2\right)\right)-d_2\left(e_2\right)\lambda\right]\right\}.$$

Endowments are probabilistic, and structured as follows: e_1 is constant and e_2 is drawn from a two-point distribution $\{e_L, e_H\}$ with probabilities π and $1-\pi$.

Let c_i denote consumption in period i, e_i denote the endowment of the agent in period i, and $d_2 \in \{0,1\}$ the default decision in period 2. Defaulting incurs a nonpecuniary cost λ. The presence of default risk on loan size leads to the need for loan prices to depend on loan size. Households are modeled as borrowing through the issuance of debt b. This debt, by virtue of being risky, will be discounted by lenders. The term $q\left(b\right)$ is the discount factor applied to a debt issuance of face-value b, and is determined by competitive markets and therefore equals the expected repayment probability $1-p\left(b\right)$ divided by the exogenous risk-free rate $1+r$:

$$q\left(b\right)=\frac{1-p\left(b\right)}{1+r}.$$

Households face period budget constraints given by

$$\begin{aligned} c_1+q\left(b_1\right)b_1 &\leq e_1 \\ c_2\left(e_2\right) &\leq b_1\left(1-d_2\left(e_2\right)\right)+e_2. \end{aligned}$$

We can represent two kinds of households in this model. Let one type be those whose endowments have (relatively) large mean and (relatively) small variance of e_2, so that income in the future is expected to be high and relatively safe; this group roughly corresponds to educated types. The second type we are interested in has small mean and large variance of e_2; one can think roughly of this group as being uneducated.

We can parameterize the endowments of the first group of agents such that three conditions hold: (i) the amount that can be feasibly repaid in the bad state is large (that is, e_L is relatively big); (ii) the household will default in both states under risk-free pricing (λ is small and e_L and e_H are close together); and (iii) the household would borrow if asset markets were complete ($\beta\left(1+r\right)<1$ and mean e_2 significantly larger than e_1). This group is (weakly) harmed by the intertemporal disruptions that default options create; because the two states tomorrow are very similar, the household would either default in both states and thus be unable to borrow at all ($q=0$), or she would not default in either state and thus care not at all about default options. As a result, the outcome may be worse than if bankruptcy were banned, since in the absence of a default option feasibility would permit borrowing against the (relatively high) value of e_L.

We can then parameterize the second type's endowments such that three conditions hold: (i) the amount of debt that can feasibly be repaid in all states is small (that is, e_L is very low); (ii) the household will default only in the low state (λ intermediate and e_L and e_H far apart); and (iii) the household would borrow if asset markets were complete ($\beta(1+r) < 1$ and mean e_2 equal to e_1). A member of this group can gain from the default option because she actually can borrow more with a bankruptcy option, as she does not intend to repay in the low state; thus, feasibility is limited only by the amount that can be repaid in the high state and additional consumption smoothing is feasible. This is a manifestation of what might be referred to as a "supernatural" debt limit, as opposed to the "natural" debt limit: feasibility involves what can be repaid in the *best* state instead of the *worst*.

Figure 1 shows a typical equilibrium. The indifference curves are monotone (over the range of interest at least), and reflect the fact that a household can receive additional consumption today in two ways: raise q or lower b, holding the other fixed. As a result, if the household borrows a little more, indifference requires that q fall. Although not shown in the figure, the typical indifference curve turns upward at very low levels of b, but these lie well outside the budget set. At the optimum the household is constrained, in the sense that additional borrowing is desired but not feasible due to the increase in the probability of default; this situation will be typical in the quantitative model as well. Thus, local to that optimal b there are welfare improvements available if q can be held fixed while b is increased.

2.1. Loan Guarantees

We now introduce a loan guarantee into this model economy. Loan guarantees will be defined by two parameters: (i) a "replacement rate" θ that determines the fraction of defaulted obligations the lender receives as a transfer from the government, and (ii) a "coverage limit" ϑ that determines the largest (riskiest) loan that the government will insure. Only loans smaller than ϑ qualify for any compensation; lenders making loans larger than the ceiling receive nothing in the event of default.[9] This structure for loan guarantees will also be used in the remainder of the paper.

Given that the loan guarantee covers θ percent of the repayments lost to default for the portion

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[9] This program assumes that the household cannot obtain a qualifying loan of size greater than ϑ by visiting multiple lenders; that is, we attach the qualification criterion to the borrower, not the lender.

of any loan less than ϑ, competitive pricing of loans must obey

$$q(b) = \frac{1-p(b)}{1+r} + \frac{p(b)}{1+r}\theta.$$

In the absence of taxes needed to compensate lenders for default under any guarantee program, it is clear that *both* types of households would gain from their introduction. Assuming default probabilities don't change, the guarantee increases the bond price for the first group from 0 to $\frac{\theta}{1+r}$ and for the second group from $\frac{1-\pi}{1+r}$ to $\frac{1-\pi+\pi\theta}{1+r}$. This increase expands the set of feasible consumption paths and raises welfare; default probabilities will not increase if θ is small enough due to the discreteness of the income process. To illustrate how a loan guarantee works, Figure 2 shows how the pricing function shifts weakly upward, which clearly raises utility because the household is currently constrained and the deadweight loss from default is the same.

The welfare effects of the tax component are negative – a proportional tax on e_2 will reduce both the mean and variance of second-period income, but the second component is second-order and therefore dominated by the reduced mean (if tax rates are uniform). Whether agents gain or lose is then a quantitative question, and hinges on two things. First, how much does the default rate change, and how much deadweight loss does this change generate? Second, how much does a particular type of household receive in transfers (the reduction in interest rate times the amount of debt borrowed) relative to the amount they pay in taxes?

2.2. Asymmetric Information

The *current* size of the U.S. unsecured credit market is large ($1.5 trillion in balances as of September 2011), and widespread in terms of the fraction of households using it (see, e.g., Bertaut and Starr-McCluer(2002), and Han and Li (2011)). It is also a market that features information storage, data sharing, and credit-risk modeling that all suggest, a priori, that private information frictions are not a central determinant of outcomes, relative especially to purely limited-commitment-related problems. This is reflected in the now-large array of models of unsecured credit, almost none of which feature asymmetric information.

Recent work of Sanchez (2010), and Athreya, Tam, Young (2011) suggests, however, that asymmetric information may have played a substantial role in stunting unsecured credit access in earlier periods. The latter in particular argues that asymmetries in terms of knowledge of factors that collectively govern *individual-level* costs of default may have once played a nontrivial role in limiting unsecured credit access to households. The implication is that in settings lacking the informational infrastructure seen in the U.S. currently, such as developing countries, unsecured credit markets may well be substantially limited. Our analysis under asymmetric information will, therefore, help inform us on the potential for guarantees under these more challenging circumstances.[10]

To adapt the model to deal with asymmetric information, suppose now that default risk, π, varies according to some characteristic that is not observable to the lender; for concreteness, let there be two such types. Private information forces (barring a rich menu of screening contracts) the lender to offer a uniform pricing function to both types of households based on the invariant measure of each type (let $\delta \in (0,1)$ be the measure of the first type); the function is contingent on the costly signal b sent by the household.[11] The pricing function without the guarantee would be

$$q(b) = \delta \frac{p(b|1)}{1+r} + (1-\delta) \frac{p(b|2)}{1+r},$$

where the conditional probabilities reflect the fact that each type will not default with the same probability at any given level of debt.

The "bad" type of borrower – that is, the borrower with the high value of π – will want to reduce b in order to look more like the good borrower, all things being equal. As discussed more completely in Athreya, Tam, and Young (2011), pooling is potentially an equilibrium if the pricing function is relatively flat just to the right of the equilibrium choice; in that case, the indifference curves of both types lie above the break-even curve for the lenders so deviations to lower debt levels do not occur. Separating equilibria occur when pricing functions are steep (relative to indifference curves), because then the good type would be better off reducing b while the bad type would not. Loan guarantees reduce the desire of bad types to pool with good types because they break the link between pricing and type; this disincentive is welfare-improving because it improves the allocation of consumption, and so under asymmetric information loan guarantees will have even better welfare properties. But as before, we must consider whether the costs outweigh the gains, and under asymmetric information the costs will increase more than under symmetric information because default is initially lower. Whether the costs or benefits are larger is the main focus of our quantitative model, which we describe in the next section.

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[10] Our results, of course, will still reflect the statistical properties of U.S. household income, which we assume throughout. A detailed quantitative cross-country analysis of unsecured credit markets under country-specific earnings and expenditure processes would certainly be useful, but is well beyond the scope of this paper. It has not, to our knowledge, been attempted even in the case of full (non-asymmetric) information, let alone under asymmetric information.

[11] We assume that no costless and credible signals are available, and that some additional hidden characteristic, such as initial wealth, thwarts the lender's attempts to infer from b the exact value of π.

3. Quantitative Model

The general framework is, under symmetric information, an entirely standard life-cycle model of consumer debt with default. It is closely related to the models of Athreya, Tam, and Young (2009), Livshits, MacGee, and Tertilt (2007) and Chatterjee *et al.* (2007), though the last uses an infinite horizon. Under asymmetric information, the models builds on Athreya, Tam, and Young (2011). We assume that the economy is small and open, so that the risk-free rate is exogenous, while the wage rate is determined by a first-order condition on factor usage.

3.1. Preferences

Households in the model economy live for a maximum of $J < \infty$ periods, supply labor inelastically, and face stochastic labor productivity and mortality risk. Households differ along several dimensions over their life-cycles according to an index of type, denoted "y" and defined in what follows. Each household of age j and type y has a conditional probability $\psi_{j,y}$ of surviving to age $j+1$. Let n_j denote the number of "effective" members in a household.

Households are risk-averse and value consumption per effective household member $\frac{c_j}{n_j}$. To smooth consumption, all households have access to risk-free savings, and also debt that they may discharge fully in bankruptcy subject to some costs. These costs reflect the variety of consequences that bankruptcy imposes on households. A first set of costs are represented by a nonpecuniary cost of filing for bankruptcy, denoted by $\lambda_{j,y}$, which we also permit to depend on household type y. This will motivated below. In addition to this non-pecuniary cost, there is an out-of-pocket pecuniary resource cost Λ that represents all formal legal costs and other procedural costs of bankruptcy. Lastly, households are not allowed to borrow or save in the same period as a bankruptcy filing. This is to reflect provisions guarding against fraud that are routinely applied in court. There are no other costs of bankruptcy in the model.

The existence of nonpecuniary costs of bankruptcy is strongly suggested by the calculations and evidence in Fay, Hurst, and White (1998) and Gross and Souleles (2002). The first paper shows that a large measure of households would have "financially benefited" from filing for bankruptcy but did not, while both papers document significant unexplained variability in the probability of default across households after controlling for a large number of observables. These results suggest the presence of implicit unobserved collateral that is heterogeneous across households, including (but not limited to) any "stigma" associated with bankruptcy (as in Athreya 2004).

A household with a relatively low value of $\lambda_{j,y}$ will obtain low value from any given *expenditure* on consumption (c_j) in a period in which they file for bankruptcy. This is meant to reflect the increased transactions cost associated with obtaining utility via consumption expenditures in the period of a bankruptcy. Examples include increased "shopping time" arising from difficulty in obtaining short-term credit and payments services, locating rental housing and car services, as well as any stigma/psychological consequences. For convenience, we will sometimes refer to $\lambda_{j,y}$ as stigma in what follows, we intend it to be more encompassing.[12] Because of the breadth of costs that λ represents, we will allow it to vary stochastically over time, and across individuals as a function of their type y.

At the time of obtaining a loan, a household that expects to have a relatively low value of λ next period will know that filing for bankruptcy will result in a relatively high cost of obtaining any given level of marginal utility, in the next period. Given the current marginal utility of consumption, consumption smoothing (i.e., keeping marginal utility in accordance with the standard euler equation) under bankruptcy will therefore be costlier, all else equal, than for a household with a high value of λ. This is further amplified by the fact that households are not allowed to borrow in the same period as when they file for bankruptcy. For convenience, we will therefore refer to *those whose value of* $\lambda_{j,y}$ *is relatively low as "low-risk" borrowers*, and vice versa. Lastly, household preferences are represented by a time-additively-separable utility function with common discount factor β and an isoelastic felicity function with parameter σ. The result is that preferences are represented by

$$U\left(\left\{\frac{c_j}{n_j}\right\}_{j=1}^{J}\right)=\frac{1}{1-\sigma}E\left[\sum_{j=1}^{J}\beta^{j-1}\psi_{j,y}\left(\left(\left[\lambda_{j,y}d_j+(1-d_j)\right]\frac{c_j}{n_j}\right)^{1-\sigma}\right)\right] \tag{3.1}$$

where d_j is the indicator function that equal unity when the household chose to default in the current period (in which case $d_j = 1$). We assume that households retire exogenously at age $j^* < J$.

3.2. Endowments

Our focus on consumer credit makes it critical to allow for both uninsurable idiosyncratic risk. Consumer default, and hence the value of loan guarantees, is by all accounts strongly tied to *individual*-level uninsurable risk (see, e.g. Sullivan et al. (1989, 2000), Chatterjee et al. (2007)).[13]

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[12] Another possibility is that these households gain the benefits from bankruptcy without filing, as suggested by Dawsey and Ausubel (2004). Athreya *et al.* (2011) extends the benchmark model to include a delinquency state in which households do not formally file for bankruptcy but also do not service their debt.

[13] In mortgage lending, loan guarantees protect lenders against house price fluctuations, which in turn are strongly tied to *aggregate risk* (or at least city-level risk). The full incorporation of the aggregate risk, private information,

There are two sources of such risk in our model. First, households face shocks to their labor productivity, and because they are modeled as supplying labor inelastically, face shocks to their labor earnings. Second, households are susceptible to shocks to their net worth. The former represent shocks arising in the labor market more generally, and the latter represent sudden required expenditures arising from the need to deal with unplanned events such as sickness, divorce, and legal expenses.

In addition to the use of credit to deal with stochastic fluctuations in income and expenditures, consumer credit also likely serves, as noted earlier, as a tool for longer-term, more purely *intertemporal* smoothing in response to predictable, low-frequency changes in labor income, such as those coming with increased age and labor market experience. This leads us to specify, in addition to transitory and persistent shocks to income, a deterministic evolution in average labor productivity over the life-cycle. This component of earnings will reflect most obviously, one's final level of educational attainment, which is represented in the model as part of an agent's type, y.

Specifically, log labor income will be determined as 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) process. The log of income at age-j for type$-y$ is therefore given by:

$$\log W + \log \omega_{j,y} + \log y + \log e + \log \nu$$

where

$$\log\left(e'\right) = \varsigma \log\left(e\right) + \epsilon', \tag{3.2}$$

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.

As for the risk of stochastic expenditures, we follow the literature (e.g. Livshits, MacGee and Tertilt (2007) and Chatterjee *et al.* (2007)), and specify a process x_j to denote the expense shock to net worth that takes on three possible values $\{0, x_1, x_2\}$ from a probability distribution $\pi_x(\cdot)$ with i.i.d. probabilities $\{1 - \pi_{x1} - \pi_{x2}, \pi_{x1}, \pi_{x2}\}$.

We will take agents' permanent type y to reflects differences between households with permanent differences in human capital. Specifically, we will consider agents with three types of human capital: those who did not graduate high school, those who graduated high school, and those who graduated

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and limited commitment needed to analyze this specific class of guarantees remains an important topic for future work.

college.[14] This partition of households follows Hubbard, Skinner, and Zeldes (1994). The central reason for allowing this heterogeneity is that the observed differences in mean life cycle productivity for each of these types of agents makes gives them different incentives to borrow over the life cycle. 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. They also face smaller shocks than the other two education groups. The life cycle aspect of our model is key; in the data, defaults are heavily skewed toward young households.[15]

3.3. Market Arrangement

As stated earlier, to smooth consumption and save for retirement, households have access to both risk-free savings as well as one-period defaultable debt. The issuance and pricing of debt is modeled as a two stage game in which households at any age j first announce their desired asset position b_j, after which a continuum of lenders simultaneously announces a loan price q. As a result, a household issuing b_j units of face value receives qb_j units of the consumption good today. A household who issues debt with face value b_j at age-j is agreeing to pay b_j in the event that they fully repay the loan, and pay zero otherwise (i.e., when they file for bankruptcy). The fact that non-repayment can occur with positive probability in equilibrium means that lenders will not be willing to pay the full face value, even after adjusting for one-period discounting. Therefore, given any gross cost of funds $\widehat{R}$, we must have $q \leq 1/\widehat{R}$.

As we will allow for both symmetric and asymmetric information, we introduce the following notation. Let I denote the information set for a lender and $\widehat{\pi} : b \times I \to [0, 1]$ denote the function that assigns a probability of default to a loan of size b_j given information I. Clearly, since default risk assessed by lenders will depend in general on both their information and the size of the loan taken by a household, so will loan prices. Therefore, let loan pricing be given by the function $q(b_j, I)$. Under asymmetric information, we allow lenders to use the information revealed by the *size* of the loan request, and lenders' knowledge of the distribution of household net worth in the economy to update their assessment of all current unobservables. Thus, lenders use their knowledge of both (i) optimal household decision making (i.e., their decision rules as a function of their state), and (ii) the endogenous distribution of households over the state vector.We will describe the determination of this function in detail below.

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[14] We say primarily because mortality rates also differ by education, although this heterogeneity is of no consequence for our questions.

[15] See Sullivan, Warren, and Westbrook (2000).

The household budget constraint during working life, as viewed immediately *after* the decision to repay or default on debt has been made, is given by

$$c_j + q\left(b_j, I\right) b_j + \Lambda d_j \leq a_j + \left(1 - \tau_1 - \tau_2\right) W \omega_{j,y} y e \nu. \tag{3.3}$$

a_j is net worth *after* the current-period default decision d_j. Therefore, $a_j = b_{j-1} - x_j$ if $d_j = 0$ and 0 if $d_j = 1$. Households default decisions also determine their available resources beyond removing debt, because default consumes real resources Λ, arising from court costs and legal fees. The last term, $\left(1 - \tau_1 - \tau_2\right) W \omega_{j,y} y e \nu$, is the after-tax level of current labor income, where τ_1 is the flat-tax rate used to fund pensions and τ_2 is the rate used to finance the loan guarantee program.

The budget constraint during retirement is

$$c_j + q\left(b_j, I\right) b_j + \Lambda d_j \leq a_j + \upsilon W \omega_{j^*-1,y} y e_{j^*-1} \nu_{j^*-1} + \Upsilon W, \tag{3.4}$$

where for simplicity we assume that pension benefits are composed of a fraction $\upsilon \in (0, 1)$ of income in the last period of working life plus a fraction $\Upsilon \in (0, 1)$ of average income W (we normalize average individual labor earnings to 1).

3.4. Consumer's Problem

The timing is as follows. In each period, *all* uncertainty is first realized. Thus, income shocks e and v, the default cost λ, and the current expense shock x, are all known before any decisions within the period are made. Following this, households must decide, if they have debt that is due in the current period, to repay or default. This decision, along with the realized shocks, then determines the resources the household has available in the current period. Given this, the household chooses current consumption and debt or asset holding with which to enter the next period, and the period ends.

Prior to making the current-period bankruptcy decision, a household can be fully described by b_{j-1}, the debt, if any, that is due in the current period, their type y, the pair of currently realized income shocks e and v, their cost of default λ, the current realization of the shock to expenses, x_j, and their age j.[16]

Letting $V(\cdot)$ denote the household's value function prior to the decision to default or repay, with primed variables denoting objects one-period ahead, we have the following recursive description. If

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[16] To avoid repetition, we display only the value functions during working life; retirement is entirely analogous.

the household chooses to repay its debt b_{j-1}, and therefore sets $d_j = 0$, then the value they derive from state $(b_{j-1}, y, e, \nu, \lambda, x, j)$ is:

$$v^{d=0}\left(b_{j-1}, y, e, \nu, \lambda, x, j\right) = \max_{c, b_j} \left\{ \begin{array}{c} \left(\frac{c_j}{n_j}\right)^{1-\sigma} + \\ \beta \psi_{j,y} \left(\sum_{e', \nu', \lambda', x'} \pi_x(x') \pi_e\left(e'|e\right) \pi_\nu\left(\nu'\right) \pi_\lambda\left(\lambda'|\lambda\right) V\left(b, y, e', \nu', \lambda', x', j+1\right) \right) \end{array} \right\} \tag{3.5}$$

subject to the budget constraint:

$$c_j + q\left(b_j, I\right) b_j + x_j \leq b_{j-1} + \left(1 - \tau_1 - \tau_2\right) W \omega_{j,y} y e \nu. \tag{3.6}$$

If the household *has* chosen bankruptcy for the current period ($d_j = 1$), since we disallow credit-market activity in the period of bankruptcy, which implies $b_j = 0$, we obtain:

$$v^{d=1}\left(b_{j-1}, y, e, \nu, \lambda, x, j\right) = \left\{ \begin{array}{c} \left(\lambda_{j,y} \frac{c_j}{n_j}\right)^{1-\sigma} + \\ \beta \psi_{j,y} \left(\sum_{e', \nu', \lambda', x'} \pi_x(x') \pi_e\left(e'|e\right) \pi_\nu\left(\nu'\right) \pi_\lambda\left(\lambda'|\lambda\right) V\left(0, y, e', \nu', \lambda', x', j+1\right) \right) \end{array} \right\}$$

subject to the budget constraint:

$$c_j + \Lambda \leq \left(1 - \tau_1 - \tau_2\right) W \omega_{j,y} y e \nu. \tag{3.7}$$

Notice that both debt due in the current period, b_{j-1}, and the current expenditure shock realization x_j get removed by bankruptcy, and hence disappear, when comparing the budget constraint under bankruptcy to one under non-bankruptcy. By contrast, the resource- and non-pecuniary costs, Λ, and $\lambda_{j,y}$, respectively, both appear.

Given this, prior to the bankruptcy decision, the current-period value function is:

$$V\left(b_{j-1}, y, e, \nu, \lambda, x, j\right) = \max\{v^{d=1}(b_{j-1}, y, e, \nu, \lambda, x, j), v^{d=0}(b_{j-1}, y, e, \nu, \lambda, x, j)\}.$$

3.5. Loan Pricing and Loan Guarantees

Loan guarantee regimes are defined by two parameters: the "replacement rate" θ and the "coverage limit" ϑ. Only loans smaller than ϑ qualify for any compensation; lenders making loans larger than the ceiling receive nothing in the event of default.[17] Conditional on default occurring, the lender, having made a loan of qualifying size, will receive partial compensation whereby the fraction θ will be paid to the lender for each dollar of face value.[18]

We focus throughout on competitive lending whereby intermediaries utilize all available information to offer one-period debt contracts with individualized credit pricing that is subject to meeting a zero profit condition. The definitions of I and $\widehat{\pi}(b, I)$ have been given above. Also, $\widehat{\pi}(b, I)$ is identically zero for positive levels of net worth and is equal to 1 for some sufficiently large debt level. Denote by r the exogenous risk-free saving rate and ϕ a transaction cost for lending, so that $r + \phi$ is the risk-free borrowing rate.

Given the preceding and the loan guarantee program parameters (θ, ϑ), the break-even pricing function on loans ($b < 0$) will depend on the size of the loan relative to the guarantee limit ϑ as follows. First, since only loans smaller than the guarantee ceiling entitle lenders to compensation, qualifying loans (those with $b \in (-\vartheta, 0)$) are priced as follows:

$$q(b, I) = \psi_{j+1|j} \left[\frac{(1 - \widehat{\pi}(b, I))}{1 + r + \phi} + \frac{\widehat{\pi}(b, I)\,\theta}{1 + r + \phi} \right] \text{ if } 0 > b \geq -\vartheta. \tag{3.8}$$

The first term, $\psi_{j+1|j}$ reflects the fact that repayment occurs, if at all, only if the borrower survives. Conditional on survival, the payoff to a loan of face value b will be complete in the event of no default, which occurs with probability $1 - \widehat{\pi}(b, I)$, and partial, according to the guarantee, if default occurs. These payoffs are then discounted according the cost of funds, inclusive of transactions costs, $1 + r + \phi$. For any loans exceeding the guarantee qualification threshold, lenders will receive nothing in the event of default. As a result, the preceding zero-profit loan price collapses (the second term goes to zero), yielding the simpler expression

$$q(b, I) = \psi_{j+1|j} \left[\frac{(1 - \widehat{\pi}(b, I))}{1 + r + \phi} \right] \text{ if } 0 > -\vartheta > b. \tag{3.9}$$

Lastly, savings are trivial to price, as they carry no transactions costs or default risk. Therefore, for $b \geq 0$, we have

$$q(b, I) = \frac{1}{1 + r} \text{ if } b \geq 0.$$

For the full information setting we assume I contains the entire state vector for the household:

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[17] This restriction seems to be standard practice in markets where some form of loan guarantee program exists. For example, FNMA (Fannie Mae) will not issue guarantees on loans which do not conform to their pre-set standards, which include a restriction on the loan-to-value ratio.

[18] As we noted earlier, qualification actually applies to the total debt of the borrower, not the total loan emanating from any one lender. An implicit assumption is therefore that this debt burden is observable.

$I = (y, e, \nu, x, \lambda, j)$. Abusing notation slightly, let $d(\cdot)$ now denote the decision *rule* governing default. As described earlier, this function drives the decision to repay a given debt or not, and hence depends on the full household state vector. Letting non-primed objects represent current period decisions, and using primed variables for objects dated one-period ahead, we have the following zero profit condition for the intermediary. Simply put, it requires that the probability of default used to price debt must be consistent with that observed in the stationary equilibrium, implying that

$$\widehat{\pi}^{fi}\left(b, y, e, \nu, x, \lambda, j\right) = \sum\nolimits_{e', \nu', \lambda', x'} d(b, e', \nu', x', \lambda', j+1) \pi_e\left(e'|e\right) \pi_\nu\left(\nu'\right) \pi_\lambda\left(\lambda'|\lambda\right) \pi_x\left(x'\right). \quad (3.10)$$

Since $d\left(b, e', \nu', x', \lambda', j+1\right)$ specifies whether or not the agent will default in state $\left(e', \nu', x', \lambda'\right)$ tomorrow at debt level b, integrating over all such events *one-period hence* produces the relevant default risk $\widehat{\pi}^{fi}$. This expression also makes clear that knowledge of the persistent components (e, λ) is relevant for predicting default probabilities, and the more persistent these characteristics are, the more useful they become in assessing default risk.

3.5.1. Asymmetric Information

As we noted at the outset, in earlier work, Sanchez (2010), and Athreya, Tam, Young (2011) both find that in past decades, unsecured credit market outcomes may well have been affected by asymmetric information. In the latter, asymmetric information governing *individual-level costs of bankruptcy* were shown to be consistent with a variety of features of the data from the 1980s and earlier. Thus, to evaluate the implications of loan guarantees under asymmetric information, we assume that nonpecuniary default costs, $\lambda_{j,y}$, is unobservable. With the exception of current household net worth following the bankruptcy decision in a period (which we denoted by "a") all other household attributes, including educational attainment, age, and the current realization of the persistent component of income are assumed observable. To be clear, the use of household decisions rules and the distribution of households over the state space to infer a borrower's current net worth, a, is *not* because the latter is relevant to forecasting income, default risk, or anything else; it is not. Rather, it is because lenders want to draw a more precise inference on the current values of the persistent aspects of a household's state. In this case the inference is about the current realization of a household's λ, something that is clearly relevant to assessing default risk.

Let $\pi^*(\lambda|b, y, e, \nu, x, j)$ denote the conditional probability of a household having a realized value of λ, given that they have observable characteristics y, e, ν, x, j, *and* that they have issued bonds of

b units of face value. To construct $\pi^*(\cdot)$, lenders use their knowledge of household decision making and the joint (conditional) distribution of households over the state-space to arrive at a probability distribution for the current value a household's non-pecuniary default cost.[19] The best estimate of default risk is then given by:

$$\widehat{\pi}^{pi}(b, y, e, \nu, x, j) = \sum\nolimits_{\lambda} \pi^*(\lambda | b, y, e, \nu, x, j)\, \widehat{\pi}^{fi}(b, y, e, \nu, x, \lambda, j)$$

3.6. Equilibrium in the Credit Market

Here, we follow Athreya, Tam, Young (2011), and employ the Perfect Bayesian Equilibrium (PBE) concept to define equilibrium in the game between borrowers and lenders.[20] 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 $\mathcal{I} \subset \mathcal{Y} \times \mathcal{E} \times \mathcal{V} \times \mathcal{L} \times \mathcal{J} \times \{0, 1\}$. Let the stationary joint distribution of households over the state be given by $\Gamma(\Omega)$. Let the stationary equilibrium joint distribution of households over the state space Ω *and* loan requests b' be derived from the decision rules $\{b'^*(\cdot),\ d^*(\cdot)\}$ and $\Gamma(\Omega)$, and be denoted by $\Psi^*(\Omega, b')$. Given $\Psi^*(\Omega, b')$, let $\mu^*(b')$ be the fraction of households (i.e., the marginal distribution of b') requesting a loan of size b'. Lastly, let the common beliefs of lenders on the household's state, Ω, given b', be denoted by $\Upsilon^*(\Omega|b')$.[21]

Definition 1. *A PBE for the credit market game of incomplete information consists of (i) household strategies for borrowing* $b'^* : \Omega \rightarrow \mathcal{R}$ *and default* $d^* : \Omega \times \lambda \times \mathcal{E} \times \mathcal{V} \rightarrow \{0, 1\}$, *(ii) lenders' strategies for loan pricing* $q^* : \mathcal{R} \times \mathcal{I} \rightarrow \left[0, \frac{1}{1+r}\right]$ *such that* q^* *is weakly decreasing in* b', *and (iii) lenders' common beliefs about the borrower's state* Ω *given a loan request of size* b', $\Upsilon^*(\Omega|b')$, *that satisfy the following:*

1. ***Households optimize**: Given lenders' strategies, as summarized in the locus of prices* $q^*(b', I)$, *decision rules* $\{b'^*(\cdot),\ d^*(\cdot)\}$ *solve the household problem.*

2. ***Lenders optimize given their beliefs**: Given common beliefs* $\Upsilon^*(\Omega|b')$, q'^* *is the pure-strategy Nash equilibrium under one-shot simultaneous-offer loan-price competition.*

3. ***Beliefs are consistent with Bayes' rule wherever possible**:* $\Upsilon^*(\Omega|b')$, *is derived from* $\Psi^*(\Omega, b')$ *and household decision rules using Bayes rule whenever* b *is such that* $\mu^*(b') > 0$.

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[19] See Athreya, Tam, and Young (2011) for details.

[20] See, e.g., Mas-Colell, Whinston, Green, Definition 9.C.3, p. 285, and the additional requirement given on p. 452).

[21] Recall that the stationary distribution of households over the state space alone is given by $\Gamma(\cdot)$.

Equilibria are located through an iterative procedure. The interested reader is directed to Athreya, Tam, and Young (2011) where we discuss the computational procedure used to solve for equilibria. As a quick summary, we define an iterative procedure that maps a set of pricing functions back into themselves, and then show three things. First, fixed points of this map are Perfect Bayesian Nash equilibria of the game between lenders and borrowers; second, that this procedure converges to a fixed point; and third, that this fixed point is maximal (in the sense of the size of the budget set for households).[22]

3.7. Government

The purpose of government in this model is to fund pension payments to retirees and to finance the loan guarantee system. The government budget constraint for pensions is

$$\tau_1 W \int \left(y\omega_{j,y} e\nu\right) d\Gamma\left(a, y, e, \nu, x, \lambda, j < j^*\right) = W \int \left(\upsilon \omega_{j^*-1,y} y e_{j^*-1} \nu_{j^*-1} + \Upsilon\right) d\Gamma\left(a, y, e, \nu, x, \lambda, j \geq j^*\right), \tag{3.11}$$

where $\Gamma\left(a, y, e, \nu, x, \lambda, j\right)$ is the invariant cumulative distribution function of households over the states. For the loan guarantee program, the budget constraint is

$$\begin{aligned} &\tau_2 W \int y\omega_{j,y} e\nu d\Gamma\left(a, y, e, \nu, x, \lambda, j < j^*\right) \qquad (3.12) \\ &= \int \psi_{j+1|j} \frac{\widehat{\pi}\left(b\left(a, y, e, \nu, x, \lambda, j\right), I\right)}{1+r+\phi} \max(0, b\left(a, y, e, \nu, x, \lambda, j\right) - \vartheta) \frac{\theta b\left(a, y, e, \nu, x, \lambda, j\right)}{b\left(a, y, e, \nu, x, \lambda, j\right) - \vartheta} d\Gamma\left(a, y, e, \nu, x, \lambda, j\right). \end{aligned}$$

3.8. Wage Determination

For both simplicity and substantive reasons, we assume constant and exogenous factor prices in our welfare calculations. In each case, the imposition of the loan guarantee program leads to more borrowing and lower aggregate wealth. In particular, we assume that the risk-free rate r is exogenous and determined by the world market for credit. Given r, profit maximization by domestic production firms implies that

$$W = (1-\alpha)\left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} \tag{3.13}$$

where α is capital's share of income in a Cobb-Douglas aggregate production technology.

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[22] Uniqueness cannot be ensured, since $q = 0$ is a fixed point of our mapping. However, simple sufficient conditions exist to rule out $q = 0$ as the maximal fixed point; again, see Athreya, Tam, and Young (2011) for details. Also, under symmetric information, the largest budget set yields the equilibrium with the highest welfare for households, but strictly speaking, this need not hold under asymmetric information.

4. Stationary Equilibrium

We have already given the definition of equilibrium for the game between borrowers and lenders. The outcomes of that interaction were, of course, part of a larger fixed point problem that included, among other things, the joint distribution of households over the state space, $\Gamma(\cdot)$, and the tax rates τ_1 and τ_2 needed to fund transfers and loan-guarantees, respectively. But this joint distribution depended on household borrowing behavior, which in turn influenced the construction of $\Gamma(\cdot)$. Given this feedback, we will focus on throughout on stationary equilibria in which all aggregate objects including, critically, the joint distribution $\Gamma(\cdot)$ remain constant over time under the decision rules that arise from household and creditor optimization.

Computing stationary equilibria requires two layers of iteration. We first specify the wage rate, interest rate, tax rates, and public sector transfer- and loan-guarantee policy. This allows us to solve the household's decision problem and locate the associated stationary distribution of households over the state space–all for a given *guess* of the equilibrium loan-pricing locus $q(\cdot)$. Our use of a risk-free rate-taking open economy allows us to iterate on the function $q(\cdot)$ without having to deal any additional feedback from loan pricing to risk-free interest rates and wages. Once we have located a price function that is a fixed point under the stationary distribution induced by optimal household decision making, which we can denote by $q^*(\cdot)$, we need to check if the government budget constraint holds. Here, we must iterate again, this time on transfers and taxes. We proceed by guessing the size of old-age and loan-guarantee transfers and tax rates, and iterate (re-solving for the fixed-point loan pricing function $q^*(\cdot)$ each time, of course) until the associated stationary equilibrium generates allocations that, given the tax rates, satisfy the government budget constraint.

5. Parametrization

To assign values to model parameters, we proceed first by imposing standard values from the literature for measures of income risk, out-of-pocket expenses, risk aversion, and demographics. We then calibrate the remaining model parameters, which are those governing bankruptcy costs and the discount factor. The goal is to match as well as possible, key facts about bankruptcy and unsecured credit markets in the US, given income risk, risk aversion and demographics. As discussed earlier, we follow the literature by calibrating to recent data and assuming *symmetric* information between borrowers and lenders.

The parametrization is relatively parsimonious and largely standard. First, as mentioned above we directly assign values to household level income risk and risk aversion at values standard in the literature. The model period is taken to be one year. The income process is taken from Hubbard, Skinner, and Zeldes (1994), who estimate separate processes for non-high school (NHS), high school (HS), and college-educated (Coll) workers for the period 1982-1986.[23] Figure 3 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 because of higher survival probabilities). The process is discretized with 15 points for e and 3 points for ν. The resulting processes are

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

for non-high school agents,

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

for high school agents, and

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

for college agents. We normalize average income to 1 in model units, and in the data one unit roughly corresponds to $40,000 in income. When we construct the invariant distribution of the model, we assume households are born with zero assets and draw their first shocks from the stationary distributions.

To assign values for the idiosyncratic risk of out-of-pocket expenses, we choose the parameters

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[23] In Athreya, Tam, and Young (2009) we study the effect of the rise in the volatility of labor income in the US and find the effect on the unsecured credit market to be quantitatively small; the key parameter for default is the persistence of the shocks. We would find similar numbers if we adjusted the variance of the shocks upward to conform to more recent data.

for the expenditure shock x_j to be the annualized equivalent of those used in Livshits, MacGee, and Tertilt (2007). For pensions, we set $\upsilon = 0.35$ and $\Upsilon = 0.2$, yielding an average replacement rate of 55 percent, and assume an exogenous retirement age of $j^* = 45$. Relative risk aversion is set to $\sigma = 2$, as is standard, and a value that also avoids overstating the insurance problem faced by households. Lastly, with respect to demographics, we set the measures of the college (Coll), high school (HS), and non-high school (NHS) to 20, 58, and 22 percent, respectively, and the maximum lifespan to $J = 65$, corresponding to a calendar age of 85 years.

Table 1 displays the targeted moments and the implied ones from the model.[24] Table 2 displays the parameters associated with this calibration, along with the other parameters of the model (such as the cost of default Λ, which is set to match the observed \$1200 filing cost). First, the default rates, measured as filings for Chapter 7 bankruptcy, are very close to the data. Second, the model does fairly well at matching the debt/income ratios in the data, measured as credit card debt divided by income (from the Survey of Consumer Finances 2004), although it gets the order backward: we understate debt for college types and overstate it for non-high-school types. Lastly, the model overstates the fraction of borrowers and understates the discharged debt to income ratio.[25]

To parameterize the non-pecuniary costs of bankruptcy while limiting free parameters, we represent λ by a two-state Markov chain with realizations $\{\lambda_{L,y}, \lambda_{H,y}\}$ that are independent across households, but serially dependent with a symmetric transition matrix Π_λ:

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

The calibrated process suggests that non-pecuniary costs of bankruptcy are largely in the nature of a "type" for any given household. This interpretation arises because the benchmark calibration reveals λ to be very persistent, and therefore very unlikely to change during the part of life where unsecured credit is useful. This persistence is also what makes the model consistent with the observed ability of households to borrow substantial amounts but still default at a nontrivial rate. Despite this "implicit collateral," debts discharged in bankruptcy are still higher in the data; however, the discharge ratio from the data (obtained as the median debts discharged in bankruptcy divided by the median income of filers taken from the survey data of Sullivan, Warren, and West-

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[24] The calibrated parameters are obtained by minimizing the (equally-weighted) sum of squared deviations between the data and moments from the invariant distribution of the model. Since the model is not linear, we cannot guarantee that there exists a set of parameters that makes this criterion zero; indeed, we find that such a vector does not exist.

[25] If we had data on discharge by education type, we could permit the persistence of λ to vary by type and possibly match the aggregates more closely.

brook (2000)) is likely an overestimate, as it includes small business defaults that are generally large and not present in the model. The size of the values for λ are relatively large, implying that even the low cost types view default as equivalent to a loss of nearly 10 percent of consumption; thus, the primary source of implicit collateral in this model is stigma rather than pecuniary costs.

Table 3 presents a decomposition of defaults according to the various combinations of expense shock and stigma. The median shock for x and the high value of λ constitute only 3.55 percent of the population but are responsible for 58.11 percent of the defaults under symmetric information, while the high shock for x and high value for λ are 0.23 percent of the population and 6.66 percent of the defaults. Thus, defaults are clearly skewed toward households that experience an expenditure shock, consistent with the model of Livshits, MacGee, and Tertilt (2007). We will return to this table when we discuss the asymmetric information case, where expenditure shocks are essentially the only source of defaults.

Lastly, while omitted from the tables for brevity, the other relevant probability is that of the likelihood of default *given the receipt of an expenditure shock*. This distribution yields two pieces of information about the model. First, getting an expenditure shock, particularly the largest one, greatly increases the likelihood of default, all else equal. Second, the vast majority of households who receive such a shock still do not default. The reason for this is that the power of such shcoks to drive default, while non-trivial, is still naturally limited by the wealth positions households take on as they move through the life-cycle. Default is most likely to happen when one has substantial debts at the same time that one receives such a shock. This rules out relatively older households from being very susceptible; as seen in Figure 6, they have, in the main, already begun saving for retirement.[26]

6. Results

We will study four types of allocations. First, we examine our benchmark setting, where information is symmetric and there is no loan guarantee program. Second, we introduce various loan guarantee programs and examine how credit market aggregates, default rates, and welfare are al-

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[26] For the high risk households (high λ in the model):
High expense shock: 26%
Median expense shock: 15%
Low expense shock (a value of zero)=1%
For the low risk households (low λ in the model):
High expense shock: 17%
Median expense shock: 2%
Low expense shock (a value of zero)=0%
The numbers are very similar under asymmetric information.

tered. Third, we relax the assumption of symmetric information and study allocations without loan guarantees; in this setting we permit lenders to use all *observable* characteristics to infer as much as they can about borrowers. Finally, we examine the introduction of loan guarantees into this asymmetric information environment. We will refer to these four allocations as FI, FI-LG, PI, and PI-LG, respectively.

To preview the results, we find that introducing a small loan guarantee program into a symmetric information economy (comparing FI with FI-LG) can benefit all newborns, independent of type, but that increasing generosity quickly eliminates the gains for skilled types. In the environments with asymmetric information (comparing PI to PI-LG), welfare gains are larger for any given generosity, but the same pattern emerges. Thus, a general lesson to be gleaned from these experiments is that loan guarantees are welfare-improving, and in fact can be welfare-improving for all newborns, provided they are not too generous.

6.1. Symmetric Information

As we noted at the outset, unsecured credit markets are most vital for the consumption smoothing needs of the least wealthy members of any society. This is obvious for any household with liquid wealth, but even those whose wealth is illiquid will, in general, be able to pledge at least a portion of that wealth to obtain credit. Moreover, as we noted, existing work suggests that information asymmetries may not be central, relative to the limited-commitment problem, in explaining current U.S. unsecured credit market activity. We therefore first isolate the role that loan-guarantees play to deal with the effects of such a friction by studying the model under symmetric information. Moreover, since loan-guarantee programs require two parameters for their specification, we simplify the results by focusing throughout the analysis – and unless otherwise stated – on the case where the replacement rate is set to cover 50 percent of lender losses, i.e., $\theta = 0.5$.

6.1.1. Allocations and Pricing

Our first main result is that loan guarantees are powerful tools in altering the use of unsecured credit. In Table 4, we see that as we move away from the case with no loan guarantees ($\vartheta = 0$), equilibrium borrowing rises for all households, and the increase in debt is non-linear. In particular for small qualifying loan sizes (e.g. $\vartheta = 0.1$, or \$4,000), allocations are fairly similar to a setting with no guarantees. In large part, this similarity reflects the presence of bankruptcy costs which serve as a form of implicit collateral. In particular, the fixed cost component of bankruptcy (Λ) will ensure the existence of a region of risk-free debt. Therefore, under a small qualifying loan size, few individuals will see their access to credit substantially altered; in fact, setting $\vartheta < -\Lambda$ would have no effect on credit, since those loans are always risk-free. Once the qualifying loan size grows large enough to make large loans "cheap" relative to default risk, matters are different. The compensation to lenders for default disproportionately subsidizes large loans, and thereby generates the significant additional default seen in Table 4.

The differential distortion to loan pricing is displayed in Figure 4, and our model suggests that this feature helps account for the striking distributional consequences seen in Table 4. In particular, borrowing behavior changes in different ways across the education groups. Relative to income, debt rises by far the most for NHS households. The differential increase in debt relative to income for the lowest skilled is also reflected in the disproportionate rise in bankruptcy rates within this group. While remaining modest under small qualifying loan ceilings, more generous ceilings create greatly increased default rates. The preceding suggests in part that the pricing of debt is a meaningful barrier to nearly all households, but especially the least skilled (NHS) households. An additional force at work is that high-skilled households have less reason to use unsecured credit beyond early life. As a result, any distortion in the pricing of debt will affect them less than their NHS counterparts. In particular, all NHS households that have income below their age-specific mean will find "artificially" cheap credit useful, while the well-educated, many of whom wish to save less for precautionary reasons and more for life-cycle reasons (arising from the more pronounced hump in their average earnings shown in Figure 3), will be far less sensitive. Lastly, under high ceilings for qualifying loan guarantees, the high tax rate will also meaningfully compress the intertemporal profile of earnings, and therefore attenuate the incentives of the skilled to borrow for pure lifecycle smoothing. This will make loan guarantees even less valuable than otherwise.

6.1.2. Welfare

Having shown results suggesting that loan guarantees will likely have sizeable and non-linear effects on credit use and default, we now turn to the issue that motivated us at the outset: can loan guarantees, by breaking the link between credit risk and loan pricing, improve welfare? And if so, for whom? Our metric for measuring welfare is standard: it is the increment to consumption at all dates and states needed to make the household indifferent, in terms of *ex ante* expected utility, between the benchmark economy and the one with loan guarantees.

A fact that will be important for welfare is that households in our economy that borrow are always *constrained*. Figure 5 plots indifference curves in (b, q) space along with the zero-profit pricing function; the optimal amount of borrowing and the resulting price lies where the highest indifference curve intersects this zero-profit curve. At this point the slope of the indifference curve is strictly smaller than the slope of the pricing function (which is infinite). This implies that borrowing more is desirable at the current interest rate, but the increase in the default rate that a marginal increase in b would generate means that lenders must charge a higher rate. As a result, by reducing the slope of the pricing function at the optimal point, loan guarantees can improve utility at the margin. What we are contemplating, however, are not marginal changes; thus, whether a discrete change is welfare-improving is a quantitative question.

We see first, from Table 4, that more generous loan guarantees come with higher taxes, and that the taxes also naturally reflect the non-linearity in household borrowing and default behavior (that is, taxes are a convex function of ϑ). However, not all households pay the same amount in taxes, and, as we noted, proportional taxes – which are used here – will by themselves provide some risk-sharing benefits. Moreover, the loan guarantee may allow for an effective form of insurance for some households, especially the low-skilled. The transfers from loan guarantees come "at the right time" for households, but require households to pay a cost akin to a deductible. Therefore, while households pay more in taxes under a generous loan guarantee scheme, they receive transfers in a manner that is effective in providing insurance. Turning to welfare in Table 5, we see that this is precisely what is at work. In this table a positive value indicates a gain to welfare from moving to loan guarantees, and vice versa. In particular, we see that generous loan guarantee schemes mainly represent transfers to the very unskilled. These are, in turn, the groups with the most to gain from improved credit access. As a result, the most skilled households lose in welfare terms from any qualifying loan sizes in excess of approximately \$4000 ($\vartheta = 0.1$). Conversely, HS households continue to gain, and gain substantially in welfare terms, from loan guarantees of up to \$16,000 ($\vartheta = 0.4$). Most strikingly, NHS households gain for very large loan guarantee levels, even to levels exceeding their mean income level. In summary, our results suggest that modest loan guarantee programs can improve welfare for all households, even those households who likely will pay the bulk of the taxes needed to finance them. However, our model also suggests that qualifying loan size is likely to be quite important in determining whether a particular guarantee program serves all households or instead functions as a very significant redistributive mechanism. In the absence of definitive means for detecting the sensitivity of aggregate credit use and default to the size of qualifying loans, instituting a program that is too generous will lead to significant welfare losses for some groups.[27]

Where do the welfare gains come from? Table 6 shows mean consumption and decomposes the variance of consumption into two moments: the variance of mean consumption by age, a measure of *intertemporal* consumption smoothing, and the mean of consumption variance by age, a measure of *intratemporal* consumption smoothing.[28]

Loan guarantees reduce mean consumption due to the combination of higher taxes, more borrowing, and more frequent default. The gain comes through a better distribution of consumption over the life cycle. We see here that this gain is driven entirely by a reduction in the intertemporal dimension as intratemporal consumption volatility actually *increases*.

We note here that our welfare results differ significantly from those in Athreya, Tam, and Young (2010), where the role of the out-of-pocket costs of default, Λ, in restricting access to bankruptcy is explored. High values of Λ restrict access to bankruptcy to high income types (who typically do not want to default), and in a wide range of models the optimal value (from an *ex ante* perspective) is infinite for all types; that is, from the perspective of a newborn household, permitting any bankruptcy in equilibrium is suboptimal.[29] The largest gains are experienced by the college types, because they have the strongest demand for purely intertemporal borrowing and this demand is thwarted by risk-based pricing. There are a number of reasons to view that result as impractical from a policy perspective. Loan guarantees, in contrast, are clearly policy-feasible and benefit the least-skilled more than the more-skilled.[30]

6.1.3. Decomposing the Effect of Taxes on Welfare

In this section we decompose the net effect of the loan guarantee program. We consider two experiments, presented in Table 7, where we ask how welfare changes if we confront an individual with the pricing emerging from the presence of a loan guarantee, with and without the taxes needed to finance the program. Starting in the top row of Table 7 we display the effect of a move from the benchmark setting to one in which a tax-free loan guarantee is provided. Welfare increases quite substantially, again by least for the skilled and by most for the unskilled. Since their income profile

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[27] The analytical work of Jia (2011) is relevant here: he shows that as a qualititative matter, barring eligibility requirements, loan guarantees will lower welfare.

[28] Specifically, we use the decomposition: $\text{var}(\log(c)) = \text{var}(\text{E}[\log(c)\,|j]) + \text{E}[\text{var}(\log(c)\,|j)]$

[29] If consumption sets can become empty, eliminating bankruptcy cannot be optimal. Athreya, Tam, and Young (2011) abstracts from expenditure shocks.

[30] Davila *et al.* (2007) shows that utilitarian constrained efficient allocations in a model with uninsurable idiosyncratic shocks are skewed toward improving the welfare of "consumption-poor" households (since they have higher marginal utility). While we do not attempt to characterize constrained efficient allocations here, it seems clear that this intuition would apply – thus, policies which raise the utility of the least-skilled would seem to be preferable from a social welfare perspective.

is flat, the NHS households experience the largest gain because they use unsecured debt over most of their life cycle. By contrast, the more-skilled types decrease unsecured borrowing as they age (see Figure 6).

Turning next to the bottom row of Table 7, we present the welfare implications of a move from a setting with a tax-free loan guarantee to one where the taxes must now break the program even. As seen from Table 5, once taxes are imposed only the unskilled benefit from a program this generous, and they lose proportionally more from taxes than do the college types. Why are the costs of a small tax so large in this model? With taxes, permanent income is reduced, leaving households more exposed to the expenditure shock. As a result, they "involuntarily" default more frequently, leading to more deadweight loss and a much larger welfare loss than one would expect from a tax of less than 4 percent. Due to the accumulation pattern of net worth, on average NHS households are more exposed to this risk (again, see Figure 6).

Table 8 decomposes the costs of the program by type. The loan guarantee program transfers resources along two dimensions. First, loan guarantees transfer resources from skilled households to less-skilled; college types pay into the program, via taxes, significantly more than they collect in terms of lower interest rates. Second, loan guarantees transfer resources from individuals who pose little default risk (those with *low* λ) to those with a high value for λ, as the latter pose more default risk, all else equal. This transfer occurs because the high risk types would pay substantially higher interest rates without intervention and therefore gain a lot from the program.

6.2. Asymmetric Information

Returning to the problem noted at the outset of the previous section, recall that the cost of limited access to unsecured credit is likely largest for the least wealthy. This is particularly likely to be true in a society that lacks the information storage, sharing, and data-analysis available in developed nations to effectively identify credit risk at the time of loan origination (and then update it regularly). As a first step in getting a sense of the quantitative potential of loan guarantees to alter outcomes in such settings, we now study stationary equilibria of our model under asymmetric information.

To remind the reader, in our economy, asymmetric information will mean that the borrower will have characteristics that are not observable to the lender; specifically, we assume neither current stigma, λ, nor current net worth, a, can be directly observed. However, any information about these variables that can be *inferred* from the observable components of the state vector, as well as from the desired borrowing level, b, is available to the lender.[31] We focus on two representative examples: one that represents a relatively modest loan guarantee program and results in welfare gains for all types under symmetric information ($\theta = 0.1$ and $\vartheta = 0.1$), and one that is more generous and reduces the welfare of college-educated types ($\theta = 0.5$ and $\vartheta = 0.4$). Our key finding is that the presence of asymmetric information will increase the gains available from loan guarantees, no matter how generous.

6.2.1. Allocations and Pricing

We first compare outcomes in the FI and PI economies. Table 9 shows that a move from symmetric to asymmetric information has the following effects. First, default falls for all types, and default skews more strongly toward the high λ type; these individuals are treated relatively better under asymmetric information, since they get terms that reflect the average default risk instead of their own, and therefore end up borrowing amounts that induce relatively high default rates. Second, overall the credit market shrinks, in the sense that we observe fewer borrowers (of each type) and lower discharged debt aggregates.

Figure 7 shows that pricing is significantly worse for the high λ (*low* bankruptcy cost) borrower and *better* for the low λ borrower. Under asymmetric information, the two types will be pooled together, so that the default premium at a given debt level reflects the average default risk. The result is that good borrowers face significantly tighter credit limits and higher interest rates, while bad borrowers face the same credit limit but lower interest rates. The shift in pricing accounts for the smaller credit market size.

Third, expenditure shocks take on a larger role in defaults under asymmetric information (see Table 3). With tighter credit limits, big expenditure shocks that hit when the household is young are hard to smooth, since income is relatively low. The result is that essentially all defaults are done by households that have received an expenditure shock, despite this group being only 7.56 percent of the population. Information has less of an impact on these defaults, since they are defaults on debt that has been acquired involuntarily.

We now turn to the effects of loan guarantees under asymmetric information. Table 9 shows that the change induced by the introduction of the particular program is larger for all credit market aggregates under asymmetric information, with the exception of the debt-to-income ratio for college

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[31] We assume that credit markets are anonymous, so that past borrowing is also not observable to the current lender. In Athreya, Tam, and Young (2011) we introduce a flag that tracks whether a household is likely to have recently defaulted. Due to computational considerations we do not examine this case here.

educated households (in which case it is of only slightly smaller magnitude). Figure 8 shows the increased access to credit that guarantees provide in these two cases. Note that the increase in the default rate is smaller under asymmetric information for every education group. As a result, the taxes required to finance the program are lower than under symmetric information.

6.2.2. Welfare

Table 10 displays the welfare effects of two different loan guarantee programs. Relative to the symmetric information case, loan guarantees are uniformly better when information is asymmetric; this result holds for every case we have computed. The larger gain is partly due to the lower tax burden required in the asymmetric information cases and partly due to the severe pricing distortion caused by asymmetric information evident in Figure 7.

To more directly describe the transfers between agents induced by loan guarantees, Table 8 collects the proportion of costs paid by each group. Now, the loan guarantee program subsidizes the high λ (low stigma cost) types much more than under symmetric information. This result is exactly what we would expect, given that this type is receiving better credit terms under asymmetric information.

6.3. Targeted Loan Guarantees

Our results suggest that loan guarantees have the potential to become primarily a means of transferring resources from the rich to the poor. Moreover, our findings suggest that they may also lower welfare, often of all types of agents, unless their generosity is modest. Moreover, in our results, default is disproportionately driven by those who have received an expenditure shock. A natural question therefore is whether the benefits of loan guarantees discussed at the outset can be preserved by limiting compensation to lenders only when a borrower has suffered such a shock. Expenditure shocks represent large increases in debts that are rare and involuntarily acquired. As a result, a policy of guaranteeing loans only under these conditions is unlikely to alter loan pricing substantially (since these states are rare) but may substantially aid households that find themselves in those rare states. Moreover, targeted guarantees are unlikely to induce significant additional deadweight loss because the default decision is more frequently heavily influenced by expenditure shocks, which again, are rare.

To investigate this question, we study a case where $\vartheta = 0.50$ and $\theta = 0.50$, but where lenders only receive compensation in the event that a bankruptcy coincides with a positive expenditure shock ($x > 0$). Table 11 shows that all groups gain from the introduction of a loan guarantee program restricted in this manner. As before, the NHS households gain most and the highly skilled gain the least. Nonetheless, the ability of the conditionality of the program to overturn what was initially a very large welfare loss to the skilled into a gain is striking.[32]

To see the effect on aggregates more generally, we turn to Table 12. It is immediately clear that the tax rate needed to sustain the restricted loan guarantee program is very small relative to the unrestricted case, even though the debt discharged in bankruptcy is similar to the unrestricted guarantee case. Nonetheless, the overall level of debt responds to the restricted guarantee far more modestly than the unrestricted case. For example, under restricted guarantees, the mean debt-to-income ratio among high-school educated borrowers is less than half that under unrestricted guarantees (0.2256 vs. 0.4707). The central reason for the low tax rate is that the default rate responds by far less than with an unrestricted program, even though borrowing does increase nontrivially, relative to the benchmark case. Under restricted guarantees, the bankruptcy rate roughly doubles, while the unrestricted program implies a nearly ten-fold increase.

7. Discussion

We have made a few assumptions in our model that require some additional discussion. First, we have assumed that factor prices are fixed. General equilibrium calculations would imply higher r and lower W would prevail under loan guarantee systems, since they produce more borrowing and less aggregate wealth (as well as increasing the amount of transactions costs that works like a reduction in aggregate supply of goods). Factor price movements of this sort are likely to make the welfare costs larger (gains smaller), since the higher risk-free interest rate would make borrowing more costly and the lower wages would reduce mean consumption. Despite these effects, we choose to abstract from equilibrium pricing because it is well known that income processes representative of the vast majority of households will, in environments such as ours, produce less wealth concentration than observed (see Castañeda, Díaz-Jiménez, and Ríos-Rull 2003), meaning that the mean wealth position will be too similar to the median. That is, the mean agent will care "too much" about changes in the debt market, implying larger factor price changes than would occur if the distribution of wealth were matched. Given the immense computational burden that matching the US Gini coefficient of wealth would impose on our OLG setup, and given that the factor price adjustments

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[32] We are implicitly assuming that expenditure shocks are likely to be easy to observe; we doubt that agents could easily hide one from the government, given the size and nature of these shocks. Our calibration, as noted above, equates x to a combination of medical and legal bills plus unplanned family costs; these expenses should be relatively easy to monitor in practice.

should be small, we feel justified in ignoring them.[33]

Second, we have financed the program using proportional labor income taxes. An obvious alternative would be to finance the program using progressive income taxes, where high income (college) types would pay higher marginal tax rates. This approach would increase the gains to the NHS types, who already gain substantially, and reduce (or even eliminate) any gains to college types. We expect a similar result from capital income taxation as well, since it will tend to tax the wealthier college types more heavily. In contrast, a *regressive* income tax would imply the types who benefit the most, the NHS, would pay a higher marginal tax rate. Regressive tax systems seem unlikely to be implemented on equity grounds, even if they are welfare-improving within a specific model. We could also introduce separate programs for each education group, so that the cross-subsidization that makes the program so attractive to NHS types would be eliminated; we conjecture that this case would result in larger gains for college types and smaller for NHS.

Third, there is a conceptual issue of the right benchmark allocation. The US corporate income tax rate is 35% and banks are permitted to deduct losses due to nonperforming loans from their taxable income. As a result, it may be that the appropriate benchmark is a case where the loan guarantee program is not zero, but rather has a large value of ϑ and $\theta = 0.35$. We can of course easily express the welfare gains relative to this benchmark instead; a more detailed investigation of this issue is part of ongoing work.

There are some natural extensions of our model that seem useful to pursue. Given our results regarding the effect of loan guarantees to redistribute towards the unskilled from the skilled, it would be productive to know if the least-skilled, for example, would benefit from a loan guarantee program that was required to be self-financing via taxes on only the unskilled. Such an extension would be along the lines explored in Gale (1991), who studies *targeted* loan guarantees designed to facilitate credit access for certain identifiable subpopulations (such as minority borrowers). Targeted programs would be related to the regulations we mentioned earlier that require certain characteristics not be reflected in credit terms; exactly how the dual goals of encouraging access to these groups without allowing their characteristics to alter credit terms would affect welfare is unknown and worth studying. It would also be straightforward to investigate loans targeted to individual borrowers who are deemed constrained by competitive lenders.[34] In our model, since borrowers are at a "cliff" in the pricing function they would benefit from government loans *at their existing interest*

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[33] In Chatterjee *et al.* (2007), the model is calibrated to the US distribution of wealth; the resulting effects of an endogenous risk-free rate are quantitatively unimportant.

[34] A stylized approach to this is taken in Smith and Stutzer (1989).

rate, provided the tax costs are not "too high."

Also, our work is a step in the direction that, in the future, will allow us to analyze the role of guarantees for mortgage lending. However, the central role of aggregate risk in driving home-loan default makes a full quantitative analysis that satisfactorily incorporates the forces we *do* allow for—asymmetric information and limited commitment—currently infeasible. But we note that such model would have the same fundamental structure as that developed here.

8. Concluding Remarks

As stated at the outset, loan guarantees are almost certainly the largest form of intervention in household-level credit markets. Our paper is the first to quantify their likely impact in a model that incorporates both a meaningful private information and limited commitment problem into a rich life-cycle model of consumption and savings. Our quantitative analysis focused on evaluating the impact of introducing loan guarantees into unsecured consumer credit markets. These markets have large consequences for household welfare, because they influence the limits on smoothing faced by some of the least-equipped subgroups in society, particularly the young and the unlucky.

Our results suggest first, that under symmetric information, loan guarantees can actually improve the ex-ante welfare of *all* household-types (by human capital) if they are not too generous. This welfare gain is disproportionately experienced by low-skilled households that face flat average income paths and relatively-large shocks. Indeed, such households gain from very generous programs, but higher-skilled types rapidly begin to experience welfare losses as loan guarantees are made more generous. These results arise because loan guarantees induce a transfer from skilled to unskilled, and this transfer can be substantial, while the gains to the skilled from seeing loan pricing terms improve as a result of guarantees is relatively small. Second, we find that allocations are quite sensitive to the size of qualifying loans: even modest limits on qualifying loan size invite very large borrowing – as perhaps intended by proponents – but also spur very large increases in default rates. As a result, loan guarantee programs transfer resources in significant amounts from all households to the lifetime poor. Under asymmetric information, the welfare gains are larger for all households, as the taxes required to finance the programs are smaller.

One interpretation of our work is that it provides an answer for why, despite the potential for welfare gains from expanding guarantees to consumer credit and thereby alleviating credit constraints for a marginalized population otherwise lacking collateral, they are rarely observed. The value of the program depends on how elastically credit demand and supply respond to default risk, which may be hard to estimate, and the programs are quite costly if too generous. As a practical matter, the forces at work in our model may well be part of explaining why student loan default rates hit 25 percent in early 1990's, at which point the government increased monitoring and enforcement (recall also the similar findings of Lelarge et al (2008) in the French entrepreneurship context). Nonetheless, the fact that consumer loan guarantees have the potential for generating widespread ex-ante welfare improvements while requiring no ex-ante promises to compensate losers is striking, and seems worth keeping in mind.

As noted at the outset, we studied the explicitly-unsecured credit market as a way to learn about consumer loan-guarantees, with the view that the insight gained would likely to carry over to markets where loans are more implicitly unsecured. The two main areas that fit this description, and have seen some form of loan guarantee, are (i) federal student loans and (ii) home loans. Our results suggest that loans of the size guaranteed by federal student loan program would have been likely to default at high rates, even under a relatively "partial" nature of the guarantee. Similarly, the FHA/VA and others have historically provided loan guarantees for seemingly large mortgage loans. The calibrated costs of default measured in our model suggest strongly that larger loans, especially if covered more fully by a loan guarantee program, would lead to even greater debt and default than that predicted for the consumer credit market. Therefore, unless such loans are vetted carefully, one should expect both a high take-up rate, a high subsequent failure rate, and nontrivial transfers from better-off households. To this point, both the FHA and VA loan guarantee programs impose strict underwriting standards with respect to loan-to-value ratios, perhaps because these agencies are cognizant of the possibility of high *ex post* default rates.

Lastly, because loan guarantees may well be a powerful tool for altering aggregate consumption decisions, our work should be of help in future examinations of the extent to which consumer spending can be amplified to spur current activity in *business-cycle* contexts. While currently intractable, we hope to address that question in future work.

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Table 1

Calibration

Calibration	Model	Target/Data
Discharge/Income Ratio	0.2662	0.5600
Fraction of Borrowers	0.1720	0.1250
Debt/Income Ratio | NHS	0.1432	0.08
Debt/Income Ratio | HS	0.1229	0.11
Debt/Income Ratio | COLL	0.0966	0.15
Default Rate | NHS	1.237%	1.228%
Default Rate | HS	1.301%	1.314%
Default Rate | COLL	0.769%	0.819%

Table 2

Calibration

Parameter	Value	Parameter	Value
x_{low}	0.0000	Prob(x_{low})	0.9244
x_{median}	0.0888	Prob(x_{median})	0.0710
x_{high}	0.2740	Prob(x_{high})	0.0046
$\lambda_{\text{low}}^{NHS}$	0.7675	$\lambda_{\text{high}}^{NHS}$	0.9087
$\lambda_{\text{low}}^{HS}$	0.7309	$\lambda_{\text{high}}^{HS}$	0.9320
$\lambda_{\text{low}}^{Coll}$	0.7830	$\lambda_{\text{high}}^{Coll}$	0.9017
$\pi_{HH}^{\lambda} = \pi_{LL}^{\lambda}$	0.9636	J	65
j^*	45	Λ	0.0300
σ	2.0000	ϕ	0.0300
α	0.3000	r	0.0100

Table 3

Default by State

	FI		PI	
	High λ	Low λ	High λ	Low λ
Low x	0.2315	0.0092	0.0089	0.0000
Median x	0.5811	0.0670	0.8033	0.0399
High x	0.0666	0.0446	0.0890	0.0588

Table 4

Aggregate Effects of Loan Guarantee Program

$\theta = 0.50$					
ϑ	0.00	0.10	0.30	0.60	0.70
τ_2	0.0000	0.0005	0.0174	0.0531	0.0664
Discharge/Income Ratio	0.2662	0.2691	0.5430	0.9907	1.1172
Fraction of Borrowers	0.1720	0.2039	0.2400	0.4023	0.4466
Debt/Income Ratio | NHS	0.1432	0.1648	0.4765	0.6562	0.7118
Debt/Income Ratio | HS	0.1229	0.1372	0.3707	0.5369	0.5934
Debt/Income Ratio | COLL	0.0966	0.1140	0.2532	0.3858	0.4124
Default Rate | NHS	1.237%	1.768%	11.651%	19.691%	20.877%
Default Rate | HS	1.301%	1.751%	11.658%	16.609%	17.836%
Default Rate | COLL	0.769%	0.987%	5.668%	11.569%	13.100%

Table 5

Optimal Generosity of Loan Guarantee Program

$\theta = 0.50$			
	COLL	HS	NHS
$\vartheta = 0.00 \rightarrow \vartheta = 0.10$	0.02%	0.08%	0.13%
$\vartheta = 0.00 \rightarrow \vartheta = 0.20$	−0.24%	0.20%	0.22%
$\vartheta = 0.00 \rightarrow \vartheta = 0.30$	−1.41%	0.27%	0.39%
$\vartheta = 0.00 \rightarrow \vartheta = 0.40$	−1.60%	0.19%	0.78%
$\vartheta = 0.00 \rightarrow \vartheta = 0.50$	−2.24%	−0.11%	1.06%
$\vartheta = 0.00 \rightarrow \vartheta = 0.60$	−2.84%	−0.35%	1.26%
$\vartheta = 0.00 \rightarrow \vartheta = 0.70$	−3.60%	−0.44%	1.02%

Table 6

Distribution of Consumption

	$\mathrm{E}(c)$	$\mathrm{var}(\log(c))$	$\mathrm{E}(\mathrm{var}(\log(c)\mid age))$	$\mathrm{var}(\mathrm{E}(\log(c)\mid age))$
Aggregate				
NO LG	0.8455	0.1894	0.1671	0.0223
LG $\vartheta = 0.5, \theta = 0.5$	0.8016	0.1977	0.1755	0.0222
College				
NO LG	1.0918	0.1776	0.1293	0.0481
LG $\vartheta = 0.5, \theta = 0.5$	1.0521	0.3874	0.3354	0.0520
High School				
NO LG	0.7767	0.2279	0.1907	0.0372
LG $\vartheta = 0.5, \theta = 0.5$	0.7575	0.3926	0.3749	0.0180
Non-High School				
NO LG	0.6579	0.2807	0.2582	0.0225
LG $\vartheta = 0.5, \theta = 0.5$	0.6514	0.3932	0.3849	0.0083

Table 7

Welfare Decomposition, Symmetric Information

$\vartheta = 0.5, \theta = 0.50$			
	COLL	HS	NHS
$\left(q^{NLG}, \tau_2 = 0.0\right) \rightarrow \left(q^{LG}, \tau_2 = 0.0\right)$	4.86%	8.30%	10.69%
$\left(q^{LG}, \tau_2 = 0.0\right) \rightarrow \left(q^{LG}, \tau_2 = 0.0386\right)$	-6.74%	-7.76%	-8.69%

Table 8

Net Costs Paid by Type

$\vartheta = 0.50, \theta = 0.50$, **FI**				
	High λ		Low λ	
	Taxes	Transfer	Taxes	Transfer
Coll	0.1366	0.1050	0.1366	0.0384
HS	0.2995	0.5082	0.2995	0.1512
NHS	0.0639	0.1333	0.0639	0.0639

$\vartheta = 0.50, \theta = 0.50$, **PI**				
	High λ		Low λ	
	Taxes	Transfer	Taxes	Transfer
Coll	0.1366	0.1155	0.1366	0.0341
HS	0.2995	0.4971	0.2995	0.1239
NHS	0.0639	0.1711	0.0639	0.0583

Table 9

Aggregate Effects of Loan Guarantees and Asymmetric Information

$\vartheta = 0.40$				
	FI		PI	
$\theta =$	0.0000	0.5000	0.0000	0.5000
τ_2	0.0000	0.0245	0.0000	0.0196
Discharge/Income Ratio	0.2662	0.6965	0.2021	0.6497
Fraction of Borrowers	0.1720	0.3109	0.1614	0.3036
Debt/Income Ratio | NHS	0.1432	0.4880	0.1209	0.4762
Debt/Income Ratio | HS	0.1229	0.3897	0.0909	0.3755
Debt/Income Ratio | COLL	0.0966	0.2691	0.0801	0.2389
Default Rate | NHS	1.237%	13.170%	0.956%	12.704%
Default Rate | HS	1.301%	12.310%	0.957%	11.407%
Default Rate | COLL	0.769%	6.304%	0.658%	5.412%

Table 10

Welfare Effects of Loan Guarantees

	COLL	HS	NHS
NO LG→ $\theta = 0.50, \vartheta = 0.40,$ **FI**	-1.60%	0.19%	0.78%
NO LG→ $\theta = 0.50, \vartheta = 0.40,$ **PI**	-1.02%	0.98%	1.59%
NO LG→ $\theta = 0.10, \vartheta = 0.10,$ **FI**	0.01%	0.02%	0.03%
NO LG→ $\theta = 0.10, \vartheta = 0.10,$ **PI**	0.04%	0.08%	0.11%

Table 11

Welfare Effects of Restricted Loan Guarantees

$\vartheta = 0.5, \theta = 0.50$			
	COLL	HS	NHS
NO LG→Restricted LG	0.40%	0.77%	0.99%
Restricted LG→Unrestricted LG	−2.66%	-0.88%	−0.07%

Table 12

Aggregate Effects of Restricted Loan Guarantees

$\vartheta = 0.50$			
$\theta =$	0.00	0.50	0.50
	No LG	Restricted LG	Unrestricted LG
τ_{LG}	0.0000	0.0004	0.0386
Discharge/Income Ratio	0.2662	0.7208	0.8657
Fraction of Borrowers	0.1720	0.2408	0.3527
Debt/Income Ratio | NHS	0.1432	0.2649	0.5738
Debt/Income Ratio | HS	0.1229	0.2256	0.4707
Debt/Income Ratio | COLL	0.0966	0.1681	0.3285
Default Rate | NHS	1.237%	2.755%	16.797%
Default Rate | HS	1.301%	2.586%	14.619%
Default Rate | COLL	0.769%	1.643%	9.072%

Figure 1: Equilibrium in Two-Period Model

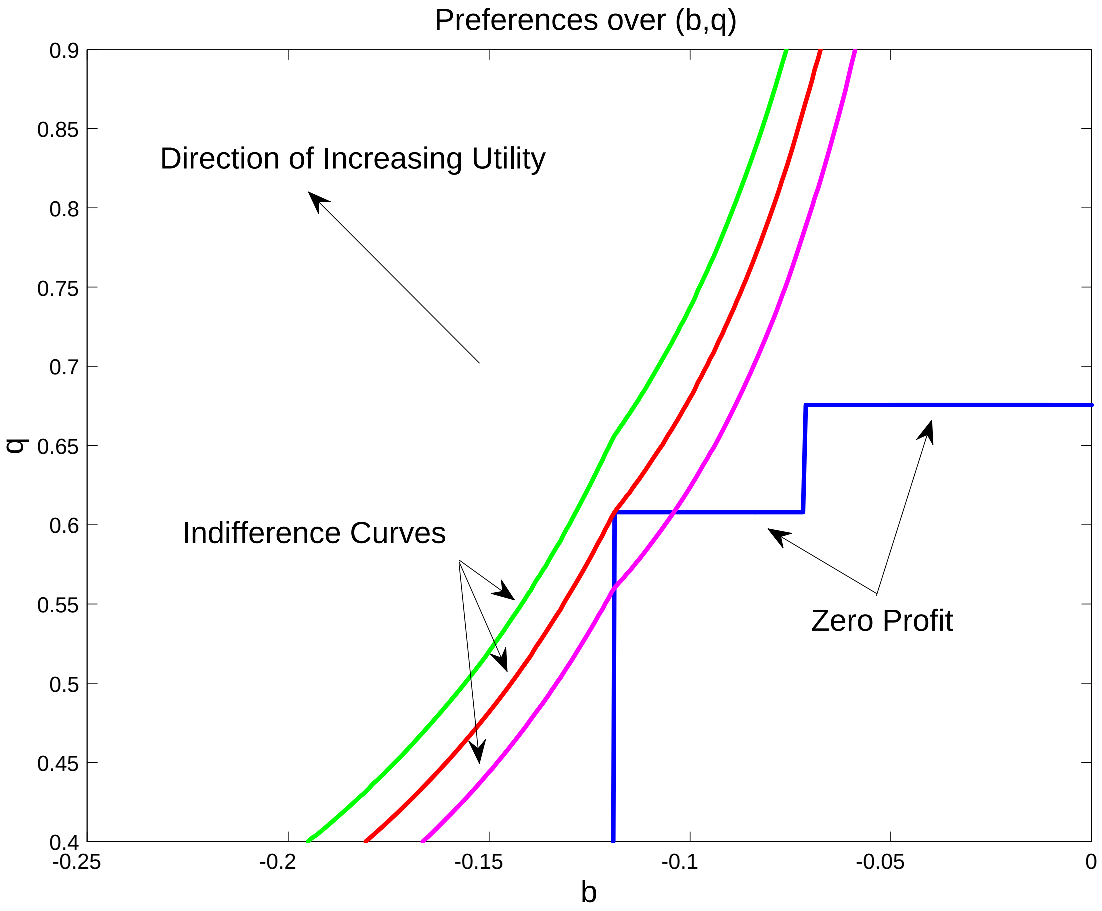

Figure 2: Loan Guarantee Equilibrium in Two-Period Model

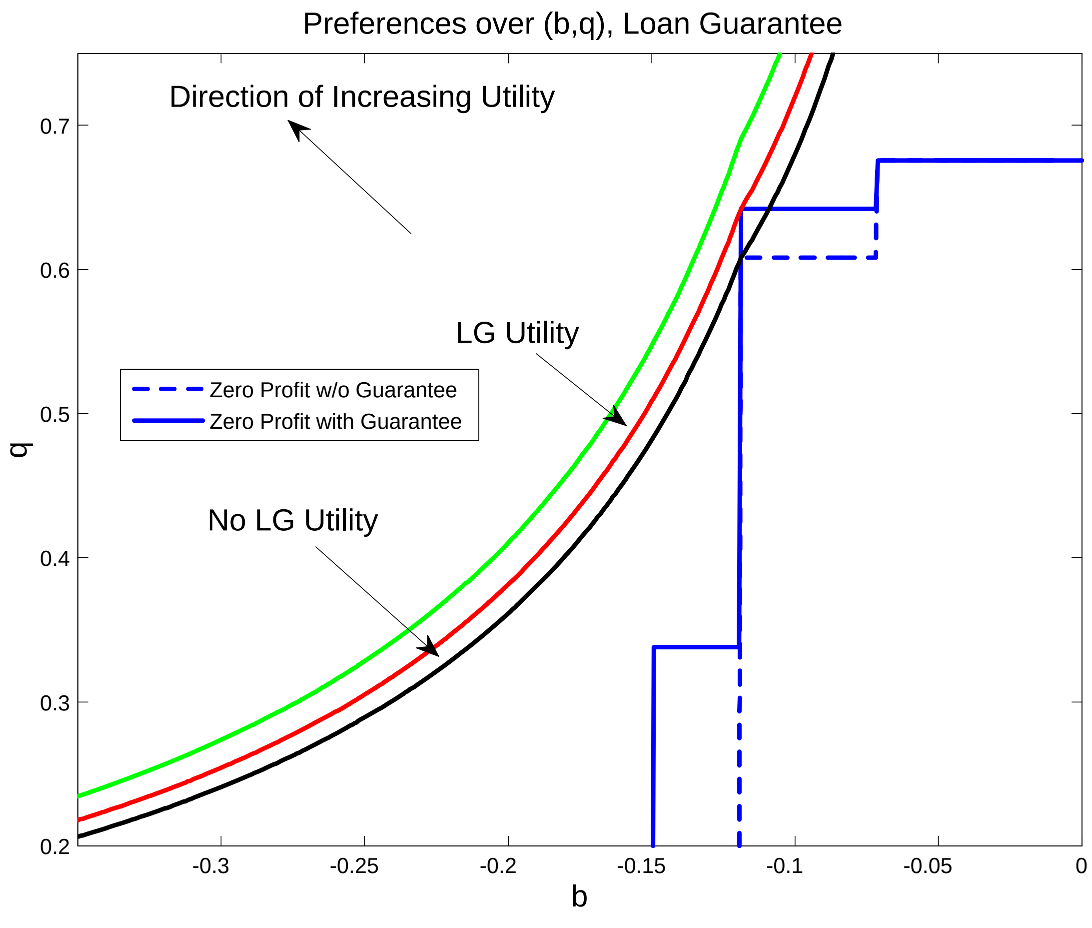

Figure 3: Efficiency Units of Labor

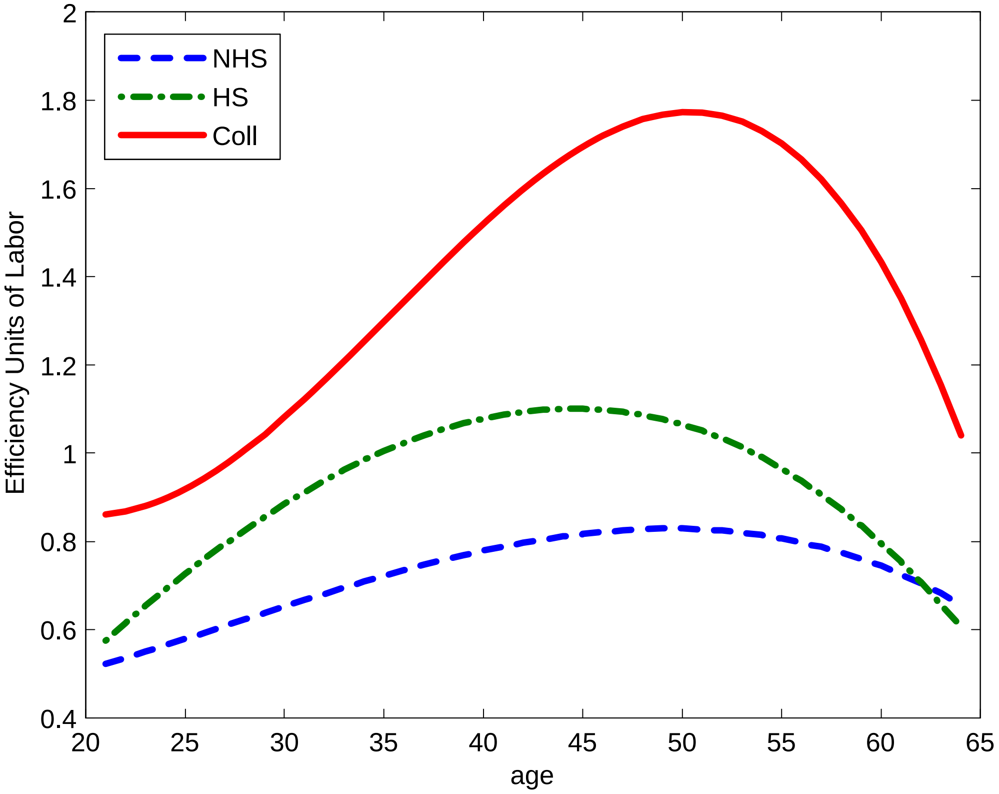

Figure 4: Pricing Functions with and without Loan Guarantees

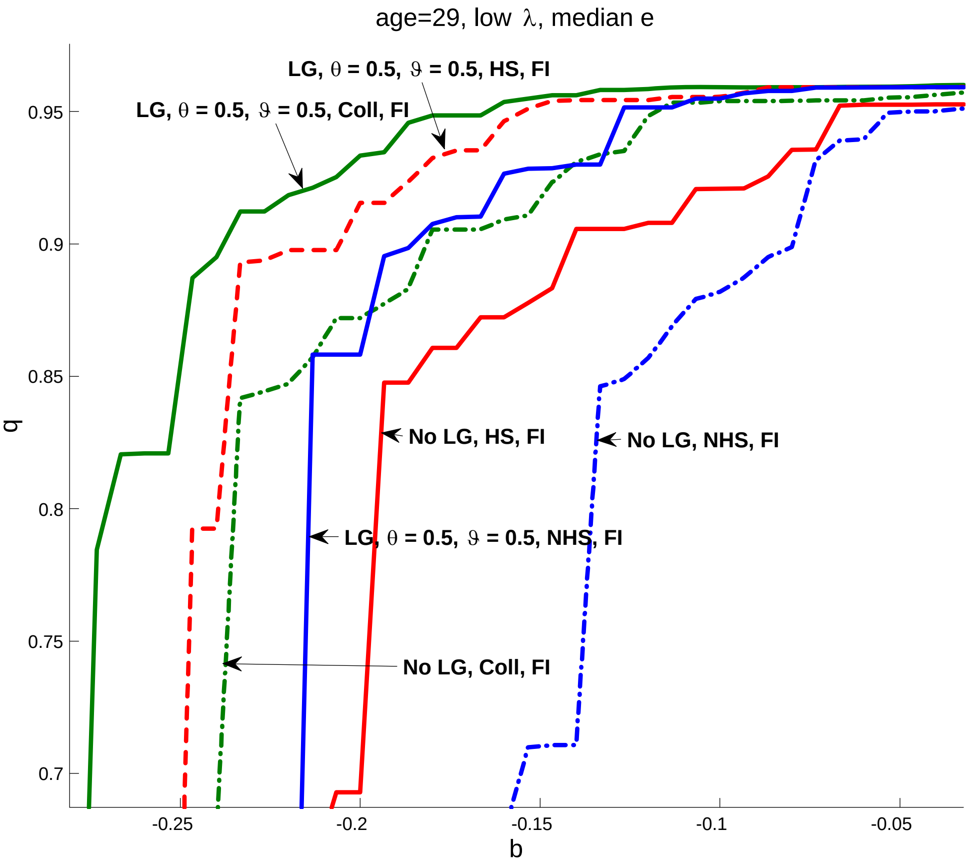

Figure 5: Optimal Choice of Borrowing

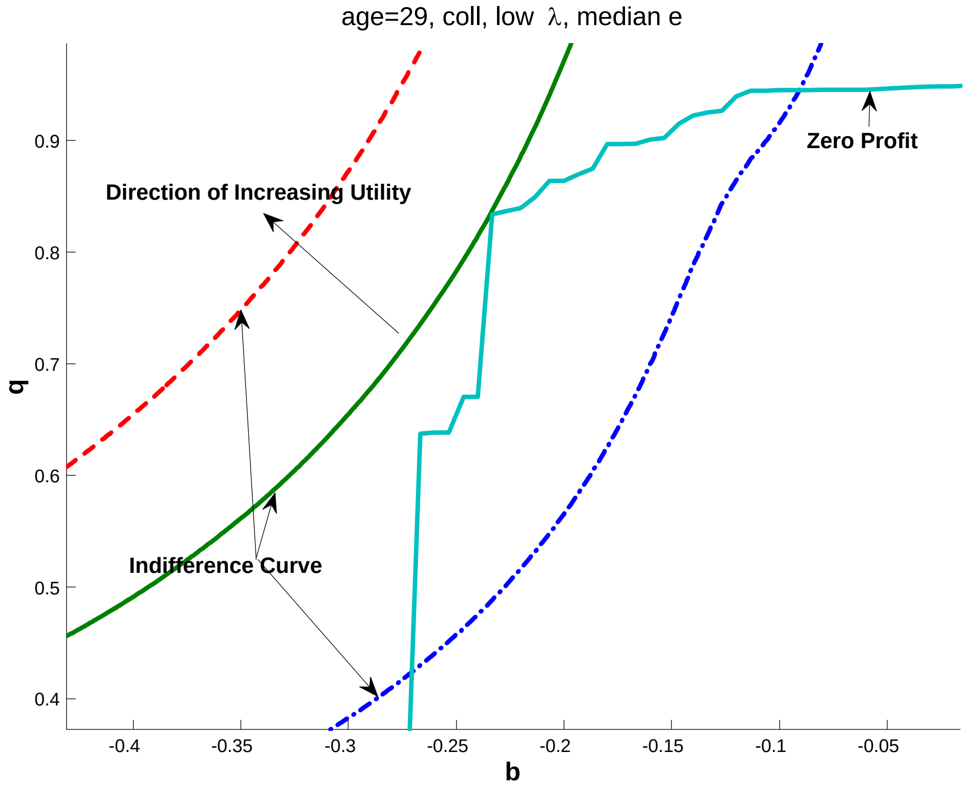
age=29, coll, low λ, median e

Figure 6: Net Worth over the Life Cycle

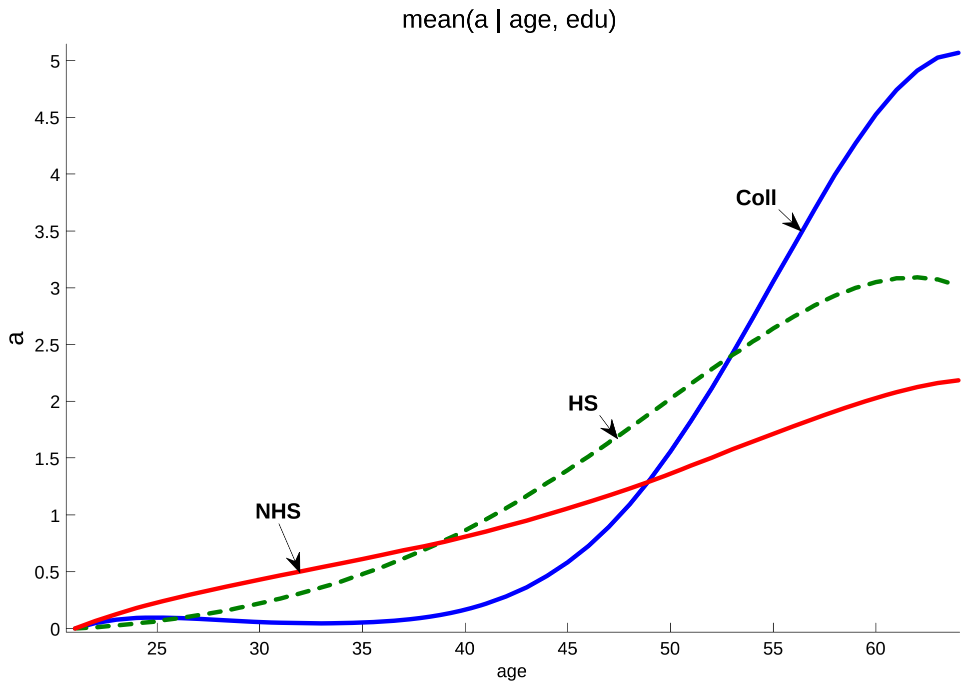

Figure 7: Pricing with Symmetric and Asymmetric Information

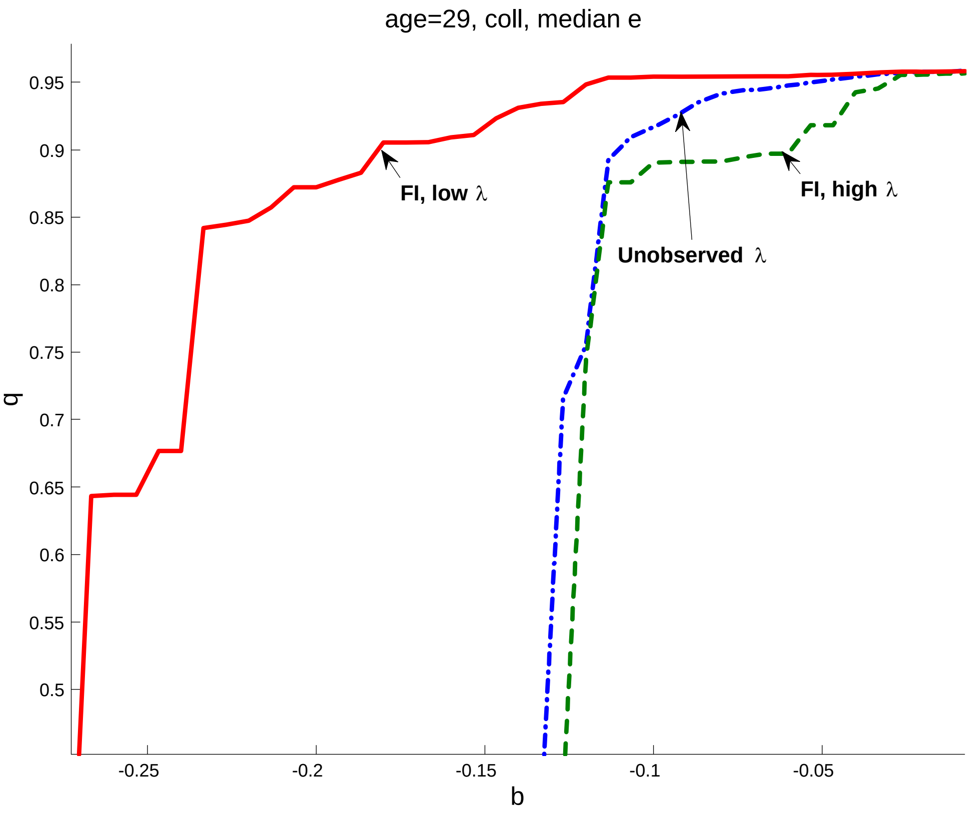

Figure 8: Pricing with Loan Guarantee, Symmetric vs Asymmetric Information