Credit risk without commitment*

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PRELIMINARY AND INCOMPLETE

Abstract

We study economies with credit risk in which, each period, borrowers cannot commit to borrow from only one lender. We extend the analysis in Bizer and DeMarzo (1992) by allowing for multiple borrowing periods. In particular, we remove the exclusive-borrowing-contract assumption from a quantitative model of household bankruptcy (e.g., Chatterjee et al., 2007). We compare equilibrium allocations with and without commitment to exclusive contracts. In contrast with Bizer and DeMarzo (1992), we find that imposing commitment increases the average debt-to-income ratio of indebted households in the simulations (from 9% to 16%). The share of indebted households is also higher with commitment. This is the case because without commitment (i) the cost of defaulting is lower, and (ii) an increase in current borrowing levels deteriorates future borrowing opportunities. These effects are not relevant in Bizer and DeMarzo's (1992) model with a unique borrowing period. In contrast with the standard household bankruptcy model, the model without commitment features (i) borrowing opportunities that resemble credit lines and depend on past borrowing (credit score), (ii) credit rationing (of younger and poorer households that are more eager to borrow), (iii) more dispersion of interest rates, and (iv) sizable welfare gains from imposing an interest rate limit.

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1 Introduction

We study a quantitative model of unsecured household debt and credit risk.[1] In contrast with previous quantitative studies, we assume that each period, households lack commitment to borrow exclusively from one lender. Thus, our analysis allows us to quantify the effects of the "sequential banking" proposed by Bizer and DeMarzo (1992).

Bizer and DeMarzo (1992) explain that "In the subgame-perfect equilibrium [of their game without commitment to exclusive contracts], interest rates charged on loans are higher than when the borrower can commit to obtaining only one loan. Although interest rates are higher, borrowing is also greater, and the probability of default is greater as well." "The results apply to markets for consumer, corporate, and international debt." Their influential results became the conventional wisdom in the literature highlighting inefficiencies generated by the lack of commitment to borrow from only one lender, also referred to as a debt dilution problem (Arellano and Ramanarayanan, 2012; Borensztein et al., 2004; Chatterjee and Eyigungor, 2012; Detragiache, 1994; Hatchondo and Martinez, 2009; Hatchondo et al., 2016b; Kletzer, 1984; Niepelt, 2014; Sachs and Cohen, 1982; Tirole, 2002).[2]

Our analysis casts doubt on this conventional wisdom. We find that equilibrium borrowing levels are significantly lower when borrowers cannot commit to exclusive contracts. We compare equilibrium allocations obtained with and without commitment to exclusive borrowing contracts. The average debt-to-income ratio of indebted households in the simulations is 9% without exclu-

[1]This model has been widely used in quantitative studies of households' unsecured credit (Athreya, 2002, 2008; Chatterjee et al., 2007; Chatterjee and Gordon, 2012; Li and Sarte, 2006; Livshits et al., 2007), mortgage loans (Corbae and Quintin, 2015; Chatterjee and Eyigungor, 2015a; Guler, 2015; Hatchondo et al., 2015; Jeske et al., 2012; Mitman, 2016), and sovereign defaults (Aguiar and Gopinath, 2006; Arellano, 2008; Eaton and Gersovitz, 1981).

[2]Debt dilution refers to the reduction in the value of existing debt triggered by the issuance of new debt. Issuing new debt can reduce the value of existing debt because it increases the probability of default or because it increases the expected loss given default. The debt dilution problem arises because the borrower cannot commit to a level of future borrowing or to borrow exclusively from one lender, and debt is priced by rational investors. Rational investors anticipate that additional borrowing in the future will lower the price of the debt they buy and, therefore, offer a lower price for this debt. The borrower could benefit from constraining future borrowing because this could increase the price at which it can sell debt. Equivalently (Hatchondo et al., 2016b), the borrower could benefit from committing to borrowing exclusively from one lender, because in the future this lender would ask to be compensated for any dilution of the value of the debt it buys, making the exclusive lender willing to pay a higher price for this debt. However, the borrower is typically unable to constrain future borrowing or commit to exclusive contracts with a lender, which creates the debt dilution problem.

sive contracts and 16% with exclusive contracts. Furthermore, the share of indebted households in higher with exclusive contracts, mostly among younger households. The key difference between the analysis presented by Bizer and DeMarzo (1992) and ours is that they assume a unique borrowing period, while we allow households to borrow throughout their life.[3]

Why would a borrower accumulate more debt without exclusive contracts? Consider first the equilibrium with exclusive contracts. In this equilibrium, the interest rate paid by the borrower is a decreasing function of how much he promises to pay to the exclusive lender (because the default probability is increasing with respect to the debt level). Therefore, the borrower has incentives to choose a lower debt level that would allow it to pay a lower interest rate.[4] These incentives to choose lower debt levels are not present without exclusive contracts. Even if the borrower borrows less from one lender, it can always borrow more from another lender. Therefore, a lender does not offer a lower interest rate when the borrower wants to borrow less from him. This explains why Bizer and DeMarzo (1992) find higher debt levels without exclusive contracts.

Why would a borrower accumulate more debt with exclusive contracts?[5] We highlight two reasons for this behavior. First, note that part of the cost of defaulting is losing access to debt markets. Exclusive contracts make debt markets more attractive and, therefore, increase the cost of defaulting. When the cost of defaulting is higher, for any debt level, the interest rate is lower. Therefore, the borrower chooses higher debt levels. This explains the majority of the difference between debt levels with and without exclusive contracts in our simulations. Note that this is

[3]The sovereign default literature assumes multiple borrowing periods and focuses on the intertemporal debt dilution that arises because governments issue long-term debt and thus dilute in future periods the value of debt issued in the current period (Arellano and Ramanarayanan, 2012; Chatterjee and Eyigungor, 2012, 2015b; Hatchondo and Martinez, 2009; Hatchondo et al., 2016b; Niepelt, 2014). However, as the household default literature, the sovereign default literature assumes the government can commit to exclusive borrowing contracts within each period and, therefore, there is no intratemporal debt dilution. We assume one-period debt and thus we do not deal with intertemporal debt dilution. As Bizer and DeMarzo (1992), we focus on intratemporal debt dilution instead. While long-term debt is clearly the empirically relevant assumption for governments, one-period debt is the relevant assumption for unsecured household debt, because of the lenders' ability to change the interest rate they charge for this debt.

[4]In the model, higher interest rates reflect an expansion in the set of states in which the borrower does not pay its debt. However, the marginal gain from increasing this set of states is compensated exactly by the marginal cost of increasing the set of states in which the borrower suffers the default cost. Therefore, the effect of borrowing on interest rates affect the borrower's optimal choices.

[5]Bisin and Rampini (2006) find that exclusive contracts increase the amount borrowed in equilibrium. In their model, exclusivity increases the equilibrium level of insurance and, consequently, it reduces precautionary savings. We highlight different mechanisms.

not a factor in the models with a unique borrowing period (Bisin and Guaitoli, 2004; Bisin and Rampini, 2006; Bizer and DeMarzo, 1992; Detragiache, 1994), because in these models the cost of defaulting is not affected by the functioning of debt markets.[6]

Second, we show that even if we assume non-exclusive borrowing contracts do not affect the cost of defaulting and therefore the zero-profit interest rate asked by lenders, they do not increase equilibrium debt levels. With non-exclusive contracts, each period, the interest rate paid by the borrower is a decreasing function of how much lenders expect him to borrow that period. If the borrower starts the period with less debt, he is expected to borrow less and, therefore, he is offered a lower interest rate. Therefore, the borrower has incentives to borrow less this period in order to start next period with a lower debt level, which would allow him to be offered a lower interest rate. These incentives are not present when the borrower can commit to exclusive contracts (as explained before, with exclusive contracts, because the borrower cannot borrow from more than one lender, the interest rate depends on how much the borrower borrows from the exclusive lender, and not on lenders' expectations about the borrowing level). Our results indicate that the incentives to not increase next-period interest rate that arise without exclusive contracts are (on average) as strong as the incentives to not increase the current-period interest rate that arise with commitment to exclusive borrowing contracts. Incentives to not increase next-period interest rate do not arise in previous studies that assume a unique borrowing period.[7]

Removing the exclusivity assumption from the standard households' credit model produces five significant differences in the implications of this model. First, removing the exclusivity assumption allows borrowing opportunities to resemble credit lines. The widespread use of credit lines (and tractability) led earlier work on household bankruptcy to assume that interest rates do not depend on the amount borrowed (Athreya, 2002; Li and Sarte, 2006).[8] But the approach

[6] In simulations of quantitative sovereign default models with intertemporal debt dilution, Hatchondo et al. (2016b) find that the debt level declines when dilution is eliminated, Chatterjee and Eyigungor (2015b) find that the debt level increases when intertemporal dilution is mitigated with seniority, and Hatchondo et al. (2016a) find that the debt level declines when intertemporal dilution is mitigated with a spread-brake fiscal rule.

[7] Kletzer (1984) studies a model in which debt is not observable and, therefore, equilibrium interest rates depend on the issuance amount expected by lenders. However, assumptions in his model are such that the current debt stock does not influence the borrower's willingness to borrow. Consequently, current debt does not influence the issuance amount expected by lenders and the interest rate at which they are willing to lend. Thus, Kletzer (1984) does not study the concerns about future borrowing conditions we highlight in this paper.

[8] The widespread use of credit lines also motivated studies in which the cost of switching credit contracts and

in earlier studies was criticized because it was seen as inconsistent with borrowing levels being observable. For instance, Chatterjee et al. (2007) explain that, in the model proposed by Athreya (2002), "financial intermediaries charge the same interest rate on loans of different sizes even though a large loan induces a higher probability of default than a small loan. As a result, small borrowers end up subsidizing large borrowers, a form of crosssubsidization that is not sustainable with free entry of intermediaries." Following Chatterjee et al. (2007), more recent studies assume a borrower affects the interest he pays by changing the amount he borrows, which is inconsistent with the widespread use of credit lines. In contrast, if the borrower cannot commit to borrow from only one lender, borrowing opportunities resemble credit lines: a borrower does not affect the interest rate in his current contract by changing the amount he borrows, and he can borrow any amount up to a limit paying the same interest rate (Bizer and DeMarzo, 1992). This occurs without crosssubsidization (different borrowers have available different credit lines).

Second, without exclusivity, borrowing opportunities (credit lines) are a function of past borrowing. It is also well know that credit scores summarizing the consumer's credit history are used by lenders to determine credit conditions. Nevertheless, in the standard household bankruptcy model with commitment to exclusive borrowing contracts, credit conditions (the interest rate paid by the borrower) are not a function of the borrower's credit history.[9] In contrast, in the equilibrium without exclusive contracts, the credit line available to the borrower is a function of its borrowing history.

Third, in the model without exclusivity, there is credit rationing. Another important characteristic of consumer credit markets is credit rationing. This is, lenders often reject loan applications instead of choosing a combination of loan amount and interest rate that would allow them to make non-negative profits. In contrast, in the standard household bankruptcy model, there is always a combination of loan amount and interest rate at which households can get credit. We show that without the exclusivity assumption, there is credit rationing. There may

the lenders' commitment to long-term contracts imply that the borrowing rate is independent from the amount borrowed (Drozd and Nosal, 2007; Mateos-Planas, 2007; Mateos-Planas and Ríos-Rull, 2007).

[9] Motivated by this discrepancy, Chatterjee et al. (2016) incorporate asymmetric information about the household's type into the standard bankruptcy model. In our model, the credit line offered to the lender is a function of the credit history even without asymmetric information.

not exist any combination of debt and interest rate such that expected profits for the lender are non-negative. This occurs because for any loan, a lender would anticipate that the household will continue borrowing from a different lender, imposing negative expected profits on the first lender. Therefore, lenders may not offer any loan to some households. In the simulations, as in the data (Jappelli, 1990), younger and poorer households (that are more eager to borrow) are more likely to be rationed. Our model presents an alternative to standard theories of credit rationing based on asymmetric information and adverse selection (Stiglitz and Weiss, 1981).

The rest of the article proceeds as follows. Section 2 presents the model. Section 3 discusses the calibration. Section 4 presents the results. Section 5 concludes.

2 Model

We study a standard quantitative model of household bankruptcy but, in contrast with previous studies, we assume that each period, households cannot commit to borrow from only one lender. As Athreya (2008) and Livshits et al. (2007), we study a life-cycle model.

2.1 The environment

The household lives T periods and works until age $t = W \leq T$. At the beginning of each period, the household observes the realization of its earnings shocks. After observing these shocks, the household decides whether to default on its debt. If the household defaults, it cannot borrow or save in the default period and suffers an utility loss (stigma) ξ. A defaulting household does not pay any of its debt and thus its lenders do not recover anything from their investment. If the household does not default, it can borrow or save using one-period bonds. Let β denote the subjective discount factor.

Each period, household i receives income y_t^i. During working age, earnings are determined by a life cycle component l_t, an i.i.d component ε_t^i, and a persistent component z_t^i:

$$\log(y_t^i) = l_t + \varepsilon_t^i + z_t^i,$$

where

$$z_t^i = \rho_z z_{t-1}^i + e_t^i,$$

and ε_t^i and e_t^i are independently normally distributed with variance σ_ε^2 and σ_e^2. After retirement, the household receives a fraction of the last realization of the persistent component of its working-age income plus a minimum income.

Financial intermediaries are risk neutral and make zero profits in expectation. Their opportunity cost of lending is given by the interest rate r. There is a transaction cost ϕ of extending loans to the household.

We study two borrowing protocols. First, as in previous quantitative studies of household bankruptcy, we assume that each period the household can commit to borrow from only one lender. Second, we assume that each period the household can borrow from as many lenders as it wants. We assume that lenders observe how much the household has borrowed from other lenders.[10]

2.1.1 Recursive formulation with exclusive contracts

We next present the recursive formulation of the problems solved by the household when it decides whether to default and how much to borrow. We first assume that each period, the household can commit to borrow from only one lender. In this case, as is standard in models of household bankruptcy, the household can sell bonds at a price

$$q_t(b', z) = \frac{E\left[[1 - \hat{d}_{t+1}(b', z', \varepsilon')] \mid z\right]}{1 + r + \phi}, \tag{1}$$

where b' denotes the number of bonds the household sells, and $\hat{d}$ denotes its equilibrium default strategy, which takes a value of 1 when the government defaults and a value of 0 when it pays.

[10] Assuming that lenders observe how much the household has borrowed from other lenders implies that if off equilibrium the household wants to borrow more than the equilibrium amount, it has to pay a higher interest rate. In our model, without this assumption, an equilibrium with positive debt levels would not exist. If the household can pay a constant interest rate (consistent with the lenders' zero expected profits for their expected borrowing amount), it can always take its utility towards infinity by taking the amount it borrows towards infinity (and defaulting in the next period). This feature of the model could be changed by making the cost of defaulting stochastic or making it an increasing function of the debt level (for instance by assuming that even after defaulting, the household has to pay a fraction of its debt).

The household's expected utility under repayment is given by

$$V_t^R(b, z, \varepsilon) = \underset{b'}{Max} \left\{ u(c) + \beta E \left[V_{t+1}(b', z', \varepsilon') \mid z \right] \right\} \tag{2}$$

s.t.

$$c = \begin{cases} y - b + b'/(1+r) & \text{if } b' < 0 \quad \text{(household is saving)} \\ y - b + q_t(b', z) b' & \text{if } b' \geq 0 \text{ (household is borrowing),} \end{cases}$$

where the household's expected utility at the beginning of period t is given by

$$V_t(b, z, \varepsilon) = \hat{d}_t(b, z, \varepsilon) V_t^D(z, \varepsilon) + [1 - \hat{d}_t(b, z, \varepsilon)] V_t^R(b, z, \varepsilon), \tag{3}$$

the value of defaulting is given by

$$V_t^D(z, \varepsilon) = u(y) - \xi + \beta E \left[V_{t+1}(0, z', \varepsilon') \mid z \right], \tag{4}$$

and the equilibrium default decision satisfies

$$\hat{d}_t(b, z, \varepsilon) = \begin{cases} 1 & \text{if } V_t^D(z, \varepsilon) > V_t^R(b, z, \varepsilon) \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Definition 1 *A recursive equilibrium with commitment to exclusive borrowing contracts is characterized by*

1. a default decision rule $\hat{d}_t$ and a borrowing decision rule $\hat{b}_t$,

2. and a bond price function q_t

such that

(a) $\hat{b}$ solves the dynamic programming problem (2) when $\hat{d}$ is given by equation (5);

(b) the bond price function solves the expected zero profit condition in equation (1).

2.1.2 Recursive formulation without exclusive contracts

We next present the recursive formulation of the problems solved by the household without exclusivity. Most equilibrium functions can still be written as when the household can commit to borrowing from only one lender. As in the commitment case, let b' denote the total debt accumulated by the household in the period. For any b', equation (1) still presents the equilibrium bond price consistent with expected zero profits by lenders, where the equilibrium default decision still arises from comparing the values of defaulting and not defaulting as presented in equation (5), the value of defaulting is still defined by equation (4), and the pre-default-decision value function still arises from comparing the values of defaulting and not defaulting as presented in equation (3).

The difference between the models with and without commitment to borrowing from only one lender arises in the borrowing problem of a non-defaulting household. With commitment, the household can choose from every point in the zero-profit price function $q_t(b', z)$. In contrast, without commitment, some points in this function are not available for the borrower.

We solve the model without commitment by imposing the "no-further-borrowing" property presented by Bizer and DeMarzo (1992) (see also the incentive compatibility constraint imposed by Bisin and Rampini, 2006). As when we assume commitment to exclusive borrowing contracts, let $\hat{b}$ denote the household's equilibrium borrowing rule. Since the household can visit as many lenders as it wants, $\hat{b}_t(b, z, \varepsilon)$ needs to be such that after selling $\hat{b}_t(b, z, \varepsilon)$ bonds at the price $q_t(\hat{b}_t(b, z, \varepsilon), z)$, the household does not want to sell $b' - \hat{b}_t(b, z, \varepsilon)$ bonds at the price $q_t(b', z)$, for any $b' > \hat{b}_t(b, z, \varepsilon)$.

Let us define the expected utility from obtaining two loans, $b'q_t(b', z)$ and $(b'_2 - b')q_t(b'_2, z)$, as

$$\tilde{V}_t^R(b', b'_2, b, z, \varepsilon) = u(y - b + b'q_t(b', z) + (b'_2 - b')q_t(b'_2, z)) + \beta E\left[V_{t+1}(b'_2, z', \varepsilon') \mid z\right]. \quad (6)$$

The set of borrowing levels that satisfy "no-further-borrowing" and thus is available to the household without exclusivity is given by

$$B_t(b,z,\varepsilon) = \left\{ b' : \tilde{V}_t^R(b',0,b,z,\varepsilon) > \tilde{V}_t^R(b',b_2',b,z,\varepsilon)\, \forall b_2' > b' \right\}. \tag{7}$$

We can write the household's expected utility under repayment without exclusivity as in the exclusivity case but constraining borrowing levels to belong to the set B:

$$V_t^R(b,z,\varepsilon) = \underset{b' \in \left\{ \mathbb{R}_{\leq 0} \cup B_t(b,z,\varepsilon) \right\}}{Max} \left\{ u(c) + \beta E\left[V_{t+1}(b',z',\varepsilon') \mid z \right] \right\} \tag{8}$$

s.t.

$$c = \begin{cases} y - b + b'/(1+r) & \text{if } b' \leq 0 \quad \text{(household is saving)} \\ y - b + q_t(b',z)b' & \text{if } b' > 0 \text{ (household is borrowing).} \end{cases}$$

The equilibrium definition without commitment to exclusive contracts is thus almost identical to the equilibrium definition with commitment. The only difference is that without commitment, the equilibrium borrowing level $\hat{b}$ is found imposing the no-further borrowing constraint in the dynamic programming problem (8) (and this constraint is not imposed in the problem with commitment in the dynamic programming problem 2).[11]

3 Calibration

The model is calibrated using U.S. data. As in Athreya (2008), a period in the model refers to a year. Households enter the model at age 25, retire at age 60, and die at age 95.

Table 1 presents parameter values. The values of the risk-free interest rate ($r = 0.04$) and the household's risk aversion and discount factor parameters ($\gamma = 2$ and $\beta = 0.96$) are within the range of accepted values. The parameters $\rho_z, \sigma_e, \sigma_\varepsilon$ and the life cycle component of the income process are calibrated following Kaplan and Violante (2010). Parameter values for the retirement income are chosen to make the replacement ratio decline with income, from 69 percent to 14

[11] As Bizer and DeMarzo (1992), we find the equilibrium borrowing level searching in the no-further borrowing set (B) because, (i) the pair $(b', q_t(b',z))$ is proffered by the borrower over the pair $(b'', q_t(b',z))$, for all $b'' < b'$, (ii) if $(b', q_t(b',z))$ does not satisfy the no-further borrowing constraint, $(b'', q_t(b',z))$ does not satisfy the no-further borrowing constraint, for all $b'' < b'$, and (iii) if $(b', q_t(b',z))$ satisfies the no-further borrowing constraint, $(b'', q_t(b'',z))$ satisfies the no-further borrowing constraint, for all $b'' > b'$. We confirm numerically that these three conditions are satisfied.

Risk free interest rate	r	0.04	Standard value
Household's risk aversion	γ	2	Standard value
Household's discount factor	β	0.96	Standard value
Autocorrelation coefficient	ρ_z	1	Kaplan and Violante (2010)
Std dev of innovations	σ_e	0.1	Kaplan and Violante (2010)
Std dev of temp. shocks	σ_ε	0.22	Kaplan and Violante (2010)
Transaction cost of lending	ϕ	0.034	Athreya (2008)
Stigma of defaulting	ξ	0.103	Calibrated to match debt ratio

Table 1: Parameter values.

percent, consistently with the U.S. replacement ratios (Aon, 2008). This implies an average replacement ratio of 47 percent, which is close to the replacement ratio in other quantitative studies (see, for example, Conesa and Krueger, 1999). The transaction cost of lending ($\phi = 0.034$) is from Athreya (2008).

The cost of defaulting parameter ξ is calibrated to match a debt ratio target using with the model without commitment to exclusive contracts. Simulation results are for the behavior of 10,000 households during their lifetime.

4 Results

This section shows that households borrow less when they cannot commit to exclusive borrowing contrast. Furthermore, the model without commitment features (i) borrowing opportunities that resemble credit lines and depend on past borrowing (credit score), (ii) credit rationing (of younger and poorer households that are more eager to borrow), (iii) more dispersion of interest rates, and (iv) sizable welfare gains from imposing an interest rate limit.

	Data	Without exclusivity	With exclusivity	Without excl. but default of excl.	With excl. $\xi = 0.0495$
Average debt/income (%)	9.2	9.2	16.3	16.2	9.2
Default rate (%)	0.5	0.2	0.1	0.2	0.2
Average int. rate on debt (%)	11.2	9.0	8.0	7.8	8.6
Std dev (int. rate) (%)	3.8	4.0	1.4	1.8	1.9

Table 2: Simulations results. In the data column, the average debt level and the default rate are from the calibration exercise in Athreya (2008), the average interest rate is the one reported by Livshits et al. (2007), and the standard deviation of interest rates is from the 1995 SCF (Livshits et al., 2016 and Narajabad, 2012 discuss the increase over time of indebtedness, defaults, and the dispersion of interest rates).

4.1 Benchmark simulations

Table 2 shows that the calibration of the cost of defaulting allows us to match the debt target. It also shows that our model without commitment to exclusive borrowing contracts generate plausible values for the non-targeted default rate, the average interest date paid by borrowers, and the dispersion of this interest rate across borrowers (as is expected for models without expense shocks, the default rate and thus the average interest rate in the simulations are relatively low).

4.2 Exclusivity and borrowing

Table 2 also shows that the average debt level is 44% lower in our benchmark economy with exclusive borrowing contracts than what it would be in an economy without exclusivity. This is in sharp contrast with the prediction of previous studies (Bizer and DeMarzo, 1992). Furthermore, Figure 1 shows that more households borrow in the economy with exclusivity. Households (combinations of age and income) that borrow in the economy without exclusivity have on average more debt in the economy with exclusivity.

There are two reasons for the lower borrowing levels in the economy without exclusivity. First, the left panel of Figure 2 illustrates how lenders demand a much higher interest rate when

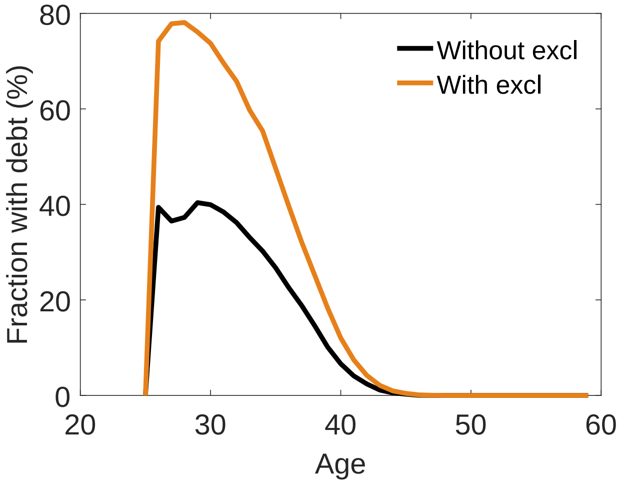

Figure 1: Fraction of households borrowing with and without commitment to exclusive contracts.

there is no commitment to exclusive borrowing contracts.

Without commitment to exclusive borrowing contracts, lenders' expected zero profits requires a higher interest rate because incentives to repay are weaker. Figure 3 shows that exclusive contracts increase more the value of repaying than the value of defaulting and, therefore, they lower the probability of default. Recall that a benefit of repaying is being able to borrow again, and borrowing is more attractive when we assume commitment to exclusive contracts. Note that in Figure 3, the increase in the value of repaying because of the commitment to exclusive contracts is larger when income is lower and, therefore, the household is more eager to borrow. It should be noted that we obtain large effects of exclusivity on the households incentives to repay even with the conservative assumption of default only excluding the household from debt markets in the default period.[12]

In order to isolate the effect of exclusivity on the incentives to repay, we solve a counterfactual economy without exclusive contracts but with the equilibrium default rule of the economy with exclusivity. Comparing the fourth and fifth column of Table 2 shows that even without affecting the default decision, eliminating exclusivity does not increase the equilibrium debt level. Why households do not borrow more without exclusivity, even when eliminating exclusivity does

[12]Other studies assume a longer duration of the exclusion from debt markets after a default. With a longer duration, being excluded from debt markets would be a more important component of the cost of defaulting. Therefore, changing the value of market access through exclusivity would have a more significant effect on equilibrium debt levels.

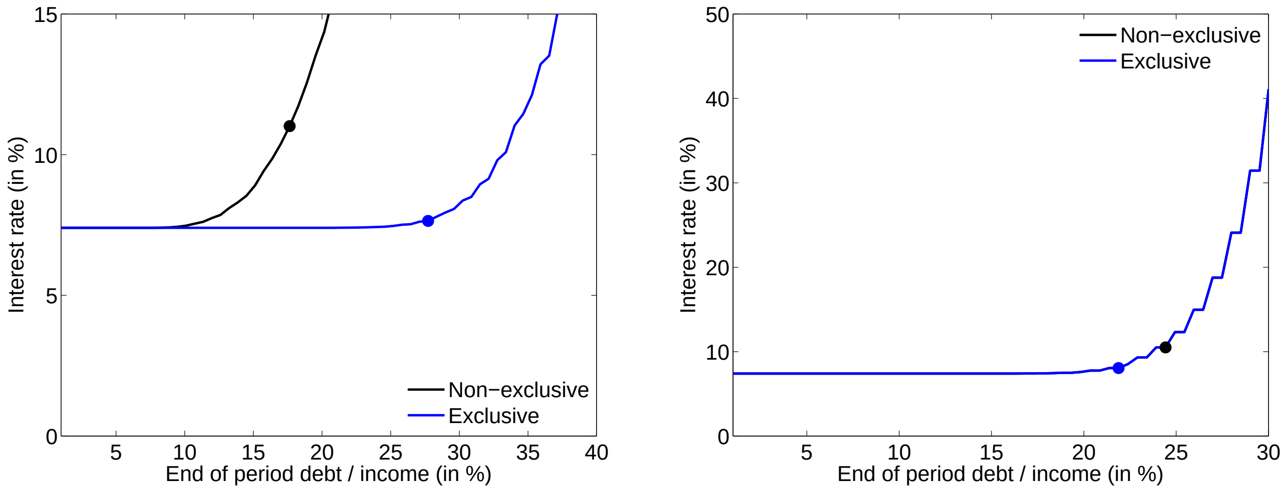

Figure 2: Borrowing with and without commitment to exclusive contracts. For any level of debt, the figure presents the interest rate consistent with expected zero profits for lenders, when the permanent income shock takes its mean value. Dots present the household optimal choices when they start the period without debt and the mean value for the iid income shock. The left (right) panel assumes the household is 30 ($W-1$) years old.

not increase the zero-profit interest rates demanded by lenders? Households may choose lower borrowing levels without exclusivity because if they borrow less this period, they will be offered a lower interest rate next period.

First note that, as explained by Bizer and DeMarzo (1992), the household's borrowing opportunities without exclusivity resemble a credit line. Each period, we can think about the household's borrowing opportunities as a credit line with the limit given by the equilibrium borrowing level $\hat{b}_t(b,z,\varepsilon)$, and the interest rate implicit in the price $q_t^l(b,z,\varepsilon) = q_t(\hat{b}_t(b,z,\varepsilon),z)$, consistent with lenders making zero profits in expectation when they believe the household will borrow $\hat{b}_t(b,z,\varepsilon)$. In a sequential banking game, we can think that after borrowing b'_n from n banks, the household has available from the bank $n+1$ it visits a credit line with limit $\hat{b}_t(b,z,\varepsilon) - b'_n$ and the same price $q_t^l(b,z,\varepsilon)$.

Note also that the interest rate (implicit in the price $q_t^l(b,z,\varepsilon)$) and the credit limit ($\hat{b}_t(b,z,\varepsilon)$) of the credit line available to the household depend of how much he borrowed in the previous period (b). In contrast, with the standard assumption of commitment to exclusive contracts, the interest rate available to the household (implicit in the zero-profit price $q_t(b',z)$) does not

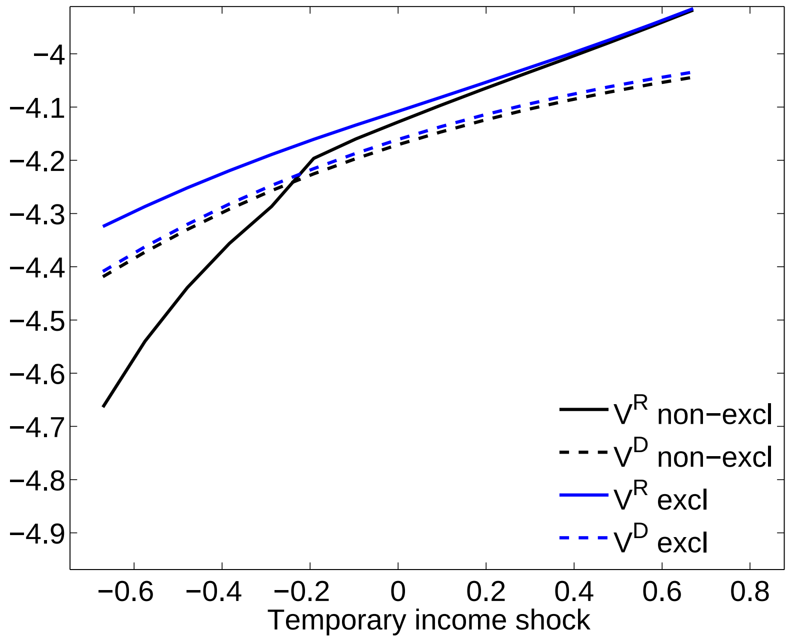

Figure 3: Value functions with and without commitment to exclusive contracts. The figure assumes that the household is 31 years old, the permanent income shock takes its mean value and the initial debt level is the optimal debt choice of a 30-years-old household without debt and the mean value for the income shocks.

depend on how much he borrowed in the past, and is a function of how much he borrows from its exclusive lender, b'.

The Euler equations (9) and (10) for the problems with and without exclusivity, respectively, show why a household may choose to borrow less without exclusivity.[13]

$$u'(c_t)\left[q_t(b',z)+\frac{\partial q_t(b',z)}{\partial b'}b'\right]=\beta E\left[(1-\hat{d}_{t+1})u'(c_{t+1})\mid z\right]. \tag{9}$$

$$u'(c_t)q^l_t(b,z,\varepsilon)=\beta E\left[(1-\hat{d}_{i+1})u'(c_{t+1})\left[1-\hat{b}_{t+1}(b',z',\varepsilon')\frac{\partial q^l_{t+1}(b',z',\varepsilon')}{\partial b'}\right]\mid z\right]. \tag{10}$$

In Equation (9), when households can commit to borrowing from only one lender, borrowing more is costly because it lowers the price of debt offered by the exclusive lender q_t and, therefore, it lowers current consumption c_t. In contrast, in Equation (10), without commitment to borrowing from only one lender, borrowing more does not change the price of debt offered by lenders, which

[13]Equations (9) and (10) assume that the price and value functions are differentiable. The numerical solution method does not rely on these assumptions.

is given by the credit-line price q_t^l. Therefore, borrowing more does not lower current consumption through the price of debt. This explains why in previous studies (e.g., Bizer and DeMarzo, 1992), without commitment to borrowing from only one lender, borrowing is less costly and equilibrium debt levels are higher.

Nevertheless, in Equation (10), when households cannot commit to borrowing from only one lender, borrowing more is costly because it lowers the next-period credit-line price q_{t+1}^l, thus lowering next-period consumption c_{t+1}. In contrast, in Equation (9), with commitment to borrowing from only one lender, borrowing more does not change next period borrowing opportunities q_{t+1}. Therefore, borrowing more does not lower next-period consumption trough the price of debt. This effect is not present in previous studies with a unique borrowing period (Bizer and DeMarzo, 1992).

Comparing the fourth and fifth columns of Table 2 shows that in the simulations of our model, incentives to constraint borrowing to improve the next-period credit-line price in the economy without commitment are (on average) quantitatively as important as the incentives to constraint borrowing to improve the current-period bond price in the economy with commitment. Figure 4 illustrates how the first incentives may be stronger and, therefore, we could see less borrowing without exclusivity.

The effects of exclusivity on the incentives to repay and on the next-period cost of borrowing are not present in period $W-1$ (as they are not present in previous studies that assume a unique borrowing period).[14] The right panel of Figure 2 illustrates how, in $W-1$, the interest rate that gives lenders zero expected profits is the same with or without commitment to exclusive borrowing contracts. The panel also shows that, as in previous studies, the borrowing level is higher without exclusive contracts.

[14]Since $W-1$ is the last period in which the household faces uncertainty about next-period income, W is the last period in which the household may default. Consequently, exclusivity does not affect the incentives to repay in W, nor the interest rate paid by a borrower in W (the risk-free interest rate).

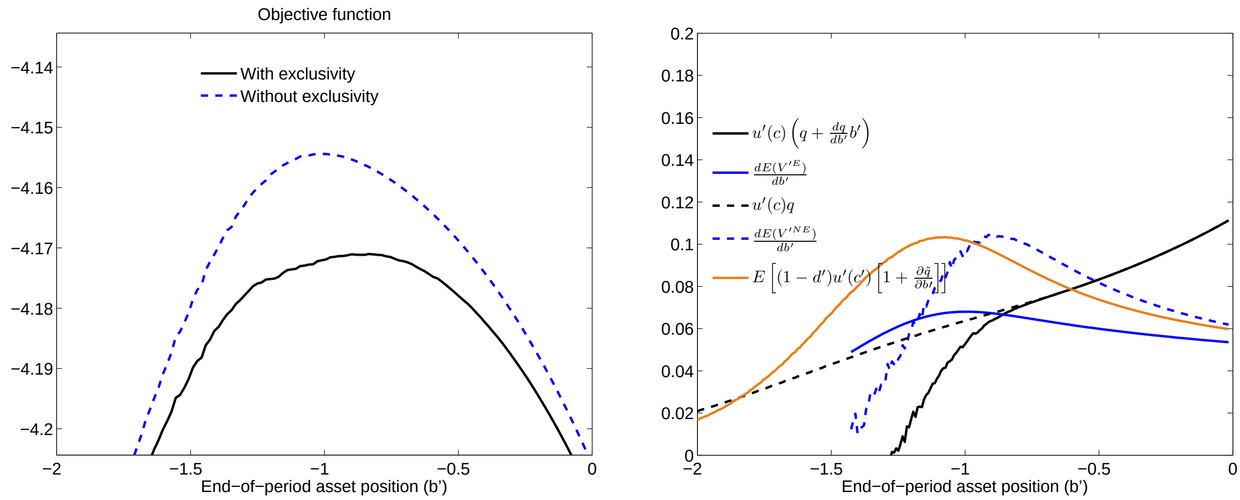

Figure 4: More borrowing with exclusivity. The left (right) panel presents the objective functions (first-order conditions) of a household in both the counterfactual economy without exclusive contracts but with the equilibrium default rule of the economy with exclusivity and the economy with exclusivity. The superscript E (NE) is used to reference the economy with (without) exclusivity. The figure shows that the household's expected utility is maximized for a higher debt level in the economy with exclusivity. The household is 29 years old, has the average level of i.i.d and persistent income, and an initial debt equal to 20% of its income.

4.3 Exclusivity and credit rationing

As illustrated in Figure 2, there are always combinations of end-of-period debt levels and interest rates that imply zero expected profits for the lenders. With exclusivity, the borrower can choose any such combination, because lenders know that if they give such combination to the borrower, the borrower is committed to stop borrowing, guarantying zero profits.

Without exclusivity, there is no such commitment. Therefore, even if there are always combinations of end-of-period debt levels and interest rates that imply zero expected profits for the lenders, lenders are not willing to give these combinations to the borrower if they expect the borrower to continue borrowing. Thus, only combinations of debt levels and bond prices in the set B defined in equation (7) are available to the borrower.

As illustrated in Figure 5. We find that the set B is more likely to be empty for younger and poorer households. Intuitively, these households are more eager to borrow and thus do not satisfy the no-further borrowing constraint. We interpret these as households being rationed out for credit markets. That is, without exclusivity, some younger and poorer households are not able to obtain credit. Even when there are combinations of debt levels and interest rates that would be consistent with expected zero profits with exclusivity, there are no combinations consistent with zero profits without exclusivity. Consistently with our findings, empirical studies identify younger and poorer households as more likely to be rationed out of credit markets (Jappelli, 1990).

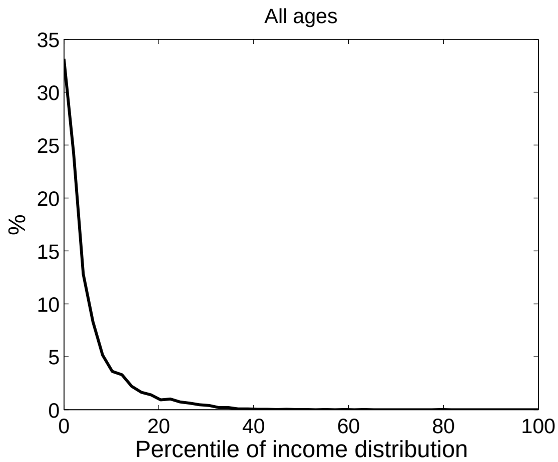

Figure 5: Share of households rationed out from credit markets.

4.4 Exclusivity and the dispersion of interest rates

We next show that assuming that there is no commitment to exclusive contracts allows the standard bankruptcy model to generate a larger dispersion of interest rates across households, bringing the predictions of the model closer to the data. Table 2 shows that the dispersion of interest rates across households is lower in the model with commitment to exclusive borrowing contracts, and is thus significantly lower than the dispersion observed in the data. The last column of Table 2 also shows that this is still the case if we recalibrate the cost of defaulting in model with commitment to match the debt target from the data.

As explained by Aguiar et al. (2016), equilibrium default models with commitment to exclusive borrowing contracts may generate low interest rate dispersions because borrowers facing negative shocks choose to borrow less, mitigating the effect of the shock on the equilibrium interest rate. In contrast, without exclusivity, the borrower cannot commit to borrow less. Suppose

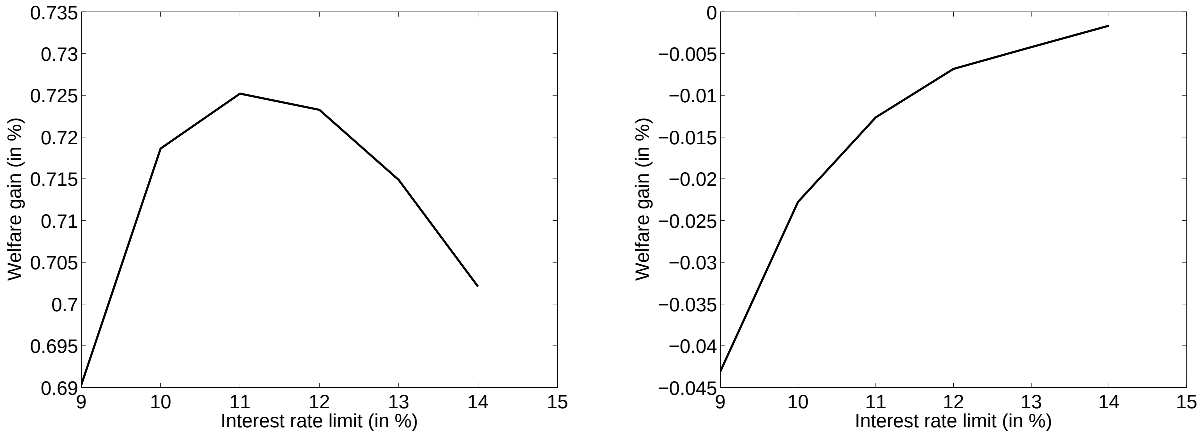

Figure 6: Ex-ante welfare gains from debt an interest rate limits. Ex-ante welfare gains are measured as the proportional increase in consumption that would make a new-born household indifferent between living in the benchmark economy and living in the economy with the interest rate limit.

for example the borrower faces a negative income shock. With exclusivity, the borrower commit to borrow less. Without exclusivity, the borrower is expected to borrow more to mitigate the effect of the shock on consumption, and he does so in equilibrium.

4.5 Exclusivity and interest rate limits

We next show that without commitment to exclusive contracts, imposing an interest rate limit generates substantial welfare gains. The left panel of Figure 6 shows that, when households cannot commit to borrowing from only one lender, ex-ante welfare is maximized with an interest rate limit of 11%, which archives gains equivalent to a permanent consumption increase of 0.7%. These welfare gains represent 80% of the welfare losses generated by the lack of exclusivity (0.9%). Interest rate limits are widely used (Maimbo and Henriquez Gallegos, 2014) and often justified by concerns about lenders' predatory behavior. Our results suggest that even without predatory lending, and because households cannot commit to borrowing from only one lender, substantial welfare gains could be achieved with an interest rate limit. The right panel of Figure 6 shows that, in contrast, since the households' lack of commitment to exclusive contracts is the only source of inefficiencies in our model, introducing an interest rate limit in the economy with commitment can only generate welfare losses.

5 Conclusions

We study a model of credit risk in which borrowers cannot commit to borrowing exclusively from one lender. We compare equilibria with and without commitment and show that the borrowers' inability to commit may significantly constraint their ability to borrow, resulting in lower levels of indebtedness and substantial welfare losses. Without commitment, borrowers choose lower debt levels because the cost of borrowing is higher, and borrowing deteriorates the terms of the credit lines available to them in the future. We also show that introducing an interest rate limit to deal with the non-exclusivity problem relaxes borrowing constraints, allowing for higher levels of indebtedness and eliminating most of the welfare losses generated by the lack of exclusivity.

Eliminating the exclusivity assumption from a standard equilibrium default model produces borrowing opportunities that resemble credit lines and depend on past borrowing (even without commitment to long-term contracts or asymmetric information). The model without exclusivity also presents a new theory of credit rationing of younger and poorer borrowers that are more eager to borrow (without assuming asymmetric information, as done by Stiglitz and Weiss, 1981). Furthermore, eliminating exclusivity helps overcome the lack of dispersion of interest rates often cited as a limitation of quantitative models of equilibrium defaults (Aguiar et al., 2016).

We can expect that the lessons learned here on the role of exclusivity on quantitative studies of equilibrium default could be meaningful in other credit markets besides the market for unsecured household credit studied in this paper. Extending our analysis to the study of other credit markets is an interesting avenue for future research. In particular, in the context of sovereign borrowing, future research could explore the extent to which credit rationing could help rationalize endogenous sudden stops.

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