

# 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 à la 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 borrowing levels are much lower without commitment. Imposing commitment increases the average debt-to-income ratio in the simulations from 9% to 16%. This is the case because (i) the cost of defaulting is lower without commitment and (ii) only without commitment, 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 and consistently with the data, the model without commitment features (i) borrowing opportunities that resemble credit lines, (ii) borrowing opportunities that depend on the borrowing history (credit score), (iii) credit rationing, and (iv) a higher dispersion of interest rates across households. Introducing an interest rate limit to deal with the non-exclusivity problem produces ex-ante welfare gains equivalent to a permanent increase in consumption of 0.7%.

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# 1 Introduction

We study a quantitative model of households’ credit risk à la Chatterjee et al. (2007).<sup>1</sup> In contrast with previous quantitative studies, we assume that each period, borrowers 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).<sup>2</sup>

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

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<sup>1</sup>This model has been widely used to study households’ debt and their ability to self-insure (Athreya, 2002, 2008; Hatchondo et al., 2015; Li and Sarte, 2006; Livshits et al., 2008).

<sup>2</sup>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. In contrast with other studies, Bisin and Rampini (2006) find that non-exclusivity of contracts reduces the amount borrowed in equilibrium because it reduces the equilibrium level of insurance and, consequently, it increases precautionary savings.

contracts and 16% with exclusive contracts. The key difference between our results and those presented by Bizer and DeMarzo (1992) is that they assume a unique borrowing period, while in our model, households borrow throughout their life.<sup>3</sup>

Why would a borrower accumulate more debt when it cannot commit to borrow from only one lender? 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 expected losses triggered by default are 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.<sup>4</sup> 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 less debt when it cannot commit to exclusive contracts with lenders? We show there are two reasons for this. 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 not a factor in Bizer and DeMarzo's (1992) model: with a unique

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<sup>3</sup>The government 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, 2015; Hatchondo and Martinez, 2009; Hatchondo et al., 2016b; Niepelt, 2014). However, as the household default literature, the government 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 case for governments, one-period debt is the relevant case for unsecured household debt, because of the lenders' ability to change the interest rate they charge for this debt.

<sup>4</sup>In the model, lower bond prices 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 pays the default cost. Therefore, the effect of borrowing on bond prices affect the borrower's optimal choices.

borrowing period, the cost of defaulting is not affected by the functioning of debt markets.<sup>5</sup>

Second, we show that even if 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 promises to pay to 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 models with a unique borrowing period (Bisin and Guaitoli, 2004; Bisin and Rampini, 2006; Bizer and DeMarzo, 1992; Detragiache, 1994).<sup>6</sup>

Removing the exclusivity assumption also allows us to bring the predictions of the household bankruptcy model closer to the data. The widespread use of credit lines (and tractability) led earlier work on household bankruptcy to assume that bond prices do not depend on issuance volumes (see, for example, Athreya, 2002, and Li and Sarte, 2006). But this approach was criticized because it was seen as inconsistent with borrowing levels being observable. For instance, Chatterjee et al. (2007) explain that, in Athreya (2002), "financial intermediaries charge the same

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<sup>5</sup>In simulations of quantitative sovereign default models with intertemporal debt dilution, Hatchondo et al. (2016b) show that the debt level declines when dilution is eliminated, Chatterjee and Eyigungor (2015) show that the debt level increases when intertemporal dilution is mitigated with seniority, and Hatchondo et al. (2016a) show that the debt level declines when intertemporal dilution is mitigated with a spread-brake fiscal rule.

<sup>6</sup>Kletzer (1984) studies a model in which debt is not observable and, therefore, equilibrium bond prices depend on the issuance amount expected by lenders. However, assumptions in his model are such that the current debt stock does not influence the government's willingness to borrow. Consequently, current debt does not influence the issuance amount expected by lenders and the price at which they are willing to buy bonds. Thus, Kletzer (1984) does not study the concerns about future borrowing conditions we highlight in this paper.

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), other studies use models in which a borrower affect the interest rate in his current borrowing contract by changing the amount he borrows.<sup>7</sup> 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).

It is also well known that credit scores summarizing the consumer’s credit history are used by lenders to determine the credit conditions. Nevertheless, in the standard household bankruptcy model with commitment to exclusive borrowing contracts, credit conditions (the interest rate paid by the borrower) is not a function of the borrower’s credit history.<sup>8</sup> In contrast, in the equilibrium without exclusive contracts, the credit line available to the borrower is a function of its borrowing history.

Another important characteristic of consumer credit markets is credit rationing. Consumers are often denied credit, including the rejection of credit card applications. In contrast, in the standard household bankruptcy model, there is always an interest rate at which consumers can get credit. We show that without the exclusivity assumption, there is credit rationing. There may not exist any combination of debt and interest rate such that expected profits for the lender are non-negative. Therefore, lenders do not offer any credit line.

We also show that the dispersion of interest rates paid by households is higher without exclusive contracts, bringing the quantitative predictions of the model closer to the data. This is true both when we compare simulations with and without exclusive contracts with our benchmark

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<sup>7</sup>The widespread use of credit lines also motivated ongoing work in which the cost of switching credit contracts and the lenders’ commitment to long-term contracts imply that the agent can borrow at a rate that is independent of the amount borrowed (Droz and Nosal, 2007; Mateos-Planas, 2007; Mateos-Planas and Ríos-Rull, 2007).

<sup>8</sup>Motivated by this discrepancy, Chatterjee et al. (2016) incorporate asymmetric information about the household’s type into the standard bankruptcy model.

calibration, and when we recalibrate the model with exclusive contracts to match the calibration target.

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. In particular, we use the life-cycle model presented by Athreya (2008).

### 2.1 The environment

The household lives  $T$  periods and works until age  $t = W \leq T$ . Let  $\beta$  denote the subjective discount factor.

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)  $\xi$ . 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.

Earnings follow exogenous processes. Each period, household  $i$  receives income  $y_t^i$ . During working age, a life cycle component  $l_t$ , an i.i.d component  $\varepsilon_t^i$ , 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  $\varepsilon_t^i$  and  $e_t^i$  are independently normally distributed with variance  $\sigma_\varepsilon^2$  and  $\sigma_e^2$ . 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  $\phi$  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 that period.<sup>9</sup>

### 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, assuming 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

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

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.

The household's expected utility under repayment is given by

$$V_t^R(b, z, \varepsilon) = \max_{b'} \{u(c) + \beta E [V_{t+1}(b', z', \varepsilon') \mid z]\} \quad (2)$$

s.t.

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

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<sup>9</sup>Assuming that lenders observe how much the household has borrowed from other lenders imply 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. 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.

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

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

the value of defaulting is given by

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

and the equilibrium default decision satisfies

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

**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, assuming that each period, it can borrow from as many lenders as it wants. As when the household can commit to borrowing from only one lender, let's denote by  $b'$  the total amount borrowed 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).

Nevertheless, without commitment to borrowing from only one lender, equation (1) no longer represents the borrowing opportunities of the household. In particular, the household cannot obtain a lower interest rate by borrowing less from a lender. As before, let  $\hat{b}_t(b, z, \varepsilon)$  denote the equilibrium borrowing function of the household. Let  $\tilde{q}_t(b, z, \varepsilon) = q_t(\hat{b}_t(b, z, \varepsilon), z)$  denote the bond price consistent with the equilibrium borrowing policy. Note that since in equilibrium lenders expect the household to borrow  $\hat{b}_t(b, z, \varepsilon)$ , even if the household wants to borrow less than  $\hat{b}_t(b, z, \varepsilon)$  from any lender, lenders always offer the price  $\tilde{q}_t(b, z, \varepsilon)$ .

The discussion above shows how, without commitment to exclusive borrowing contracts, we can think about the household's borrowing opportunities as credit lines. Let  $\tilde{b}'$  denote how much a household borrowed in a period before visiting a lender. This lender expects to make zero profits in expectations if it offers to the household any credit line with a borrowing limit lower or equal to  $\hat{b}_t(b, z, \varepsilon) - \tilde{b}'$  and the interest rate implicit in the price  $\tilde{q}_t(b, z, \varepsilon)$ . Clearly, the household can obtain the equilibrium borrowing level  $\hat{b}_t(b, z, \varepsilon)$  borrowing from any number of lenders, and the number of lenders the household deals with is indeterminate and inconsequential (Bizer and DeMarzo, 1992). Thus, we can abstract from the number of lenders the household deals with, and think about the aggregate borrowing opportunities available to the household in any given period as a credit line with limit  $\hat{b}_t(b, z, \varepsilon)$  and the interest rate implicit in the price  $\tilde{q}_t(b, z, \varepsilon)$ .

Since the household can visit as many lenders as it wants, it must also be true that for  $\hat{b}_t(b, z, \varepsilon)$  to be an equilibrium, the household does not want to borrow more from other lenders. This is equivalent to the “no-further-borrowing” property imposed by Bizer and DeMarzo (1992) and the incentive compatibility constraint imposed by Bisin and Rampini (2006). In order to guarantee the equilibrium satisfies “no-further-borrowing”, we impose that after selling  $\hat{b}_t(b, z, \varepsilon)$  bonds at the price  $\tilde{q}_t(b, z, \varepsilon)$ , the household does not want to sell  $b' - \hat{b}_t(b, z, \varepsilon)$  bonds at the price  $q_t(b', z)$ , for any  $b' > \hat{b}_t(b, z, \varepsilon)$ .

Imposing the borrowing opportunities described above, the household's expected utility under repayment is given by

$$V_t^R(b, z, \varepsilon) = \underset{b'}{Max} \{u(c) + \beta E [V_{t+1}(b', z', \varepsilon') \mid z]\} \quad (6)$$

s.t.

$$c = \begin{cases} y - b + b'/(1+r) & \text{if } b' < 0 \\ y - b + b'\tilde{q}_t(b, z, \varepsilon) & \text{if } b' \in [0, \hat{b}_t(b, z, \varepsilon)] \\ y - b + \hat{b}_t(b, z, \varepsilon)\tilde{q}_t(b, z, \varepsilon) + [b' - \tilde{q}_t(b, z, \varepsilon)]q_t(b', z) & \text{if } b' > \hat{b}_t(b, z, \varepsilon), \end{cases}$$

where the functions  $V_t$ ,  $V_t^D$ , and  $\hat{d}_t$  are defined as in the problem with commitment to exclusive borrowing contracts in equations (3), (4), and (5), respectively. Note that, without commitment to exclusive borrowing contracts, finding the equilibrium borrowing policy  $\hat{b}_t$  requires solving a fixed point problem because in problem (6) the equilibrium borrowing level is a constraint for finding the equilibrium borrowing level. This is not the case when we solve the standard model with commitment to exclusive borrowing contracts (see problem 2).

**Definition 2** *A recursive equilibrium without 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 (6) when  $\hat{d}$  is given by equation (5);
- (b) the bond price function solves the expected zero profit condition in equation (1).

The borrowing level that solves the fixed point problem in (6) may not be unique (Lorenzoni and Werning, 2014). We find all fixed points that solve problem (6) and select as the equilibrium borrowing level the one that maximizes the household's expected utility  $V_t^R$ . Note that if the household asked a lender this borrowing level and offered the corresponding equilibrium bond price  $\tilde{q}_t$ , the lender could accept this offer and make zero profits in expectation.

|                             |                      |       |                                |
|-----------------------------|----------------------|-------|--------------------------------|
| Risk free interest rate     | $r$                  | 0.04  | Prior literature               |
| Household's risk aversion   | $\gamma$             | 2     | Prior literature               |
| Household's discount factor | $\beta$              | 0.96  | Prior literature               |
| Autocorrelation coefficient | $\rho_z$             | 1     | Kaplan and Violante (2010)     |
| Std dev of innovations      | $\sigma_e$           | 0.1   | Kaplan and Violante (2010)     |
| Std dev of temp. shocks     | $\sigma_\varepsilon$ | 0.22  | Kaplan and Violante (2010)     |
| Transaction cost of lending | $\phi$               | 0.034 | Athreya (2008)                 |
| Stigma of defaulting        | $\xi$                | 0.103 | Calibrated to match debt ratio |

Table 1: Parameter values.

### 3 Calibration

The model is calibrated using U.S. data. The 2001 Survey of Consumer Finances (SCF) is used as a reference.<sup>10</sup> 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. A household's initial asset position is 65 percent of its initial income, which allows us to match the mean net asset position at age 25 in the SCF.

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 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). Mean income is 5.74. The transaction cost of lending ( $\phi = 0.034$ ) is from Athreya (2008).

<sup>10</sup>For households between 25 and 60 years of age that are not in the top 5 percentile of the wealth distribution.

The cost of defaulting parameter  $\xi$  is calibrated to match debt ratio in the data with the model without commitment to exclusive contracts. The model is solved numerically using value function iteration and interpolation.<sup>11</sup> Simulation results are for the behavior of 10,000 households during their lifetime. Statistics are computed using Census data to assign population weights to each cohort.

## 4 Results

This section first shows that households do not borrow more without commitment to exclusive borrowing contrast. It also shows 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. In addition, we show that without commitment to exclusive contracts, imposing an interest rate limit generates substantial welfare gains.

### 4.1 Equilibrium borrowing levels

Table 2 shows that the calibration of the cost of defaulting allows us to match the debt target well. It also shows that our model without commitment to exclusive borrowing contracts generate plausible values for the non-targeted default rate, the average interest rate 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 are lower than in the data).

Table 2 also shows that the average debt level is 78% higher in the economy with commitment to exclusive borrowing contracts. This is in sharp contrast with the prediction of previous studies (Bizer and DeMarzo, 1992). The left panel of Figure 1 shows that this occurs in part because lenders demand a much lower interest rate when there is commitment to exclusive borrowing contracts.

With commitment to exclusive borrowing contracts, lenders' expected zero profits requires

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<sup>11</sup>Value functions are approximated using Chebychev polynomials. Fifteen polynomials on the asset space and ten on the endowment shock are used.

|                               | Data  | Without<br>exclusivity | With<br>exclusivity | Without excl.<br>but default of excl. | With excl.<br>$\xi = 0.0495$ |
|-------------------------------|-------|------------------------|---------------------|---------------------------------------|------------------------------|
| Average debt/income (%)       | 9.15  | 9.17                   | 16.32               | 16.17                                 | 9.15                         |
| Default rate (%)              | 0.5   | 0.2                    | 0.14                | 0.19                                  | 0.19                         |
| Average int. rate on debt (%) | 11.79 | 8.95                   | 8.06                | 7.78                                  | 8.61                         |
| Std dev (int. rate) (%)       | 3.75  | 4.03                   | 1.40                | 1.77                                  | 1.92                         |

Table 2: Simulations results.

a lower interest rate because incentives to repay are stronger. Figure 2 shows that exclusive contracts increase more the value of repaying than the value of defaulting and, therefore, 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 2, 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 likely to borrow.

This effect of exclusivity on the incentives to repay (and in turn in the cost of borrowing and the equilibrium borrowing level) is not present in previous studies that assume a unique borrowing period (Bizer and DeMarzo, 1992). This effect is also not present in period  $W - 1$ . This is the last period in which the household faces uncertainty about next-period income and, therefore,  $W$  is the last period in which the household may default. Consequently, exclusivity does not affect the incentives to repay in  $W$ . The right panel of Figure 1 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.

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. Table 2 shows that the effect of exclusivity on the borrowing levels through the incentives to repay is large: the average debt level without exclusivity is 78% higher in the

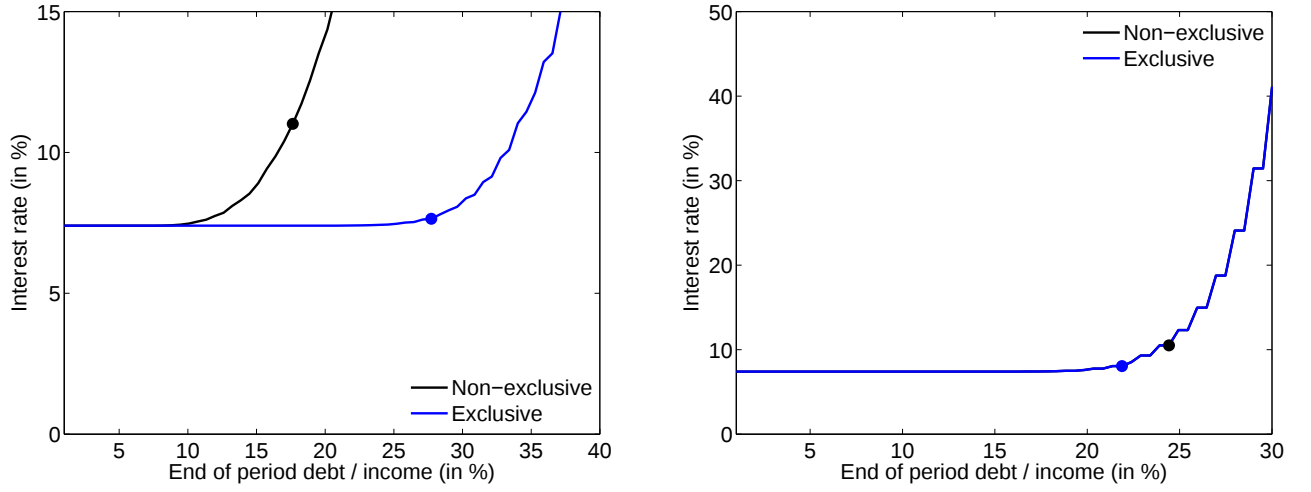


Figure 1: Borrowing with and without commitment to exclusive contracts. For any level of debt, the figure presents the interest rate consistent with expected zero profits for lenders, when the permanent income shock takes its mean value. Dots present the household optimal choices when they start the 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.

counterfactual economy with the equilibrium default rule of the model with exclusivity. It should be noted that we obtain these large effect even with the conservative assumption of default only excluding the household from debt markets in the default period.<sup>12</sup> Table 2 also shows that, in contrast with the results presented in previous studies, even when we eliminate the effect of exclusivity on the incentives to repay, households do not borrow more (on average) without commitment to exclusive borrowing contracts.

For the same incentives to repay and equilibrium bond prices  $q_t$ , why do households not borrow more (on average) without commitment to borrowing from only one lender? The intuition behind this result transpires from Euler equations (7) and (8) for the problems with and without commitment, respectively.<sup>13</sup>

<sup>12</sup>Other studies assume a much larger duration of the exclusion from debt markets after a default. With a larger duration, being excluded from debt markets is a more important component of the cost of defaulting. Therefore, changing the value of market access through exclusivity has a more significant effect on equilibrium debt levels.

<sup>13</sup>Equations (7) and (8) assume that the price and value functions are differentiable. The numerical solution method does not rely on these assumptions.

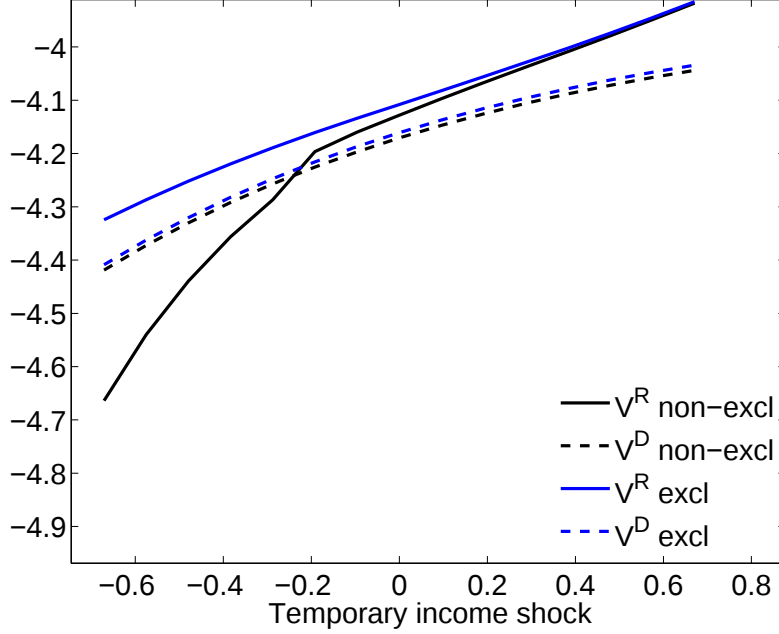


Figure 2: Value functions with and without commitment to exclusive contracts. The figure assumes that the household is 31 years old, the permanent income shock takes its mean value and the initial debt level is the optimal debt choice of a 30-years-old household without debt and the mean value for the income shocks.

$$u'(c_t) \left[ q_t(b', z) + \frac{\partial q_t(b', z)}{\partial b'} b' \right] = \beta E \left[ (1 - \hat{d}_{i+1}) u'(c_{i+1}) \mid z \right]. \quad (7)$$

$$u'(c_t) \tilde{q}_t(b, z, \varepsilon) = \beta E \left[ (1 - \hat{d}_{i+1}) u'(c_{i+1}) \left[ 1 - \hat{b}_{t+1}(b', z', \varepsilon') \frac{\partial \tilde{q}_{t+1}(b', z', \varepsilon')}{\partial b'} \right] \mid z \right]. \quad (8)$$

In Equation (7), when households can commit to borrowing from only one lender, borrowing more is costly because it lowers the price of debt  $q_t$  offered by the exclusive lender and, therefore, it lowers current consumption. In contrast, in Equation (8), without commitment to borrowing from only one lender, borrowing more does not change the price of debt offered by lenders, which is given by the credit-line price  $\tilde{q}_t$ . 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 (8), when households cannot commit to borrowing from only one

lender, borrowing more is costly because it lowers the next-period credit-line price  $\tilde{q}_{t+1}$ , thus lowering next-period consumption. In contrast, in Equation (7), 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 through the price of debt. This effect is not present in previous studies with a unique borrowing period (Bizer and DeMarzo, 1992). Table 2 shows that in the simulations of our model, these 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.

## 4.2 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. 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.

## 4.3 Policy experiments

We next show that without commitment to exclusive contracts, imposing an interest rate limit generates substantial welfare gains. The left panel of Figure 3 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%. 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 (right panel of Figure 3). Interest rate limits are widely used and often justified by concerns about lenders' predatory behavior. Our results suggest that even

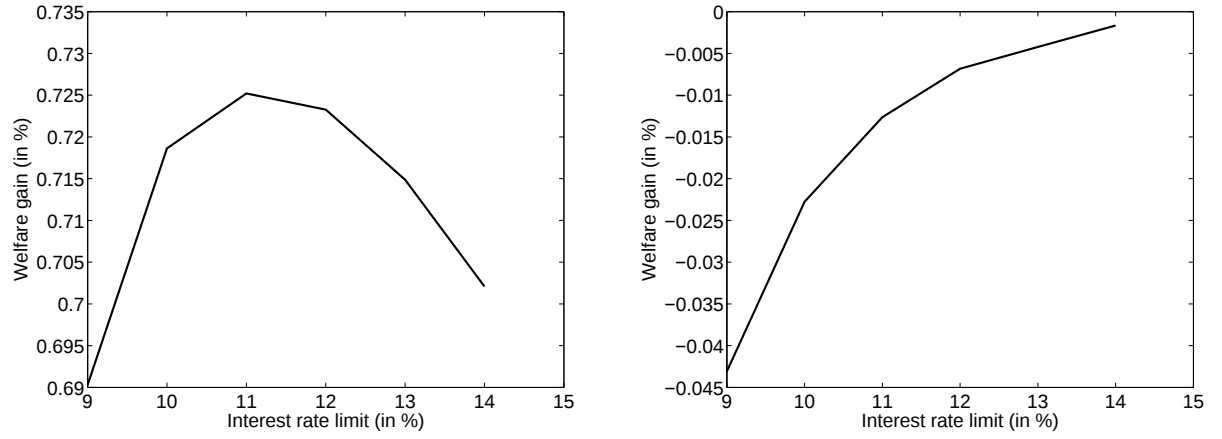


Figure 3: Ex-ante welfare gains from debt and interest rate limits. Ex-ante welfare gains are measured as the proportional increase in consumption that would make a new-born household indifferent between living in the benchmark economy and living in the economy with the interest rate limit.

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.

## 5 Conclusions

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