

A Simple Model of Subprime Borrowers and Credit Growth

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During the boom that preceded the Great Recession, aggregate mortgage debt and house prices surged in tandem across the United States, while interest rates fell. This sharp increase in household borrowing, and in the house values that collateralized it, was also characterized by a well-defined geographic pattern. As first documented by Mian and Sufi (2009), both credit and house prices rose disproportionately in ZIP codes with a higher percentage of “subprime” borrowers.

We reproduced these stylized facts using micro data from the FRBNY Consumer Credit Panel/Equifax (CCP) and CoreLogic for over seven thousand ZIP codes, between 2000 and 2006. The regression of cumulative credit growth over this period on the share of subprime borrowers in each ZIP code has a slope of 0.3. This coefficient implies that mortgage debt grew by 30 percentage points more in a hypothetical ZIP code inhabited only by subprime borrowers, compared to one populated only by prime borrowers. Similarly, the slope for the growth in house prices in the corresponding regression is 0.35.¹

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¹Details on the specification of these regressions and on the underlying data can be found in the working paper version of this article (Justiniano, Primiceri and Tambalotti, 2016)

The fact that aggregate debt rose and interest rates declined during this period points to an expansion in the supply of credit as the ultimate driver of the boom. In Justiniano, Primiceri and Tambalotti (2015, henceforth JPT), we formalize this intuition through a simple general equilibrium model, in which the expansion in credit supply is brought about by a relaxation of lending constraints, or equivalently, of leverage restrictions on financial intermediaries. A progressive reduction in these barriers to lending, which captures the explosion of securitization and of market-based financial intermediation starting in the late 1990s, produces a credit boom in the model that is consistent with four key aggregate stylized facts about the U.S. economy in the early 2000s: the surge in house prices and in household debt, the stability of debt relative to home values, and the fall in mortgage rates.

The contribution of this paper is to confront this same mechanism with the cross-sectional evidence presented above. To do so, we extend the representative borrower model of JPT to include both prime and subprime borrowers, which we assume are heterogeneously distributed across ZIP codes. We then subject a calibrated version of this economy to a progressive relaxation of lending constraints that increases the supply of credit, reducing interest rates from 5 to 2.5 percent, roughly as observed in the data between 2000 and 2006.

The main result of this experiment is that, in response to the expansion in credit supply, the model closely reproduces the distribution of changes in mortgage debt and house prices across ZIP codes described above. In particular, ZIP codes with a higher fraction of subprime borrowers experience higher increases in both debt and house prices, with a slope of approximately 0.25, remarkably close to the empirical

slopes of 0.3 and 0.35 for debt and house prices.²

The intuition for the more pronounced increase in debt among subprime borrowers is fairly straightforward, and arguably realistic. Subprime households have low incomes, and hence a limited capacity to afford interest payments. This limit, in turn, constrains their ability to borrow and hence the value of the house that they can purchase. In contrast, prime households are richer and only subject to a collateral constraint that limits their borrowing to a fraction of the value of their real estate.

As a result of this asymmetry, the two types of households respond differently to the fall in interest rates and the rise in house prices that are triggered by the expansion in credit supply. Prime households' collateral constraint slackens as a function of the equilibrium increase in the value of real estate, driving the increase in their debt. Instead, subprime households get a direct boost to their ability to borrow from the fall in the interest rate, which makes bigger mortgages affordable for them, driving up their housing demand. In equilibrium, this latter effect is always larger, leading to more debt accumulation by subprime borrowers, and to larger house price increases in areas in which those borrowers are more concentrated.

I. A Simple Model with Subprime Borrowers

This section presents a simple macroeconomic framework to address the cross-sectional facts discussed in the introduction. The model features impatient borrowers and more patient lenders. Lenders are the same as in JPT, except that for simplicity we assume here that they do not own houses. Lenders have a discount factor β_l and face a lending limit, denoted by \bar{L} . This restriction on the ability of savers to extend credit captures a variety of implicit and explicit regulatory, institutional and technological constraints that hamper

the free flow of funds towards mortgage borrowers, as discussed at length in JPT.

A. Prime and subprime borrowers

To address the cross-sectional evidence presented in the introduction, we introduce a distinction between two sets of borrowers, prime (p) and subprime (s). Both have a discount factor $\beta < \beta_l$, but the latter are poorer. In the data, subprime borrowers are usually identified as having a low credit score. For example, Mian and Sufi (2009) set this threshold at a FICO score of 660. Credit scores, which are primarily designed to capture risk of default, depend on a person's credit history, and hence are correlated with the level and volatility of individual income. Here, we base the distinction between prime and subprime borrowers on their level of income alone, both for simplicity, and because this characteristic correlates strongly with the credit score (e.g. Mayer and Pence, 2009; Mian and Sufi, 2009).

Borrowers are distributed across geographic areas, say ZIP codes, which are indexed by the fraction α of subprime households that live there. Households in these locations borrow from a representative national (or international) lender at interest rate R_t , using houses as collateral. They can trade houses within a ZIP code, but not across them, and they cannot migrate. In the model, some equilibrium prices and allocations depend on α , but we explicitly introduce this dependence only at a later stage, to streamline the notation.

In each location, representative borrower $j = \{p, s\}$ maximizes utility

$$E_0 \sum_{t=0}^{\infty} \beta^t [c_{j,t} + v(h_{j,t})],$$

where $c_{j,t}$ denotes consumption of non-durable goods, and $v(h_{j,t})$ is the utility of the service flow derived from a stock of houses $h_{j,t}$ owned at the beginning of the period.

Assuming that utility is linear in non-durable consumption, as in JPT, helps to obtain clean analytical solutions, without compromising the model's basic mech-

²In the model, this slope is the same for debt and house prices.

anisms. However, here we accompany this simplifying assumption with the explicit consideration that consumption cannot fall below a subsistence level \underline{c} , i.e.

$$c_{j,t} \geq \underline{c}.$$

If we ignored this constraint, which is usually enforced at zero by suitable Inada conditions, consumption could become very low or negative, depending on the level of income. As shown below, this lower bound on consumption effectively imposes a maximum coverage ratio—a limit on the amount of debt-service payments that low-income borrowers can afford at a given interest rate.

Utility maximization is subject to the flow budget constraint

$$(1) \quad c_{j,t} + p_t [h_{j,t+1} - (1 - \delta) h_{j,t}] + R_{t-1} D_{j,t-1} \leq y_{j,t} + D_{j,t},$$

where δ is the depreciation rate of houses, p_t is their price in terms of the consumption good, and $D_{j,t}$ is the amount of one-period debt accumulated by the end of period t , and carried into period $t + 1$, with gross interest rate R_t . $y_{j,t}$ is an exogenous endowment of consumption and housing goods, which is lower for subprime borrowers, so that $y_{s,t} < y_{p,t}$.

Finally, borrowers' decisions are subject to a collateral constraint *a la* Kiyotaki and Moore (1997), which limits debt to a fraction θ of the value of the housing stock they own,

$$(2) \quad D_{j,t} \leq \theta p_t h_{j,t+1},$$

where θ is the maximum allowed loan-to-value ratio. This ratio could in principle be different for prime and subprime borrowers, but we abstract from this source of heterogeneity here.

B. Steady-state equilibria

The steady state of the model presented in the previous section depends on the parameter configuration, which determines the constraints that bind in equilibrium. In what follows, we focus on a steady state in

which a) the income of subprime borrowers, y_s , is low enough to push their consumption against the subsistence point, b) prime borrowers are always away from this constraint, and c) both lending and borrowing constraints bind, as in JPT.

In this steady state, the budget constraint of the subprime agents, together with $c_s = \underline{c}$, implies

$$(3) \quad D_s = \frac{y_s - \underline{c} - \delta p(\alpha) h_s(\alpha)}{R - 1},$$

where we are now making explicit the dependence on α of those variables that vary with it in equilibrium.

Although this equation is derived under stylized assumptions, it captures quite literally the idea that poor, subprime households are likely to be in a “corner.” Their borrowing is limited by the present discounted value of their disposable income, once they have met the subsistence level of consumption and replaced the depreciated portion of their house. Multiplying both sides by $R - 1$ makes clear that (3) represents a coverage limit on mortgage obligations, restricting the amount of debt that a borrower can take on as a function of the income at her disposal to service the debt. This restriction is similar to that assumed by Greenwald (2015).

Equation (3), together with the binding collateral constraint, implies the following housing demand equation for subprime households

$$p(\alpha) = \frac{y_s - \underline{c}}{(R - 1)\theta + \delta} \cdot \frac{1}{h_s(\alpha)},$$

from which we see that their housing expenditure is limited by their ability to make mortgage payments, and hence to take on leverage.

In contrast, prime households price housing according to a fairly standard Euler equation, adjusted for the effect of the binding borrowing constraint. Assuming $v(h) = \phi \ln h$, the steady state pricing equation for prime borrowers is

$$p(\alpha) = \frac{\beta}{1 - \theta\mu - (1 - \delta)\beta} \frac{\phi}{h_p(\alpha)},$$

where μ is the multiplier on the collateral constraint, which is a negative function of interest rates.

Together with housing market clearing in each ZIP code, $\alpha h_s(\alpha) + (1 - \alpha) h_p(\alpha) = \bar{h}$, the two housing demand equations yield

$$p(\alpha) = \frac{1}{\bar{h}} \left[\alpha \frac{y_s - \underline{c}}{(R - 1)\theta + \delta} + (1 - \alpha) \frac{\beta\phi}{1 - \mu\theta - (1 - \delta)\beta} \right],$$

from which we see that house prices are a weighted average of the valuations of prime and subprime households, making them a function of the share of the latter in each ZIP code. Similarly, total debt in each ZIP code is

$$D(\alpha) = \alpha D_s + (1 - \alpha) D_p = \theta p(\alpha) \bar{h},$$

and therefore also depends on the share of subprime households in that area, through its effect on house prices.

Since subprime borrowers spend less in housing than their prime counterparts, housing expenditure, house prices and mortgage debt are lower in areas with a higher share of subprime households. However, a relaxation of credit supply that lowers interest rates directly reduces mortgage payments for subprime households, allowing them to expand their borrowing and house purchases more than prime households. Therefore, home prices and debt will grow more in areas with a higher fraction of subprime borrowers when interest rates fall, despite starting from a lower level. The next section studies this cross-sectional response of the economy to a relaxation of the lending constraint in a calibrated version of the model.

II. An Increase in Credit Supply

In this section, we study quantitatively the response of house prices and household debt to an outward shift in credit supply, due to a slackening of the lending constraint \bar{L} . This progressive relaxation of the existing barriers to lending moves the economy from a steady state with high mortgage rates, low debt and low house prices circa 2000, to

one with low mortgage rates, high debt and high house prices around 2006. As shown in JPT, this experiment captures the main aggregate dimensions of the housing boom during this period. The question that we ask in this section is if it can also reproduce the cross-sectional evidence presented in the introduction. Details on the experiment and the model calibration using the Survey of Consumer Finances and the CCP are in Justiniano, Primiceri and Tambalotti (2016).

As in JPT, the premise of this exercise is that at the end of the 1990s the U.S. economy was constrained by a limited supply of credit. In this initial steady state, we set \bar{L} so that the lending constraint is binding and the interest rate is equal to $\frac{1}{\beta}$, which we calibrate at 5%. We then increase \bar{L} until the economy reaches a new steady state in which the lending constraint is not binding, and, consequently, the interest rate falls to $\frac{1}{\beta_t}$, which we set equal to 2.5%.

In the model, this reduction in the interest rate enhances the ability of both types of borrowers to take on debt, but at different rates. More precisely, mortgage debt increase by 46 percent for subprime borrowers, but only by 21 percent for prime borrowers. For comparison, in the CCP the percentage increase in real mortgage balances of the average subprime and prime borrowers between 2000 and 2006 is 62 and 39 percent respectively. In absolute terms, the model generates about two thirds of the observed increase in debt for the two classes of borrowers. In relative terms, however, the model reproduces the evidence almost exactly. In the initial steady state, the relative debt of subprime to prime borrowers is pinned to 74 percent by the calibration. It then rises endogenously to 90 percent in 2006, compared to 87 percent in the data.

Since the debt of subprime borrowers is more sensitive to the decline in interest rates, the model also implies a higher percentage increase of household debt in locations with a larger fraction of subprime borrowers, as in the data. The model-implied relationship between mortgage debt growth and the share α of subprime borrowers in a

ZIP code is close to a straight line, with slope equal to 0.25. This slope is virtually identical to the regression coefficient of cumulative mortgage credit growth between 2000 and 2006 on the share of subprime borrowers (measured in 1999) across ZIP codes from the CCP discussed in the introduction.³

Finally, in the model the percentage increase in credit across ZIP codes in response to the fall in interest rates is equal to that in home values, since the two are connected by the binding collateral constraints. In the data, the ZIP-level regression coefficient of cumulative house price growth between 2000 and 2006 from CoreLogic on the share of subprime borrowers (measured in 1999) is equal to 0.35. This value is very close to the 0.3 estimated for credit growth, and to the 0.25 obtained in the model, supporting the model's assumption that debt and house price growth covary closely in the cross-section during the boom.

III. Conclusion

As documented by Mian and Sufi (2009), house prices and mortgage debt between 2002 and 2005 surged more in ZIP codes with a higher concentration of subprime borrowers. We presented a simple model that is consistent with this empirical evidence, which we also extend to the period between 2000 and 2006, to cover a larger swath of the boom.

The key ingredient of the model is a distinction between two types of borrowers, based on their income level. Due to the presence of a minimum consumption level, poorer borrowers face an upper limit on the mortgage payments they can afford. For this reason, we label them "subprime". In this environment, an expansion in credit supply that lowers mortgage rates enhances all borrowers' ability to acquire additional debt. However, the effect is larger for subprime borrowers, since it directly lowers

their mortgage payments, hence slackening the coverage ratio constraint that they are effectively subject to. A calibration using micro data from the CCP and the Survey of Consumer Finances shows that the model is quantitatively consistent with the evidence about the higher growth of debt and house prices in ZIP codes with relatively more subprime borrowers.

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³This slope is also very close to that estimated by Mian and Sufi (2009) in similar regressions, for instance in the fifth column of their table V, once we take into account that they look at the period 2002 to 2005 and that their left-hand-side variable is annualized.