1 Introduction

Lax lending standards in mortgage markets are usually blamed as one of the causes of the last housing boom (see for example Acharya and Richardson 2009, Allen and Carletti 2009, Rajan 2010 and Taylor 2009). The usual argument is that lenders extended credit to borrowers with low income relative to the amount they were borrowing. As a consequence, one of the major policy proposals from the Dodd–Frank Reform is the Qualified Mortgage (QM) rule recently implemented by the Consumer Financial Protection Bureau (CFPB) and the U.S. Department of Housing and Urban Development (HUD). Among other things, this rule requires lenders to check the income of the borrower to verify that she can afford to repay the loan in full. There is also a requirement to insure that the monthly loan payment plus the borrower's other debt payments do not exceed 43 percent of the borrower's gross monthly income.

During the housing bust, lending standards are usually blamed for the opposite reason. Bernanke (2012) claimed that "the pendulum has swung too far the other way" and overly tight lending standards prevented qualified borrowers from getting home loans. In the words of President Obama: "There are still millions of families with strong enough credit profiles to qualify for a mortgage but who are nonetheless being denied loans. According to the Federal Reserve, from 2007 to 2012, mortgage lending to borrowers with credit scores above 780 fell by a third, while lending to borrowers with credit scores between 620-680 declined by roughly 90%. For many of these borrowers, they are denied a loan because lenders are unclear of the rules of the road for lending and are protecting themselves by only lending to those with the most pristine credit. The Administration is continuing to work with housing regulators and stakeholders on reasonable approaches to clarify rules and reduce overlapping regulations, in order to expand access to credit for qualifying families" (Obama 2013). Loan guarantees is the more popular way used by the U.S. Government to encourage lenders to relax their lending standards.

This paper proposes a tractable model to study how lenders decide lending standards in mortgage markets. I focus on the extensive margin of credit. That is, on the lenders' decision about who are the borrowers qualified for credit.[1] In Section 3 I document the empirical relevance of the fluctuations in this margin. Then, I characterize in closed form the optimal lending standards. Finally, I use the model to analyze Government loan guarantees in mortgage markets. And to highlight an unintended consequence of the new QM rules.

In the model there are borrowers, savers, banks, real estate developers and a government.

[1] Loan-to-Value or the maturity of the loan are other variables usually defined as lending standards. To simplify, I do not model them in this paper.

The main contribution of the paper is the way the borrowers and banks' decisions are modeled. Borrowers live for two periods but only receive income in their second period. In their first period they need to borrow to buy a house. Borrowers' income depends on an aggregate shock that is time-varying and captures the business cycle, and on idiosyncratic characteristics. Borrowers are heterogenous on the idiosyncratic characteristics (some borrowers will have higher income). Banks select their lending standards to ensure they only give credit to borrowers with a minimum level of the idiosyncratic characteristics. For example, to qualify a borrower for a loan banks ask for a minimum credit score. This requirement can change over time, thus lending standards can be time-varying.

Tight standards means that banks are more selective when qualifying a borrower for a loan. That is, the idiosyncratic quality of the pool of financed borrowers increases (for example, banks ask for a higher FICO score), which in turn reduces the risk of loan default if the aggregate income shock goes down. Implementing the lending standards is costly (for example banks may need more loan officers allocated to screening tasks) and may imply that a bank does not lend because it does not meet a borrower satisfying its minimum standards. In that case the bank places its funds in government bonds.

Banks' expectations about house price growth (the value of collateral) and about borrowers' income (that changes over the business cycle), together with banks' cost of funds, return on government bonds (or the opportunity cost of giving mortgage credit) and foreclosure costs drive banks' choice of lending standards. When banks expect house price growth to be higher there is less risk in lending to low quality borrowers as the collateral has more value. Similarly, when the aggregate economy is expected to be good all borrowers will be more profitable (bad borrowers are less bad in a booming economy) and banks relax their standards to save on screening costs and maximize their chances of giving credit. Banks also relax their standards when their costs of funds decrease.

The model highlights that there is a tradeoff between homeownership and financial stability. A tradeoff that resembles the tradeoff in the Phillips curve between inflation and unemployment. In this case, to increase homeownership banks need to lend to borrowers of lower income quality. That is risky because it is more likely that those borrowers default if the aggregate business cycle turns out bad. Thus, higher levels of homeownership are associated with higher financial instability as banks are more exposed. Bank losses are larger for bad business cycle shocks.

The new QM rules are supposed to help borrowers understand the true costs of the mortgage they apply for. And to keep lenders from lending money to borrowers who cannot afford to make those payments over time. According to policy officials, they should not affect bank lending standards because they impose good criteria that reasonable banks should already be following. However, I show that it is enough that the new rules increase the compliance costs associated with lending for the new rules to imply tighter lending standards. The intuition is that banks when they lend they think on the alternative return of their investment. The new rules make mortgage credit more costly while not penalizing other alternative investments. Thus, banks will need to be pickier when qualifying borrowers.

The structure of the paper is the following: Section 2 reviews the related literature. Section 3 documents several facts on the relation between lending standards and housing markets. It focuses on the dynamics of the extensive margin of credit. Section 4 presents the model. Section 5 discusses the lending standard decision. Section 6 shows how the model can generate changes in lending standards and the extensive margin of credit over the business cycle. Section 7 analyzes the effects of government loan guarantees and shows the trade-off between home-ownership and financial stability. Section 8 studies an unintended consequence of the new QM regulations. Section 9 concludes.

2 Related Literature

This paper contributes to several literatures. First, it is the first paper to propose a quantitative general equilibrium model to study the interaction between real estate prices and lending standards modeled as the extensive margin of credit. This work complements a large empirical literature that has studied the link between credit and real estate markets. See for example, Crowe et al. (2011), Goetzmann et al. (2012), Herring and Wachter (1998) and Reinhart and Rogoff (2009) among others. As noted by Pavlov, Steiner and Wachter (2012) that there is not much research on the channels through which real estate dynamics affects the price and volume of credit. This is the main contribution of the paper.

Second, the paper is related to the macroeconomic literature on housing markets. Related examples are Aspachs-Bracons and Rabanal (2010), Davis and Heathcote (2005), Ferrero (2013), Garriga et al. (2012), Gete (2009), Iacoviello and Neri (2010), Favilukis et al. (2010) or Justiniano et al.(2013) among others. This literature has focused on the intensive margin of credit. That is, the amount borrowed when loan-to-value constraints are relaxed.

Third, my model complements models of lending standards such as Dell'Aricia and Marquez (2006), Ruckes (2004), Shaffer and Hoover (2008), and Weinberg (1995). In those models lending standards change along with the quality of borrowers over the business cycle. In this paper I model lending standards differently. Most of the literature models lending standards as a creditworthiness test, for example Broecker (1990), Gorton and He (2008), Ruckes (2004) or Thakor (1996). That is, tighter standards means that the banks screen more and are more likely to discover the true type of their borrowers. But the income threshold that qualifies them for credit does not change, thus good borrowers are unaffected by tighter lending standards. In my model tighter standards means that banks are pickier and change the qualification threshold. That is, when banks tighten their standards, some borrowers who were previously considered good enough to receive credit no longer qualify for it. This modeling assumption was inspired by the new literature on trade (Melitz 2003, Eaton and Kortum 2004). In new trade models, only the most productive firms decide to export, and in our model, the banks only qualify the most productive borrowers for a loan.

3 Some Facts

In this section I document several facts on the relation between lending standards and housing markets. I focus on the extensive margin of credit because, as discussed above, this is a dimension unexplored in the literature. This will be the focus of the model presented in the next section. As I will show, there is strong evidence on the fluctuations on the extensive margin of credit in mortgage markets.

Figure 1 plots the dynamics of U.S. lending standards and real house prices. The lending standards on mortgage credit are measured from the Federal Reserve System's Senior Loan Officer Opinion Survey on Bank Lending Practices. Banks are asked whether their "credit standards" for approving loans have tightened. Banks do not specify what they mean by "standards". Several facts are relevant. First, the lending standards did not change much during the housing boom period of the late 1990s and the 2000s. However, lending standards increased dramatically once house prices started to drop in 2007. This timing may suggest causality from house prices towards lending standards. However, the lending standards started to soften before house prices started to recover. What suggests the opposite direction of causality.

Insert Figure 1 about here

Figure 2 shows that mortgage borrowers with low credit scores (FICO scores below 620) used to be a significant share of first-time homebuyers. They were around 30% of the market before the housing bust and they have dropped below 10%.

Insert Figure 2 about here

Figure 3 shows different evidence that suggests that low credit score borrowers have reduced their participation in housing markets because they do not qualify for credit. Surveys of lenders practices show that these borrowers are less likely to be approved for a loan, mortgage originations have fallen specially for these borrowers, many lenders are not offering quotes on mortgages to these borrowers, and their share of FHA and Prime loan originations have contracted.

Insert Figure 3 about here

A borrower with a FICO credit rating of 620 or above is generally considered a prime borrower and a safe credit risk. However, even prime borrowers have found mortgage lending standards much tighter since the start of the recession. For example, the median FICO score for prime borrowers has risen about 40 points to over 760 and has not declined even as the economy has been recovering. Thus, a prospective homeowner must have a much higher credit rating than in the past to qualify for a loan.

Figure 4 presents evidence on lending to different FICO score groups using publicly available data from Lending Club, the leading Peer-to-Peer lender. The evidence is consistent with what I discussed above.

Insert Figure 4 about here

It is important to highlight that the tight mortgage lending standards discussed above happened while the Federal Reserve's accommodative monetary policy has kept interest rates at historically low levels. For example, the federal funds rate has been essentially zero for over four years and counting, and the 10-year Treasury yield is below 2%. Thirty-year fixed-rate mortgages remain below 3.5%. Tight standards make it difficult for many households to take advantage of low mortgage interest rates.

4 Model

There are two sets of households: 1) The representative infinite horizon household standard in general equilibrium models. 2) Borrowers who live for two periods. These households borrow in their first period to buy a house. Houses are large and indivisible goods. In their second period they pay back their debts, or default. The infinitely lived household provides the savings for the borrowers via the banks, and the inputs that real estate developers transform into new houses. The next Figure summarizes the structure of the model. In addition, there is a Government to close the model and pay risk free interest on government bonds.

Insert Figure 5 about here

4.1 Borrowers

At each period t there is a continuum of mass one of young households who live for two periods.[2] I call them "borrowers" because in period 1 they try to borrow to buy a house. In the second period of their lives they are heterogeneous in their income. Each borrower has n_b units of labor income that become ωn_b units of effective labor. The idiosyncratic factor ω is heterogeneous among borrowers. I assume that ω follows a Pareto distribution with support $[M, \infty)$ and distribution function $G(\omega) = 1 - \left(\frac{M}{\omega}\right)^{\mu}$, where $\mu > 0$ is the shape parameter. As μ increases, the dispersion of ω decreases and it is increasingly concentrated towards the lower bound M. The Pareto assumption is analytically tractable and fits households' wealth distribution.

The income of a borrower in her second period is $W_t \omega n_b$ where W_t is the wage per unit of effective labor. Then borrowers' income depends on aggregate (W_t) and individual (ω) characteristics, the aggregate component fluctuates over time.

Borrowers enjoy consumption goods and houses. Houses are indivisible and of size $\bar{h}$, for simplicity, owning more than one does not give extra utility and I do not model a rental market. I denote by Ψ_t an indicator function which takes the value 1 if the household owns a house. Households can borrow l_t at gross rate R_t^l.

The problem of a young household in her first period is to decide if to buy a house or not. In her second period she works for the firm, receives her income, sells her house, pay her debts and consume the leftovers. Thus, households budget constraints are

$$l_t = p_t \bar{h} \tag{1}$$

$$c_{t+1}^t = \max\left\{(1-\delta)\, p_{t+1} \Psi_t \bar{h} + W_{t+1} \omega n_b - R_t^L l_t, 0\right\} \tag{2}$$

where c_{t+1}^t is consumption in period 2, and δ is the depreciation rate of a house.[3] The *max* operator takes into account that in period 2 the household may not have enough revenue to

[2] The two period assumption keeps the heterogeneity very tractable as there is not persistence in the wealth distribution. This is similar to Gourio (2013) who assumes i.i.d. shocks for firm's idiosyncratic productivity.

[3] Since at each period there are two cohorts of borrowers alive (those born yesterday and those born today) I use the superscript to denote the period when they are born, and the subscript to denote the period of the

return the loan and has to default. In this model default is not strategic. Households default when households' wealth is not enough to repay their debts. It is never optimal for the lenders to finance a borrower who is expected to default. Thus, in equation (2) the left hand side of the max operator is always larger or equal than zero.

To simplify, I assume that elder households do not receive utility from owning a house and that their marginal utility of consumption is constant.[4] Thus, the young borrower solves:

$$V\left(\Psi_t, c_{t+1}^t\right) = \max_{\Psi_t, l_t, B_t, c_{t+1}^t} E_t\left[\Psi_t \log\left(\bar{h}\right) + \beta c_{t+1}^t\right] \quad (3)$$
$$s.t. \; (1) - (2)$$

4.1.1 Young Borrowers

I will calibrate the model to focus on equilibria in which young households try to buy a house. That will be the case if

$$V\left(1, c_{t+1}^t\right) \geq V\left(0, c_{t+1}^t\right) \quad (4)$$

where $V\left(1, c_{t+1}^t\right)$ is the utility from the case in which the household owns a house. If $\bar{h}$ is large enough, or β small enough, we can insure that (4) holds and households try to buy a house.

The desired loan amount is

$$l_t = p_t \bar{h} \quad (5)$$

Thus, credit demand (5) is independent of the borrower type ω and unique. That is, even if borrowers are heterogenous in second period income they all demand the same amount of credit. Thus, (5) pins down loan size in the model. It is increasing in house prices. From a lender's perspective bad borrowers exist in the model because not all borrowers will be able to return that loan size.

4.1.2 Elder Borrowers

Elder borrowers in period t who were financed when they were young $(\omega \geq \pi_{t-1})$, either can repay their debts or they cannot. In this later case they default and the bank can claim

economy. That is, c_t^{t-1} denotes the consumption in period t of the households born in period $t-1$, they are the elder households of period t.

[4] Quasilinearity insures that I do not need to bound the income process to insure that the natural borrowing limits applies. Moreover it allows to solve in closed form for the default thresholds.

the house and the income of the borrower.[5] If elder borrowers can repay then they do so and consume the difference between their wealth (income plus the sale of the house) minus the loan repayment. If elder borrowers were not financed ($\omega < \pi_{t-1}$) they just consume their endowment of goods. Thus, elder consumption is

$$c_t^{t-1}(\omega) = \begin{Bmatrix} \max\left\{(1-\delta)\,p_t\bar{h} + W_t\omega n_b - R_{t-1}^L l_{t-1}, 0\right\} & \text{if } \omega \geqslant \pi_{t-1} \\ W_t\omega n_b \quad \text{if } \omega < \pi_{t-1} \end{Bmatrix} \tag{6}$$

where the max operator insures that consumption cannot be negative. In that case the borrower would default. Thus, at period t defaulting borrowers are those financed elder borrowers with not enough wealth to repay, that is, $\omega < \hat{\omega}_t$ where $\hat{\omega}_t$ is defined as

$$\hat{\omega}_t = \frac{R_{t-1}^L l_{t-1} - (1-\delta)\,p_t\bar{h}}{W_t n_b} \tag{7}$$

4.2 Savers

There is continuum of N_s identical savers in the market. They can work in either goods or real estate sectors, and earn wage income $W_t N_s$. The firms give all profits (Π_t) to the savers. Savers can save using banks' deposits (D_t). Savers own the banks and receive their profits (Π_t^B). Savers are subject to a lump-sum tax (T_t) by the government to finance the interests on government bonds.[6]

$$\max_{\tilde{c}_t, D_t} E_t\left[\sum_{t=0}^{\infty}\beta^t u(\tilde{c}_t)\right] \tag{8}$$

$$s.t. \qquad R_{t-1}^D D_{t-1} + \Pi_t + \Pi_t^B + W_t N_s = \tilde{c}_t + D_t + T_t \tag{9}$$

where T is determined by the government's problem and R_{t-1}^D is the return on banks' deposits. I assume log utility:

$$u(\tilde{c}_t) = \log(\tilde{c}_t) \tag{10}$$

[5] If preferences were not quasilinear and utility concave on second period consumption then households would try to avoid default (that brings marginal utility of zero consumption to infinity) by respecting the natural borrowing limit.

[6] This is just a technical trick since those interest payments are rebated to the savers who own the bank.

4.3 Firms

Firms convert workers' labor into goods and houses (of size $\bar{h}$) according to the following production functions

$$y_{c,t} = z_{c,t} N_{c,t}^{\phi} \tag{11}$$

$$y_{h,t} = z_{h,t} N_{h,t}^{\phi} \tag{12}$$

where $\phi < 1$ is a parameter. $z_{c,t}$ and $z_{h,t}$ are technology progress in goods production and housing construction. The decreasing returns to scale technology ($\phi < 1$) insures that rising housing prices imply increased investment in new houses.

Firms' objective function is to maximize profits from selling goods and houses. Profits are then returned to the savers:

$$\Pi_t = \max_{N_{h,t}, N_{c,t}} \left[p_t y_{h,t} + y_{c,t} - W_t \left(N_{h,t} + N_{c,t} \right) \right] \tag{13}$$

$$s.t.\ (11) - (12) \tag{14}$$

Then FOCs are

$$\phi p_t z_{h,t} N_{h,t}^{\phi-1} = W_t \tag{15}$$

$$\phi z_{c,t} N_{c,t}^{\phi-1} = W_t \tag{16}$$

4.4 Banks and Lending Standards

In every period t there is a continuum of mass one of one-period banks, each bank meets one young borrower applying for a one-period loan. Banks can be thought of as a representative bank because I abstract from strategic interactions between them. Banks are price takers and take interest rates on government bonds, deposits and loans $\left(R_t^B,\ R_t^D,\ R_t^L\right)$ as given.

From young borrowers' problem we know that borrowers only ask loans of size l_t determined by (5). Banks decide their lending standards π_t such that only borrowers with idiosyncratic income above (π_t) get financed. That is, banks lending rule is of the form

$$l_t(\omega) = \left\{ \begin{array}{ll} l_t & \text{if } \omega \geq \pi_t \\ 0 & \text{if } \omega < \pi_t \end{array} \right\} \tag{17}$$

with l_t determined by (5). We can interpret π_t as the minimum FICO score to qualify for credit. As this Figure displays, any borrower with idiosyncratic productivity to the left of π_t is rejected credit:

Insert Figure 6 about here

If the bank meets with a borrower who does not satisfy its lending standards $(\omega < \pi_t)$, then it does not lend and instead it invests in Government bonds. Thus, total credit given by banks is

$$L_t = \int_{\pi_t}^{\infty} l_t dG(\omega) \tag{18}$$

and the amount invested in Government bonds is the difference between the deposits it received minus the loans:

$$B_t = D_t - L_t \tag{19}$$

In equilibrium, it must be that

$$R_t^B = R_t^D \tag{20}$$

Otherwise, given than both are safe assets, banks would enjoy an arbitrage opportunity raising an infinite level of deposits to invest in government bonds. Or banks not lending would not accept deposits.

If the loan defaults banks face a foreclosure cost such that the bank only received $(1-\epsilon)\%$ of the value of the house of the defaulted borrower.

A borrower receiving credit at t will default at $t+1$ if $\omega < \hat{\omega}_{t+1}$ where the default threshold $\hat{\omega}_{t+1}$ is defined by (7).

Banks' expected profits are

$$E_t\left[\Pi_{t+1}^B\right] = \left\{ \begin{array}{c} E_t\left[\int_{\pi_t}^{\max\{\pi_t,\hat{\omega}_{t+1}\}} \left\{W_{t+1}\omega n_b + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right\} dG(\omega)\right] + \\ +E_t\left[\int_{\max\{\pi_t,\hat{\omega}_{t+1}\}}^{\infty} R_t^L l_t dG(\omega)\right] + R_t^B B_t - R_t^D D_t \end{array} \right\} \tag{21}$$

with the default threshold $\hat{\omega}_{t+1}$ is defined by (7). From period t perspective the default threshold, house prices and aggregate income are random variables. The area $[M, \pi_t]$ is the region where the banks are not lending. If $\max\{\pi_t, \hat{\omega}_{t+1}\} = \pi_t$ then the lending standard were high enough and no default happens. If max $\{\pi_t, \hat{\omega}_{t+1}\} = \hat{\omega}_{t+1}$ then the lending standard would allow default to happen. In that case, the bank would get the income and the house of the borrower.

Banks choose π_t to maximize (21) subject to (18) and (19) .And the realized bank profit Π_t^B is defined as

$$\Pi_t^B = \left\{ \begin{array}{c} \int_{\pi_t - 1}^{\max\{\pi_{t-1}, \hat{\omega}_t\}} \left\{ W_t \omega n_b + (1-\epsilon)(1-\delta) p_t \bar{h} \right\} dG(\omega) + \\ + \int_{\max\{\pi_{t-1}, \hat{\omega}_t\}}^{\infty} R_{t-1}^L l_{t-1} dG(\omega) + R_{t-1}^B B_{t-1} - R_{t-1}^D D_{t-1} \end{array} \right\} \tag{22}$$

4.5 Government

The government sells in period t 1-period bonds promising return R_t^B in period $(t+1)$. The government taxes the savers with a lump-sum tax T_t to help repay the period $(t-1)$. Government's budget constraint is:

$$T_t = R_{t-1}^B B_{t-1} - B_t \tag{23}$$

4.6 Shocks

I assume log-normal AR(1) processes as it is common in the macroeconomic Real Business Cycle literature in which productivity is the main driver of business cycle fluctuations

$$\log z_{ct} = \rho \log z_{ct-1} + \varepsilon_{zc,t} \tag{24}$$

$$\varepsilon_{zc,t} \sim N\left[0, \sigma^2\right] \tag{25}$$

$$\log z_{ht} = \rho \log z_{ht-1} + \varepsilon_{zh,t} \tag{26}$$

$$\varepsilon_{zh,t} \sim N\left[0, \sigma^2\right] \tag{27}$$

4.7 Market Clearing Conditions

In an equilibrium all agents of the economy must be optimizing and the following four markets must clear:

1) *Goods market*: Goods produced by firms must equal the goods consumed by borrowers

who are not financed and live in Autarky, plus goods consumed by borrowers (young being financed and elderly not defaulting) and savers.

$$y_{c,t} = \int_{M}^{\infty} c_t^{t-1}(\omega)\, dG(\omega) + \tilde{c}_t \tag{28}$$

where

$$c_t^{t-1}(\omega) = \left\{ \begin{array}{c} (1-\delta)\, p_t \bar{h} + W_t \omega n_b - R_{t-1}^L l_{t-1} \qquad \text{when } \omega \in [\max\{\pi_{t-1}, \hat{\omega}_t\}, \infty) \\ W_t \omega n_b \qquad \text{when } \omega \in [M, \pi_{t-1}) \end{array} \right\}$$

that can be simplified to

$$\begin{aligned} & y_{c,t} - W_t n_b \tfrac{\mu}{\mu-1} M^{\mu} \left(M^{1-\mu} - \pi_{t-1}^{1-\mu}\right) \\ &= \left[(1-\delta)\, p_t \bar{h} - R_{t-1}^L l_{t-1}\right] M^{\mu} \max\{\pi_{t-1}, \hat{\omega}_t\}^{-\mu} + W_t n_b \tfrac{\mu}{\mu-1} M^{\mu} \max\{\pi_{t-1}, \hat{\omega}_t\}^{1-\mu} + \tilde{c}_t \end{aligned}$$

2) *Housing market*: the demand for houses from the new financed homeowners ($\omega \geq \pi_t$) must equal the existing housing stock minus the housing stock lost due to foreclosure processes plus the new houses built. I assume then no stock of vacant houses.

$$\int_{\pi_t}^{\infty} \bar{h}\, dG(\omega) = H_t = (1-\delta)\, H_{t-1} + z_{h,t} N_{h,t}^{\phi} \bar{h} - \int_{\pi_{t-1}}^{\max\{\pi_{t-1}, \hat{\omega}_t\}} \epsilon (1-\delta)\, \bar{h}\, dG(\omega) \tag{29}$$

which can be simplified to

$$H_t = (1-\delta)\, H_{t-1} + z_{h,t} N_{h,t}^{\phi} \bar{h} - \epsilon (1-\delta)\, \bar{h} M^{\mu} \left[\pi_{t-1}^{-\mu} - \max\{\pi_{t-1}, \hat{\omega}_t\}^{-\mu}\right]$$

3) *Credit market*: Supply of funds equals use of funds:

$$D_t = B_t + \int_{\pi_t}^{\infty} l_t\, dG(\omega) \tag{30}$$

that can be simplified to

$$D_t = B_t + l_t M^{\mu} \pi_t^{-\mu} \tag{31}$$

4) *Labor market*: Supply of labor equals demand for labor:

$$N_s + \int_M^{\infty} \omega n_b dG(\omega) = N_{h,t} + N_{c,t}$$

that can be simplified to

$$N_s + \frac{\mu M}{\mu - 1} n_b = N_{h,t} + N_{c,t} \tag{32}$$

5) Moreover, in equilibrium the interest on reserves equals the deposit rate:

$$R_t^B = R_t^D \tag{33}$$

6) Finally, a zero expected profit condition must hold for banks to pins down R_t^L

$$0 = E_t\left[\Pi_{t+1}^B\right] \tag{34}$$

$$= \begin{array}{c} E_t\left[\int_{\pi_t}^{\max\{\pi_t,\hat{\omega}_{t+1}\}} \left\{W_{t+1}\omega n_b + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right\} dG(\omega)\right] + \\ +E_t\left[\int_{\max\{\pi_t,\hat{\omega}_{t+1}\}}^{\infty} R_t^L l_t dG(\omega)\right] + R_t^B B_t - R_t^D D_t \end{array} \tag{35}$$

that can be simplified to

$$0 = M^{\mu} \cdot E_t\left[\begin{array}{c} (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\left(\pi_t^{-\mu} - \hat{\omega}_{t+1}^{-\mu}\right) + \frac{\mu}{\mu-1}W_{t+1}n_b\left(\pi_t^{1-\mu} - \hat{\omega}_{t+1}^{1-\mu}\right) \\ +R_t^L l_t \hat{\omega}_{t+1}^{-\mu} - R_t^B l_t \pi_t^{-\mu} \end{array}\right] \tag{36}$$

5 The Lending Standards Decision

To characterize the lending standards we need to solve bank's problem. Since Banks' expected profits, $E_t\left[\Pi_{t+1}^B\right]$ which is defined in equation (21) can be written as

$$E_t\left[\Pi_{t+1}^B\right] = M^{\mu} \cdot E_t\left[\begin{array}{c} (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\left(\pi_t^{-\mu} - \hat{\omega}_{t+1}^{-\mu}\right) + \frac{\mu}{\mu-1}W_{t+1}n_b\left(\pi_t^{1-\mu} - \hat{\omega}_{t+1}^{1-\mu}\right) \\ +R_t^L l_t \hat{\omega}_{t+1}^{-\mu} - R_t^B l_t \pi_t^{-\mu} \end{array}\right] \tag{37}$$

From the FOC we obtain that the optimal standards π_t^* are determined by the expression

$$\underbrace{R_t^B l_t}_{\text{Return of Gov. Bond}} = \left(\underbrace{E_t [W_{t+1}] n_b \pi_t^*}_{\text{Value borrower income}} + \underbrace{(1-\epsilon)(1-\delta) E_t [p_{t+1}] \bar{h}}_{\text{Value borrower assets net of foreclosure costs}} \right) \tag{38}$$

as long as $\pi_t^* \leq E_t [\hat{\omega}_{t+1}]$, where the expected default borrower, $E_t [\hat{\omega}_{t+1}]$, is computed taking expectations on equation (7)

$$E_t [\hat{\omega}_{t+1}] = E_t \left[\frac{R_t^L l_t - (1-\delta) p_{t+1} \bar{h}}{W_{t+1} n_b} \right] \tag{39}$$

Since

$$\pi_t^* = \frac{R_t^B l_t - (1-\epsilon)(1-\delta) E_t [p_{t+1}] \bar{h}}{E_t [W_{t+1}] n_b} \tag{40}$$

It is possible to show that banks' lending standards would allow for expected default to happen ($\pi_t^* \leq E_t [\hat{\omega}_{t+1}]$) as long as

$$\epsilon (1-\delta) E_t [p_{t+1}] \bar{h} \leq \left(R_t^L - R_t^B \right) l_t.$$

Or, using (5) ,

$$\epsilon \leq \frac{\left(R_t^L - R_t^B \right) p_t}{(1-\delta) E_t [p_{t+1}]}$$

That is, banks allow defaults as long as the loss rate associated with default (ϵ) is less than the percentage-wise reduction in return which the bank would experience from switching from loans (returning R_t^L) to safe government bonds ($R_t^B \leq R_t^L$) weighted by the house price appreciation.

When banks allow for standards that induce some expected default ($\pi_t^* \leq E_t [\hat{\omega}_{t+1}]$) expression (38) characterizes banks' choice of standards. The economics of the expression are intuitive. The banks chooses the lending standards so the default borrower at least guarantees the return on government bonds. Using the Implicit Function Theorem is easy to show that higher expected house prices and borrowers' income leads to lower standards.

$$\frac{\partial \pi_t^*}{\partial E_t [W_{t+1}]} = -\frac{\pi_t^*}{E_t [W_{t+1}]} < 0$$
$$\frac{\partial \pi_t^*}{\partial E_t [p_{t+1}]} = -\frac{(1-\epsilon)(1-\delta) \bar{h}}{E_t [W_{t+1}] n_b} < 0$$

And higher costs of foreclosing or higher return on government bonds imply tighter standards.

$$\frac{\partial \pi_t^*}{\partial \epsilon} = \frac{(1-\delta) E_t [p_{t+1}] \bar{h}}{E_t [W_{t+1}] n_b} > 0$$
$$\frac{\partial \pi_t^*}{\partial R_t^B} = \frac{l_t}{E_t [W_{t+1}] n_b} > 0$$

The next Figure plots these patterns

Insert Figure 7 about here

6 Dynamics in the Extensive Margin of Credit

Among the different drivers of lending standards discussed above, expectations of borrowers' income and house prices are key drivers. In this Section I show that it is enough a boom/bust pattern on expectations to replicate changes in the extensive margin of credit that looks very similar to the data presented in Section 3.

Figure 8 contains a simulation that shows that the model can account for the patterns of Figure 3. As income and house price growth decrease, lender become pessimistic and increase the lending standards. What reinforces the house price drop. And since less borrowers qualify for credit, the quality of the different percentiles of the financed borrowers is higher as reflected in the lower right panel of Figure 8.

Insert Figure 8 about here

7 Policy Analysis I: Loan Guarantees

The US Government has usually believed that good borrowers are often being denied loans and designed policies to encourage lenders to lend to Government defined creditworthy borrowers. Obama (2013) is a recent example. Government loan guarantees is the more popular policy. For example, in the current housing finance system, the government guarantees more than 80% of all mortgages through Fannie Mae and Freddie Mac and FHA (Obama 2013). Other examples include the Veterans Affairs mortgages, known as VA loans, and the Section 184 Indian Home Loan Guarantee Program.

In this Section, I show that usually loan guarantees lead to laxer lending standards and higher homeownership. However, this comes at a cost. I show that there is a trade-off between expanded homeownership and financial stability. That is, the risk of credit losses suffered by the Government is an increasing function of the higher homeownership rate induced by the loan guarantees.

First, I reformulate banks' problem to introduce a loan guarantee. I assume that in case of borrowers' default, the Government insures that the lender received at least $x\%$ of the principal plus interest owed by the borrower. That is, if a borrower defaults the lender receives

$$x\left[R_t^L l_t - \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]\right] + \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]$$

where x is the percentage of the loss insured by the Government. If x is 1 then the lender is perfectly insured and knows it will receive R_t^L per each loan granted. If x is 0 then there are no loan guarantees. Thus, now lenders' profits are:

$$E_t\left[\Pi_{t+1}^B\right] = \left\{ \begin{array}{c} E_t\left[\begin{array}{c} \int_{\pi_t}^{\max\{\pi_t,\hat{\omega}_{t+1}\}} \left\{x\left[R_t^L l_t - \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]\right] + \right. \\ \left. + \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]\right\} dG(\omega) \end{array} \right] + \\ +E_t\left[\int_{\max\{\pi_t,\hat{\omega}_{t+1}\}}^{\infty} R_t^L l_t dG(\omega)\right] + R_t^B\left(D_t - \int_{\pi_t}^{\infty} l_t dG(\omega)\right) - R_t^D D_t \end{array} \right\} \quad (41)$$

with the default threshold $\hat{\omega}_{t+1}$ defined again by (7).

From the banks' FOC we obtain that the optimal lending standards π_t^* would be determined by:

$$\underbrace{\left(R_t^B\right)\cdot l_t}_{\text{Return of bond}} = \underbrace{xR_t^L}_{\text{Gov. guarantee}} + (1-x)\cdot\left[\underbrace{\left(E_t\left(s_{t+1}\right)+\pi_t^*\right)}_{\text{Value borrower income}} + \underbrace{(1-\epsilon)(1-\delta)E_t\left[p_{t+1}\right]\bar{h}}_{\text{Value borrower assets}}\right] \quad (42)$$

And, by comparing with (38) we observe how the guarantees affect lenders' behavior. The Government is leading the lender to compute as return of the defaulted loan a weighted combination between the return if no default $\left(R_t^L\right)$ and the return if the borrower defaults (value of her income and her house net of foreclosure cost).

From (42) we can obtain the lending standards in closed-form:

$$\pi_t^* = \frac{\left(R_t^B - xR_t^L\right) \cdot l_t}{1-x} - (1-\epsilon)(1-\delta) E_t [p_{t+1}] \bar{h} - E_t (s_{t+1}) \tag{43}$$

And by taking partial derivative we can characterize the marginal effect of the loan guarantee

$$\frac{\partial \pi_t^*}{\partial x} = \frac{R_t^B - R_t^L}{(1-x)^2} l_t < 0 \tag{44}$$

which is negative given $R_t^B < R_t^L$, that is, higher loan guarantees lead to laxer standards. The next Figure contains a simulation that illustrates that the larger the fraction of the loan revenue guaranteed by the government, the lower the lending standard each bank sets

Insert Figure 9 about here

Loan guarantees have a strong effect on the homeownership rate. In the model, this rate is governed by those households with $\omega \geq \pi_t^*$ who are financed by the bank to purchase houses. Therefore, we can define the percentage of homeownership $Q\%$ as

$$Q = \int_{\pi_t^*}^{\infty} dG(\omega) = \left(\frac{M}{\pi_t^*}\right)^{\mu} \tag{45}$$

The homeownership rate is decreasing in lending standards and increasing in government guarantees.

Insert Figure 10 about here

However, the guarantees imply a risk. Bad realizations of aggregate income (s_t) will induce bank losses that have to be absorbed by the government. Solving the integrals we can rewrite bank profits as

$$\Pi_t^B = M^{\mu} \left\{ \begin{array}{c} xR_{t-1}^L l_{t-1} \left[\pi_{t-1}^{-\mu} - \hat{\omega}_t^{-\mu}\right] + (1-x)\left[s_t + (1-\epsilon)(1-\delta) p_t \bar{h}\right] \left(\pi_{t-1}^{-\mu} - \hat{\omega}_t^{-\mu}\right) \\ +(1-x)\frac{\mu}{1-\mu}\left[(\pi_{t-1})^{1-\mu} - (\hat{\omega}_t)^{1-\mu}\right] + R_{t-1}^L l_{t-1} \hat{\omega}_t^{-\mu} - \left(R_{t-1}^B\right) l_{t-1} \pi_{t-1}^{-\mu} \end{array} \right\} \tag{46}$$

where

$$\hat{\omega}_t = R_{t-1}^L l_{t-1} - (1-\delta) p_t \bar{h} - s_t \tag{47}$$

The next Figure shows how banks profits (Π_t^B) would be affected by the gap between lenders' expectations on borrowers' income and borrowers' realized income, that is, the ratio $(\frac{s_t}{E_{t-1} s_t})$.

When the realization is small enough relative to the expectation the bank make losses. And a share of them would be covered by the government.

Insert Figure 11 about here

Therefore, there is a tradeoff between homeownership and financial stability. Larger levels of homeownership imply that lower quality borrowers qualified for credit (lower π_t^*) and thus bank losses after bad income shocks would be larger. The next figure illustrates the relation, the x-axis plots ownership ratios and the y-axis the bank profits. Different lines imply different levels of borrower's income realizations relative to lender's expectations, that is $(\frac{s_t}{E_{t-1}s_t})$,

Insert Figure 12 about here

High rates of homeownership imply that society must be ready to absorb potentially large bank losses if the aggregate income shocks are not good.

8 Policy Analysis II: Qualified Mortgages and Regulatory Burden

One of the major policy proposals from the Dodd–Frank Reform is the Qualified Mortgage (QM) rule, that really is a set of rules. If the lenders satisfy the rules the mortgage is considered "a qualified mortgage". Banks can lend outside the guidelines but are likely to do so rarely because a "nonqualified" loan lacks legal protection if it fails. In fact, most mortgage officials think that the overwhelming majority of lenders, will not lend outside the boundaries of qualified mortgages. A conclusion that seems supported because there is no discernible secondary market for nonqualified mortgages.

Will the new QM rules restrict access to credit? Most officials believe that no because the rules set up criteria that are not usually binding (as a 43% cap on borrower's debts to gross monthly income). However, in this section I show that that reasoning misses one very important point. The rules impose compliance costs to the banks when they lend. That is, the bank will need to devote resources to insure the loan satisfies the QM rules. And as I will show up, the costs of this greater deal of attention to the details of the new regulations will lead to tighter standards.

I assume that for every loan granted the bank needs to pay a cost ψ to insure that the loan is conforming with the QM rules. For example, ψ may be the wages of the extra loan officers needed to implement the new regulation. Therefore, lenders' profits are now:

$$E_t\left[\Pi_{t+1}^B\right] = \left\{ \begin{array}{c} E_t\left[\begin{array}{c} \int_{\pi_t}^{\max\{\pi_t,\hat{\omega}_{t+1}\}} \left\{ x\left[R_t^L l_t - \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]\right] + \right. \\ \left. + \left[s_{t+1} + \omega + (1-\epsilon)(1-\delta)p_{t+1}\bar{h}\right]\right\} dG(\omega) \end{array} \right] + \\ +E_t\left[\int_{\max\{\pi_t,\hat{\omega}_{t+1}\}}^{\infty} R_t^L l_t dG(\omega)\right] + R_t^B\left(D_t - \int_{\pi_t}^{\infty} l_t dG(\omega)\right) - R_t^D D_t - \psi\int_{\pi_t}^{\infty} l_t dG(\omega) \end{array} \right\} \tag{48}$$

Solving the new problem of the bank from the FOC we obtain that the optimal lending standards π_t^* would be determined by:

$$\underbrace{\left(R_t^B + \psi - xR_t^L\right) \cdot l_t}_{\text{Return of bond + transaction cost - Gov. compensation}} = (1-x) \cdot \left[\underbrace{\left(E_t\left(s_{t+1}\right) + \pi_t^*\right)}_{\text{Value borrower income}} + \underbrace{(1-\epsilon)(1-\delta)E_t\left[p_{t+1}\right]\bar{h}}_{\text{Value borrower assets}} \right] \tag{49}$$

where I keep the assumption that x is the percentage of the loss insured by the Government. It is easy to show that the lending standards in closed form are

$$\pi_t^* = \frac{\left(R_t^B + \psi - xR_t^L\right) \cdot l_t}{1-x} - (1-\epsilon)(1-\delta)E_t\left[p_{t+1}\right]\bar{h} - E_t\left(s_{t+1}\right) \tag{50}$$

The effect of the compliance costs on the lending standards are captured by the following partial derivative

$$\frac{\partial \pi_t^*}{\partial \psi} = \frac{l_t}{1-x} > 0 \tag{51}$$

which is positive. That is, the larger the cost associated to issuing new loans, the higher the lending standards that each bank sets. The next figure confirms this result, it plots the standards as a function of the costs of satisfying the new regulations

Insert Figure 13 about here

Therefore, it seems that the new mortgage regulations will have unintended consequences. They will restrict access to credit because lenders will increase lending standards. This result is not due to the regulations in itself, but to the increase in the compliance costs associated with giving credit.

9 Conclusions

This paper has presented a tractable model of lending standards in housing markets. I focused on the extensive margin of credit. That is, the number and quality of the borrowers qualified for credit. The model can generate patterns similar to the tightening and relaxations of lending standards that I documented in Section 1.

I showed that loan guarantees imply a trade-off between homeownership and financial stability. Policymakers need to choose among homeownerhips and financial stability. Next versions of the paper will do a welfare analysis. I also showed that new mortgage regulations will tighten lending standards by increasing the compliance costs associated with lending. This is an unintended consequence of new regulations as the new Qualified Mortgage rules.

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Figures

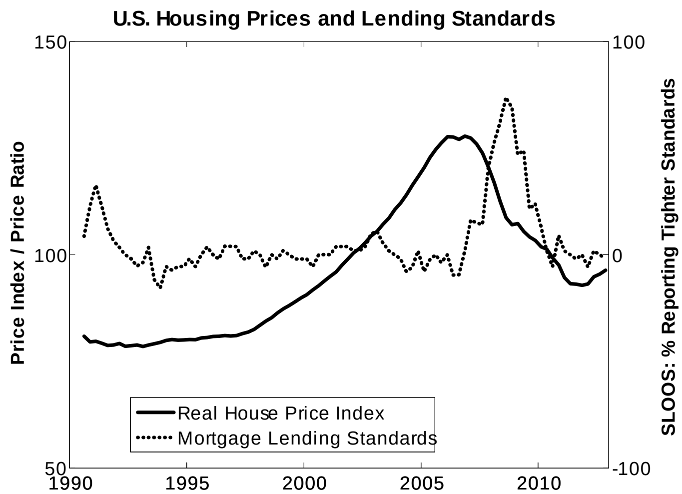

Figure 1: Real House Prices and Mortgages Lending Standards. Source: SLOOS and OECD.

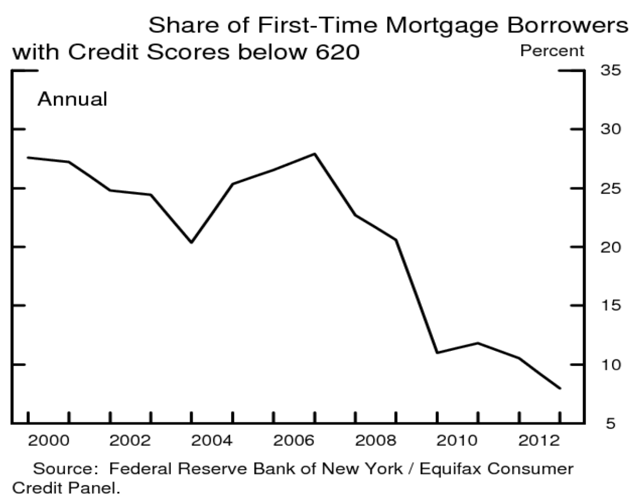

Figure 2: Share of First Time Borrowers with Low FICO Scores. Source: Federal Reserve Board.

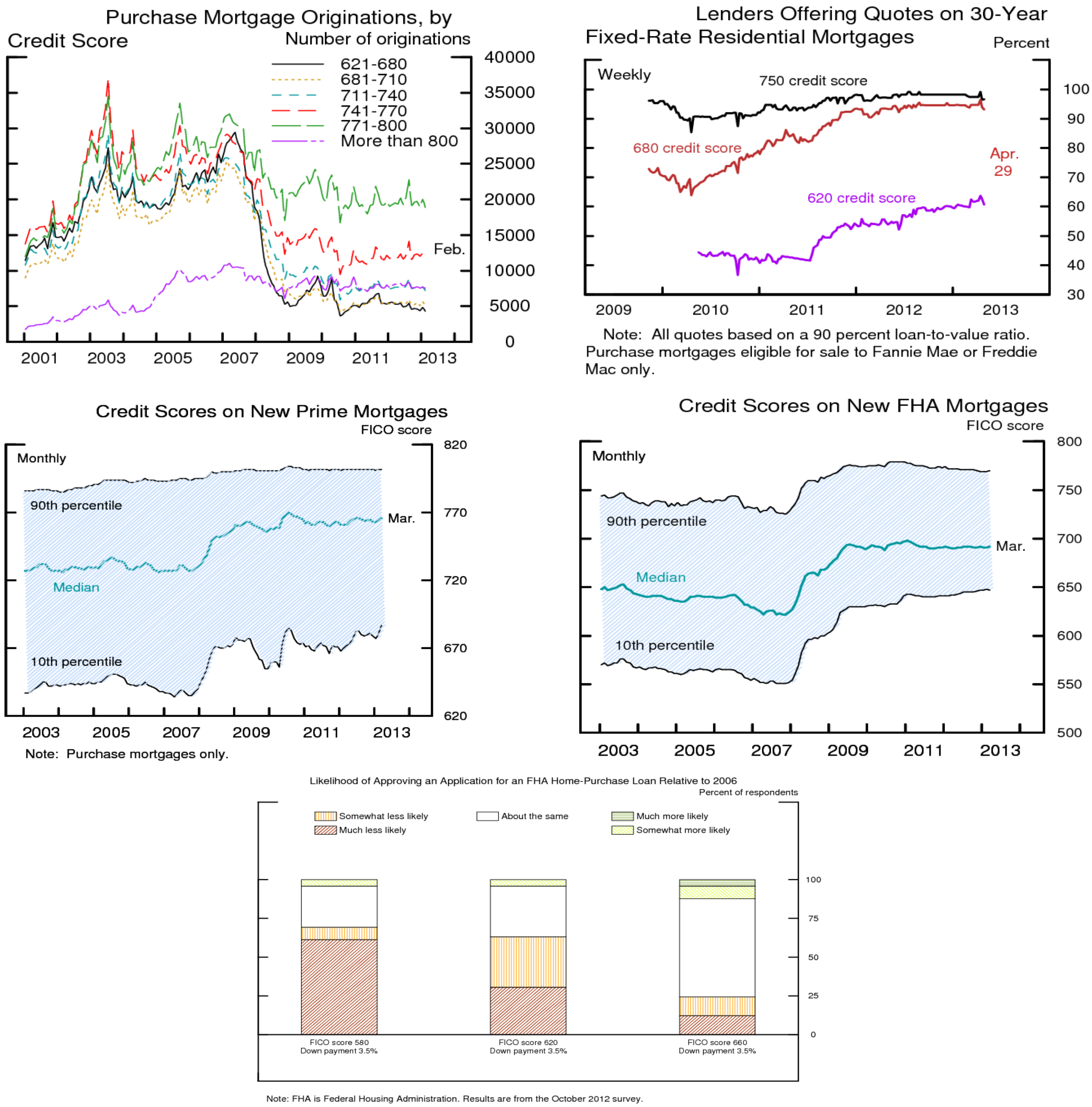

Figure 3: Mortgage Lending Standards. Source: Federal Reserve Board.

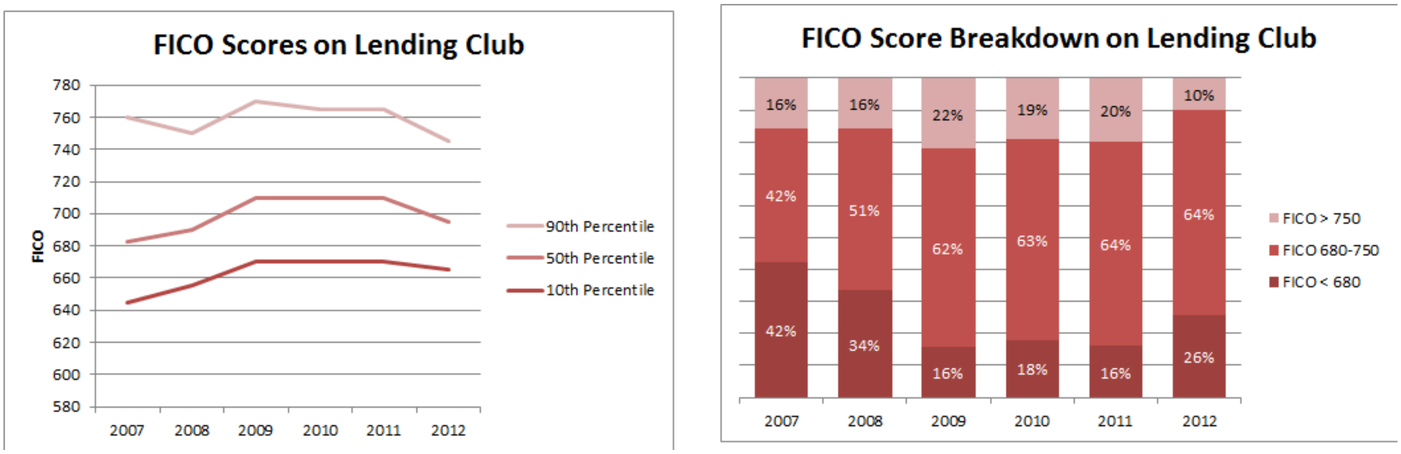

Figure 4: Lending Standards on Peer-to-Peer Lending. Source: Lending Club and Author's calculations

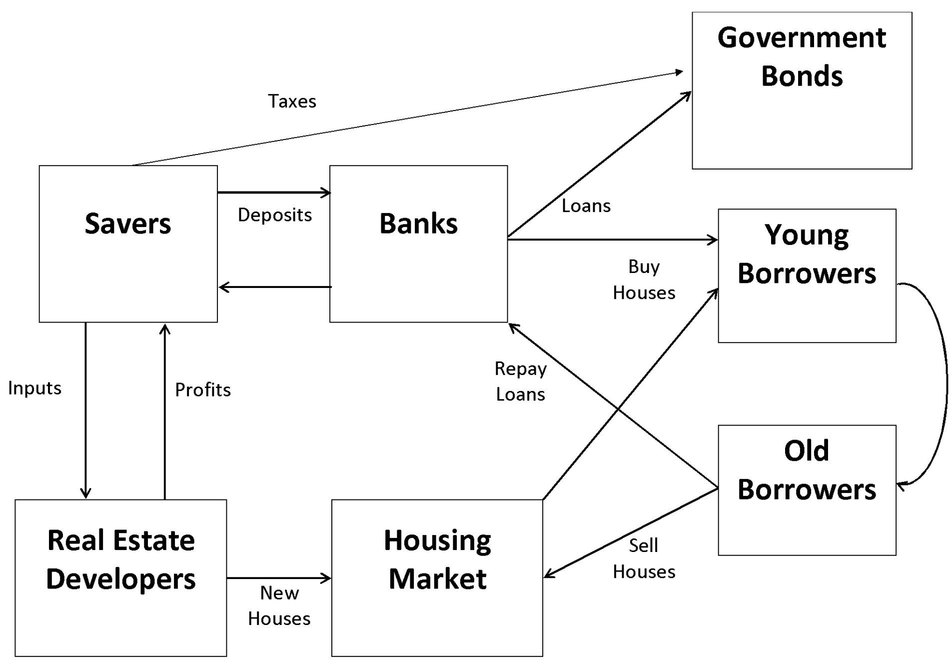

Figure 5: Summary of the Model

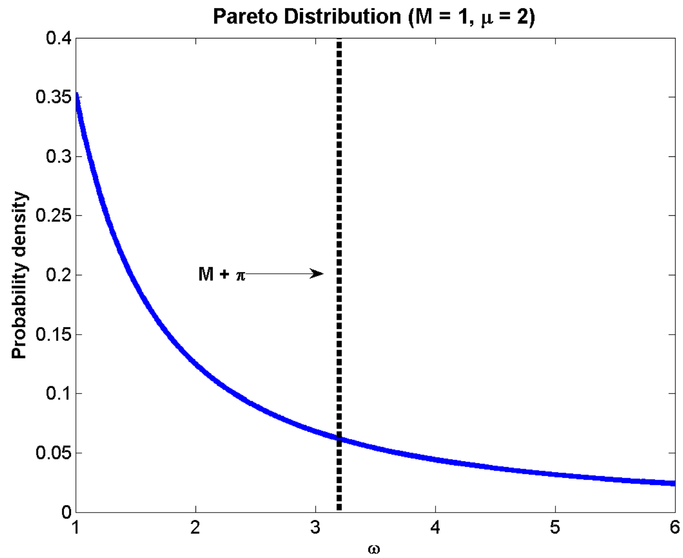

Figure 6: Distribution of Borrowers' Idiosyncratic Income and Lending Standards. This picture plots the Pareto distribution of borrowers and how lending standards are modeled as a cut-off such that no borrower below it qualifies for credit.

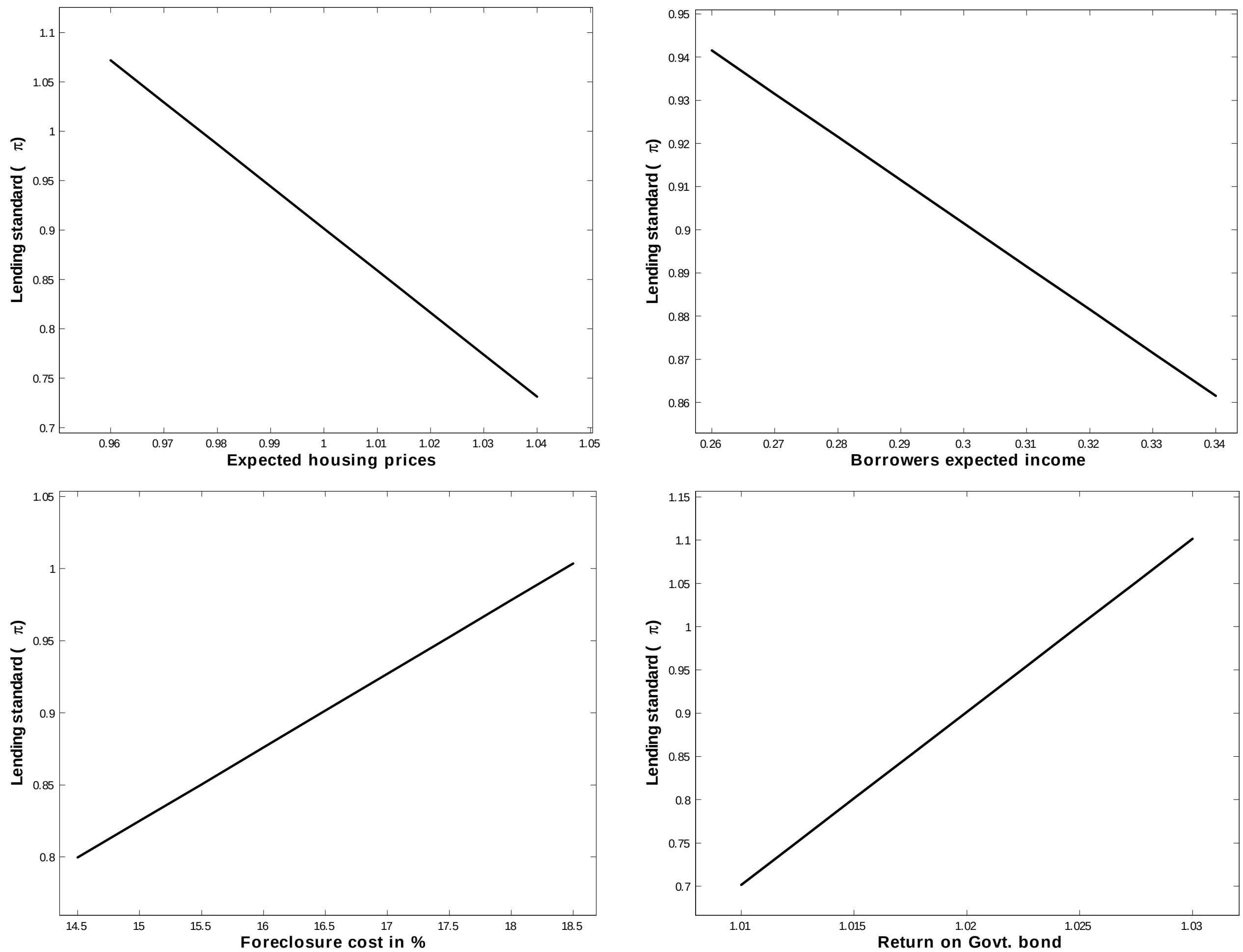

Figure 7: Lending Standards as a Funtion of Different Variables See Section 5 for discussion.

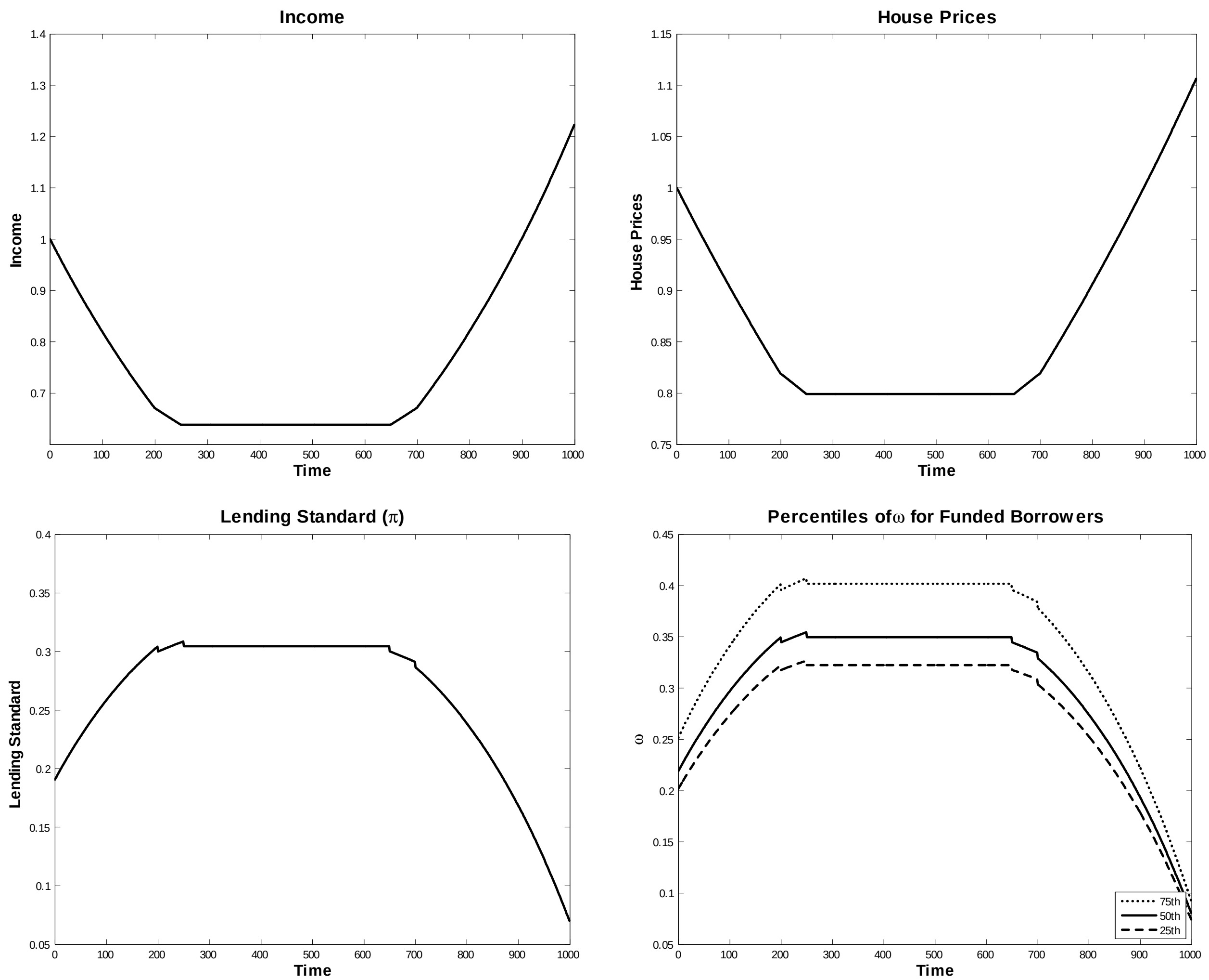

Figure 8: Simulations of Lending Standards and the Quality of Financed Borrowers. See Section 6 for discussion.

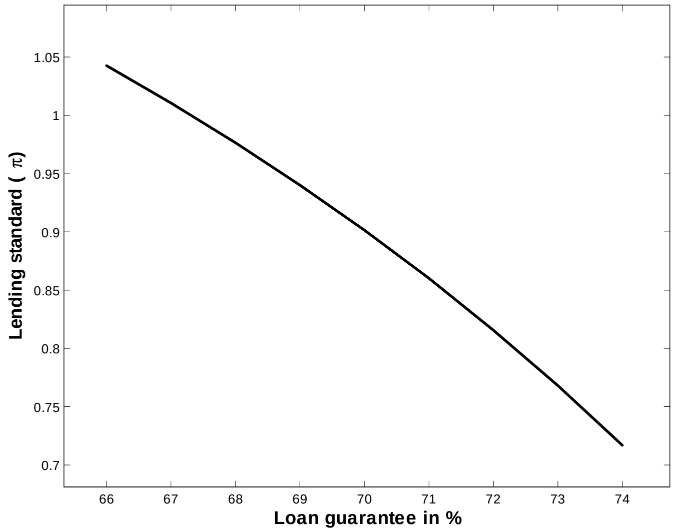

Figure 9: Lending Standards and Government Loan Guarantees. See Section 7 for discussion.

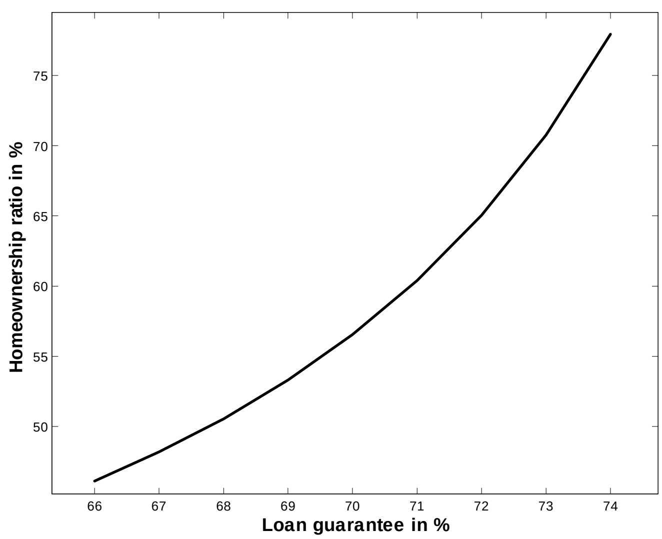

Figure 10: Homeownership Ratio and Government Loan Guarantees. See Section 7 for discussion.

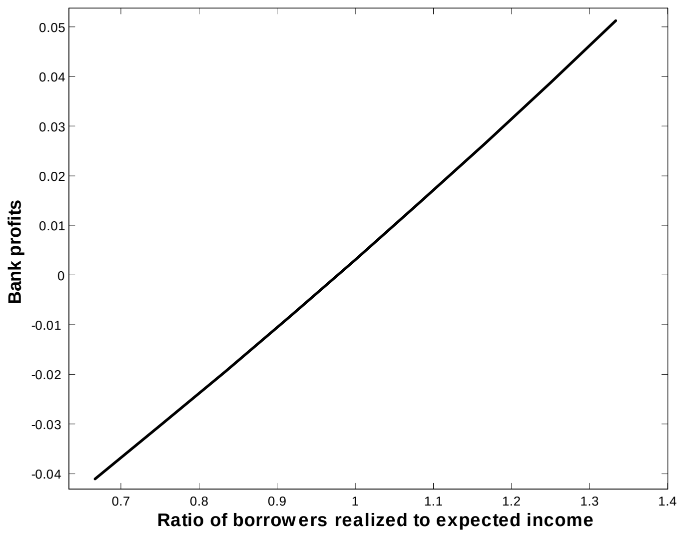

Figure 11: Banks' Profits as a Function of Borrowers' Realized Income Relative to Expected Income. See Section 7 for discussion.

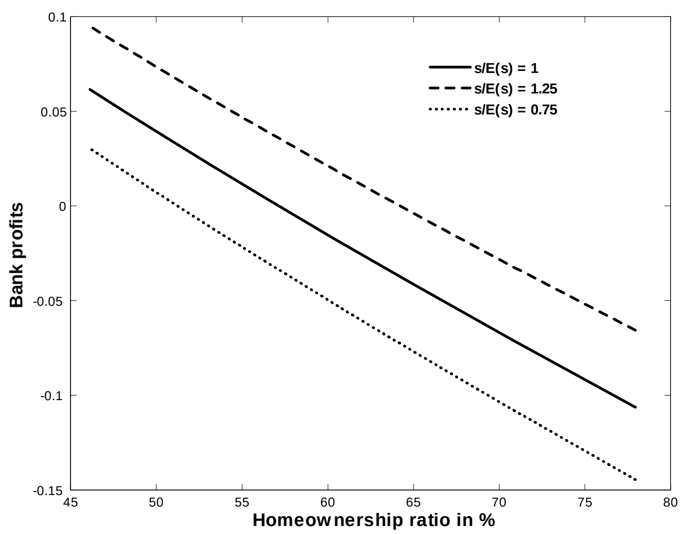

Figure 12: The Homeownership vs Financial Stability Tradeoff. See Section 7 for discussion.

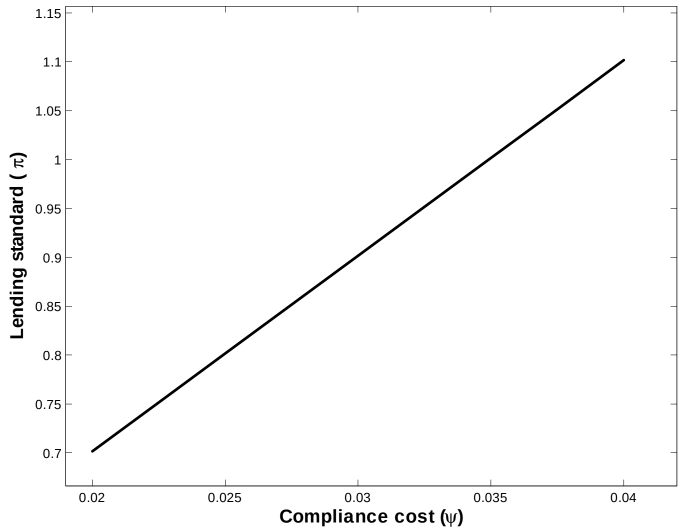

Figure 13: Lending Standards and Compliance Costs. See Section 8 for discussion.